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In Silico and In Vitro Approach of Preeclampsia Prophylaxis from Water of Kalianda Kopyor

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Abstract

Preeclampsia (PE) stands as a prominent cause of maternal mortality in developing nations, yet a standardized therapy for PE has not been established. Some pregnant women in Lampung have consumed the water of young kopyor coconut fruit from the Kalianda variety (WKK), although its therapeutic effects remain unexplored. This study aimed to investigate WKK phytochemicals through in vitro and silico analyses. Liquid Chromatography-Mass Spectrometry (LCMS) was employed for phytochemical analysis, while an in silico study involved Autodock, Autodock Tools, Autodock Vina, Biovia Discovery Studio 2020, and Open Babel GUI, alongside pharmacokinetics prediction using the pkCSM strategy. The study assessed the inhibitory potential of WKK on Gentiatibetine and curcumenolacto C, targeting the PE ACE2 receptor (1R24) through molecular docking with the 3D structure. Post-docking analysis, including binding affinities, hydrophobic interactions, and pharmacokinetic predictions, was conducted. WKK exhibited relatively low binding affinities for Gentiatibetine (-4.86 kcal/mol), curcumenolactone C (-2.96 kcal/mol), and aspirin (-5.12 kcal/mol). Multiple hydrophobic interactions were observed, such as Van der Waals, Salt Bridge, Conventional Hydrogen Bond, Alkyl, 162, and Lys 129. The receptor IR displayed a high bond-free energy, like aspirin docked with the same gene receptor. Pharmacokinetics predictions indicated that WKK possesses a favorable profile. In conclusion, WKK phytochemicals demonstrated a notable docking score comparable to aspirin, suggesting its potential for preventive therapy use.

Introduction

Preeclampsia (PE) is one of the obstetric disorders that increases maternal mortality in developing countries, which accounts for 15 % of deaths every year and also leads to mortality for fetuses and neonates (World Health Organization, UNICEF, UNFPA, 2019). Approximately 2–8% of total pregnant women globally tend to suffer PE after 20 weeks of gestation (Poon *et al.*, 2021). Preeclampsia is a heterogeneous condition that can be challenging to diagnose, given the broad spectrum of presentation and the current lack of a robust diagnostic test. The cardinal features of preeclampsia are new-onset hypertension (defined as systolic blood pressure ≥140 mm

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Hg or diastolic blood pressure ≥90 mm Hg) and proteinuria (300 mg or greater in a 24-h urine specimen) (Qi, Wu, Chen, Wei, & Yao, 2022). Severe pre-eclampsia can be followed by placental abruption, eclampsia, HELLP syndrome (hemolysis, elevated liver enzymes, and low platelet count syndrome), and even multiple systemic organ damage (Assersen, Sumners, & Steckelings, 2020).

However, a standard therapy for PE has not been established. Recently, it has been reported that 1.5 mg aspirin/day can reduce symptoms and signs of PE. Still, this therapy for long-term periods has negative impacts, including bleeding in late pregnancy (Golyanovskyi, 2021). Another PE treatment uses herbal medicine such as Extra Virgin Olive Oil (EVOO), which contains high monounsaturated fatty acid able to inhibit angiotensin-converting enzyme (ACE), which regulates blood pressure and reduces low levels of nitric oxide and 8-isoprostanes in the urine. Furthermore, some people who drink high olive oil can experience weight gain and nausea (Fitriana *et al*., 2024). Another natural functional food that is used to reduce high blood pressure is coconut water (Bhagya, Prema and Rajamohan, 2012). A coconut tree, also known as the tree of life, is a tropical plant. It is widely distributed in tropical and subtropical countries, and every part of the coconut tree has beneficial effects on human life (Rao and Najam, 2016). However, the widely used antihypertensive drugs are not available for pregnant women. The common hypertensive drug categorized as an ACE inhibitor cannot be used safely by a pregnant woman because this type of drug may cause fetal developmental abnormalities (Chrismis *et al*., 2020).

Several bioactive natural products are sources of compounds that have been used either prophylactically or therapeutically to prevent/alleviate diseases (Ahmadu & Ahmad, 2020). The advantage of using natural products is that they are usually well-tolerated with minimal side effects (Cragg & Pezzuto, 2016). Although TCW reduces paw edema and accelerates wound healing in experimental models, the mechanism behind its anti-inflammatory properties has not been determined (Radenahmad *et al*., 2012),(Rao & Najam, 2016). TCW's reported anti-inflammatory effects would regulate the expression of inflammation mediators and cytokine-mediated NO production, Nos2 mRNA, and iNOS protein expression in primary rat hepatocytes (Lakshmanan *et al*., 2020). Given TCW's reported anti-inflammatory and endotelial dysfunction effects, we hypothesized that TCW would regulate the reduction of inflammation mediators and mediated NO production in PE therapy. In addition, water from young Kopyor coconut fruit of Kalianda (WKK) has been drunk by some pregnant women in Indonesia to facilitate the smooth labor process. However, the WKK benefits for their labor process are not supported by scientific data and evidence (Fitriana *et al*., 2024). Unfortunately, the information regarding the antihypertensive potency of this plant is unknown.

With the current development of bioinformatics tools and databases, the prediction of the biological activity of a compound can be performed in silico. Molecular docking is a method for predicting biological activities based on their structural properties (Jiao *et al*., 2021). Molecular docking is a method often used to foresee the binding mode of compounds toward a protein that gives us insights into how the compound may interact with the protein (Yong, Ge, Ng, & Tan, 2009). Therefore, the objective of this research study was to investigate phytochemicals and molecular docking using a bioinformatics approach; a preliminary assessment of WKK potential as an anti-PE was performed within the WKK (Fitriana *et al*., 2024).

Material and Method

Coconut fruits (Cocos nucifera L var. Kopyor) of the puan Kalianda variety were obtained from Tanjung Anom village, Kalianda district, South Lampung Regency, Lampung Province, Indonesia, and registered in the Indonesian Ministry of Agriculture with number Surat Keputusan Menteri Pertanian Nomor: 96/Kpts/KB.010/2/2017. The coconut fruits were picked up by a 5-month-old and sent to the PT Saraswanti Indo Genetech (SIG), Bogor City, West Java province, Indonesia, for further chemical analysis. The tools, programs, and applications used in this study

were Lenovo YOGA Slim 7i Carbon, Processor Core i7, Chemdraw (v16.0), Python (v3.10.0), Open Babel GUI (v3.1.1.1), MGL Tools or AutoDock Tools (v1.5.7), Biovia Discovery Studio Visualizer 2021 (v21.1), AutodockVina, Command Window, pkCSM web server (http://biosig.unimelb.edu.au/pkcsm/). The three-dimensional structure of trans-WKK, as a test compound, and Aspirin, as a standard compound, was downloaded from https://pubchem.ncbi.nlm.nih.gov/. Target gene structures of luxS (PDB ID: ACE2 (1R24) were downloaded from www.rcsb.org.

Bioactive compounds of the WKK, such as flavonoids, tannins, saponins, steroids, and triterpenoids, were analyzed using a liquid chromatography/mass spectrometry-quadrupole—time (LCMS/MS-QTOF) device, equipped with the UniFi software (Neacsu *et al*., 2022). According to the SIG protocol, 1g of the WKK was ultrasonically mixed with methanol solvent for 30 minutes and filtered using a 0.22 µm PTEF membrane. Furthermore, 10 µL of the WKK sample was injected into the UPLC system with a C18 Column, 400°C column temperature, and 15°C Autosampler temperature. This LC system used 0.1 % (volume/volume) formic acid in acetonitrile as a mobile phase A and 0.1 % (v/v) formic acid in double-distilled water as a mobile phase B. The flow rate of the LC system was set up at 0.6 mL/min, and the MS settings were the mode of operation, to MSE, ionization: ESI (-)/ESI (+), and acquisition range: 50-1,200 Da. The mass spectra of the bioactive compounds in the WKK sample were identified by comparison to the mass spectra in the library of the UniFI software.

The proteins of WKK (Gentiatibetine, Curcumenolactone C) and aspirin were prepared using the Biovia DS Visualizer application (Trott & Olson, 2010). The preparation of Gentiatibetine, Curcumenolactone C, and aspirin proteins was done by separating the proteins from their native ligands and the residues in their receptors. Then, all files were saved in pdb format. Meanwhile, the ligand preparation was done by optimizing the 3D WKK structure, then the file was saved in .pdb and converted to .pdbqt by Autodock tools (v1.5.7) (Ferdian *et al*., 2021), while the validation result was expressed as Root Mean Square Deviation (RMSD) with PyMol 2.4.0. The materials used are the 3D structure of ACE2 (1R24) with Protein Data Bank (PDB) format downloaded at https://www.rcsb.org/, which is the main protease of preeclampsia, and the 3D structure of the compound ligands Gentiatibetine and Curcumenolactone C in the Kopyor young coconut water plant, which is downloaded at https://pubchem.ncbi.nlm.nih.gov/. Before belaying, set the number of torsions first. Gentiatibine uses a torsion number of 20, while Curcumenolactone C is 30. The anchorage used in the grid box is center x = 20,035, y = - 27,532, z = -31.9, size x, y, z = 40. The accuracy value (exhaustiveness) used is 7.

The first step for the research procedure is the preparation of the ligands (Gentiatibetine and Curcumenolactone C), which will be changed in format from .sdf to .pdb in the Open Babel GUI application. Next, to prepare the ACE2 receptor (1R24), open the Biovia Discovery application to clean the water molecules and native ligands on the receptor to get a pure receptor. After the ligand and receptor have been prepared, open the receptor in the Autodock Tools application to add hydrogen atoms with the aim of equalizing the receptor computing temperature, and open the ligand to set the number of torsions, then save. The next step is the anchoring process. To find out where the ligand is attached to the receptor, open the Computed Atlas of Surface Topography of Protein website to see the active binding sites on the receptor and then dock using the blind docking method. Note down all the numbering and formatting in Notepad. After that, combine all the files along with the Autodock Vina application (autodock vina, vina_split, and vina_license) in one folder, then enter the formula for calculations in the Command Prompt, as follows: D:\>cd file name> vina –config file notepad.txt – log log.txt vina_split –input out.pdbqtAfter that, look at the lowest binding affinity value because the smaller the binding affinity value, the stronger the binding ability between the ligand used and the receptor. The final step is visualization of the receptor and ligand in the Biovia Discovery application, both in 2D or 3D, to see the bonds and amino acid residues formed. Figure 1

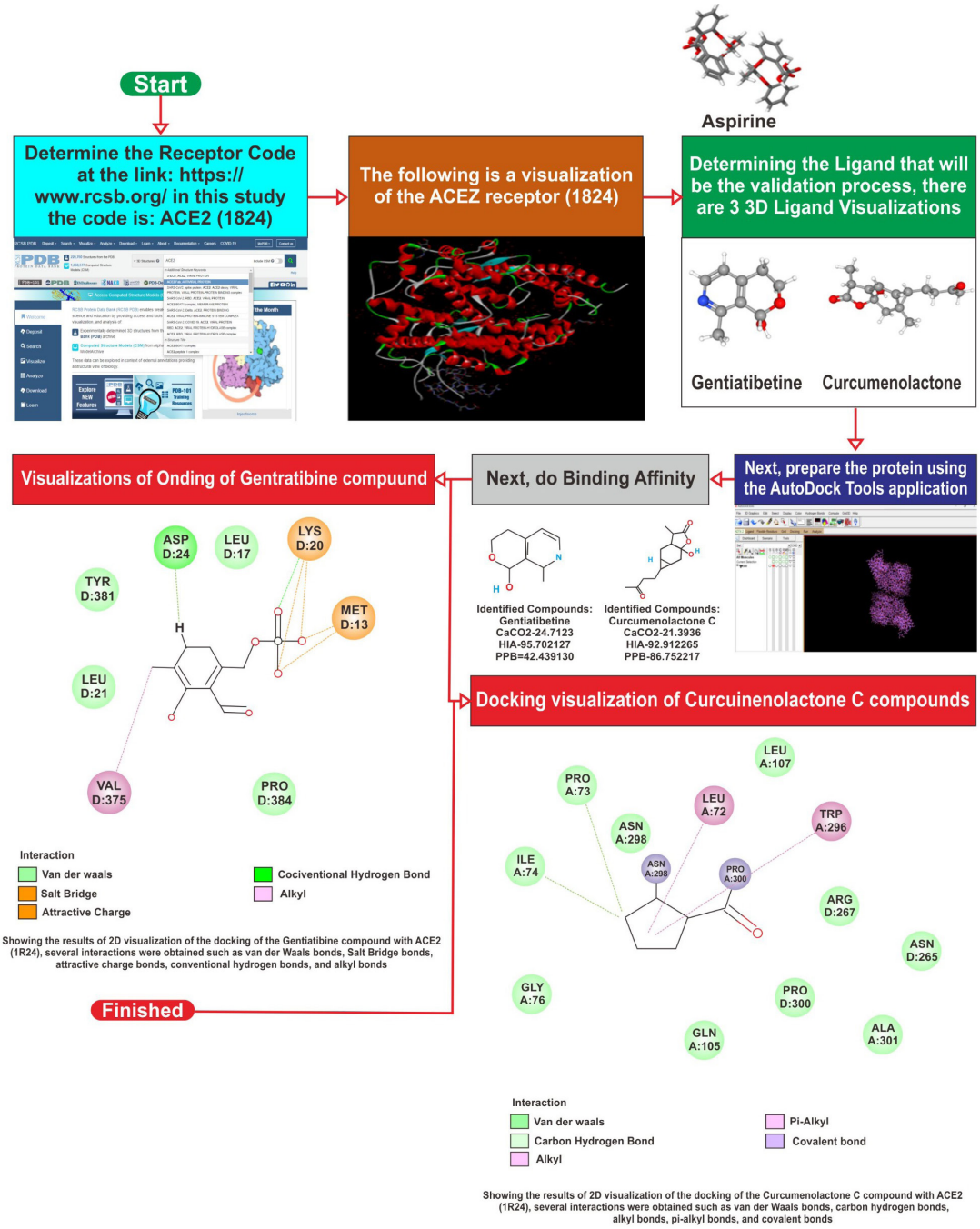

Figure 1. Molecular Docking Using Autodock Tools, Autodock Vina, Biovia Discovery Studio

shows Molecular docking Using autodock.

Prediction of the pharmacokinetics and toxicity profile of WKK was carried out using the pkCSM web server. The results obtained were in the form of ADMET properties represented as absorption, distribution, metabolism, excretion, and toxicity properties, as well as Lipinski's rule of five.

Result and Discussion

Those two phytochemicals were found in the WKK using positive and negative ionization

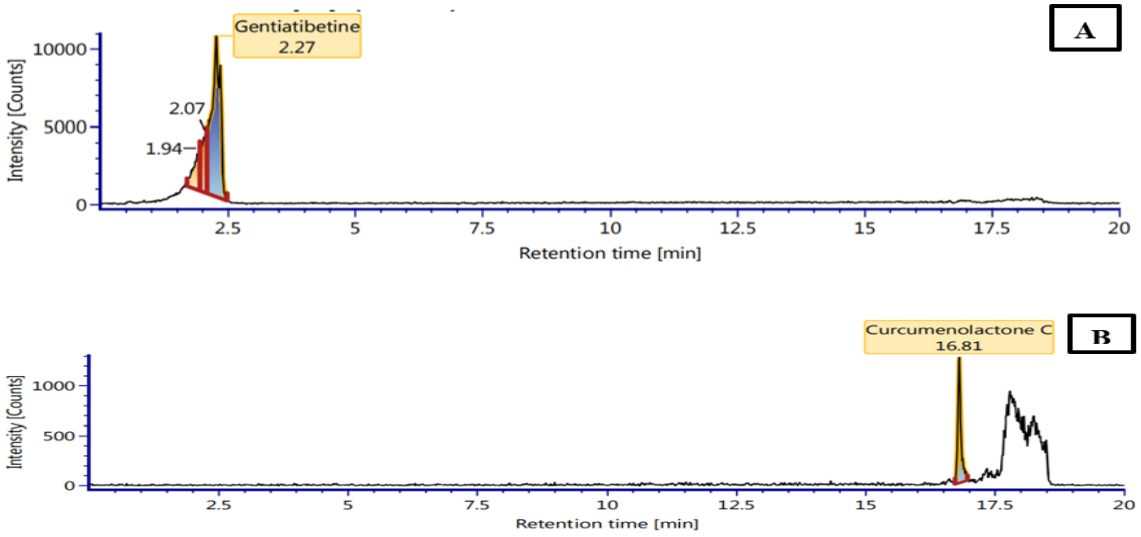

Figure 2. Chromatograms of Phytochemicals in the WKK Sample Were Analyzed Using the LCMS/MS QTOF Method

modes. Figure 2 shows the Chromatograms of phytochemicals in the WKK sample were analyzed using the LCMS/MS QTOF method.

A and B indicated peaks of gentiatibetine and curcumenolactone C phytochemicals, respectively. 10 µL of WKK samples was injected into the UPLC system with a C18 column and the flow rate in the LC system was 0.6 mL/min. The mass spectra of the bioactive compounds in the WKK sample were identified by comparison to the mass spectra in the library of the UniFI software. Results showed MS (MH) M/Z (ppm) of 2.30 and 4.55 indicated gentiatibetine ($C_9H_{11}NO_2$) and curcumenolactone C ($C_{15}H_{20}O_4$), respectively. In addition, results revealed the percentage of MZ RMS of 7.85% and 6.59% for gentiatibetine and curcumenolactone C, respectively, followed by the retention time of gentiatibetine (2.27 min) and curcumenolactone C (16.81 min). The molecular structure of gentiatibetine ($C_9H_{11}NO_2$) and curcumenolactone C ($C_{15}H_{20}O_4$) is shown in Figure S1. Figure 3 shows the results of 3D ligands visualization.

Table 1 shows molecular docking between ligands (Gentiatibetine and Curcumenolactone C) and receptor Preeclampsia (aspirin).

Figure 4a shows a 2D visualization of molecular docking between ligands (Gentiatibetine and Curcumenolactone C) and receptor Preeclampsia (aspirin), and Figure 4b shows a 3D visualization of molecular docking between ligands (Gentiatibetine and Curcumenolactone C) and receptor Preeclampsia (aspirin).

In determining the ligand, it is best to comply with the rules formulated by Christopher A. Lipinski, as the name suggests, namely Lipinski's Rule of Five or often known as the Rules of Five (RO5) Lipinski's rules include: molecular weight <500, logP <5, donor hydrogen bonds <5, and acceptor hydrogen bonds <10.5, shown in Table 1. In addition, results revealed the predicted pharmacokinetic characteristics as shown in Table S2. The selected parameters include human colon adenocarcinoma (Caco2) permeability, Human Intestinal Absorption (HIA), and Plasma Protein Binding (PPB) cells. The ability of drugs to be absorbed in the intestine and the permeability capacity of Caco-2 cells are used to predict drug absorption. HIA is total bioavailability and high absorption determined by the ratio of urine, bile, and fecal excretion. Most anthocyanidin compounds have a high HIA absorption percentage, ranging from 70-100%, except for the chloramphenicol compound. Caco-2 cells are an in vitro model used to determine drug transport through the intestinal epithelial origin of human colon adenocarcinoma. The highest Caco-2 values were found in Gentiatibetine and Curcumenolactone C, namely 24.713 and 21.3936 nm.

In vitro study to identify Gentiatibetine

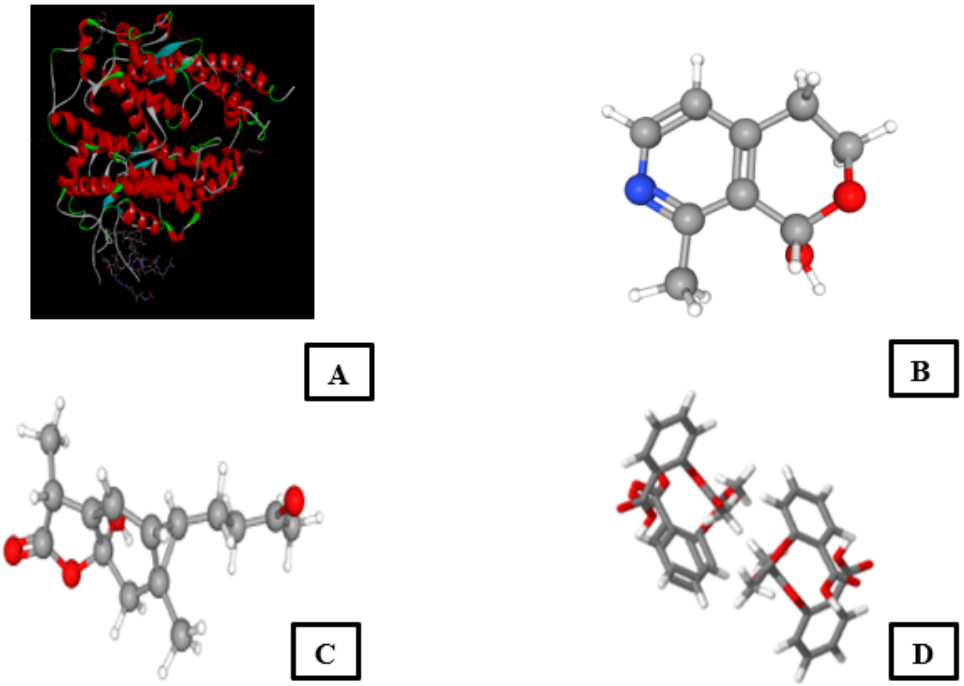

Figure 3. Molecular docking using autodock tools, autodock vina, biovia discovery studio 2020, dan open babel GUI (A) Reseptor ACE2 (1R24), (B) Gentiatibetine, (C) Curcumenolactone C, (D) Aspirine

TABLE 1. Molecular Docking Between Ligands (Gentiatibetine and Curcomenolactone C) and Receptor Preeclampsia (Aspirin)

Protein Confirmation	Interactions	Asam Amino Recidu
Gentiatibetine	Van der Waal	Leu D-17, Thr D-381, Leu D-21, Pro D-384
	Salt Bridge	LSP-D20, Met D-13
	Conventional Hidrogen Bond	Asp-D 24,
	Alkyl	Val-D375
Curcumenolactone C	Van der Waals	Leu A:107, ASN A:298, ARG D:267, ASN D:265, Pro A:300, ALA A:301, GLN A:105, GLY A:76.
	Carbon Hydrogen Bond	Pro A:73, ILE A:76.
	Alkyl	Leu A:72
	Pi- Alkyl	TRP A:296
	Covalent bond	Asn D-298: Pro A-300
Aspirin	Van Der Waals	GLY 108, SER 297, LEU 113, TRP 141
	Salt Bridge	ATG 267- Conventional Hydrogen Bond
	Attractive Charge	ATG 267
	Water Hydrogen Bond	HOH 495, HOH 445
	Conventional Hydrogen Bond	ASN 195, TYR 226, THR 110, GLY 109, SER 256
	Carbon Hydrogen Bond	ASP 24, alkyl pada VAL 375
	Unfavorable Acceptor	ASP 23
	Pi- Donor Hydrogen Bond	TRP 410-Pi-Pi Stacked
	P- -Pi Stacked	TRP 14 -alkyl
	Alkyl	HS 190
	Pi- Alkyl	Alkyl-Alkyl

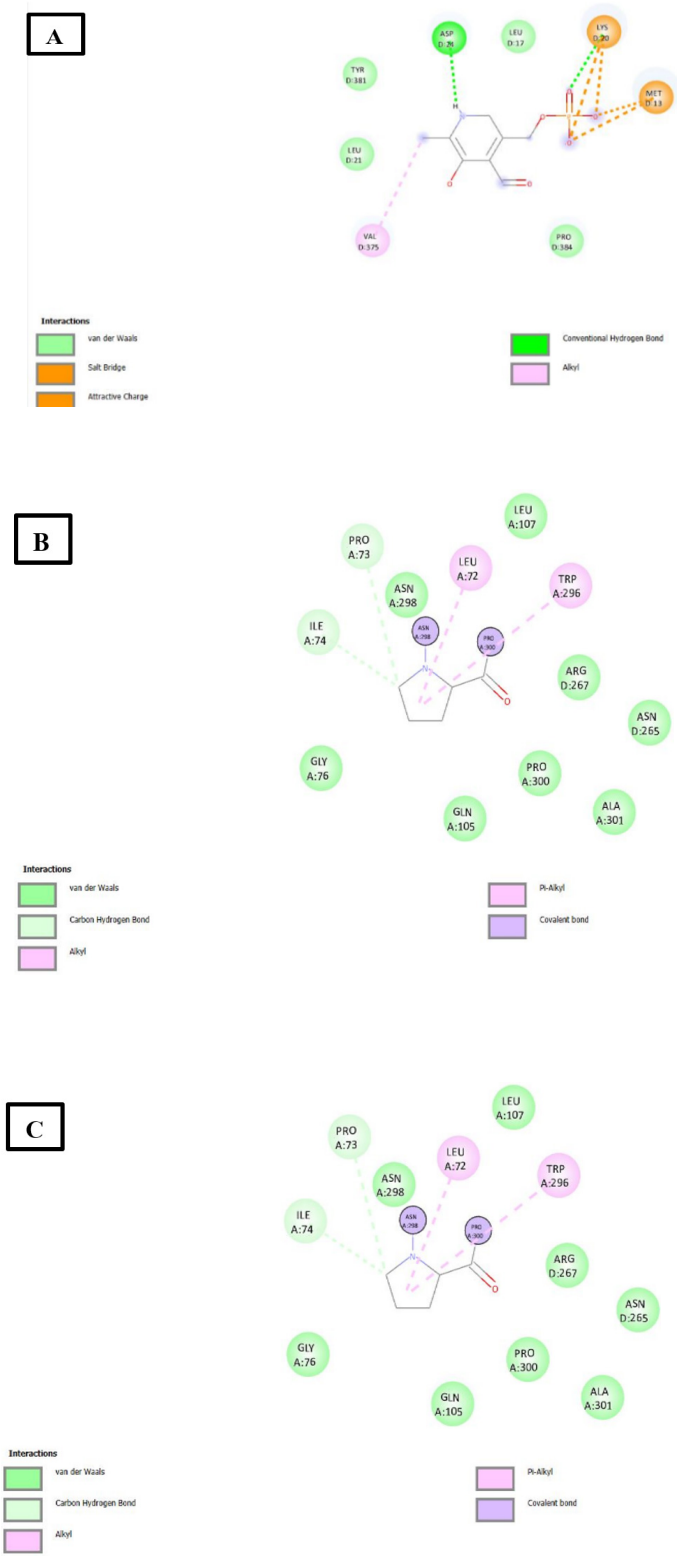

Figure 4. 2D Visualization of Molecular Docking Between Ligands (A) Gentiatibetine, (B) Curcumenolactone C, and (C) Receptor Preeclampsia (Aspirin)

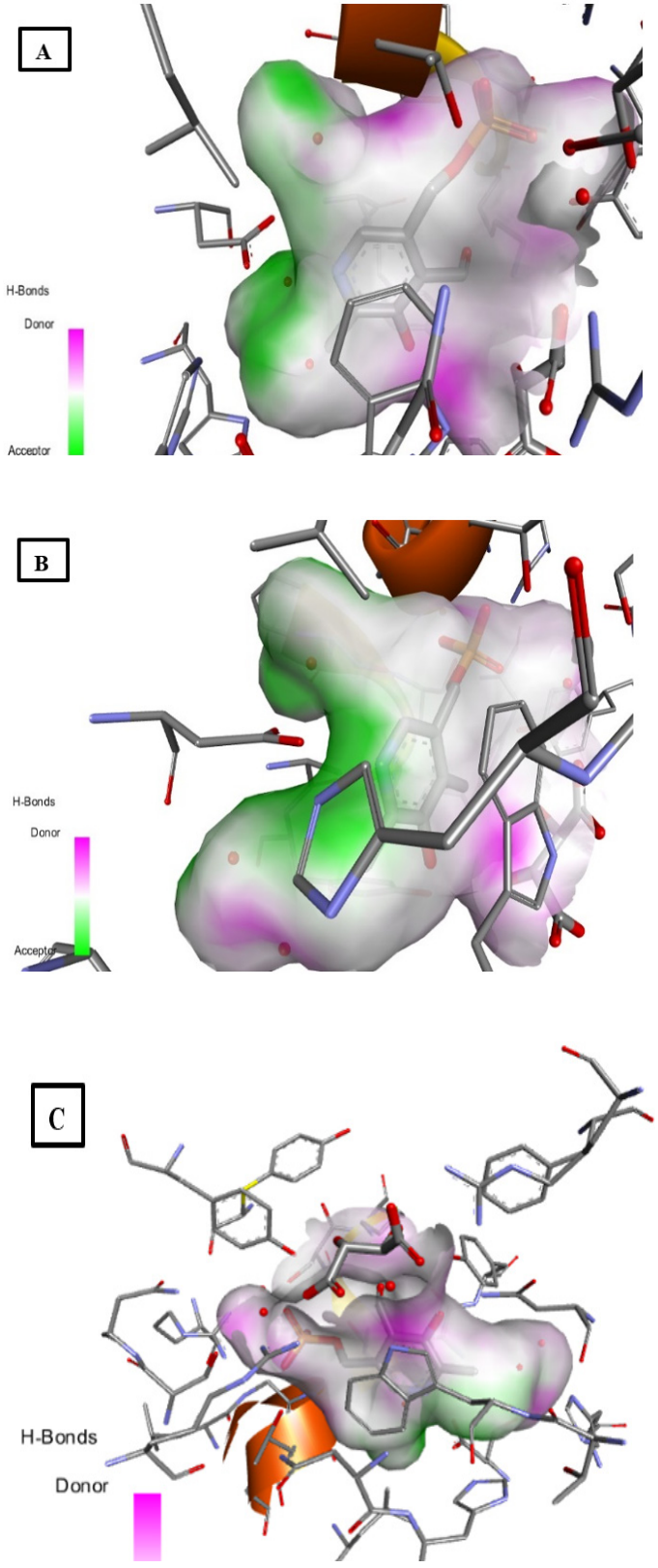

Figure 5. 3D visualization of molecular docking between ligands (A) Gentiatibetine, (B) Curcumenolactone C, and (C) Receptor Preeclampsia (Aspirin)

(alkaloid family) and Curcumenolactone C (terpenoid Family). The materials used are the 3D structure of ACE2 (1R24) identified for ligand and protein preparation using pubchem, result molecular docking between the PE receptor ACE2 (1R24) with gentiatibetine contained 5 interactions and 8 amino acid residues, with Curcumenolactone C sustained 5 interactions and 14 amino acid residues and aspirine 14 interactions and 19 amino acid residues, the pharmacokinetics and toxicity characteristic using PreAdmet to detected CaCO2, Human Intestinal Absorption (HIA), and Plasma Protein Binding (PPB). Results exhibited that the WKK consists of gentiatibetine and curcumenolactone C. A previous study reported that gentiatibetine, an alkaloid family member, has anti-convulsant activity and brain protective effect (Rahayu & Timotius, 2022). Therefore, this bioactive compound is more likely to be beneficial for preventing PE complications, inhibiting eclampsia development that requires anti-convulsant therapy, such as using MgSO4 18. The second bioactive compound in the WKK is curcumenolactone C (a terpenoid family member), which is also found in white turmeric (Zedoariae rhizoma) 19 and God's Crown (Phaleria macrocarpa Schef) 20, with a hepatoprotective activity. This substance is a lactone and might have crucial bioactive characteristics. Studies have been conducted on the possible anti-inflammatory and antioxidant properties of lactones in general. Curcomenolactone C may be beneficial in lowering inflammation and shielding cells from oxidative damage, both of which are essential for controlling and averting the consequences of preeclampsia (Afrose, *et al*., 2022). Hemolysis Elevated Liver Enzyme and Low Platelet Count. (HELLP) Syndrome is another PE complication that is characterized by hemolysis, elevated liver enzyme function (transaminase >40 IU /L), and low platelet counts (<150,000/microL) 7. Altogether, it suggests that drinking the WKK potentially inhibits PE complications by protecting the brain and liver from damage.

Fulfillment of the RO5 requirements is intended to help increase the success rate of the experiment (Ferdian *et al*., 2021). Absorption, distribution, and toxicity parameters were measured with the help of a program accessed online via the site https://preadmet.bmdrc.kr/adme/ (Bhat & Chatterjee, 2021). The application can automatically determine expected values when the structure and chemistry of a compound are pulled into a website. Permeability to pass through the testicular epithelium is still considerably small, which can affect bioavailability in the blood. Therefore, both pharmaceutical and structural modifications are needed to increase the permeability properties of the compound. PPB is a small portion of the free drug to be distributed to various tissues (Bhat & Chatterjee, 2021). Binding is described through a percentage from 0-100%, which indicates the strength of the bond. Meanwhile, drug irreversibility can occur due to strong chemical bonds that can cause.

Conclusions

Water of Kalianda Kopyor, a major constituent of Gentiatibetine and Curcumenolactone C, has a high docking score comparable to that of aspirin. Molecular docking of WKK with genes of PE ACE2 (1R24) produced data that predicted substantial binding genes with docking scores of -5.6, -5.0, and -6.5 kcal/mol, respectively. The docking score of aspirin against it was -6.0, -7.5, and -7.0 kcal/mol, respectively. These values indicate that the activity of WKK genes of KPE is like that of the standard drug aspirin. Pharmacokinetics prediction using the pkCSM approach has also shown WKK as an active compound with a good pharmacokinetics profile. Therefore, WKK has the potential to be developed as a nutrition therapy agent against PE. The pharmacokinetics prediction made with the pkCSM approach points to advantageous properties for WKK. However, it should be noted that these predictions are based on computational models and might not fully capture the behavior of the compound *in vivo*. Therefore, to verify these hypotheses and evaluate the actual bioavailability, metabolism, and elimination of WKK in biological systems, experimental pharmacokinetic investigations would be required.

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Demographic Factors and BMI on Declined Lung Function and Vitamin D Levels in Active Smokers

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Abstract

Cigarettes are one of the causes of health problems in the world. Smoking has been known to have a direct impact on reducing lung function. Smoking increases the risk of vitamin D deficiency. Vitamin D is a vital nutrient as a lung immunomodulator. Deficient levels will cause problems with lung health, especially in active smokers. This cross-sectional research using multivariate path analysis and the SEM-PLS method has three objectives. The direct influence of three independent variables, including obesity, smoking, and demographics. Regarding vitamin D status and lung function, analyzing the direct effect of vitamin D on lung function, and thirdly, analyzing the indirect one of the three independent variables on lung function through vitamin D levels. This research took time from October 2023 to January 2024 and involved 47 active smoker respondents whose vitamin D level status and lung function were measured. There was a significant direct effect of obesity level on vitamin D levels in the active smoker population ($p<0.05$;f-square=2.889). While demographic factors ($p>0.05$;f-square=0.030) and smoking frequency ($p>0.05$;f-square=0.003) did not have a direct significant effect. Demographic factors, obesity, and smoking frequency don't have significant direct effect on lung function in active smokers ($p>0.05$).

Introduction

Indonesia is one of the countries with the highest number of smokers in the world. Based on data from the 2021 Global Adult Tobacco Survey (GATS) released by the Ministry of Health of the Republic of Indonesia (KEMENKES RI), the smoking prevalence of the adult population in Indonesia reached 33.5% in 2021 with an addition of 8 million people over the last 10 years (CDC, 2021). Exposure to cigarette smoke can cause inflammation of the airways and accumulation of mucus in the lungs, resulting in symptoms of shortness of breath and accelerating the decline in lung function. It is often associated with the emergence of lung diseases such as lung cancer, chronic obstructive pulmonary disease (COPD), asthma, and tuberculosis (Chung *et al*., 2023). Smokers experience decreased lung function compared to non-smokers, which can be measured using spirometry through a decrease in forced expiratory volume in 1 second (FEV1) values reaching >50 mL per year (Lorensia *et al*., 2021). The higher the intensity of smoking, the lower the rate of decline in FEV1 and FVC. Greater than non-smokers.8 Further reduction in lung function due to smoking will have an impact on various lung health problems, such as COPD, including emphysema, chronic bronchitis, and asthma (Tian *et al*., 2023).

Another mechanism that also plays a role in causing damage or decreased lung function is the involvement of levels of a vitamin in the body, namely vitamin D. Vitamin D has a protective mechanism for lung function

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through increasing the secretion of the antimicrobial peptide cathelicidin, decreasing chemokine production, inhibiting dendritic cell activation and changing cell activation. T. This cellular mechanism is vital for the response of the lung organ to the threat of infection and the development of allergic lung diseases such as asthma (Bishop *et al*., 2020). A decrease in the production of the inactive form of vitamin D (25(OH)D) in lung epithelial cells is thought to be caused by exposure to smoke due to smoking activities (Lorensia *et al*., 2024). A meta-analysis result by Yang *et al*. (2021) of 24 studies with 11,340 participants showed that levels of vitamin D in the inactive form 25(OH)D were lower in smokers than non-smokers (Yang *et al*., 2021). In addition, the expression level of vitamin D receptors can also be influenced by exposure to cigarette smoke (Ahn *et al*., 2021). A study by Ghosh *et al*. (2020) also stated that vitamin D deficiency plays a role in changes in lung structure and decreased lung function.

There are other influencing factors that can be part of the impact of decreased lung function besides smoking, namely, obesity. Individuals who are obese show reduced lung volume and capacity when compared to people of normal weight. Larger fat deposits in the abdominal area produce greater resistance to diaphragm contraction, thereby inhibiting respiratory ventilation mechanisms (Cao *et al*., 2022). Based on the explanation above, several previous studies have been conducted that examined the effect of vitamin D on lung function. However, there have been no studies that have examined this by involving factors such as obesity levels, smoking, and demographics in Indonesia, which is one of the countries with the highest prevalence of smoking, accompanied by consequences in the form of increased death rates and lung disease sufferers due to smoking. Therefore, research will be carried out that will examine the influence of demographic factors, BMI, and smoking intensity, on the decline in lung function and vitamin D levels in active smokers. There is a study by Abi-Ayad *et al*. (2023) who measured smokers' vitamin D levels using blood plasma samples, found that vitamin D deficiency was associated with lower lung function conditions, lung function in this case FEV1, FVC, and FEV1/FVC measured using a spirometer experienced faster decrease in smoking subjects. It shows that adequate serum vitamin D levels are associated with a protective effect against the detrimental effects of smoking on lung function.

Method

This study used an observational clinical trial with a cross-sectional design where the data collection stage was carried out once at a time. The independent variables in this study were demographic factors, BMI, and smoking intensity. The dependent variable in this study was the lung function value (percentage of FEV1/FVC ratio). The mediating variable in this study was vitamin D levels. Demographic factors consist of age and education level. Age is a measure of the patient's length of life, which is calculated based on the patient's date of birth until they become a research respondent. Educational level is a measure of the respondent's level of education as evidenced by possession of the latest educational certificate. Body Mass Index, or BMI, is a value obtained from the mass and height of each sample individual. BMI can be calculated using a formula by dividing the individual's body weight in kilograms (kg) by the square of body height in meters squared (m^2) (Weir & Jan, 2023). Smoking intensity is the habit of smoking tobacco cigarettes. Smoker classification can be calculated using the Brinkman Index (IB)=number of cigarettes smoked per day x length of smoking (years) (Herath *et al*., 2022). Lung function measurements using a handheld spirometer. The level of lung function impairment based on the percentage of the FEV1/FVC ratio is divided into 4 categories, namely normal-mild obstruction, moderate obstruction, severe obstruction, and very severe obstruction (Stanojevic, 2021).

The vitamin D levels that will be measured are the most abundant metabolite form in serum, namely 25(OH)D, 25(OH) levels reflect skin production of vitamin D3 and vitamin D (D2 and D3) from food, 25(OH) D has a half-life (The long t½) in the blood circulation is 3-4 weeks compared to the active vitamin D metabolite 1,25(OH)2D which only has a short t½ of around 4-6 hours (Tuckey *et al*., 2019). Methods for observing vitamin

D levels (25(OH)D), which are the ELFA (Enzyme Linked Fluorescent Assay) method used is the VIDAS tool from bioMerieux. The type of specimen that can be used in testing can be serum or blood plasma. In this study, serum 25(OH)D levels were classified as deficient (<20 ng/mL), insufficiency (20-29 ng/mL), and normal (30-100 ng/mL) (Ahn *et al.*, 2021; Amrein *et al.*, 2020).

The population is active smokers located in the Mejoyo area, Rungkut District, Surabaya City. The accessible population is active smoking respondents in the Mejoyo 2 RT 6 Surabaya area who have filled out the questionnaire, can be found, and are not included in the exclusion criteria. The sample in this study was part of the affordable population who met the criterias: (1) aged 18-60 years; (2) didn't use vape; (3) no history of COVID-19 infection; (4) no history of diseases or conditions that can affect serum vitamin D levels; (5) not taking supplements containing vitamin D during the last 1 month before checking 25(OH)D levels; and (6) no history of diseases or conditions that can affect lung function. The minimum number of samples was calculated using the Slovin method. So the number of samples required in this research was 45 people. The sampling technique was purposive sampling.

The first meeting involved a recording of demographic data for the entire sample through a direct interview process with research respondents, and then continued with measuring height and weight. The researcher measured the height of the sample using a height measuring device with the Onemed brand type HT701 Wireless. Body weight measurements were carried out by researchers using a SPEEDS brand digital weight scale, type LX040-8 USB, which has a sensitivity of one digit after the comma. Lung function measurements were carried out by researchers who had received special training from clinicians using a Contec SP10 handheld spirometer to obtain FEV1 and FVC values. The lung function measurement procedure for each respondent was repeated 3 times. The results in milliliters (mL) are recorded to calculate the percentage of the FEV1/FVC ratio. Measurement of Vitamin D or 25(OH)D levels using the VIDAS® 25 OH Vitamin D TOTAL (VITD) tool with the ELFA technique carried out by a standardized laboratory in Surabaya.

The aim of carrying out multivariate analysis is to determine the magnitude of the influence between variables determined based on the P_{value} and $t_{statistic}$ value using the Structural Equation Modeling with Partial Least Squares (SEM-PLS) method with the help of the SmartPLS application. SEM-PLS is a powerful analysis method and is often referred to as soft modeling, because it eliminates the assumptions of Ordinary Least Square (OLS) regression such as data must be normally distributed in a multivariate manner and there is no problem of multicollinearity between independent variables, SEM-PLS can be used to testing weak theories and weak data (small samples and data normality problems). The analysis of the magnitude

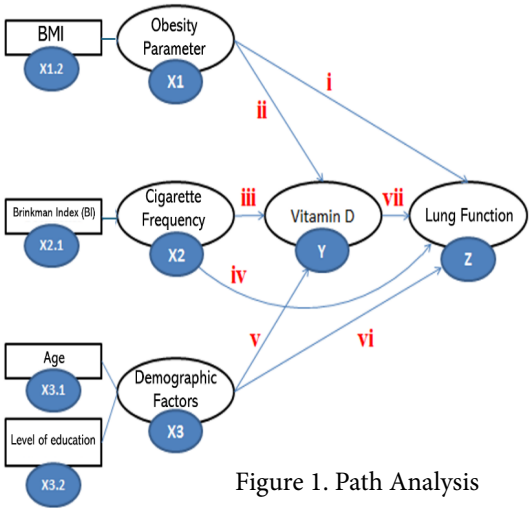


Figure 1. Path Analysis

Information :

i. Direct influence of obesity level on lung function
ii. Direct influence of obesity level on vitamin D levels
iii. Direct effect of smoking on vitamin D levels
iv. Direct effect of smoking on lung function
v. Direct influence of demographics on vitamin D levels
vi. Direct influence of demographics on lung function
vii. Direct influence of vitamin D levels on lung function

of the effect in this research will estimate the value of the P_{value} and also the value of the $t_{statistic}$. If the test results show a $P_{value}<0.05$ and a $t_{statistic}\geq t_{table}$ value, then the influence of the two variables is said to be significant. It comes along with the conclusion that there is an influence of the independent variable on the dependent variable of active smoking. However, if the $P_{value}>0.05$ and the $t_{statistic}<t_{table}$ value, then the influence of the two variables is said to be insignificant, with the conclusion that there is no influence of the independent variable on the dependent variable in active smokers. An overview of the path analysis model used in the research can be seen in **Figure 1**.

Result and Discussion

This research was conducted from October 2023 to March 2024, located in the Mejoyo 2 RT 6 Surabaya, Kalirungkut, East Surabaya. This research has received an ethical certificate number 232/KE/IX/2023 from the University of Surabaya. Based on the preliminary study, the affordable population was 54 smokers in the area, and 47 people were willing and met the research subject criteria. Most of the respondents were the largest early elderly, 23 respondents (48.93%). Based on BMI measurements, the normal BMI group was the largest, namely 29 respondents (61.70%). Based on the measurement of education level, the Secondary Education group was the largest, namely 20 respondents (42.55%). Based on smoking frequency, the moderate smoker group was the largest, namely 27 respondents (57.44%). Data on the distribution of respondents' characteristics can be seen in Table 1.

In this study, vitamin D (25(OH)D) levels were measured in 47 respondents using the ELFA method with the VIDAS® tool from Biomerieux. Based on the classification of vitamin D levels of the total respondents measured, the insufficiency group was the largest group with 23 respondents (48.93%). The results of the percentage value of the FEV1/FVC ratio, of the total respondents who were measured, the moderate obstruction group had the largest, namely 21 respondents (44.68%) (**Table 2**).

The implementation of multivariate statistical analysis in this research was carried out using a quantitative technical approach, where there were two analyzes used, namely descriptive analysis and hypothesis testing or statistical analysis using the Partial Least Square (PLS) method using the SmartPLS program. There are 5 (five) variables involved in this research, which include obesity levels, smoking, demographics, vitamin D, and lung function.

Table 1. Demographic Profile of Respondents

		Frequency (n=47)	Percentage (%)	$\bar{x}$ ±SD
Age (years)	Late Adulthood (36-45)	10	21.27	51.20±6.43
	Early Seniors (46-55)	23	48..93	
	Late Seniors (56-60)	14	29.78	
Level of education	Basic Education (elementary school-junior high school)	19	40.42	
	Secondary Education (senior high school)	20	42.55	
	higher education	8	17.02	
BMI (kg/m^2)	Normal (18.5-25.0)	29	61.70	
	Fat (Overweight) (25.1-27.0)	14	29.78	
	Obesity (>27)	4	8.51	
Brinkman Index (BI)	Light (<200)	14	29.78	
	Moderate (200-599)	27	57.44	
	High (>600)	6	12.76	

$\bar{x}$ = average; SD= standard deviation
Source: Primary Data, 2024

Table 2. Distribution of Vitamin D and Lung Function Examination

		Frequency (n=47)	Percentage (%)	$\bar{x}$ ±SD
Vitamin D Classification -25(OH) D Content (ng/mL)	Deficiency (<20)	15	31.91	23.52±8.75
	Insufficiency (20-29)	23	48.93	
	Normal (30-100)	9	19.14	
Lung Function Classification (FEV1/ FVC ratio) (%)	Normal-Mild Obstruction (≥ 80)	7	14.89	95.43±5.72
	Moderate Obstruction (50-79)	21	44.68	
	Severe Obstruction (30-49)	10	21.27	
	Very Severe Obstruction (<30)	9	19.14	

$\bar{x}$ = average; SD= standard deviation
Source: Primary Data, 2024

The research model evaluation stage in PLS consists of measuring model evaluation and structural model evaluation. The measurement model in this research consists of a reflective measurement model for the variables Levels of Obesity, Smoking, Demography, Vitamin D, and Lung Function by examining loading factor values ≥0.50, composite reliability ≥0.60, and average variance extracted (AVE) ≥ 0.50. The level of obesity is measured by BMI **(X1.2)**, where the outer loading value is between 0.688-0.936, which shows that BMI is strongly correlated in explaining the obesity level variable. Every change in BMI on obesity levels has a more significant effect. The smoking variable is measured from the Brinkman index (IB) of smoking frequency **(X2.1),** where the outer loading value is between 0.243-0.996, which shows that IB is correlated in explaining the smoking variable. The level of reliability of the motivation variable is well accepted, with a composite reliability value (0.618)>0.60. Any change in smoking frequency on smoking activity has a more significant effect.

Demographic variables are measured by 2 (two) indicators, namely age **(X3.1)** and education level **(X3.2),** where the outer loading value is between 0.243-0.996, which shows that these two indicators correlate in explaining the obesity level variable. The level of reliability of the motivation variable is acceptable, even though the composite reliability value (0.406) is <0.60, but has an AVE value close to 5.0. Between the two measurement indicators, the validity of demographic variables appears to be more strongly reflected by the education level indicator **(X3.3).** It means that every change in age demographics has a more significant effect. The vitamin D variable is measured directly with 1 (one) indicator, namely the 25(OH)D level, where the outer loading value is 1,000, which shows that this indicator has a strong correlation in explaining the vitamin D variable. The level of reliability of the vitamin D variable is acceptable, with the composite reliability value (1,000)>0.60. The validity measurement of the vitamin D variable looks strong, as reflected by the 25(OH)D level indicator **(Y)**. The lung function variable is measured directly with 1 (one) indicator, namely the P_{value} of the percentage of the FEV1/FVC ratio, where the outer loading value is 1,000, which shows that this indicator has a strong correlation in explaining the lung function variable. The level of reliability of the vitamin D variable is acceptable, with a composite reliability value (1,000)>0.60. The validity measurement of lung function variables appears to be strong, as reflected by the percentage indicator of the FEV1/FVC ratio **(Z)**.

Structural model evaluation is a form of evaluation to determine the influence of various endogenous variables on exogenous ones by observing the R-square (R^2) value (coeffecient determination), if the R^2value=0.19 then the exogenous influence on the endogenous is weak,

Table 3. Evaluation Results of Reflective Measurement Model, Inner VIF Measurement

Variables	Measurement Item Code	Indicators	*Outer Loading*	*Composite Reliability*	AVE	VIF
Obesity Rate	X1.2	BMI	0.936	0.802	0.675	1.178
Cigarette Frequency	X2.1	Smoking Frequency	0.996	0.618	0.525	1.024
Demographics	X3.1	Age	0.137	0.406	0.485	1.007
	X3.2	Level of education	0.975			1.007
Vitamin D	Y	25(OH)D levels	1.000	1.000	1.000	1.000
Lung Function	Z	FEV1/FVC ratio	1.000	1.000	1.000	1.000

AVE=*average variance extracted; BMI=Body Mass Index; FEV_1=Forced Expiratory Volume in 1 second; VIF = Variance Inflated Facto*

Source: Primary Data, 2024

if the R^2value=0.33 the exogenous influence on the endogenous is moderate, if the R^2value=0.67 the exogenous influence on the endogenous is strong. Next, hypothesis testing is carried out to find out the significance of the influence of the observed research variables by observing the path coefficient value. The influence of the level of obesity, smoking, and demographics on vitamin D, with an R^2value of 0.782, means that the endogenous variable vitamin D is influenced by 78.2% by the exogenous variables the level of obesity, smoking, and demographics, while 21.8% is influenced by other factors outside the variable. It can be concluded that the influence of exogenous variables on endogenous variables is strong. The influence of the level of obesity, smoking, demographics, vitamin D on lung function with an R^2value of 0.190, meaning that the endogenous variable lung function is influenced by 19% by the exogenous variable the level of obesity, smoking, demographics, and vitamin D, while 81% is influenced by other factors in outside the variables studied. It can be concluded that the influence of exogenous variables on endogenous variables is weak.

Next, the evaluation of the structural model with path coefficients was carried out in three stages: The first stage, namely checking the absence of multicollinearity between variables and the inner VIF (Variance Inflated Factor). If the estimation results show an inner VIF value <5, then the level of multicollinearity between variables is low. All indicators have an inner VI value <5, so the estimates of all variables and indicators in SEM-PLS are not robust (not biased). The second stage, hypothesis testing, is carried out between variables by looking at the $t_{statistic}$ value and P_{value}. If the $t_{statistic}$ = calculation result is greater than the t_{table} (2.0166) and the P_{value} of the test results is <0.05, then there is a significant influence between the variables. The third stage, analysis of the results of the f-square value is carried out, namely the influence of variables at the structural level with the criteria f-square 0.02 ≤ no effect, 0.02 ≤ f-square ≤0.14 small effect, 0.15 ≤ f-square ≤ 0.35 has a medium effect, and >0.35 has a high effect. The patch coefficient assesses the magnitude of the direct influence of exogenous variables on endogenous variables; the magnitude of the influence ranges from -1 (negative influence) to +1 (positive influence).

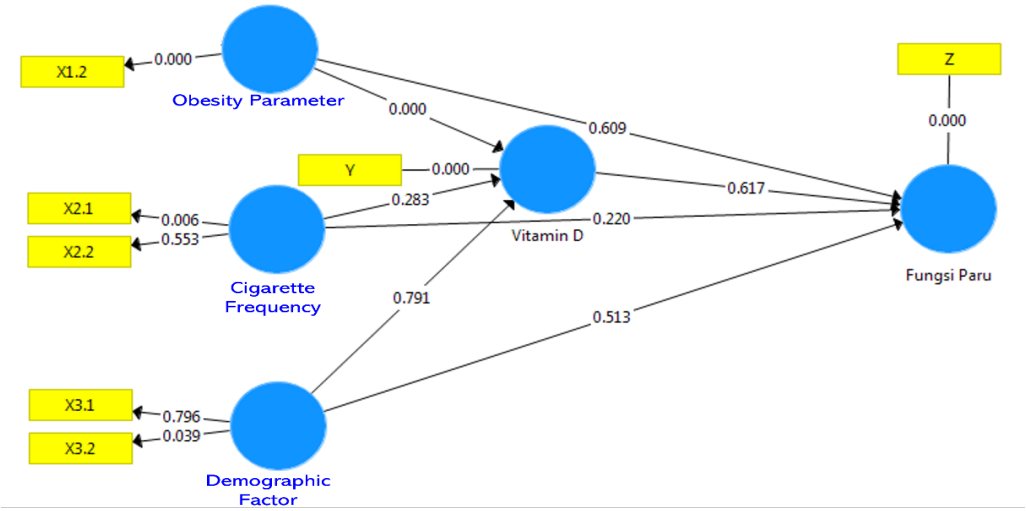
Hypothesis testing is not only direct observation between exogenous variables and endogenous variables, but also tested indirectly through mediating variables (vitamin D). The SEM-PLS model can also be useful as a predictor in developing strategies to improve health promotion related to the influence of obesity, smoking, and demographic factors on lung function and vitamin D levels directly, as well as on lung function indirectly through vitamin D levels in active smokers. Education provided in terms of increasing vitamin D (25(OH)D) levels is by reducing body weight through BMI indicators and reducing the frequency of smoking. It also applies to implementing education to improve lung function by improving or increasing vitamin D levels (Figure 2).

Body mass index (BMI) is the ratio of body weight to height squared. Most of the respondents had normal BMI values, namely 29 respondents (61.70%) and safe limit abdominal

Table 4. Structural Model Evaluation Results, consisting of Research Hypothesis Testing and Effect Size (f-square)

	Hypothesis	*Path coefficient*	$t_{statistic}$	P_{value}	*f-square*	Interpretations
Direct Hypothesis	Is there a direct effect of obesity level on vitamin D in active smokers?	0.908	9.497	0.000	2.889	There is a direct influence of the level of obesity on vitamin D levels in active smokers. The significant influence of the level of obesity on vitamin D has a high influence value.
	Is there a direct effect of the level of obesity on lung function in active smokers?	-0.090	1.076	0.283	0.030	There is no direct effect of the level of obesity on lung function in active smokers. The obesity level variable on vitamin D has a moderate influence value.
	Is there a direct effect of smoking on vitamin D in active smokers?	0.030	0.265	0.791	0.003	There is no direct effect of smoking on vitamin D in active smokers. The cigarette variable on vitamin D has a small influence value.
	Is there an effect of smoking on lung function in active smokers?	0.815	0.512	0.609	0.161	There is no direct effect of smoking on lung function in active smokers. The smoking variable on lung function has a small influence value.
	Is there a direct influence of demographics on vitamin D in active smokers?	-0.319	1.229	0.220	0.098	There is no direct influence of demographics on vitamin D in active smokers. Demographic variables on vitamin D have no influence.
	Is there a direct influence of demographics on lung function in active smokers?	0.122	0.654	0.513	0.016	There is no direct influence of demographics on lung function in active smokers. Demographic variables on lung function have no influence value.
	Is there a direct effect of vitamin D on lung function in active smokers?	-0.791	0.500	0.617	0.168	There is no direct effect of vitamin D on lung function in active smokers. The vitamin D variable on lung function has a moderate influence value.
Indirect Hypothesis	Is there an effect of obesity level on lung function through vitamin D levels in active smokers?	-	0.256	0.798	-	There is no influence of obesity level on lung function through vitamin D levels in active smokers. Vitamin D does not mediate the indirect relationship between obesity level and lung function.
	Is there an effect of smoking on lung function through vitamin D levels in active smokers?	-	1.087	0.277	-	There is no effect of smoking on lung function through vitamin D levels in active smokers. Vitamin D does not mediate the indirect relationship between smoking and lung function.
	Is there a demographic influence on lung function through vitamin D levels in active smokers?	-	0.454	0.650	-	There is no demographic influence on lung function through vitamin D levels in active smokers. Vitamin D did not mediate the indirect relationship between demographic variables and lung function.

Source: Primary Data, 2024



Source: Primary Data, 2024

Figure 2. SEM-PLS Model After Boostrapping with P_{value} = between Variables Based on SmartPLS analysis

circumference of 38 respondents (80.85%). It is supported by the results of research in Indonesia which analyzed the BMI picture and found that the majority of respondents had a normal BMI of 45%. 75 Another study in Indonesia which aimed to find out the factors related to the incidence of central obesity in adults found that there was a prevalence Central obesity with excessive abdominal circumference based on age 25-34 years (22.9%) and 35-44 years (33.5%), indicates that there are more respondents with abdominal circumference within safe limits. The results of this study found 4 respondents (8.51%) in the peripheral obesity category (BMI>27 kg/m^2) and 9 people (19.14%) with central obesity (abdominal circumference >90 cm). Based on the evaluation of the structural model (inner model) using SmartPLS version 3, there was a significant direct influence between the obesity level variable on vitamin D levels (P_{value}<0.05 and $t_{statistic}$>t_{table}) in active smokers. It is supported by a theory that states the relationship between obesity mechanisms in causing a decrease in vitamin D levels, including three mechanisms that can explain the relationship between deficiency in vitamin D levels in obese individuals. Individuals who are obese experience decreased exposure to sunlight compared to non-obese individuals (Mirza *et al.*, 2022). The release of adiponectin from fatty tissues was inversely correlated with body weight and BMI suggesting a link between vitamin D deficiency and insulin resistance (Kauser *et al.*, 2022).

The evaluation of the control model (inner model) found no direct significant influence between the obesity level variable on lung function (P_{value} >0.05 and $t_{statistic}$<t_{table}) in active smokers. 'These results have conclusions that are the opposite of several theories which state that obesity harms the lung organs, one of which is the development of OHS which is defined as a combination of obesity (BMI ≥30 kg/m^2), hypercapnia (arterial CO2 ≥45 mmHg) and the presence of breathing disorders during sleep which causes alveolar hypoventilation (Masa *et al.*, 2019; Palma *et al.*, 2022). Research results that are not in accordance with theory or previous research can be caused by only a small portion of respondents being classified as obese, whereas based on lung function examinations also the majority of respondents (44.68%) included in the moderate obstruction category. Individuals who are obese show a decrease in lung volume and capacity when compared to people with a normal body weight, this is because in people with a normal BMI the diaphragm contracts to push the contents of the stomach down and forward without any obstacles from excess fat deposits, when Likewise, contraction of the external intercostal muscles (muscles that play a role in

the inspiration process) can push the ribs up and forward without resistance (Svartengren *et al*., 2020). Therefore, in this study, the majority of respondents had a normal BMI and the majority were in the obstruction category. moderate (27.65%), because the majority of respondents had breathing patterns that were not influenced by obesity.

Most of the smokers were moderate smokers (57.44%). Evaluation of the structural model (inner model) found that there was no direct significant influence between smoking variables on vitamin D levels (P_{value}>0.05 and $t_{statistic}$<t_{table}) in active smokers. Smoking, ultraviolet radiation, and age are considered important factors that contribute to the skin aging process in humans by increasing wrinkles on the skin surface. In addition, tobacco smoke can affect the expression level of vitamin D receptors. If the expression of vitamin D receptors increases, the physiological effects of vitamin D will be better, one of which is the effect on lung function (Yang *et al*., 2021). Most of the respondents fell into the moderate level with IB. Based on the evaluation of the inner control model using SmartPLS, it was found that there was no direct significant influence between smoking variables on lung function (P_{value}>0.05 and $t_{statistic}$<t_{table}) in active smokers. These results have conclusions that are the opposite of several theories, which state that cigarettes contain various dangerous substances and their pathophysiological mechanisms, which can disrupt lung function. Nicotine was found to be chemotactic for human neutrophils, neutrophils being the first cells recruited in the process of lung inflammation due to cigarette smoke, which ultimately causes airway obstruction (Ham *et al*., 2022). Cigarettes cause airway inflammation, which occurs more precisely in the bronchioles, causing lung remodeling. - The lungs lose their elasticity during the air exchange process, which then results in chronic obstructive airway limitations (Karnati *et al*., 2021). Inappropriate research results can be caused by other factors or variables that are not observed but can influence, among others, genetics, physical activity, food intake, knowledge, attitudes, and behavior, sun exposure, skin color, and air pollution.

Patient demographics, which include age and level of education, are one of the factors that have been widely studied and influence the reduction in vitamin D levels. Based on the evaluation of the structural model (inner model), the results found that there is no direct significant influence between demographic variables on vitamin D levels (P_{value}>0.05 and $t_{statistic}$<t_{table}) in active smokers. These results are aligned with the theory regarding demographic relationships, whether studied in terms of age or education level, which can influence vitamin D levels. In terms of age, physiologically an individual can experience a decrease in kidney function, resulting in reducing the production of the active metabolite 1,25(OH)D with increasing age, due to a decline in the activity of the kidney enzyme 1α-hydroxylase which converts 25(OH)D to 1,25(OH)D. Serum 1,25(OH)D levels are inversely proportional to serum creatinine levels and proportional to glomerular function rate (GFR). Aging is not only associated with a decrease in kidney function, but is also associated with a decrease in vitamin D production in the skin, in the form of a decline in the concentration of 7-dehydrocholesterol in the epidermis and a reduced response to UVB light exposure in elderly individuals compared to young adults, resulting in a decrease in the formation of previtamin D3 by 50% (Turner *et al*., 2022; Huish *et al*., 2021). The higher the level of education, the greater the knowledge and awareness of the importance of adequate vitamin D nutrition (Hamhoum & Aljefree, 2022). Therefore, this is a limitation of this research because there are several factors that were not observed but tend to influence vitamin D levels, including the influence of physical activity, knowledge and attitudes towards vitamin D, and genetics.

Age and education level are also considered factors that influence lung function. Based on the evaluation of the inner control model using SmartPLS, there was no direct significant influence between demographic variables on lung function (P_{value}>0.05 and $t_{statistic}$<t_{table}) in active smokers. These results have conclusions that are the opposite of several theories, which state that demographics, both in terms of age and level of education, can influence lung function, especially in active

smokers. Other research results show that the older a person is, the lower the FEV1 value will be. In particular, the smaller the FVC value due to advanced age, the more significant the decrease in FEV1/FVC (Thomas *et al.*, 2019). It is different from the results of this study, where there was no influence of demographics on lung function. This result can be caused by factors that influence these two variables (demography and lung function), each of these two variables can be influenced by smoking factors and the level of obesity studied in this study to factors that were not examined in this study but can be contribute to changes in lung function such as physical activity, knowledge, attitudes and behavior, etc. as previously explained.

The largest number of respondents belonged to the vitamin D insufficiency and moderate obstruction group (25.53%). Based on the evaluation of the inner control model, it was found that there was no direct significant influence of the vitamin D variable on lung function (P_{value}>0.05 and $t_{statistic}$<t_{table}) in active smokers. These results have conclusions that are the opposite of several theories, which state that vitamin D can affect lung function, especially in active smokers. It is not aligned with previous theory and research, which states that there is an inverse relationship between vitamin D levels and lung function. Previous research by Ganji *et al.* (2020) involved 11,983 respondents aged ≥20 years. This study combines three NHANES data from 2007-2008, 2009–2010, and 2011–2012. The results of the study concluded that serum 25(OH)D levels were directly related to FVC and FEV1; in other words, serum 25(OH)D levels were associated with improved lung function values in healthy people, but not with the prevalence of asthma, emphysema, and chronic bronchitis. Other research also supports previous research, such as Wannamethee *et al.* (2021), who used a prospective cohort design involving 3575 male respondents (60-79 years), concluded that male respondents with COPD tend to experience vitamin D deficiency when compared to male respondents with normal lung function. In contrast to the results of this study, there was no effect of vitamin D on lung function. This result can be caused by factors that influence these two variables (vitamin D and lung function), each of these two variables can be influenced by obesity, smoking and demographic factors studied in this study to factors that were not studied such as genetics, physical activity, food intake, knowledge, attitudes and behavior, sun exposure, skin color, air pollution.

The results of the evaluation of the structural model (inner model) found that there was no influence of the level of obesity on lung function through vitamin D levels in active smokers. Therefore, vitamin D does not mediate the indirect relationship between obesity levels and lung function. This result could be caused by factors that influence these two variables (vitamin D and lung function), each of these three variables can be influenced by smoking and demographic factors studied in this study to factors not studied such as genetics, physical activity, food intake, knowledge, attitudes and behavior, sun exposure, skin color, air pollution and so on, as previously explained.

This research still has several limitations, including other factors that cannot be controlled such as genetic factors, physical activity, knowledge, attitudes and behavior, intensity of exposure to sunlight, use of sunscreen, air pollution, food intake cannot be controlled in this research so that it can influence the research results. Current knowledge finds that a lack of physical activity is an important risk factor for vitamin D deficiency. Various observational studies show that maintaining vitamin D nutritional status is related to physical activity/exercise habits, where the level of physical activity is significantly positively correlated with 25(OH)D levels (Song *et al.*, 2020; Lorensia *et al.*, 2022). Variations in sun exposure can cause vitamin D levels to fluctuate. Indoor activity may be a factor in these fluctuations and may cause a decrease in vitamin D levels. A systematic review and meta-analysis aimed at identifying whether physical activity or exercise indoors compared to outdoors has a significant effect on vitamin D levels through subgroup analysis and multivariate meta-regression (Bârsan *et al.*, 2023).

Conclusion

Obesity level factors (BMI) have a significant direct effect on vitamin D levels in active smokers. The demographic factors and smoking frequency do

not have a direct significant effect on vitamin D in active smokers. Demographic factors, obesity level, and smoking frequency do not have a significant direct effect on lung function in active smokers. Vitamin D has no direct significant effect on lung function in active smokers. Demographic factors, obesity level, and smoking frequency do not have a significant effect on lung function via vitamin D in active smokers. Therefore, it is recommended to maintain body weight and lose weight, especially in obese populations, to reduce the incidence of vitamin D deficiency. So it is necessary to carry out further research on the influence of other factors on vitamin D levels and lung function, such as genetic factors, physical activity, knowledge and attitudes, and behavior, intensity of exposure to sunlight, use of sunscreen, air pollution, and food intake that were not observed in this study to develop theories about the influence of broader factors.

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Household Wood Fuel Usage and Lung Cancer Predictor Symptoms in Primary Care: A Retrospective Cross-Sectional Study for Lung Cancer Early Detection

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Abstract

Biomass fuel combustion is a major contributor to household air pollution, posing risks to various health concerns, including lung cancer (LC). In Yogyakarta, 13.68% of households still depend on firewood as their primary source of cooking fuel. This retrospective cross-sectional study involved 302 patients attending the outpatient department at Pundong District Health Centre between July and August 2023. The primary outcomes were the number of reported LC predictor symptoms and LC suspicion referral status, based on the NG12 referral criteria. Wood fuel usage (WFU), respiratory disease history, and smoking history were the independent factors. Significant symptoms associated with high-risk WFU were cough (OR = 3.16, $p < 0.001$), dyspnoea (OR = 3.66, $p = 0.001$), fatigue (OR = 2.26, $p = 0.016$), and weight loss (OR = 4.46, $p = 0.043$). WFU and respiratory disease history were significantly associated with the number of LC predictor symptoms ($p < 0.001$). WFU, respiratory disease history, and smoking history demonstrated a significant relationship with LC suspicion referral status ($p < 0.001$). This study highlights the association between WFU and LC predictor symptoms, as well as the need for LC suspicion referral in limited resources settings. Further research is needed to validate the LC predictor symptoms with radiologic findings and final diagnosis.

Introduction

The utilisation of solid fuels, particularly biomass fuels, remains widespread among the majority of rural households primarily for cooking purposes (Ravindra *et al*., 2020). Approximately 2.8 billion people worldwide still depend on solid fuels. The highest prevalence was observed in the regions of Africa and Southeast Asia, constituting 77% and 61% respectively (Bonjour *et al*., 2013). According to the 2023 report from the Indonesian Central Statistics Agency (Badan Pusat Statistik), 9.19% of households still rely on firewood as their primary source of cooking fuel. In Yogyakarta, this percentage rises to 13.68% (Badan Pusat Statistik, 2023). Biomass fuel combustion is a significant contributor to household air pollution (HAP), posing risks to various health concerns, particularly non-communicable diseases (NCDs) such as stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD), and lung cancer (Aunan *et al*., 2019; Fullerton *et al*., 2008; WHO, 2022). HAP alone accounted for 3.2 million deaths in 2020, including 237,000 deaths in children under 5 years of age (WHO, 2022). Children, the elderly, and women are the groups at the highest risk of exposure to biomass fuel combustion byproducts, particularly through cooking and heating, leading to a range of acute to chronic respiratory symptoms (Das *et al*., 2017; Desalu *et al*., 2010; Enyew *et al*., 2021; Van Vliet *et al*., 2019). These are compounded by factors such as the type of fuel and stove utilised, inadequate

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ventilation, integrated kitchen within living spaces, and the practice of mothers carrying children while cooking in the kitchen (Das *et al*., 2017; Enyew *et al*., 2021; Fullerton *et al*., 2008).

Lung cancer (LC) is the leading cause of cancer-related mortality worldwide, accounting for 1,796,144 global deaths. According to the Global Cancer Observatory (GLOBOCAN) report in 2020, LC ranks as the third most common cancer in Indonesia, with the highest number of new cases occurring in males, totalling 25,953 cases per year (14.1%) (Sung *et al*., 2021). Based on the 2018 Basic Health Research, the prevalence of cancer in Indonesia stands at 1.79%. The province with the highest recorded cancer diagnoses is Yogyakarta, reporting 14,602 cases (4.86%) (Kemenkes RI, 2018). The primary cause of lung cancer is smoking, contributing to over 60% of global LC deaths (*Global Burden of Disease*, 2019). To date, more than one in three adults in Indonesia smoke, according to the 2021 Global Adult Tobacco Survey (GATS) report (GATS, 2021). Based on a 2018 meta-analysis, the relative risk of LC is not significantly different between male and female smokers, with values of 8.78 and 7.48, respectively. However, the prevalence of LC among non-smokers is found to be higher in females (O'Keeffe *et al*., 2018).

The proportion of LC cases among smokers has decreased in comparison to never-smokers. This decline may be associated with the global reduction in tobacco smokers over the past three decades (Dai *et al*., 2022; Pelosof *et al*., 2017). Risk factors for LC among non-smokers include age, passive smoking, biomass fuel combustion, air pollution, asbestos exposure, radon exposure, genetic factors, a history of radiation therapy, lung disease history, oestrogen, dietary factors, and obesity (Akhtar & Bansal, 2017; David M Mannino, 2021; Dubin & Griffin, 2020). Individuals who have never smoked still carry a relatively high risk and may benefit from LC screening (Kerpel-Fronius *et al*., 2022). Numerous studies have investigated the risk of LC from biomass fuel smoke exposure, particularly wood fuel, yet have not yielded conclusive findings (Lim & Seow, 2012). A systematic review conducted by Bruce *et al* identified a stronger association, particularly in the context of biomass fuel use for cooking, compared to previous research studies (Bruce *et al*., 2015). A retrospective cohort study in China reported an increased lifetime risk of LC associated with exposure to household coal smoke (Barone-Adesi *et al*., 2012). Furthermore, a meta-analysis in 2012 concluded that coal usage is significantly linked to LC compared to other biomass fuels (Kurmi *et al*., 2012). A systematic review conducted in Sub-Saharan Africa in 2020 did not mention LC as a health consequence of wood smoke exposure but rather emphasised the risk of oesophageal cancer (Bede-Ojimadu & Orisakwe, 2020). Nevertheless, based on recent case-control research in 2021, exposure to wood smoke has been established as a risk factor for LC (Báez-Saldaña *et al*., 2021).

Primary care plays a crucial role in the early diagnosis of LC. Primary care physicians need to identify symptoms that raise suspicion of LC and make referrals for further examination (Bradley *et al*., 2019). Early diagnosis is vital because most cases of LC are diagnosed at an advanced stage, leading to poor prognosis and limited therapeutic management options (Okoli *et al*., 2018). Symptomatic diagnosis of LC was not feasible due to the lack of systematic studies measuring the predictive value of symptoms (Shim *et al*., 2014). However, several extensive studies, including meta-analyses, established possible predictive symptoms of LC (Iyen-Omofoman *et al*., 2013; Levitsky *et al*., 2019; Okoli *et al*., 2018; Shim *et al*., 2014).

Haemoptysis is a pre-diagnostic symptom of LC with the highest predictive value across all studies (Iyen-Omofoman *et al*., 2013; Levitsky *et al*., 2019; Okoli *et al*., 2018; Shim *et al*., 2014). Symptoms such as cough, dyspnoea, and chest pain also exhibit high and consistent diagnostic value (Okoli *et al*., 2018; Shim *et al*., 2014). Levitsky *et al* identified 63 symptom descriptors and 7 background variables, reporting symptoms consistent with previous research, including haemoptysis (blood-mixed/brown sputum), dyspnoea (breathing worse upon exertion), cough problems (cough that varied over the day), appetite loss, and voice hoarseness (Levitsky *et al*., 2019). Patient backgrounds such as smoking history, chronic obstructive pulmonary disease (COPD), and

recent respiratory infections are also important predictor variables (Iyen-Omofoman *et al.*, 2013; Levitsky *et al.*, 2019).

Recommendations for LC referrals in primary care have been developed by the National Institute for Health and Care Excellence (NICE) in 2015 (NG12), with the latest update in 2021. This guideline includes referral criteria for performing chest X-ray (CXR) examinations on patients with suspected LC symptoms (NICE Guideline, 2015). The listed symptom criteria were consistent with the LC predictor symptoms identified in other studies (Iyen-Omofoman *et al.*, 2013; Okoli *et al.*, 2018; Shim *et al.*, 2014). Computed Tomography scans (CT scans) offer higher sensitivity for early LC diagnosis compared to CXRs, but their access is considerably more limited (Bradley *et al.*, 2019). The systematic implementation of LC referral systems has yet to be established in Indonesia, while early detection and diagnosis protocols need to be developed to enable earlier LC diagnosis (Dewi *et al.*, 2021).

Based on direct observations during visits to several households in the Pundong District of Bantul, it is evident that many households still use firewood for indoor cooking. Even though only 8.72% of households in Bantul use wood as their primary source of cooking fuel, it is estimated that some households have transitioned to gas as their primary fuel but still use firewood, particularly for boiling water (Badan Pusat Statistik, 2023). Considering household wood fuel usage (WFU) as one of the potentially impactful risk factors for LC, the medical staff of the Pundong District Health Centre aim to assess the relationship between household WFU and predictor symptoms, as well as the LC suspicion referral status in patients at the Pundong District Health Centre.

Methods

This study employed a retrospective cross-sectional design with convenience sampling. The participants were recruited from the medical records of patients attending the outpatient clinic at Pundong District Health Centre who underwent lung cancer (LC) screening between July and August 2023. Eligible subjects were identified by primary care doctors through medical record reviews. Approval from the Health Department of Bantul Regency was acquired to conduct this study as a part of Pundong District Health Centre's healthcare program. The inclusion criteria were individuals aged 40 and above who have never smoked or have not smoked in the last 28 days. The history of persistent cardiovascular symptoms and other notable systemic diseases

NICE Guideline (NG12) on Lung Cancer Recognition and Referral
Refer people using a suspected cancer pathway referral for lung cancer if they: • have chest X-ray findings that suggest lung cancer or • are aged 40 and over with unexplained haemoptysis. [2015]
Offer an urgent chest X-ray (to be done within 2 weeks) to assess for lung cancer in people aged 40 and over if they have 2 or more of the following unexplained symptoms, or if they have ever smoked and have 1 or more of the following unexplained symptoms: • cough • fatigue • shortness of breath • chest pain • weight loss • appetite loss [2015]
Consider an urgent chest X-ray (to be done within 2 weeks) to assess for lung cancer in people aged 40 and over with any of the following: • persistent or recurrent chest infection • finger clubbing • supraclavicular lymphadenopathy or persistent cervical lymphadenopathy • chest signs consistent with lung cancer • thrombocytosis. [2015]

FIGURE 1. NICE Guideline (NG12) on Lung Cancer Recognition and Referral (NICE Guideline, 2015)

were excluded. The primary outcome measures were the number of reported LC predictor symptoms and LC suspicion referral status. The independent factors were wood fuel usage (WFU), respiratory disease, and smoking history. The secondary outcome measures were age group, gender, education levels of participants, and whether these characteristics predicted wood fuel usage.

High-risk group was defined as wood fuel users who use wood fuel combustion for cooking and heating in the household at regular intervals of at least twice a week, located inside the house (indoor), or partially outdoors or close to the house's ventilation. The low-risk group was defined as users with regular usage intervals and located outdoors. Non-users were defined as participants who had never used wood fuel or had only used it occasionally. Other household air pollution (HAP) factors, like indoor smoking, were not accounted for this study. LC predictor symptoms and LC suspicion referral status were established based on the NG12 referral guideline from the National Institute for Health and Care Excellence (NICE), as shown in **FIGURE 1.** (NICE Guideline, 2015). The listed "unexplainable symptoms" were adjusted to be either "unexplainable or persistent symptoms" as stated in the older version of the NG12 guideline, considering the feasibility of screening and the relatively low-educated participants, ensuring a more representative reporting of symptoms.

Data collection was through the medical records of patients who underwent LC screening by primary care doctors with a previously arranged set of questions. Interview answers were systematically transcribed into the medical record. Patients who matched the referral criteria were labeled as being referred for LC suspicion. Data were analysed using the IBM SPSS 26.0. Descriptive statistics were used to describe the participants' demographic characteristics and other study data. Chi-square tests were used to explore the differences in the demographic characteristics and WFU. Nonparametric independent tests were used to identify the relationship between WFU, respiratory disease history, smoking status, number of lung predictor symptoms, and the differences among the WFU groups. Bivariate analysis was executed to compare each LC predictor symptom among the WFU groups. In addition, the LC suspicion referral status was compared with the WFU groups using the Chi-square test.

Results and Discussions

A total of 302 patients who attended the outpatient clinic were included in the study. The mean age was 60 years, ranging from 41 to 89 years (SD = 9.36). The majority of the patients were female (n = 221, 73.2%) and demonstrated a lack of formal education. Most patients had only completed primary school (n = 135, 44.7%). Wood fuel usage (WFU) was found in 38.4% of participants (n = 116), whereas the percentage of low-risk users and high-risk users was 10.3% (n = 31) and 28.1% (n = 85). There was a significant difference in gender on WFU (p = 0.005, chi-square), with 72 (84.7%) females in the high-risk group compared to males. Education level was found to have a significant difference (p = 0.005, linear-by-linear association) on WFU. The primary school group showed the highest percentage in the high-risk group (56.8%). The age groups divided among participants also showed significant differences in WFU (p = 0.035, linear-by-linear association). The age group of 60 to 69 years old was the most prevalent in the high-risk group (n = 41, 48.2%). Respiratory disease history, ranging from

TABLE 1. Pairwise Comparisons of Wood fuel usage.

	Test statistic	**Raw p-value**	**Adj. p-value[a]**
Non-user - Low-risk	0.422	0.516	1.000
Non-user - High-risk	16.206	0.000	0.000
Low-risk - High-risk	8.460	0.004	0.011

[a] Bonferroni correction

TABLE 2. Comparison Between Demographic Characteristics of Patients on Wood Fuel Usage

Demographic Characteristics	Low-risk / Non-user n = 217	High-risk n = 85	p-value
	n (%)	n (%)	
40-49	33 (15.2)	9 (10.6)	0.035[a]
50-59	82 (37.8)	21 (24.7)	
60-69	71 (32.7)	41 (48.2)	
≥70	31 (14.3)	14 (16.5)	
Male	68 (31.3)	13 (15.3)	0.005[b]
Female	149 (68.7)	72 (84.7)	
No Education	16 (7.4)	8 (9.4)	0.005[a]
Primary School	87 (40.1)	48 (56.5)	
Middle School	42 (19.4)	13 (15.3)	
High School	61 (28.1)	14 (16.5)	
College/diploma	11 (5.1)	2 (2.3)	

[a] Linear-by-linear association
[b] Chi-square

Source: Primary Data, 2023

asthma, chronic obstructive pulmonary disease (COPD), respiratory Tuberculosis (TB) history, and recent lung infection, was documented in 22 (7.3%) patients. Past smoking history was reported in 46 (15.2%) patients, all male patients, with active smokers excluded.

Pairwise comparisons between groups of WFU on the number of symptoms were executed and adjusted with Bonferroni correction, as shown in **TABLE 1.** The result showed that the non-user group and the low-risk group showed no significant difference in the number of symptoms ($p = 1.000$), while both groups, when compared to the high-risk group, showed significant differences ($p = 0.000$ and $p = 0.011$). The non-user and low-risk groups were assigned to the same group in **TABLE 2** to simplify comparisons between demographic characteristics. WFU, respiratory disease history, and smoking history were identified as factors affecting the LC predictor symptoms. Mann-Whitney test was assigned to assess associations between the covariates and the number of LC predictor symptoms as shown in **TABLE 3.** Both WFU and respiratory disease history showed significant association ($p < 0.001$) with the number of symptoms, while smoking history showed no significant

TABLE 3. Association Between Covariates and the Number of Lung Cancer Predictor Symptoms

Covariates		n (%)	Z	p-value
Wood Fuel Usage	Low-risk / Non-user	217 (71.9)	-4.505	<0.001
	High-risk	85 (28.1)		
Respiratory Disease History	No	280 (92.7)	-4.481	<0.001
	Yes	22 (7.3)		
Smoking History	Never smoker	256 (84.8)	-0.996	0.319
	Past smoker	46 (15.2)		

Source: Primary Data, 2023

TABLE 4. Lung Cancer Predictor Symptoms Distribution in Wood Fuel Usage Groups

Lung Cancer Predictor Symptoms	No. of Cases n = 94	Outcome	WFU Group		OR	p-value
			Low-risk / Non-user	High-risk		
	n (%)		n = 217	n = 85		
Haemoptysis	4 (4.3)	Yes	2 (0.9)	2 (2.4)	2.59	0.315[a]
		No	215 (99.1)	83 (97.6)		
Cough	48 (51.1)	Yes	24 (11.1)	24 (28.2)	3.16	<0.001[b]
		No	193 (88.9)	61 (71.8)		
Dyspnoea	27 (28.7)	Yes	12 (5.5)	15 (17.6)	3.66	0.001[b]
		No	205 (94.5)	70 (82.4)		
Chest pain	13 (13.8)	Yes	6 (2.8)	7 (8.2)	3.16	0.054[a]
		No	211 (97.2)	78 (91.8)		
Fatigue	41 (43.6)	Yes	23 (10.6)	18 (21.2)	2.26	0.016[b]
		No	194 (89.4)	67 (78.8)		
Weight loss	8 (8.5)	Yes	3 (1.4)	5 (5.9)	4.46	0.043[a]
		No	214 (98.6)	80 (94.1)		
Appetite loss	20 (21.3)	Yes	12 (5.5)	8 (9.4)	1.77	0.222[b]
		No	205 (94.5)	77 (90.6)		

[a]Fisher's Exact

[b]Chi Square

Source: Primary Data, 2023

association (p = 0.319).

Cough (n = 48, 15.9%) and fatigue (n = 41, 13.6%) were the most common Lung Cancer (LC) predictor symptoms reported in the population. Among symptomatic patients, the prevalence of cough and fatigue is 51.1% and 43.6% respectively. The other symptoms, in order of case frequency, were dyspnoea (n = 27, 8.9%), appetite loss (n = 20, 6.6%), chest pain (n = 13, 4.3%), weight loss (n = 8, 2.6%), and haemoptysis (n = 4, 1.3%). **TABLE 4** demonstrates the percentage of cases among symptomatic patients and the number of each LC predictor symptom reported among WFU groups, enabling comparison between the low-risk/non-user group vs. the high-risk group. The symptoms that were observed to be significantly associated with high-risk WFU were cough (p < 0.001), dyspnoea (p = 0.001), fatigue (p = 0.016), and weight loss (p = 0.043). The odds ratio (OR) of "weight loss" was 4.46 (1.4% vs. 5.9%), which was comparably highest among other symptoms. It was followed by "dyspnoea" with an OR of 3.66 (5.5% vs. 17.6%), "cough" with an OR of 3.16 (11.1% vs. 28.2%), and "chest pain" with an OR of 3.16 (2.8% vs. 8.2%). The OR for "haemoptysis" was 2.59 with only 4 cases reported (0.9% vs. 2.4%). "Fatigue" had an OR of 2.26 (10.6% vs. 21.2%) and "appetite loss" had an OR of 1.77 (5.5% vs. 9.4%). The relationship of each LC predictor symptom among WFU groups was analysed using the Chi-square and Fisher's exact test.

The number of LC predictor symptoms and smoking history were assessed using the NG12 guideline. A total of 45 (14.9%) patients were assigned to be referred for CXR. Among these, 22 patients (48.9%) were in the low-risk group and 23 patients (51.1%) were in the high-risk group. In the respiratory disease history group, 11 (24.4%) patients were referred to respiratory disease. In the smoking history group, 16 (35.6%) were past smokers. The association between referral status and covariates was analysed using the Chi-square test. WFU, respiratory disease history, and smoking history all demonstrated significant association (p <0.001) as shown in **TABLE 5.**

This study demonstrated the association between WFU and Lung cancer (LC) predictor

TABLE 5. Association Between Covariates and Lung Cancer Suspicion Referral Status

		No Refer n = 257	Refer for CXR n = 45	p-value
		n (%)	n (%)	
Wood Fuel Usage	Low-risk / Non-user	195 (75.9)	22 (48.9)	<0.001
	High-risk	62 (24.1)	23 (51.1)	
Respiratory Disease History	No	246 (95.7)	34 (75.6)	<0.001
	Yes	11 (4.3)	11 (24.4)	
Smoking History	Never smoker	227 (88.3)	29 (64.4)	<0.001
	Past smoker	30 (11.7)	16 (35.6)	

symptoms and LC suspicion referral status. The two main factors related to an increased number of LC predictor symptoms in this study were wood fuel usage (WFU) and respiratory disease history. WFU was reported in 38.4% of patients, a relatively high number compared to the national survey in 2023, which documented the primary source of cooking fuel in the Indonesian household. In Bantul (the same region where this study took place), only 8.72% of households still rely on wood fuel for cooking (Badan Pusat Statistik, 2023). The secondary source of cooking fuel was not reported in the survey, concealing the number of households still using wood fuel with cleaner fuels concurrently. WFU as a type of biomass fuel was often used together with other biomass ones, such as grass or straw (Bonjour *et al*., 2013; Bruce *et al*., 2015). During several short interviews, some households use painted wood scraps and plastic wastes incorporated with firewood combustion.

Older patients, female gender, and lower education level were associated with high-risk WFU in this study. Older populations used to rely on wood fuel before the twenty-first century and might not be accustomed to converting to modern or safer fuel combustion methods (Bonjour *et al*., 2013). The female gender was reported to be significantly associated with high-risk WFU, but this may lead to potential bias since the gender majority in this study was female. Considering gender role distinction, females were reported to be at risk for more exposure to household air pollution (HAP), including biomass fuel combustion like WFU for cooking and heating (Van Vliet *et al*., 2019; Vermeulen *et al*., 2019). HAP does not only include indoor biomass fuel combustion. Fumes from outdoor combustion can penetrate houses exposing connecting rooms to harmful gases, including neighbourhood air pollution. Poor ventilation, low-quality inefficient cookstoves, and the choice of cooking fuel contribute significantly in HAP (Aunan *et al*., 2019; Das *et al*., 2017; Fullerton *et al*., 2008; Ravindra *et al*., 2020). A 2019 study revealed that women who cook using cleaner fuels such as liquefied petroleum gas (LPG) have improved lung function and respiratory health status compared to those who use solid biomass fuel (Kaur-Sidhu *et al*., 2019). While these factors were not documented comprehensively in this study, we identified several factors that might alter the risk of wood fuel combustion exposure through short interviews: house ventilation, frequency of WFU (not all households use wood fuel daily), stove location (inside, outside, or near the house), and type of stove. Outdoor WFU and sporadic WFU were estimated to be low-risk in terms of HAP exposure, while indoor or partially outdoor WFU and frequent WFU were considered high-risk (Goldstein *et al*., 2021).

Cough, dyspnoea, fatigue, and weight loss are the LC predictor symptoms most consistent with the high-risk WFU group. Cough, dyspnoea, and chest pain were LC predictor symptoms with the highest predictive value, after haemoptysis, based on recent systematic reviews and meta-analysis (Okoli *et al*., 2018; Shim *et al*., 2014). While this may

suggest a correlation between the established symptoms and LC, common respiratory symptoms could also arise from acute exposure to fumes from biomass fuel combustion (Das *et al*., 2017; Desalu *et al*., 2010; Van Vliet *et al*., 2019). Cough was the most common symptom found in all groups. Cough and dyspnoea were also common respiratory symptoms frequently reported among the geriatric population, even in non-smokers (Enright *et al*., 1994). Older age is also a major risk factor for LC (Akhtar & Bansal, 2017; David M Mannino, 2021).

A previous study of 269 adult women in Nigeria with similar mean age and educational background to this study reported that 59.9% of respondents used biomass fuel for cooking. The OR for the presence of respiratory symptoms, particularly "cough" in the biomass fuel group, was 4.82 ($p = 0.01$) compared to the non-biomass fuel group (13.7% vs. 3.7%). The OR of chest pain and breathlessness were 3.82 ($p = 0.09$) and 1.54 ($p = 0.35$), respectively (Desalu *et al*., 2010). In this study, the OR of "cough" was 3.16 ($p < 0.001$), comparing the low-risk/non-user group vs. the high-risk group (11.1% vs. 28.2%). The OR of chest pain and breathlessness had a different ratio, which was 3.16 ($p = 0.054$) and 3.66 ($p = 0.001$), respectively. The quality of firewood was also compared to the presence of respiratory symptoms in a 2017 study. It was revealed that low-quality firewood was positively associated with shortness of breath, phlegm at night, and other non-respiratory symptoms (Das *et al*., 2017).

There was a significant difference between high-risk and low-risk WFU in the number of LC predictor symptoms ($p < 0.001$). High-risk WFU also showed a significant association with LC suspicion referral status, as determined by the NICE guideline (NG12) referral pathway. It suggested the need to further CXR examination, which had not been implemented for all subjects during the time of this study. Smoke exposure from biomass fuel combustion, especially wood fuel, has been hypothesised as a potential LC risk (Dean Hosgood *et al*., 2010). It was revealed in a 2015 systematic review that the strength of association between wood smoke and LC was weak. On the contrary, when restricted to studies among the majority of women, larger ORs were seen in the range of 1.6 to 2 (Bruce *et al*., 2015). A 2021 case-control study concluded that exposure to wood smoke is a risk factor for LC (Báez-Saldaña *et al*., 2021), in contrast to several other studies that did not mention the significance of WFU. It was highlighted several times that coal was a solid biomass fuel associated with LC (Barone-Adesi *et al*., 2012; Bede-Ojimadu & Orisakwe, 2020; Kurmi *et al*., 2012).

Respiratory disease history showed a significant correlation with LC predictor symptoms ($p < 0.001$). Certain respiratory diseases like chronic obstructive pulmonary disease (COPD) can exacerbate symptoms like dyspnoea and cough. Moreover, decreased lung function (Miravitlles & Ribera, 2017). The history of tuberculosis was also a strong predictor of respiratory symptoms (Van Kampen *et al*., 2019). It is also worth noting that the respiratory disease record, including COPD and recent lung infection, was established as one of the predictors of LC based on recent studies (Levitsky *et al*., 2019; Okoli *et al*., 2018). Smoking history (past smoking) was observed to have a significant difference between referral status groups, but had no significant association with the number of LC predictor symptoms. It might be influenced by the NG12 criteria, which include smoking history as one of the scoring factors for LC suspicion status (NICE Guideline, 2015). In this study, current or active smokers were excluded, leaving past smokers and never smokers for comparison. Conversely, the majority of the patients in this study were females living in a relatively rural region of Indonesia. Smoking history in women is uncommon, which may cause disproportion when comparing never smokers and past smokers. Furthermore, any history of smoking is considered a significant risk of LC (David M Mannino, 2021; O'Keeffe *et al*., 2018).

Conclusions

We have established a positive association between wood fuel usage (WFU) and the presence of lung cancer (LC) predictor symptoms in primary care patients. Symptoms such as cough, dyspnoea, fatigue, and weight loss are common in individuals with high-risk WFU. A history of respiratory disease

not only increases the risk of these symptoms but may also contribute as an LC predictor variable. Additionally, high-risk WFU are more frequently referred for LC suspicion compared to low-risk WFU and non-users. Further research is needed to confirm the association between the reported LC predictor symptoms and the radiologic findings, as well as the final diagnosis. The idea of implementing symptom-based early LC detection could be of great value in Indonesia, especially in limited-resource areas where access to standard diagnostic tools is still limited.

Finally, it is crucial to acknowledge the potential impact of firewood quality and other supplementary solid fuel sources in exacerbating air pollution, potentially increasing the risk of developing LC. Future research should adopt a more detailed yet practical approach in reporting WFU, particularly in rural households.

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The Double Burden: A Bibliometric Analysis on Tuberculosis with Diabetes Mellitus Comorbidity

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Abstract

Many studies have been conducted independently and collaboratively to find effective ways to control TB. However, the prevalence of TB continues to increase, especially in low- and middle-income countries. This study highlights the breadth of research conducted worldwide and collaborative networks over the past decade. Between 2003 and 2023, 410 research articles on TB with comorbid diabetes were analyzed using the Scopus database, with an annual growth rate of 7.18%, reaching its peak in 2022. The keywords "tuberculosis" and "diabetes mellitus" were found to have a total link strength of 2895 and 3101, respectively. The most published articles on TB-DM were published in the International Journal of Tuberculosis and Lung Disease (23). Babu, Subash (23) authored the most TB-DM article publications. The National Institute for Research in Tuberculosis is the most productive affiliation (12), making India the country with the most published articles. Still, the Netherlands led in average article citations (32.8%), and the United States has the most collaborative link country (324). Visualization of the co-occurrence and co-authorship networks was conducted using R-Studio and VOS-Viewer. The study highlights the rising tuberculosis and diabetes incidence, identifies research trends, disparities, and bidirectional control innovations, providing valuable insights for policy recommendations.

Introduction

The co-epidemic of diabetes mellitus (DM) and tuberculosis (TB) is a significant worldwide health concern, especially among countries with low to middle incomes where the incidence of both exceeds high (GBD & Diabetes Collaborators, 2023). The number of tuberculosis-related deaths increased dramatically between 2019 and 2021, with 1.6 million tuberculosis-related deaths reported. The WHO End TB Strategy's first success was a 5.9% decline in infections between 2015 and 2021. 10.6 million cases were reported in 2021, an increase of 4.5% from 2020. The 2% annual decline in incidence was reversed by a reduction in the incidence of TB by 2%. An increase of 3.6% (WHO, 2022).

The World Health Organization (WHO) has not achieved its target of reducing the death rate by 35% and the TB infection rate by 20% by 2020, despite a decrease in the annual death rate and global incidence rate. The target is to reduce the death rate by 90% or the TB incidence rate by 80% by 2030 (IDF, 2022; WHO, 2022). The endemicity of tuberculosis (TB) in developing countries is expected to increase the number of people with type 2 diabetes by 51% to 700 million in 2045, and the proportion of new TB cases with diabetes mellitus to 33.3% in 2050 (Awad *et al.*, 2019; IDF, 2022; McMurry *et al.*,

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2019). Diabetes mellitus ranks fourth among all causes of death, with an estimated 6.7 million cases globally in 2021. Together with HIV and malnutrition, people experiencing DM are more likely to get active TB or have latent TB reactivated, which is one of the main risk factors for TB, worsening treatment outcomes, and premature death. According to the International Diabetes Federation (IDF), roughly 45% of DM sufferers worldwide are undiagnosed, with Type 2 DM causing 90% of all DM cases. In Indonesia, 19.5 million people suffer from DM, and 73% of them are undiagnosed (Eckold *et al*., 2021; Indonesian Ministry of Health, 2018; Magliano D. J & Boyko E. J, 2021; Ngo *et al*., 2021; Verma *et al*., 2021).

Bibliometric analysis is a technique of analyzing published information and associated metadata, which is often used in systematic literature reviews and involves quantitative analysis to describe relationships between published articles (Akmal *et al*., 2020; Chen *et al*., 2020; Yang *et al*., 2021). Bibliometric analysis differs from systematic and scoping reviews in providing additional information about research activities. Bibliometric analysis is a brief overview of both domestic and foreign contributions to the literature. It usually uses a single database to provide background data, pinpoint research gaps, and conduct precise quantitative evaluation of the literature that constitutes the basis for subsequent research and funding (Donthu *et al*., 2021; Ninkov *et al*., 2022). However, bibliometric analysis excludes grey literature, which is prevalent in systematic reviews. The strength of this bibliometric approach lies in its comprehensive and detailed coverage (Linnenluecke *et al*., 2020) Increased development and accessibility of software that utilizes quantitative algorithms and techniques, such as VOSviewer (Center for Science and Technology Studies, Leiden University, Leiden, The Netherlands) and scientific databases (Scopus, PubMed, Web of Science, Crossref, Google Scholar, Semantic Scholar) makes bibliometrics has become very popular in recent years as a form of large-scale data analysis. Official guidelines exist for systematic reviews, but the coverage and depth of bibliometric methods in these guidelines remain inadequate. Bibliometric analysis is regarded as a scholarly approach for gathering and combining published research on a fixed subject, notwithstanding its drawbacks (Donthu *et al*., 2021; Passas, 2024). There are many accessible systematic reviews with varying research focuses regarding TB, DM, or TB-DM. However, there are not many systematic reviews that apply bibliometric analysis. In this study, we gathered research articles indexed in the Scopus database between 2013 and 2023 that dealt with the co-morbidity of TB and diabetes and then analyzed and visualized them bibliometrically.

Method

The bibliometric analysis was applied from 2013 to 2023, employing the SciVerse Scopus database, which provides various benefits compared to different databases. Due to its easy-to-use interface, Scopus provides more global coverage than Web of Science and more precise data analysis than Google Scholar or PubMed (Beovich *et al*., 2021; Keighobadi *et al*., 2021). Scopus-indexed data collected by over 25,000 active titles and 7,000 publishers, all of which have been extensively verified and approved by a third-party assessment council. Scopus uniquely merges an exhaustive, highly managed abstract and citation database with enhanced data and connected academic literature spanning several fields (https://elsevier.international/en-gb/solutions/scopus.html). Scopus was selected due to its all-encompassing perspective on worldwide research productivity in medical science, technology, arts, humanities, and behavioural sciences. It provides tools for tracking research trends, publication year, document type, analysing citations, computing h-index (Hirsh-index), journal name, authors, affiliations, mapping keywords, and collaborating on international research (Sweileh, 2018).

Data collection was carried out on November 16, 2023. A comprehensive search was carried out on Scopus data collection to retrieve data of original research publications on the topic of TB with comorbid DM. This bibliometric study began with identifying sources and establishing inclusion and exclusion criteria. However, the most significant consideration is keyword selection,

since it has a direct effect on the discoveries and outcomes (Sweileh, 2018). In the initial data collection process, according to keywords, 715 articles were collected. Furthermore, data cleaning is required to remove duplicate articles and articles published in the period 2013 to 2023. Only full-text original articles published in English and final stage are considered to meet the inclusion criteria; all other types of documents, articles with unprovided English translations, and unrelated articles are excluded. The results of data extraction produced a total of 505 articles. The data search method in the Scopus database involves combining the terms TITLE ("tuberculosis" OR "lung tuberculosis" OR "pulmonary tuberculosis" AND diabet* AND "diabetes mellitus" OR "diabetes") AND ABS ("tuberculosis" AND "diabetes mellitus") AND ALL ("tuberculosis" AND "diabetes mellitus")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYP, "j").

The data gathered was applied to figure out the number of original research publications by year, subject area, journals, authorship, institutions, countries, research funding, co-occurrence networks, and co-authorship networks. Data from Scopus regarding 15 journals, 15 authors, 15 institutions, and 15 active countries—which are thought to contribute the most scientifically to the literature—are exported into an Excel spreadsheet (Microsoft® Excel® for Microsoft 365 MSO Version 2405). All subsequent data will be analyzed after exporting to ".csv" (comma-separated values) format. The number of articles given to every country may overlap since Scopus determines the entire articles for every country by considering the author institutions, irrespective of the author's rank on the author roster. Direct assessment or quantification of a publication's quality is challenging. As an indirect indicator of publication impact or quality, one can look at the overall number of citations obtained, the mean count of articles cited, the Hirsch index (h index), and the proportion of mostly cited articles (Aksnes *et al*., 2019; Thelwall & Sud, 2022).

A construct and visualized bibliometric map was produced using Biblioshiny (R studio version 2023.12.0–369) software applied to map country production, article language, and the most cited countries. VOSviewer (version 1.6.20) visualization to showcase the authors who have published the most papers and the collaboration networks between authors. The most popular subjects were found using title analysis and co-occurrence network visualization. The link strength in a map was strongly correlated with the size of the node and the line that connected the authors. Visualized maps were also generated to provide insight into the scope of worldwide collaboration. Based on the thickness of the connecting lines and the quantities of articles, VOSviewer determines the degree of partnership involving two or more countries. The link strength is supplied by the software; hence, the author does not compute it. In terms of the quantity of co-authored articles in comparison to those in other countries, the greater the collaboration between the two countries, the greater the link. VOSviewer is also useful for determining how a scientific area is organized and pinpointing potential avenues for further inquiry.

Result and Discussion

Through bibliometric analysis of research findings, we looked at 410 publications from various viewpoints published in 222 journals and featured 2175 authors. The trend in years of publication of original research articles on TB and DM has increased over the past ten years. A total of 23 research articles published in 2013 were indexed in the Scopus Database. However, from 2014 onwards, there were more than 100 publications. The study has steadily expanded since 2017 (32 documents) until it reached its peak in 2022 (58 documents). Overall, research interest in TB and DM has begun to grow over the last decades with an annual growth rate of 7.18%. Even though the increase in research annually insignificant, the number tends to increase. There has been a drastic spike in the last two years (2021 – 2022). This increase in the number of publications is in line with the increasing prevalence of tuberculosis and diabetes mellitus globally, both in developed and developing countries (IDF, 2022; WHO, 2022).

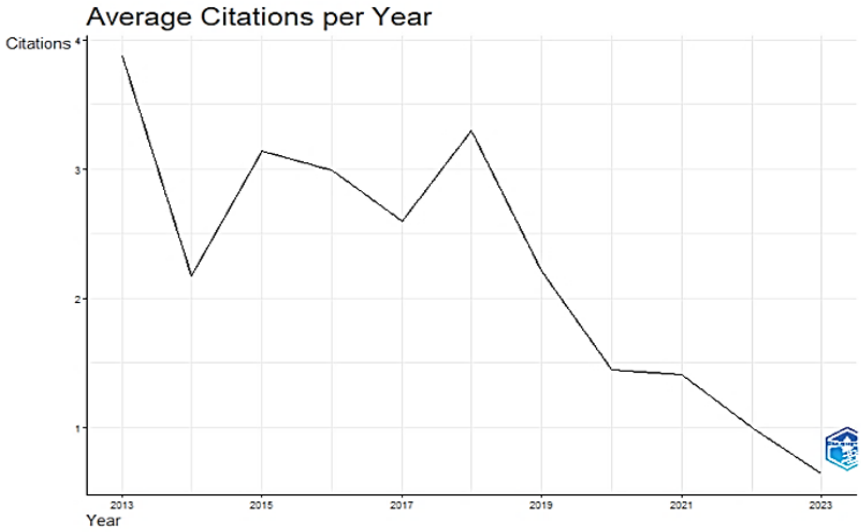

FIGURE 1. Annual citations of original research articles on TB – DM publications per year.

The average annual citation of documents is displayed in Fig. 1. The graph clearly illustrates an inverse link, where the frequency of citations swings with a high tendency from 2013 to 2018, peaking at 46.48 cited publications in 2013, then declines even further from 2019 to 2023. The average number of citations for published articles is decreasing, with average citations per article of 14.86%, although the number of publications is increasing. It suggests that the influence of publications is waning, even though several research paths are being explored in the field of TB and DM. In addition, there were social and economic difficulties brought on by the COVID-19 pandemic, which struck in 2019 and continued until 2021. Worldwide emphasis was mostly focused on COVID-19 research, which contributed to a decline in the amount of attention devoted to TB research overall (Delardas *et al*., 2022; Mofijur *et al*., 2021).

A total of 410 original articles on TB and DM published by authors affiliated in 83 countries; The top 15 countries publishing TB articles with DM comorbidity, including India (n = 86, Total citation = 929) taking the top spot, followed by the United State (n = 78, Total citation = 893), China (n = 67, Total citation = 710), United Kingdom (n = 39, Total citation = 118), and Indonesia (n = 31, Total citation = 77) in fifth position. The subsequent countries listed in sequence are Mexico (n = 24), Netherlands (n = 21), South Korea (n = 20), Taiwan (n = 17), France and South Africa (n = 16), Brazil (n = 15), Tanzania (n = 14), Denmark and Thailand (n = 12). The Netherlands led the world in average article citations (32.8%), followed closely by the United States (31.9%), the United Kingdom (23.6%), and Mexico (23.1%). Due to the vast quantity of publications and relatively low quality of those articles, India has substantially lower average article citations, even though overall citations are more than in other countries/regions. Interestingly, the three Asian countries with the highest TB caseloads are included in "The Big Five" (India, Indonesia, and China). It reveals a clear correlation between "high burden TB-DM countries" and research contributions, as evidenced by the most published articles. Research on TB itself is increasing, and controlling its spread has become one of the main health priorities in the world, with the United States, United Kingdom, India, and China dominating research in this field (Abdullah *et al*., 2022; Garrido-Cardenas *et al*., 2020). Similar results to the bibliometric analysis of DM (Kong *et al*., 2023). Bibliometric analyses of TB and DM, although separately, report similar results regarding the most contributing countries.

Fig. 2 depicts the worldwide collaboration cluster network of linked countries and regions. These data were used to create eleven clusters. At least one publication was released by 46 nations or territories, and 32 of those were linked together to create a cooperative network. The United States was the most collaborative

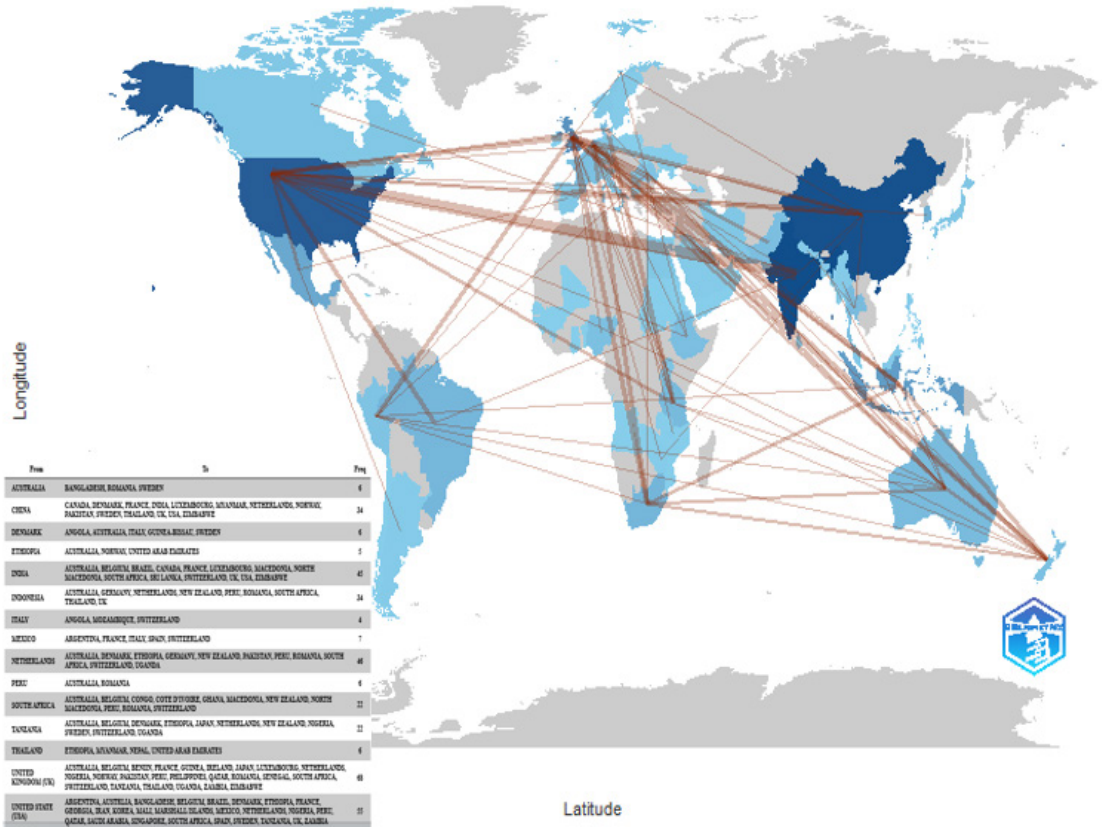

FIGURE 2. Countries' Partnership World Map.

country with the highest total link strength (TLS = 324), followed by the United Kingdom (TLS = 232), the Netherlands (TLS = 94), China (TLS = 78), and India (TLS = 70). Indonesia (TLS = 17), on the other hand, is a member of the red cluster and collaborates with nine other nations/territories, both inside and outside of its cluster. The countries that collaborate with Indonesia the closest include Australia, the Netherlands, New Zealand, South Africa, and the United Kingdom. Thus, Indonesia must strengthen the influence of publications and global collaboration in the areas of diabetes and TB, in light of both quantity and quality.

The original articles gathered for the present research have been published in open-access journals of various categories, including all open-access (n = 302), gold (n = 233), green (n = 149), bronze (n = 28), and hybrid gold (n = 16). Original research articles published in 161 peer-reviewed publications were included, and the top 15 journals are listed in Table 1, along with their associated 2023 CiteScore, frequency of articles published in each journal, and their citations. CiteScore 2023 is determined by dividing the total number of citations received in 2020–2023 for articles, reviews, conference papers, book chapters, and data papers published in 2020–2023 by the total number of publications created in 2020–2023. The International Journal of Tuberculosis and Lung Disease is the journal with the most published articles (n = 23) related to the topic of TB-DM, while Plos One is in the second place, has the highest number of citations (TC = 653). Meanwhile, the highest 2023 CiteScore is the International Journal of Infectious Diseases (18.9), which reflects the highest annual average number of citations to recent articles published in that journal.

Firstly, the h-index was developed for individual scientists or academics, act as an author-level indicator that assesses the productivity and citation effect of publications.

The most frequently referenced papers and citations from other journals serve as its foundation. It has more recently been used with an academic journal's influence and production. The International Journal of Tuberculosis and Lung Disease has grown since 2021 – source details obtained from Scopus – by releasing 23 of 90 TB-DM related publications in 2023 with 12 citations and an h-index of 12. Among the top 15 journals, Plos One had the most citations (TC = 653) and the highest h-index (15) out of 20 publications about TB-DM. The growing trend of research based on numerous published and cited documents related to TB cases with DM comorbidity draws the international spotlight on the spread and control of TB with DM comorbidity factors in two directions since it can have a significant global impact on public health (Bai & Ameyaw, 2024; Villar-Hernández *et al*., 2023). Original articles on TB and DM, written by a total of 2175 authors, co-authors per document 7.37, and international co-authorship of 37.32%. Fig 3. shows a comparison of the number of published articles and the top five authors with most publications were authored by Babu, Subash S. currently affiliated with the National Institute of Allergy and Infectious Diseases, United States (n = 23; h-index = 14; total link strength = 65; total citations = 613). Those reflect the outstanding standard and significant impact of Babu's publications. Second position is Kumar, Nathella P. who is affiliated in Tuberculosis Research Centre, India (n = 20; h-index = 11; total link strength = 48; total citation = 438), then followed by Kornfeld, Hardy with affiliations in University of Massachusetts Chan Medical School, United States (n = 17; h-index = 11; total link strength = 26; total citation = 488). Critchley, Julia A. is in fourth position affiliated in St. George's

TABLE 1. The 15 Leading Journals by Number of Articles in the Field of Tuberculosis with Diabetes.

Journal	Articles	h-index	g-index	CiteScore 2023	Total citation
International Journal of Tuberculosis and Lung Disease	23*	12	19	4.9	389
Plos One	20	15*	20	6.2	653*
BMC Infectious Diseases	17	9	14	6.5	217
Tuberculosis	12	6	12	4.6	280
Scientific Reports	9	6	9	7.5	241
BMJ Open	8	4	5	4.4	36
International Journal of Infectious Diseases	7	5	7	18.9*	62
Infection And Drug Resistance	6	3	6	5.6	45
International Journal of Mycobacteriology	6	4	6	2.2	57
BMC Health Services Research	5	4	5	4.4	60
Frontiers In Public Health	5	3	3	4.8	15
BMC Public Health	4	3	4	6.5	25
Frontiers In Endocrinology	4	1	3	5.7	12
Immunology	4	4	4	11.9	110
Indian Journal of Public Health Research and Development	4	2	2	Covered discontinued in Scopus	

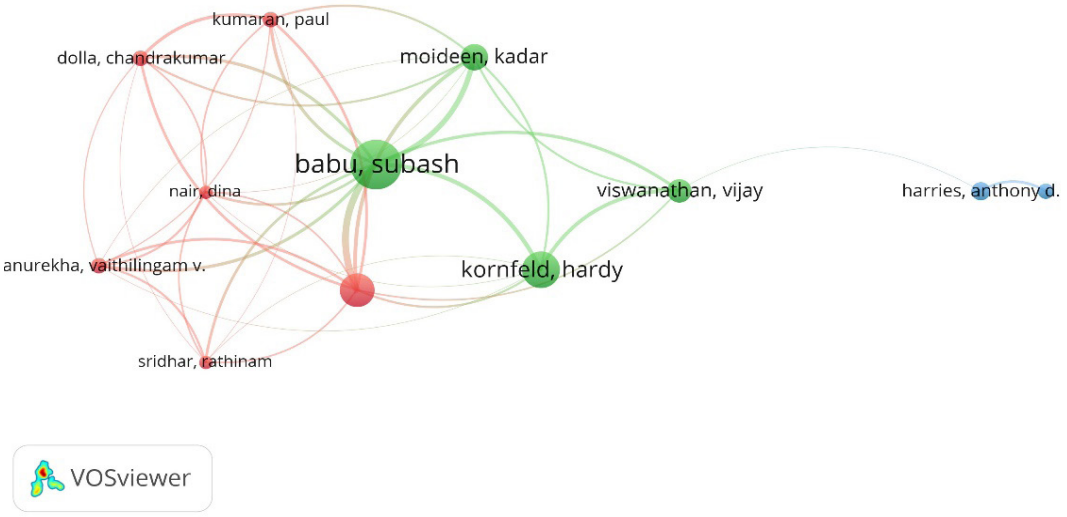

FIGURE 3. Network Visualization Map of Authors' Connections

University of London, United Kingdom (n = 12; h-index = 7; total link strength = 29; total citation = 139), and lastly Moideen, Kadar affiliated in Tuberculosis Research Centre, India (n = 9; h-index = 8; total link strength = 35; total citation = 145). The item weight determines the size of the item label and circle. The item label and circle are larger, the heavier the object is. Fifteen connected authors are displayed in Fig. 3. The item's color is dictated by the cluster it belongs to. Links are shown by the lines connecting the objects. In terms of co-authorship links, the distance between two writers in the graphic generally represents how linked the authors are to one another. Broadly speaking, the stronger the relatedness of two writers, the closer they are to one another.

The three-field plot diagram shown in Fig, 4, consisting of the author, country, and affiliation of the author, aims to highlight the collaboration network of Indonesian researchers in the field of tuberculosis with diabetes comorbidity. In a collaborative study, three authors—Hill PC, Van Crevel, and Critchley J.—focused on Indonesia. London School of Hygiene and Tropical Medicine, University of London, is the organization working with an Indonesian university, in this instance, Padjadjaran University. The Padjadjaran University collaboration network is established by South Africa, the Netherlands, Indonesia, and England.

The three-field plot diagram represents the top 15 affiliates based on the highest number of citations. The top five affiliates include National Institute for Research in Tuberculosis, Chennai, India which is the most productive affiliate (articles = 12; citations = 469; total link strength = 21), followed by Government Stanley Medical Hospital, India (articles = 5; citations = 310; total link strength = 8), Department of Medicine, University of Massachusetts Medical School, United States (articles = 6; citations = 287; total link strength = 16), International Union Against Tuberculosis and Lung Diseases, France (articles = 5; citations = 228; total link strength = 13), and Laboratory of Parasitic Diseases, National Institute of Allergy and Infectious Diseases, NIAID, United States (articles = 3; citations = 177; total link strength = 6). Total link strength within institutions with co-authorship shows the total strength of co-authorship links between researchers from a particular institution and researchers from other institutions. This shows the strength of the collaboration network between institutions and countries. The institutions of Asian countries—particularly Taiwan, Indonesia, and India—seem predominant in the list of top 15 institutions, with Indonesia in 13th place.

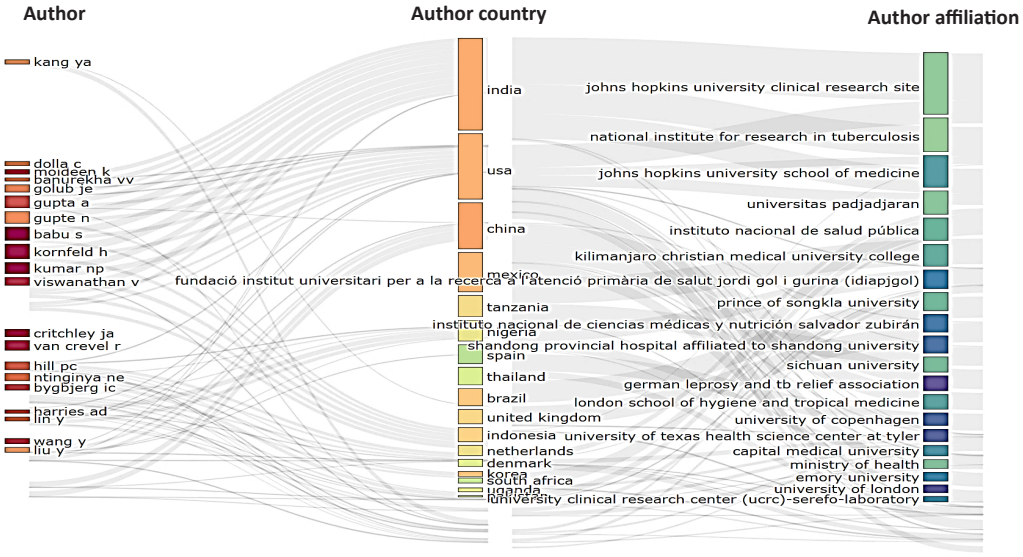

FIGURE 4. Three fields plot of collaboration of the institutions that publish articles about TB and DM.

The trending topics that shift over a ten-year period (2013-2023) are shown in Fig. 5 to compile statistics on keywords that have observed an enormous rise in TB and DM-related research. By displaying the intensity (frequency) and time length, the graph visualizes problems with hot spots. The 30 most popular keywords in the 2013 research featured are "tumor necrosis factor alpha" and "adaptive immunity", which were trending topics until 2014 and 2015 with frequencies of 10 and 9, respectively. Research with the trend topic of "pulmonary tuberculosis" started in 2015 to 2019 (freq = 126), "mycobacterium tuberculosis" started in 2016 to 2021 (freq = 131), and the trend topic of "tuberculosis" only started in 2017 to 2022 with the second highest frequency (freq = 490). Meanwhile, the topic trend of "diabetes mellitus", which also started in 2017 to 2022, has the highest frequency (freq = 504) among the top 30 keywords. Starting from 2022 to 2023, the research trend shifted towards the topics of "metabolomics" (freq = 8), "multivariate logistic regression analysis" (freq = 6), and "bioinformatics" (freq = 5).

Co-occurrence networks visualization and title analysis were performed to reveal the most active topics. To investigate co-occurrence, title keyword analysis was performed. Those terms used at least ten times by the authors within published articles on TB – DM included, and not a single keyword is isolated in the network visualization—all keywords are interconnected. The title field with the minimum number of occurrences of a term is 10 out of 2377 keywords, only 215 of which meet the threshold. The total strength of each keyword's relationship with other keywords will be computed every thirty. The thirty keywords with the highest overall strength of connection will be chosen and split into four clusters. The network visualization displays a line linking the keyword "tuberculosis" (occurrences = 240, total link strength = 2895) and "diabetes mellitus" (occurrences = 256, total link strength = 3101), signifying their link connection. The keyword "tuberculosis" has a larger label, indicating frequent co-occurrence compared to "lung tuberculosis" (occurrences = 164, total link strength = 2240) and "pulmonary tuberculosis" (occurrences = 98, total link strength = 1445). Meanwhile, diabetes mellitus type 2 has occurrences 97 with a total link strength of 1355. The keyword diabetes mellitus type 1 label is not displayed on network visualization, possibly due to low occurrence and total link strength despite being included in the trending topics (Yu *et al.*, 2020).

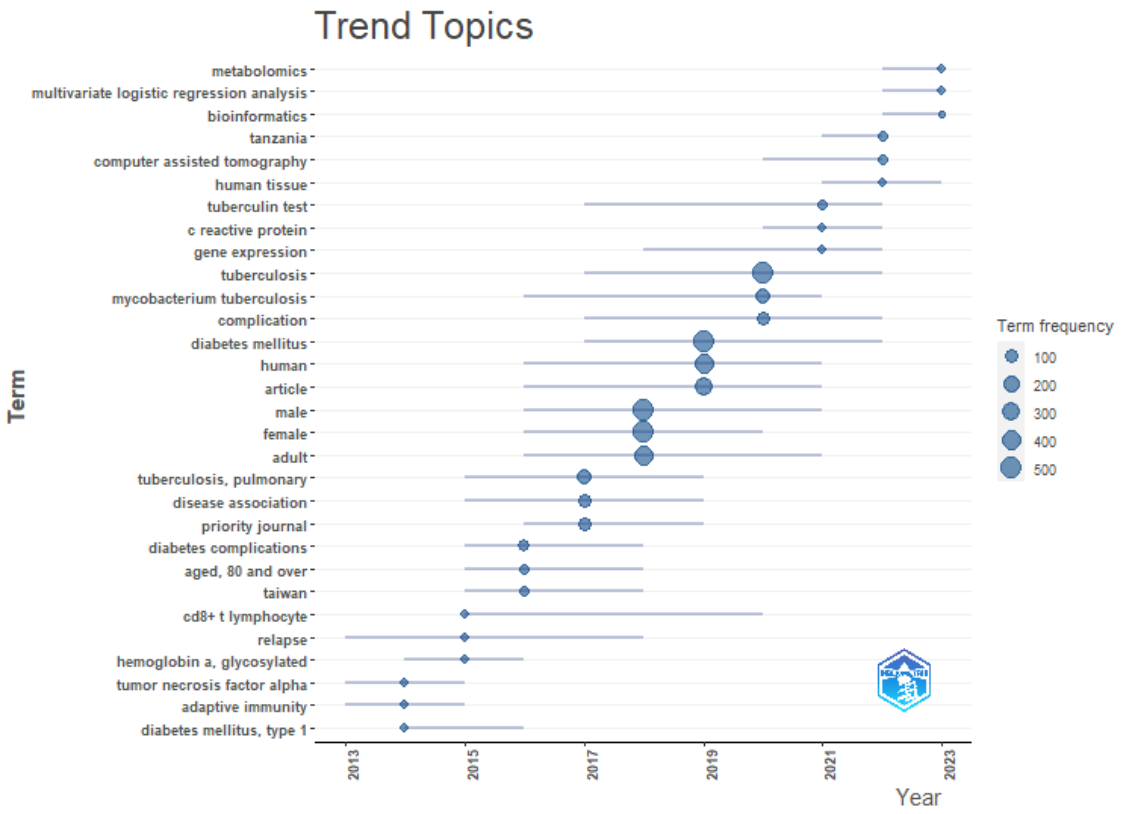

FIGURE 5. Trends Topic on Tuberculosis and Diabetes mellitus.

Conclusion

Research interest in tuberculosis and diabetes mellitus (TB) and DM has grown at an annual rate of 7.18% over the past decades. Beginning in 2014 and peaking in 2022, a batch of studies published and indexed in the Scopus Database has grown rapidly. The average annual citations of documents showed an inverse relationship. The average number of citations per article decreased, but the number of publications increased. Interestingly, authors affiliated with Indonesia are included in the top 15 positions with quite high collaboration link strength. This study provides thorough information to support creative research projects and decision-makers in formulating policy recommendations. The results of this bibliometric analysis will be material for further research entitled "Development of Machine Learning Models to Predict Tuberculosis Disease in Children".

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Mineral Content and Antioxidant Capacity of Cookies Formulated with Spinach and Pangas Catfish

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Abstract

Spinach is a leafy green vegetable that contains various nutrients and antioxidant compounds. Meanwhile, Pangas catfish contains calcium and minerals that are very good for health. Spinach and Pangas catfish can be utilized as raw ingredients to manufacture functional food products in the shape of cookies, increasing the nutritional value and antioxidant content of the cookies to increase the fulfillment of food and public health needs. This research was conducted from February to July 2024. Cookies were prepared with three variations of spinach flour to Pangas catfish flour ratio designated as F1 (45:15), F2 (30:30), and F3 (15:45). Analysis of mineral, vitamin C, TPC, TFC, and antioxidant activity was performed on each cookie formula. The study results showed that the mineral content in terms of potassium and calcium was in the range of 323.538 to 671.186 mg/100g and 44.307 to 93.006 mg/100g, respectively. Meanwhile, the bioactive compounds in the form of vitamin C, TPC, and TFC were in the range of 9.92 to 20.02 mg/100g, 16.74 to 24.97 mg GAE/g, and 32.55 to 110.84 mg QE/g, respectively, and the antioxidant activity was 8.11-17.84%. The cookies prepared using the formula F1 showed significant content of minerals, i.e., potassium and calcium, vitamin C, TPC, TFC, and significant antioxidant activity. These cookies have the potential to be developed as a functional food product that is rich in nutrients and antioxidants to better meet the nutritional and public health needs.

Introduction

Spinach is a leafy vegetable that is very popular. The most consumed part of spinach is the characteristic green leaves. Various nutritional contents, including vitamin C, carotene, calcium (Ca), potassium (K), phosphorus (P), dietary fiber, antioxidants, and bioactive compounds of spinach have shown their potential benefits for health and disease control (Lasya, 2022; Munir *et al*., 2019). The mineral content, such as calcium, is reported to be more than 25%, while the potassium content is around 171.69 mg/100g (Galla *et al*., 2017). Dietary fiber from spinach may help reduce total cholesterol and plasma triglyceride levels while increasing HDL (Drisya *et al*., 2015). The antioxidant content, vitamin C, phenolics, and flavonoids act as anticancer agents (Jyoti *et al*., 2022).

Fish is a high-protein food source. Fish can be processed into various forms so that it can influence people's consumption levels of fish (Widyaningrum *et al*., 2022). Several types of fish, including Pangas catfish (Pangasius pangasius), can be processed into processed food products. Pangas catfish contains protein,

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fat, carbohydrates, ash, and water. Catfish have a higher fat content compared to other freshwater fish like snakeheads and goldfish (Yaqin *et al*., 2021). In addition, the meat of Pangas catfish is easily digestible by the intestines and contains calcium and minerals that are very good for health. The high nutritional content of Pangas catfish shows its potential to be developed as a functional food product in order to better meet food and public health needs. Spinach and Pangas catfish have been extensively researched and used as main ingredients of food products. Spinach has been used in products such as biscuits (Jyoti *et al*., 2022), sandwich biscuits, food bars (Ariyanti *et al*., 2022), cookies (Yudhistira *et al*., 2019), and cakes (Koc *et al*., 2019). Pangas catfish has also been used in products such as snack bars, biscuits, cookies, and nuggets (Putri *et al*., 2023).

Cookies are one of the most popular and extensively consumed food products on the market due to their variety of forms and flavors, long shelf life, and inexpensive pricing, occupying an important position in the snack food industry. Cookies are a sort of snack or dessert produced from a soft, high-fat dough consisting of wheat flour, vegetable or animal fat, and leavening agents. Cookies are often abundant in sugar and energy, but poor in minerals, fiber, antioxidants, and bioactive substances (ŠťAstná *et al*., 2021). Currently, consumers tend to choose to consume healthy foods, including cookies made from natural ingredients, because of the increasing public awareness of the health implications and understanding of the importance of nutritional content and bioactive compounds in food.

Using natural substances also avoids the overuse of synthetic additives, which have been linked with carcinogenic effects (Najjar *et al*., 2022). Wheat flour, which is the main ingredient in the manufacturing of cookies, can be replaced with other flours made from natural ingredients that are rich in antioxidant compounds, thus providing healthier product choices to the public as consumers (Antonic *et al*., 2021). Replacing wheat flour can also enrich the nutritional content, especially vitamins and minerals. It also aims to reduce the community's dependence on wheat flour (Ariesthi *et al*., 2021; Soesilowati *et al*., 2018). Several studies have examined the potential of natural ingredients in the development of functional food products. The use of spinach flour and Pangas catfish flour can increase the nutritional value and antioxidant content, so that cookies are not mainly high in carbohydrates and fat, but are also rich in potential antioxidant compounds for health. This study aimed to analyze the content of minerals, vitamin C, total phenolics content (TPC), total flavonoids content (TFC), and antioxidant activity of cookies formulated with spinach and Pangas catfish.

Methods

The main ingredients used in this research were spinach flour and Pangas catfish meal. A total of 300 g of spinach leaves were dried in a dehydrator at 60°C for approximately 19 hours. After that, mashed in a blender for 5 minutes and sifted through a No. 70 mesh sieve. One kilogram of fresh Pangas catfish was cleaned and flavored with lime juice and salt. They were then steamed for about 10 minutes until cooked. After that, the pangas catfish were crushed, the fat was squeezed out with a cloth, and the crushed Pangas catfish were dried in a dehydrator for 10 hours at a temperature of 40°C. The dried, crushed Pangas catfish was ground using a blender, then mixed with wheat flour until evenly mixed, then sieved with a No. 80 mesh sieve. The approval and ethical clearance from the Health Research Ethics Committee of Poltekkes Kemenkes Palangka Raya was attained upon commencement of the study [Reference No: 178/III/KE.PE/2024].

The main ingredients used were spinach flour and Pangas catfish meal, with three formulas labeled F1 (45 g spinach flour and 15 g Pangas catfish meal), F2 (30 g spinach flour and 30 g Pangas catfish meal), and F3 (15 g spinach flour and 45 g Pangas catfish meal). Other ingredients used, consisting of wheat flour, eggs, milk powder, margarine, baking powder, vanilla, salt, and sugar, were purchased from local markets. All ingredients were mixed according to the formulation and then stirred until evenly mixed. The mixture was then poured into the mold and baked in the oven at 100°C for 35 minutes. The cookies were stored in a tightly closed container. Analysis of calcium and potassium

mineral contents was performed using atomic absorption spectroscopy (AAS) (Bolang *et al*., 2022). The vitamin C content (mg/100 g) of the cookies produced with three different formulas was analyzed and determined by iodometric titration (Bahar *et al*., 2021; Dinnah *et al*., 2020). TPC was measured using UV-Vis spectrophotometry with the Folin-Ciocalteu reagent. TPC was reported as mg gallic acid equivalent (GAE) per gram dry weight of the sample (Azuan *et al*., 2020; Najjar *et al*., 2022). TFC was measured using UV-Vis spectrophotometry with the aluminum chloride colorimetric method. TFC was expressed as mg of quercetin equivalents (QE) per gram of dry sample weight (Nabil *et al*., 2020; Najjar *et al*., 2022). The antioxidant activity test was performed using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) method. The wavelength at which the absorbance was measured was 520 nm (Chikpah *et al*., 2023; Mahloko *et al*., 2019).

Result and Discussion

Healtay food is necessary to improve the quality of human life. Nutrients include minerals and naturally occurring bioactive substances with antioxidant activity that can be found in many healthful diets. Vegetables contain most of the natural polyphenols and are also a source of a variety of nutrients such as vitamins, minerals, and fiber. Fish, however, is high in minerals and protein (Dhalaria *et al*., 2020; Igbinosa *et al*., 2013). Minerals in food are crucial for human well-being. Minerals have anti-oxidant properties that can prevent and treat certain chronic diseases (Rahaman *et al*., 2023). The body's mineral balance can control membrane transport, osmotic pressure, acid-base balance, metabolic processes, and tissue development. Minerals indirectly contribute to growth. The roles of minerals in the body are interrelated (Haro *et al*., 2018). In this study, the contents of potassium, calcium, vitamin C, total phenolics, and flavonoids, and antioxidant activity of the cookies formulated with spinach and Pangas catfish were analyzed. Food contains minerals, which are essential nutrients that organisms require to grow and carry out a variety of vital tasks to survive (Ferreira, 2023; Weyh *et al*., 2022). Calcium and potassium are needed for the repair of damaged cells, the formation of bones and teeth, the formation of red blood cells, and body mechanisms (Cheng *et al*., 2015; Gebreslassie, 2016).

Analysis of potassium content showed that F1 cookies contained 671.186 mg of potassium per 100g of cookies, F2 cookies contained 382.672 mg of potassium per 100g of cookies, and F3 cookies contained 323.538 mg of potassium per 100g of cookies. Meanwhile, analysis of calcium content showed that F1 cookies contained 93.006 mg of calcium per 100g of cookies, F2 cookies contained 54.578 mg of calcium per 100g of cookies, and F3 cookies contained 44.307 mg of calcium per 100g of cookies (Table 1). The results of potassium (K) content analysis showed that the highest potassium content was in F1 cookies with 671.186 mg/100 g, which was higher than that of F2 cookies with 382.672 mg/100 g and F3 cookies with 323.538 mg/100 g. The potassium content in the cookies increased significantly in proportion to the addition of spinach flour ($p<0.05$). Spinach flour has a relatively high potassium content of 233.38 mg/100 g (Waseem *et al*., 2021). A study by Ariyanti *et al*. (2022) showed that the potassium content of food bar P1, which contained a 10% blend of oat and amaranth flour, was 52.66 mg/100g. The use of a 20% spinach flour as a substitute in the production of food products

TABLE 1. Minerals and Vitamin C Content of Cookies Formulated with Spinach and Pangas Catfish

Cookie	K (mg/100 g)	Ca (mg/100 g)	Vitamin C (mg/ 100 g)
F1	**671,186 ± 0,14***	**93,006 ± 0,10***	**20,02 ± 0,02***
F2	**382,672 ± 0,15***	**54,578 ± 0,15***	**14,54 ± 0,11***
F3	**323,538 ± 0,07***	**44,307 ± 0,08***	**9,92 ± 0,02***

*The data shows the mean ± standard mean error of readings taken in triplicate.
Source: Primary Data, 2024

resulted in a potassium content of 493.86 mg/100 g, while the use of 2.5% spinach flour as a substitute resulted in a potassium content of 452.01 mg/100 g (Waseem *et al*., 2021). The potassium mineral content of fresh and grilled Pangas catfish is known to be 239.70 and 319.44 mg/100 g, respectively (Ajai *et al*., 2019). In a study, the combination of 100% superior quality breadfruit flour, 0% wheat flour and fishmeal produced the highest potassium content, 582 mg/100 g, while the combination with a percentage of 86.53%: 6.79%: 6.68% produced the lowest potassium content, 377.50 mg/100 g (Bakare *et al*., 2020). These results suggest that the increase in potassium levels in the cookies was influenced by the good micronutrient profile of spinach flour.

The results of calcium (Ca) content analysis showed that the highest calcium content was in F1 cookies with 93.006 mg/100 g, followed by F2 cookies with 54.578 mg/100 g and F3 cookies with 44.307 mg/100 g. Spinach flour has a relatively high calcium content, 1,304 mg/100 g. The use of 20% spinach flour as a substitute in the production of food products resulted in high calcium content, which was 301.26/100 g, while the use of 2.5% spinach flour as a substitute resulted in the lowest calcium content, i.e., 72.71 mg/100 g (Waseem *et al*., 2021). The calcium contents of fresh and grilled Pangas catfish were 69.35 and 110.824 mg/100 g, respectively, according to Ajai *et al*. (2019). The combination of 100% superior quality breadfruit flour, 0% wheat flour and fishmeal produced the lowest calcium content, which was 100 mg/100 g, while the combination with a percentage of 60%: 0%: 40% produced the highest calcium content, 754 mg/100 g (Bakare *et al*., 2020). The calcium content in the cookies increased significantly in proportion to the addition of spinach flour ($p<0.05$). These results suggest that the increase in calcium levels in the cookies was influenced by the high calcium content of the spinach flour.

One kind of vitamin that is essential to the body's health is vitamin C, which also functions as an antioxidant. It is a crucial cofactor in the body's metabolic processes and helps in hormone synthesis (Dosedˇ *et al*., 2021; Koc *et al*., 2019). In order to limit the amount of vitamin C content lost during processing, it is crucial to determine the vitamin C content present in food products. The results of the analysis of vitamin C content in the cookies showed that F1 contained 20.02 mg of vitamin C per 100 g of cookies, F2 contained 14.54 mg of vitamin C per 100g of cookies, and F3 contained 9.92 mg of vitamin C per 100g of cookies (Table 1). The statistical analysis resulted in a significant difference ($p<0.05$) in vitamin C content between cookies made with different formulations. Based on the analysis of vitamin C levels, F1 cookies had the highest vitamin C level (20.02 mg/100 g), which were prepared using the 45 g of spinach flour and Pangas catfish flour 15 g. Meanwhile, F2 and F3 cookies had low vitamin C content, 14.54 mg/100g and 9.92 mg/100g, respectively, with the use of less spinach flour than F1, which was 30 g for F2 and 15 g for F3. The vitamin C content in the cookies increased significantly with the addition of spinach flour ($p<0.05$). Increasing the amount of spinach increased the vitamin C content of the cookies to increase because spinach has a relatively high vitamin C content, 61.29 mg/100 g of material (Singh & Harshal, 2016). One could argue that the product's vitamin C content increases with the amount of spinach flour added to the cookies (Koc *et al*., 2019). In this instance, though, the cookies' vitamin C level was minimal. The amount of vitamin C in food products, including cookies, is negatively impacted by food processing methods, including baking and drying. Food processing involves heating food in order to prepare it for consumption and extend the shelf life of food products (Galla *et al*., 2017; Lešková *et al*., 2006; Rakcejeva *et al*., 2011). Phenolic compounds are potential compounds containing hydroxyl groups. The level of phenolic chemicals in antioxidant activity plays a role in donating hydrogen ions from their hydroxyl groups to scavenge free radicals (Chong *et al*., 2022; Lim *et al*., 2023). Plant phenolic chemicals, which possess potent antioxidant qualities, have been demonstrated scientifically to avert a range of chronic diseases linked to oxidative stress, including cardiovascular ailments, cancer, and neurological disorders (Bhuyan & Basu, 2018).

The TPC of the cookies formulated with spinach and Pangas catfish are shown in Table

TABLE 2. TPC and TFC of Cookies Formulated with Spinach and Pangas Catfish

Cookies	TPC Value (mg GAE/g)	TFC Value (mg QE/g)
F1	24,97 ± 0,08*	110,84 ± 0,08*
F2	20,33 ± 0,10*	68,34 ± 0,11*
F3	16,74 ± 0,15*	32,55 ± 0,03*

*The data shows the mean ± standard mean error of readings taken in triplicate.
Source: Primary Data, 2024

2. The total phenolic contents of the cookies prepared with formulas F1, F2, and F3 were 24.97, 20.33, and 16.74 mg GAE/g, respectively. After analyzing the cookies made using the three recipes, the analysis revealed a significant difference ($p<0.05$), and the highest TPC was found in cookies prepared with the formula containing the most spinach, namely F1, followed by F2 and F3. This is because the total phenolic content in fresh spinach is quite high, 2088 mg GAE/kg, or ranging from 183.2 to 1344.7 mg/100 g, according to studies (Bunea *et al*., 2008; Turkmen *et al*., 2005). Increasing the amount of spinach had an effect on increasing the TPC in cookies because of the high bioactive compounds in spinach. The results of other studies showed that an increase in the total phenolic content in cookies occurred along with the addition of clove flour concentration, depending on the formula used. Clove flour has high bioactive properties (Aljobair, 2022). In this study, the process of processing spinach powder into cookies affected the TPC of the cookies. These results are consistent with studies by Mohd *et al*. (2023) and Ikram *et al*. (2022), which stated that heating is a processing method that can affect the levels of secondary metabolites, including TPC. When a phenol-containing plant is heated, its TPC value can increase, and the antioxidant activity becomes better because the phenolic compounds that accumulate in the cell membrane vacuoles are released as the cell components and cell membrane are damaged (Fei *et al*., 2018).

Flavonoid substances are secondary metabolites found in plants that feature an aromatic ring and at least one hydroxyl group. In addition to vitamin C and phenolic content, the content of flavonoid compounds in foods with antioxidant activity has attracted attention in the fields of nutrition, food, and health (Aryal *et al*., 2019). Flavonoids are believed to have anti-inflammatory, anticarcinogenic, diabetes mellitus, anticancer, antiallergic, antimicrobial, and antioxidant properties, and cardiovascular disease, and obesity (Kustiawan *et al*., 2022; Xhaxhiu *et al*., 2023). The TFC of the cookies formulated with spinach and Pangas catfish is in Table 2. The total flavonoid contents in the cookies prepared with formulas F1, F2, and F3 were 110.84, 68.34, and 32.55 mg QE/g, respectively. The results of the analysis showed that there were significant differences, and the highest total flavonoid content was found in cookies prepared with formula F1, followed by those prepared with formulas F2 and F3. The total content of flavonoids in the cookies prepared with formulas F1, F2, and F3 was high, 110.84, 68.34, and 32.55 mg QE/g, respectively. In addition to the increase of vitamin C and total phenolic content, the increase in the amount of spinach powder resulted in the increase of total flavonoids in the cookies. Sarker *et al*. (2020) discovered that spinach includes flavonoid molecules, which contribute significantly to spinach's high antioxidant activity. Quantitative investigations revealed that the total flavonoid concentration in spinach is approximately 1000-1200 mg/kg, or 128.54 mg QE/100 g (Hossain *et al*., 2017; Singh *et al*., 2018). The flavonoid content increases and is effective for extraction at temperatures ranging from 50 to 130 °C (Howard & Pandjaitan, 2008).

DPPH radical scavenging reflects a sample's antioxidant capacity. A sample's antioxidant activity is essentially measured by the total phenolic and flavonoid content produced during non-enzymatic browning processes (Mohd *et al*., 2023). The percentage of DPPH radical scavenging activities of the cookies prepared using formulas F1, F2, and F3 was 17.84%, 13.45% and 8.11%, respectively (Table 3). The statistical analysis resulted in a significant difference in the percentage of

TABLE 3. DPPH Radical Scavenging Activity of Cookies Formulated with Spinach and Pangas Catfish

Cookies	%DPPH Radical Scavenging
F1	17,84 ± 0,14*
F2	13,45 ± 0,34*
F3	8,11 ± 0,14*

*The data shows the mean ± standard mean error of readings taken in triplicate.
Source: Primary Data, 2024

DPPH radical scavenging activity ($p<0.05$) between the cookies prepared using the three formulas. The cookies prepared with formula F1 showed the highest activity compared to the cookies prepared with formulas F2 and F3. These findings suggest that the addition of spinach flour increased the antioxidant activity of the cookies.

Fresh spinach has an antioxidant activity of no more than 19.8% (Ligor *et al*., 2013). Hatamian *et al*. (2020) found that roasting soybeans significantly increased their antioxidant activity ($P < 0.05$). Melanoidin production may account for the increase in antioxidant activity observed during the roasting process. Melanoidin formation is contributed to by non-enzymatic browning reactions that occur during heating (Ahmed *et al*., 2020; Hatamian *et al*., 2020). These findings emphasize the potential of roasting as a method for improving the antioxidant capabilities of spinach and its potential as a key ingredient in the production of cookies, as spinach has demonstrated its potential as a food ingredient rich in antioxidants. Vitamin C and bioactive compounds such as phenolics and flavonoids are thought to be the primary contributors to antioxidant activity in plants, including spinach, which can be employed as a main ingredient in food products, such as cookies (Jing *et al*., 2015; Šťastná *et al*., 2021).

Conclusion

This research has shown that cookies prepared with formula F1 contain minerals, vitamin C, total phenolics, and flavonoids content in significant amounts and exhibit antioxidant activity. Increasing the amount of spinach has increased the content of minerals, vitamin C, total phenolics, and flavonoids in the cookies. It has also increased the antioxidant activity of the cookies because of the high bioactive compounds in spinach. Spinach flour and Pangas catfish meal can be recommended as main ingredients and functional food ingredients to increase the nutritional value and antioxidant content of the cookie product. Further study must be conducted to analyze the nutritional content of cookies, especially their relationship with the use of Pangas catfish as one of the main ingredients. In the future, the study can be continued in clinical trials to observe whether or not these cookies can have a good impact on public health.

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Infertilization of dengue vector (*Aedes aegypti*) with Bromelin Solution and Extract From Ananas comosus

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Abstract

Dengue fever remains a significant public health problem in the tropics, with *Aedes aegypti* as the primary vector. Insecticide resistance among mosquitoes has been increasing, so an environmentally friendly alternative approach with biolarvicides is needed. This study aimed to evaluate the effects of bromelain and pineapple (*Ananas comosus*) extracts on the reproductive parameters of *Aedes aegypti*. Experiments were conducted in a controlled laboratory, where mosquitoes were exposed to various concentrations (0% to 10%) of bromelain and pineapple extracts. The number of egg production, hatching rate, and lifespan of adult mosquitoes were measured. Our results showed Bromelain, especially at higher concentrations, significantly reduced egg production, hatching rate, and longevity compared to the control and pineapple extract. At 6% and 8% bromelain concentrations, egg production and hatchability were very low, and mosquito lifespan was reduced. Pineapple extract also showed an inhibitory effect on egg production, although less consistently than bromelain. The sugar solution used as a control produced more eggs and live longer. In conclusion, bromelain from Ananas comosus showed promising insecticidal potential by reducing mosquito fertility and longevity, indicating its utility as an alternative vector control strategy for managing dengue outbreaks.

Introduction

Dengue fever continues to be a dominant public health threat in tropical and subtropical regions, with *Aedes aegypti* identified as the primary vector responsible for its transmission. As of recent estimates, approximately 50 million dengue infections occur annually, leading to significant morbidity and mortality worldwide(Yang *et al.*, 2021). Efforts to control the spread of dengue have traditionally focused on reducing mosquito populations, primarily through chemical insecticides(Achee *et al.*, 2015). However, with the rapid rise of insecticide resistance in mosquito populations (Konan *et al.*, 2021) alternative approaches to vector control are becoming increasingly critical. There is a pressing need for new, environmentally friendly, and sustainable solutions to tackle the ever-growing challenge of vector control in dengue-endemic regions.

Botanical insecticides have emerged as a promising area of research in recent years due to their biodegradable nature and low toxicity to non-target organisms(Damalas and Koutroubas, 2020; Duarte *et al.*, 2020; Riyaz *et al.*, 2022). Among the natural compounds with

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potential insecticidal properties, bromelain—an enzyme extracted from the pineapple (Ananas comosus)—has garnered attention for its ability to influence reproductive processes in various insects, acari and nemathoda(Domingues *et al.*, 2013; Castro *et al.*, 2023). Bromelain is known for its proteolytic activity, which disrupts cellular processes(Hikisz and Bernasinska-Slomczewska, 2021; Varilla *et al.*, 2021), and recent studies have shown its potential to interfere with the reproductive mechanisms of insects(Castro *et al.*, 2023). Pineapple extracts also contain serotonin(Istiqomah *et al.*, 2021), which can influence reproductive cycles by stimulating uterine contractions in mammals, hinting at potential applications for mosquito infertility. Previous research on the effects of bromelain on the reproductive system of insects, especially the *Aedes aegypti* mosquito, is limited. Most studies related to mosquito control have focused on the use of chemical or other biological agents, such as larvicides and plant-based insecticides(Tominik and Haiti, 2018). But the potential of proteolytic enzymes, such as bromelain, in affecting mosquito egg and larval development has not been widely studied. However, since bromelain is known to have the ability to affect uterine contractions in mammals, researchers hypothesized that this enzyme may affect the development of the reproductive system in insects, including mosquitoes(Almeida *et al.*, 2018).

The objective of this study was to explore the effects of pineapple extract and bromelain on the fertility of *Aedes aegypti* mosquitoes. This research aims to evaluate the egg production, hatch rate, and longevity of mosquitoes exposed to varying concentrations of pineapple extract and bromelain enzyme. By understanding how these natural compounds influence mosquito reproduction, we hope to offer an alternative, eco-friendly vector control strategy that could complement existing measures in combating dengue fever outbreaks.

Method

The research was conducted at the Entomology Laboratory of Poltekkes Kemenkes Banjarmasin, Banjarbaru, Indonesia, under controlled conditions simulating a natural mosquito habitat. Laboratory temperatures were maintained between 25°C and 30°C with a relative humidity of 70–80%. Banjarbaru, situated in South Kalimantan, is a region with high dengue incidence, making it a suitable location for studying mosquito behavior and exploring potential control methods. The study was ethically approved by the Health Ethics Commission of Muhammadiyah University of Banjarmasin under certificate number 100/UMB/KE/VII/2019. Mature pineapples (*Ananas comosus*) were procured from local farms in Banjarbaru for preparing the experimental extracts. The preparation process involved washing, peeling, and chopping the fruit, followed by blending with distilled water in a 1:2 ratio to produce a clear solution. Bromelain was extracted from the pineapple cores using a 24-hour maceration process, followed by centrifugation at 4000 RPM for 15 minutes. The resulting bromelain was purified using gel filtration chromatography. Both pineapple and bromelain extracts were diluted to seven concentrations: 0% (control), 1%, 2%, 4%, 6%, 8%, and 10%. A sugar solution was also prepared as a control to evaluate mosquito responses to a carbohydrate-based diet.

The *Aedes aegypti* larvae were collected from natural breeding sites around Banjarbaru, such as stagnant water in flower pots and discarded tires. Only third and fourth-instar larvae were selected for the study. These larvae were transferred to breeding tanks containing distilled water under conditions conducive to their growth, including temperatures of 25°C–27°C and a pH range of 6.5–7.5. They were fed ground liver powder, facilitating their development into pupae within 7–10 days. The pupae were transferred to mosquito cages (30 cm x 30 cm x 30 cm) to allow emergence into adults. Upon emergence, male and female mosquitoes were separated. Female mosquitoes were fed a blood meal from a marmot to support egg production, while males were sustained with a sugar solution. This step was crucial for ensuring adequate protein for oogenesis in females. Experimental treatments involved exposing groups of 10 paired adult mosquitoes to pineapple extract, bromelain extract, or sugar solution for three consecutive days, following a 12-hour mating period. Each treatment was replicated three times. Mosquitoes were given

oviposition opportunities, and the eggs laid were counted daily. Observations included egg morphology and viability, and hatch rates were calculated by counting larval emergence after five days.

Longevity was assessed by monitoring the survival of mosquitoes daily until death. Any abnormalities in mosquito behavior were recorded, alongside environmental data such as temperature and humidity levels in the cages. The data were analyzed using a two-factor factorial design to evaluate the effects of treatment type and concentration on egg production, hatch rates, and mosquito longevity. When assumptions of normality and homogeneity were unmet, non-parametric tests like the Friedman test were applied. Post-hoc analyses were conducted using Wilcoxon Signed Rank tests where applicable. Statistical analyses were performed using IBM SPSS software version 26 (George and Mallery, 2019), with a significance level set at $p < 0.05$.

Results and Discussions

The findings of this study are presented in the tables and figures below, showing the effects of pineapple extract, bromelain, and sugar solution on the reproductive parameters of *Aedes aegypti*. The results of this study are summarized in the following tables and figures, showing the effects of pineapple extract, bromelain, and sugar solution on the reproductive and longevity parameters of *Aedes ae*gypti mosquitoes.

This table shows that *Aedes aegypti* exposed to higher concentrations of bromelain (6% and 8%) produced significantly fewer eggs compared to the control and other treatments. Pineapple extract also showed a reduction in egg production, but the effect was more variable (Table 1).

Bromelain demonstrated a marked reduction in the hatchability of eggs, particularly at higher concentrations, while the sugar solution maintained relatively high hatch rates, indicating its neutral effect on egg viability (Table 2).

This table shows that bromelain significantly shortened the life span of mosquitoes, particularly at lower concentrations (1%-4%). In contrast, mosquitoes exposed to sugar solution lived the longest, indicating the neutral effect of the sugar solution on longevity (Table 3). This study revealed significant differences in the reproductive performance of *Aedes aegypti* when exposed

TABLE 1. Total Egg Production by *Aedes aegypti* at Different Concentrations

Concentration (%)	Pineapple Extract	Bromelain Extract	Sugar Solution
0%	994	994	994
1%	702	1003	1031
2%	514	1198	1235
4%	643	1652	1038
6%	475	2001	1203
8%	706	1602	552
10%	636	1351	1017

TABLE 2. Hatch Rate of Eggs Produced by *Aedes aegypti* at Different Concentrations

Concentration (%)	Pineapple Extract (%)	Bromelain Extract (%)	Sugar Solution (%)
0%	89	189	189
1%	114	119	61
2%	265	114	29
4%	93	36	20
6%	84	16	32
8%	62	77	53
10%	197	34	26

TABLE 3. Longevity of Adult *Aedes aegypti* Exposed to Different Concentrations

Concentration (%)	Pineapple Extract (days)	Bromelain Extract (days)	Sugar Solution (days)
0%	13	13	13
1%	9	19	34
2%	9	20	34
4%	13	24	33
6%	11	45	42
8%	13	45	45
10%	13	38	47

to varying concentrations of pineapple extract and bromelain enzyme. The results show that bromelain at higher concentrations (6% and 8%) had the most substantial inhibitory effect on egg production, with the total number of eggs laid by female mosquitoes significantly reduced compared to those in the control and sugar solution groups. It is consistent with previous studies that have demonstrated the ability of proteolytic enzymes like bromelain to disrupt cellular processes critical to reproduction(Page *et al.*, 2014; Fani and Sri, 2019; Chakraborty *et al.*, 2021), such as oogenesis and egg maturation. The decline in egg production with increasing bromelain concentration suggests that this enzyme interferes with the hormonal regulation of reproduction in *Aedes aegypti*.

Moreover, the pineapple extract, while less potent than bromelain, also showed some reduction in egg production, particularly at higher concentrations. It can be attributed to the presence of other bioactive compounds in pineapple, such as serotonin, which is known to stimulate uterine contractions and could potentially induce premature egg expulsion in mosquitoes(Norville, Sweeney and Elliott, 2010). Although the mechanism of action remains unclear, it is hypothesized that the compounds in pineapple extract may interact with the mosquito's neuroendocrine system, leading to disrupted reproductive cycles. The sugar solution, used as a control, did not significantly reduce egg production. Mosquitoes fed on sugar solution produced more eggs at lower concentrations, likely due to the increased availability of carbohydrates, which are essential for energy during egg development(Barredo and DeGennaro, 2020; Maestas, Lee and Choi, 2023).

This figure displays a plot of the average number of *Aedes aegypti* eggs produced when exposed to three different types of solutions: pineapple juice (Ananas comosus), bromelain extract from pineapple, and sugar solution. The plot shows variations in the number of eggs produced at different concentrations of each solution (0%, 1%, 2%, 4%, 6%, 8%, and 10%). The data indicate that the bromelain extract produced the highest number of eggs, while the sugar solution resulted in the lowest egg count (Figure 1A). Figure 1B illustrates the average percentage of *Aedes aegypti* eggs that successfully hatched when subjected to the same three solutions (pineapple juice, bromelain extract, and sugar solution) at various concentrations. The plot shows that the hatching rate was highest in the pineapple juice group, with a lower percentage in the bromelain extract and sugar solution groups. Figure 1C presents a plot of the average lifespan of *Aedes aegypti* mosquitoes that were exposed to different solutions and concentrations. The results indicate explicit differences in the longevity of mosquitoes depending on the solution consumed. The sugar solution resulted in the expanded lifespan, followed by the bromelain extract, while the pineapple juice group had the shortest average lifespan.

The ANOVA results show a significant effect of both treatment and concentration on the total number of eggs produced by *Aedes aegypti* mosquitoes ($p < 0.001$). The interaction between treatment and concentration is also significant, indicating that the effect of the treatments depends on the concentration used. Similarly, both treatment and concentration significantly affect the hatch rate of mosquito eggs ($p < 0.001$), with a notable interaction effect. It suggests that higher concentrations of bromelain or pineapple extract have a

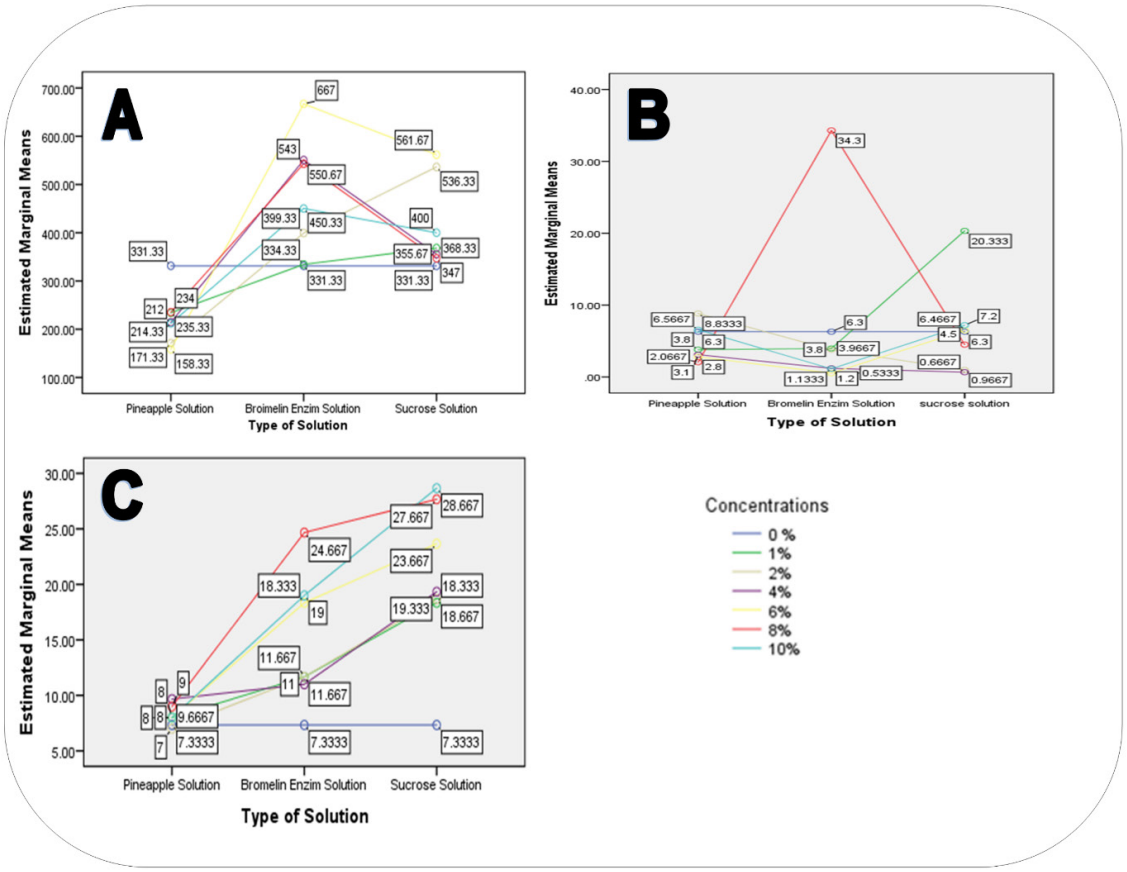

FIGURE 1. Concentration of 3 Types of Solution (Pineapple, Bromeline enzyme and Sucrose against *Aedes aegypti*. A. Average Number of Eggs; B. Average Number of Eggs Hatched; C. Average Length of Life of Hatched Eggs

TABLE 4. Two-Way ANOVA for the Effects of Pineapple Extract, Bromelain, and Sugar Solution on Egg Production, Hatch Rate, and Longevity of *Aedes aegypti*

Parameters	Sources of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)		
Egg Production	Treatment	12480.45	2	6240.23	35.67	< 0.001
		3125.67	6	520.95	12.89	< 0.001
	Treatment x	2789.34	12	232.45	8.56	< 0.001
	Error	1745.23	63	27.70		
Hatch Rate	Treatment	9823.12	2	4911.56	42.45	< 0.001
		2190.58	6	365.10	9.34	< 0.001
	Treatment x	1887.40	12	157.28	6.78	< 0.001
	Error	1460.80	63	23.18		
Longevity	Treatment	5432.90	2	2716.45	31.21	< 0.001
		1842.67	6	307.11	7.43	< 0.001
	Treatment x	1523.44	12	126.95	4.65	< 0.001
	Error	2040.22	63	32.39		

more pronounced impact on egg viability. The longevity of mosquitoes is significantly affected by both treatment and concentration ($p < 0.001$), and the interaction effect between treatment and concentration is also statistically significant. It means that the lifespan of the mosquitoes was reduced differently depending on the concentration of the treatment they were exposed to.

Hatch rate is a critical measure of reproductive success, as it reflects the viability of the eggs laid(Assersohn *et al.*, 2021). In this study, the percentage of eggs that successfully hatched varied significantly across the treatment groups. Bromelain extract showed a pronounced negative effect on egg viability, with hatch rates dropping as low as 16% at the highest concentrations. It supports the hypothesis that bromelain not only affects egg production but also compromises the structural integrity of the eggs, potentially through its proteolytic activity(Varilla *et al.*, 2021; Ávalos-Flores *et al.*, 2022). Bromelain may break down essential proteins in the eggshell, rendering the eggs non-viable(Tsopmo, Tsige and Udenigwe, 2019; Lavanya *et al.*, 2020). In *contrast*, eggs laid by mosquitoes exposed to pineapple extract exhibited more variability in hatch rates. While some concentrations showed reduced hatchability, others, particularly the 10% concentration, saw a hatch rate comparable to the control. It suggests that while pineapple extract may influence egg production, its effect on egg viability is less consistent than that of bromelain. The sugar solution, as expected, maintained relatively high hatch rates across all concentrations, further highlighting the inhibitory effects of bromelain and pineapple extract.

Longevity is an essential factor in determining the success of vector control strategies, as longer-lived mosquitoes are more likely to spread disease(Shaw and Catteruccia, 2019). In this study, mosquitoes exposed to bromelain had the shortest life span, particularly at higher concentrations. It could be attributed to the enzyme's systemic effects, which may weaken the mosquitoes' overall health and immune response(Vicente-Crespo, 2021). Pineapple extract, on the other hand, had a less pronounced effect on longevity, with mosquitoes living slightly longer than those exposed to bromelain. It suggests that while both treatments affect reproductive parameters, bromelain is more effective at reducing mosquito life span. Interestingly, mosquitoes fed on sugar solution had the longest life span, particularly at higher concentrations. It aligns with previous research that has shown the importance of sugar feeding in maintaining mosquito longevity. In natural settings, sugar serves as a critical energy source for mosquitoes, particularly males. They do not feed on blood(Airs, Kudrna and Bartholomay, 2019). The results of this study highlight the importance of sugar availability in sustaining mosquito populations and suggest that limiting sugar sources in the environment could further enhance vector control efforts.

One of the limitations of this study is the laboratory setting, which may not fully reflect real-world environmental conditions where *Aedes aegypti* mosquitoes thrive. The controlled environment may have limited the understanding of how factors such as fluctuating temperatures, humidity, and the presence of other ecological interactions influence the efficacy of bromelain and pineapple extract. Additionally, the study only explored short-term effects on egg production, hatch rates, and longevity, leaving the long-term implications of using bromelain as a vector control method unexplored. Future research should focus on field trials to assess the practical application of these findings in diverse ecological conditions and over extended periods. Despite these limitations, the study offers promising prospects for using bromelain as an eco-friendly alternative to chemical insecticides, contributing to sustainable dengue vector control strategies. Bromelain's ability to reduce mosquito fertility and lifespan positions it as a potential biolarvicide, which could be integrated into existing vector control programs to combat insecticide resistance and minimize environmental impact.

Conclusion

This study demonstrates the potential of *Ananas comosus* extract and bromelain enzyme as biological agents for controlling *Aedes aegypti* populations. The significant reduction

in egg production, hatch rate, and mosquito longevity observed in the bromelain treatment group indicates that this natural compound could be an effective alternative to chemical insecticides in vector control programs. Future studies should focus on field trials to assess the practical application of these findings and explore the long-term effects of using botanical extracts for mosquito population management.

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Identification and Treatment for Depressive Disorder: Descriptive Study from Indonesia

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Abstract

Access to professional mental health services was low worldwide, especially in lower-middle-income countries. Indonesia encounters several challenges in providing adequate mental health care. Poor detection could reduce the treatment coverage. This study aimed to determine how many individuals with depression recognize their condition or receive an appropriate diagnosis, as well as the types of treatments they receive. We analyzed secondary data from the Indonesian Family Life Survey 5th edition (IFLS-5), which included socio-demographic data, levels of well-being, subjective experiences of mental health issues, and treatment information. We found that 6,645 respondents (22.8%) exhibited significant depressive symptoms, yet only 15 respondents (0.1%) reported having a lifetime psychiatric disorder that met the criteria for depression. Most lifetime psychiatric diagnoses (LPD) were made by doctors (93.3%). A significant portion of respondents with a history of psychiatric disorders did not receive any treatment (70.5%), and among those who did, medication was the most common approach. There was considerable gap between the identified significant depressive symptoms and LPD, warranting further exploration. Low detection rates and stigma, potentially linked to Indonesian culture and perceptions of mental health, may underlie these issues. A variety of treatment options must be available and accepted to be beneficial for patients

Introduction

World Health Organization (WHO) stated that in one in every 8 people living with a mental disorder, and an estimated 970 million people from anxiety and depressive disorders (World Health Organization, 2022). In 2018, National Basic Health Research (Riskesdas) reported that more than 19 million Indonesians aged 15 years and above emotional and mental problems (Kementerian Kesehatan Republik Indonesia, 2018). In the second year of the COVID-19 pandemic in Indonesia, anxiety and depressive disorder rose significantly to about 18.5% and 29.2% (Hardi *et al.*, 2023) is also supported by data from Universitas Negeri Semarang, severe depressive disorder is 17% and there is a high risk of PTSD (Mega *et al.*, 2021). Research from Universitas Sumatera Utara also stated that depressive and anxiety with smartphone addiction (Wijaya and Megawati, 2023).

In 2022, Health Ministry of Indonesia revealed that suicide cases increased to 826, in contrast to the previous year's 613 (Universitas Gadjah Mada, 2023). Mortality was significantly higher among people with mental disorders and caused by unnatural death, which estimates that 14.3% of deaths

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worldwide are attributable to mental health (Werlen *et al*., 2020). Anxiety and depressive disorders highly contribute to and often do not adequate care. An online survey of Swiss adults showed that almost half of those with anxiety and depression had not perceived the need for treatment, with never accessing health care and over four in five currently not using any mental health services (Werlen *et al*., 2020). Indonesia also faced similar low mental health treatment coverage and treatment maintenance. Only 84.9% of individuals with mental disorders seek and 49.9% of them receive routine treatment (Kementerian Kesehatan Republik Indonesia, 2018). Among 48.9% of patients with schizophrenia who received treatment, less than half maintained their treatment (Kementerian Kesehatan Republik Indonesia, 2018). There were only around 9% of patients with depression who received evidence-based treatment (Kementerian Kesehatan Republik Indonesia, 2018). Indonesia National Adolescent Mental Health Survey (I-NAMHS) stated that only 2.6% of young adults with mental health problems seek help (Center for Reproductive Health *et al*., 2022).

In Indonesia, mental health issues have been ranked list. Treatment gaps have been estimated to be above 90% and even reaching 95% in rural Indonesia (World Health Organization, 2014). There were several challenges in diagnosing mental such as uneven mental health services (Munira *et al*., 2023) awareness of mental health. Hartini *et al*., 2018a) barriers to traditional and cultural beliefs (Subu *et al*., 2022). Indonesia's health coverage is low, especially for mental which results in declining and limited funds for mental health hospitals (Pols and Wibisono, 2017). Mental health services are unequally and not every hospital has professionals (Munira *et al*., 2023). The ability to seek help is also relatively low in Indonesia due to limited knowledge and awareness (Munira *et al*., 2023). Most Indonesian people have a negative view of mental, instead of seeking professional help, they often do *pasung* practices (chains and cages) to isolate people with mental illnesses (Baklien *et al*., 2023). Patients also prefer family or even religious to seek help rather than professionals (Munira *et al*., 2023). Those conditions could be potential barriers to receiving proper treatment for mental health. Data about mental health especially in lower and middle-income countries (LMIC) and mainly collected from high-income resulting in inequality of mental health well-being (Moitra *et al*., 2023).

Indonesia Family Life Surveys (IFLS) is a longitudinal household survey conducted in Indonesia. The cross-sectional national population survey also investigated depression. In 2015, depression was found among 27,86% (Purborini *et al*., 2021), 15% (Peltzer and Pengpid, 2018), and 19,4% (Fahmi *et al*., 2019) of young adults, adults, and older adults, respectively. Several depression risk factors, including younger age, stressors, lack of social support, and behavior, have been identified (Peltzer and Pengpid, 2018). However, information about mental health treatment coverage was not studied. Considering the limited data and noteworthy issues regarding the low treatment utilization in Indonesia, it is crucial to evaluate whether the actual depression cases received help. Proper assessment and treatment are crucial in managing mental health issues. It requires professional skills to determine mental health disorders. Poor detection and diagnosis could widen the treatment gap, which leads to individuals not recognizing their mental health problems. This study aimed to learn how many individuals with depression recognize or receive a proper diagnosis of their mental health issues. Moreover, the treatment types received by them were also explored. The data could provide insight into how individuals perceived mental health and could help increase professional awareness of mental health (Kraus *et al*., 2019).

Methods

This cross-sectional research used secondary data from the Indonesian Family Life Survey 5th edition (IFLS-5). The data collection period was from 2014 to 2015. The survey collected data from Indonesia's most populated provinces, 13 provinces comprising 83% of the national population. The survey sampling was grouped by provinces and urban/rural locations, then sampled randomly by those strata. IFLS randomly selected 321 enumeration areas (EAs) in each of the 13 provinces, sampling urban EAs and EAs in

smaller provinces to facilitate urban-rural and Java-non-Java comparison. The IFLS-5 collected data on a wide range of health and socioeconomic variables, including measures related to mental health (19,20). Variables used in this study were selected from some parts of IFLS-5 data, namely books 3A and 3B. Sociodemographic data were retrieved from book 3A, which is intended for respondents aged 15 and above. Some sociodemographic data typically related to mental health were selected: age, sex, educational levels, and occupational status. Age was divided into 18-24, 25-44, 45-59, and above 59 years old. Sex was categorized into men and women. Educational levels were classified into less than 9 years and 9 years and above. Occupational status consisted of two groups, namely actively working or not working (STRAUSS *et al*., 2016).

Meanwhile, book 3B provided mental health conditions and treatment data in our study. The mental health problems assessment is based on the results of a health worker's diagnosis (Have a doctor/paramedic/nurse/ midwife ever told you that you have emotional, nervous, or psychiatric problems]? "Yes" or "No"). Questions related to who diagnosed the condition consisted of the answer categories "Doctor", "Paramedic", "Nurse", and "Midwife". Meanwhile, questions regarding the type of treatment include: Are you now taking the following treatments to treat […] and its complications? with the categories "Traditional Medicine", "Modern Medicine", "Other treatments", "No treatments". Depression was evaluated in this study using the CES-D-10 (Center for Epidemiological Studies Depression Scale), a self-report measure consisting of 10 question items for depression regarding the frequency of several depressive symptoms (e.g., how you felt in the past week "I felt hopeful about the future") with the answer category "rarely or none (≤1 day)", "Some days (1-2 days)," Occasionally (3-4 days)", "Most of the time (5-7 days)". The results are divided into the presence or absence of significant depressive symptoms, an accumulation of scores above 10 is categorized as depression. The instrument has good reliability and validity in screening depressive symptoms among the general population. It has also been widely used in several studies (Monica, 2020).

There were 34,257 data points retrieved from IFLS-5. Incomplete data from demographic sections (n=2) and depression questions (n=2810) were excluded. The study only included respondents older than 18 years old, so some data were excluded, resulting in 29,165 completed data points to be analyzed further. Further information is in Figure 1. All statistical analyses were performed using SPSS version 26. Descriptive data are used to describe sociodemography (age, sex, educational levels). Respondent with depression, and lifetime psychiatric diagnosis (LPD), and receiving treatment was shown in percentage (%). We conducted a sub-analysis to see the description of subjects who received a diagnosis by health workers and the type of treatment for subjects with psychological problems and psychological problems with depression. All human research procedures followed were in accordance with the Institutional Review Board (IRBs) in the United States at Research and Development (RAND) Corporation, in Indonesia at the University of Gadjah Mada, and the Helsinki Declaration of 1975. The ethical clearance number obtained from the Human Subjects Protection Committee of the RAND was s0064-06-01-CR01.

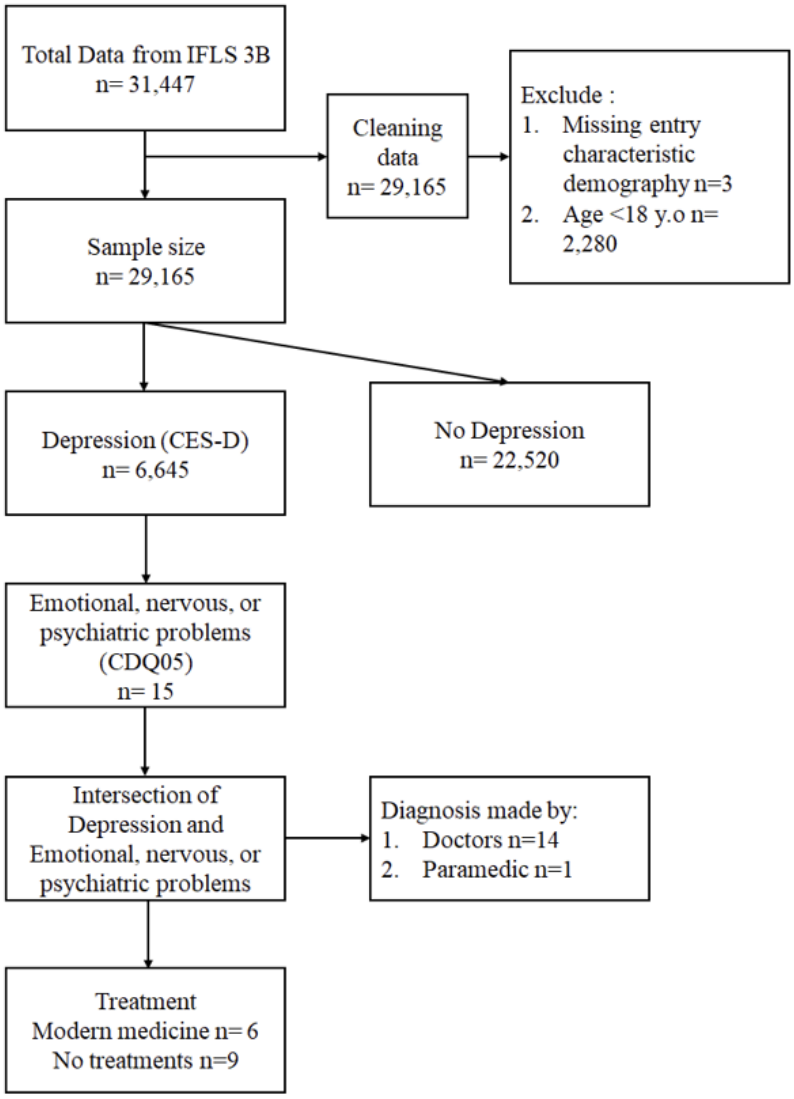

Figure 1. The flow of the research

Results and Discussion

Among the completed data, we found 6645 (22.8%) respondents with significant depressive symptoms. There were only 15 respondents (0.1%) who reported having any lifetime psychiatric disorder and met the depressive criteria. Most of the respondents with depression (53.5%) and lifetime psychiatric diagnoses (63.6%) were adults. Please refer to Table 1 for further information about demographic data.

Most of the lifetime psychiatric diagnoses (LPD) were made by doctors (93.3%). Most of the respondents with a history of psychiatric disorders did not receive any treatment (70.5%). The findings were also in line with the respondents who had clinically significant depressive symptoms. Most of them did not receive treatment (60%). Among respondents who received treatment, modern medicine is the majority treatment approach. Details of who made the diagnosis and types of treatment are displayed in Table 2.

The study intended to explore individuals with depression, properly diagnosed and treated in Indonesia. The prevalence of clinically significant depressive symptoms was 22.8%. Lifetime psychiatric disorders reported by the respondents were collected to explore awareness. Since the lifetime psychiatric disorders covered more than depression, near or higher proportions were expected compared

Table 1. Demographics Data of the Significant Depressive Symptoms and 15 People with Lifetime Psychiatric Diagnoses

Variables	Significant depressive symptoms N (%)	Lifetime psychiatric diagnoses N (%)	Lifetime psychiatric diagnoses with depression N (%)
Prevalence (%)	6645 (22.8)	44 (0.2)	15 (0.1)
Age			
18-24	1438 (21.6)	2 (4.5)	0 (0)
25-44	3557 (53.5)	28 (63.6)	12 (80)
45-64	1375 (20.7)	13 (29.5)	3 (20)
≥65	275 (4.1)	1 (2.3)	0 (0)
Gender			
Male	3015 (45.4)	22 (50)	7 (46.7)
Female	3630 (54.6)	22 (50)	8 (53.3)
Marital Status			
Single	1276 (19.2)	7 (15.9)	4 (26.7)
Married	4814 (72.4)	36 (81.8)	11 (73.3)
Separated/ divorced/ widow	555 (8.4)	1 (2.3)	0 (0)
Educational Levels			
No school	227 (3.4)	0 (0)	0 (0)
< 9 years	3412 (51.4)	11 (25.0)	3 (20.0)
≥ 9 years	2988 (44.9)	33 (75.0)	12 (80.0)
Occupational Status			
Not Working	4111 (61.9)	28 (63.6)	9 (60.0)
Working	2426 (36.5)	16 (36.4)	6 (40.0)
Other	108 (1.6)	0 (0)	0 (0)
Receiving treatment			
Yes		13 (29.5)	6 (40.0)
No		31 (70.5)	9 (60.0)

Table 2. Diagnosis and Types of Treatment Received by the Respondents

Variables	Lifetime Psychiatric diagnosis n=44	Lifetime Psychiatric Diagnosis with depression n=15
Diagnose by		
Doctor	39(88.6)	14(93.3)
Paramedic	2(4.5)	1(6.7)
Midwives	3(6.8)	0(0.0)
Type of Treatment		
Traditional Medicine	1(2.3)	0(0.0)
Modern Medicine	9(20.5)	6(40.0)
Other treatments	3(6.8)	0(0.0)
No treatments	31(70.5)	9(60.0)

to the clinically significant depressive group. However, the actual report on lifetime psychiatric disorders was low, even among the respondents who had clinically depressive symptoms. Most of them did not receive any mental health treatment during their lifetime. The clinically significant depressive symptoms in this study corroborate the previous data estimation for the LMI countries (Moitra *et al*., 2022). This result also falls in the range of previous IFLS-5 research (Handajani *et al*., 2022). Compared to the recent study in 2022, the prevalence (29.2%) was slightly higher than our findings (Hardi *et al*., 2023). It indicated that depressive disorder was on the rise after the IFLS-5 survey, which prompted an intervention at the community level. Information about how individuals with depression were diagnosed and managed in Indonesia is described below.

A good treatment was initiated by a careful diagnosis. A diagnosis is usually informed or known by the individual, which is reflected by how individuals remember their experience and whether they have had any psychiatric diagnosis during their lifetime. To our surprise, less than 1% of the respondents reported any lifetime psychiatric diagnosis, and an even smaller proportion when compared with those who met the clinically significant depressive disorder during the survey. It indicates there is a possibility of a low detection rate among Indonesians. It raised a concern about whether the respondents were aware of their mental status or had ever been properly screened. A previous study on LMIC stated that the severity of depression and suicidality were under-detection, especially in primary care clinics (Fekadu *et al*., 2022). A low detection rate implies huge neglect of people with depression, especially in LMIC (Fekadu *et al*., 2022). However, careful interpretation of the result should be warranted. Some possibilities should be considered before exploring the potential factors underlying the phenomenon. It was unknown whether the respondent had any emotional, nervous, or psychiatric issues. Low identification of depression may occur due to depression may not be a lifelong experience and may go unnoticed while visiting any healthcare professional. The prevalence of depression in the survey may be accidental, unknown to the respondent, and undiagnosed by professionals, which partly explains the low detection rate. Limitations to recall psychiatric history could happen due to the recall bias, which potentially underestimate the lifetime prevalence of mental disorders, thus resulting in small results but could have a large prevalence in the population (Takayanagi *et al*., 2014). Mental health care availability, cultural factors, and stigma could also contribute to the discrepancy between the detected depression and the subjective report.

Doctors were reported as the majority source of diagnosis among the respondents. No further data about which doctor diagnosed the respondents was available. In Indonesia, most mental health care was centralized in the secondary or tertiary care settings, where psychiatrists were available (Cipta *et al*., 2023). Individuals may be referred by general practitioners using national health insurance or gain direct access through their own money to a psychiatrist or clinical psychologist (Cipta *et al*., 2023). However, the latest option is not always feasible for everyone (Cipta *et al*., 2023). Visiting the general practitioners in primary care could be the best alternative and gain a referral to the psychiatrist (Cipta *et al*., 2023). General practitioners are the spearhead in primary care, including addressing a wide range of mental health issues (Regier *et al*., 1978). However, misdiagnosis and underdiagnosis of mental health disorders could happen. Research from Ethiopia reported that 39.16% of psychiatric disorders were misdiagnosed (Ayano *et al*., 2021). It is also found that undetected diagnoses of depression have reached as high as 80% (Ayano *et al*., 2021; Fernández *et al*., 2010). Understandably, primary care is more focused on medical care settings that are also high in prevalence and overlook psychological distress (Rogers *et al*., 2021). Poor detection on the primary care level could partly be related to the prioritizing of health issues with a high prevalence (Borowsky *et al*., 2000). Limited knowledge about mental health disorders, lack of extensive staff training in detecting mental health disorders, short consultation duration during the office visit, and restrictive reimbursement policies occured in the primary care settings (Cipta *et al*., 2023; Romer and McIntosh, 2005). Limited mental health services

access is noteworthy and has been a part of the consideration for the allocation of primary care medical services to assist in tackling common mental health problems (Munira *et al*., 2023).

Collaborative care in primary health care can promote better mental health care. Reflecting on the unequal general practitioners to patient ratio in Indonesia (1:1706), it shows that the service coverage figures are not evenly distributed (Sutrisno, 2023). Collaboration with other medical personnel, such as midwives and paramedics, was performed to wider the coverage in the community. Thus, it is common for patients to get help from them. Consistent with HI countries, a higher proportion of individuals with MDD in LMI countries accessed general health services that included general medical doctors, nurses, or other health professionals not related to mental health (Moitra *et al*., 2023). It indicated the importance of having the same vision and knowledge in detecting mental health problems to enhance mental health services in Indonesia.

Indonesian culture and perspective about mental health disorders are related to "insanity", which elicits stigma or discrimination (Hartini *et al*., 2018b; Subu *et al*., 2022). It led to a delay in help-seeking, especially before mental health disorders worsen or are experienced with functional deficit (Doll *et al*., 2021). Indonesian people were tolerant of individuals with mental health problems, as long as no aggression was shown. When the individual showed aggression, some initial measures were performed before utilizing mental health services, such as conducting physical confinement (known as *pasung*), visiting respected traditional healers (such as *dukun*), or consulting religious teachers as their first choice (Anjara *et al*., 2021; Kaligis *et al*., 2021; Subu *et al*., 2022; Mahendrata *et al*., 2017). The low level of mental health utilization was also observed in another study. Research from Switzerland shows that among respondents with anxiety and depression, almost half of them did not perceive a need for treatment, two-thirds had never utilized professional health care, and more than four in five were not currently using health care services (Werlen *et al*., 2020). Accepting mental illness and seeking treatment can be inherently difficult for Indonesians. Some respondents might keep their lifetime psychiatric diagnosis a secret due to embarrassment, shame, or stigma, especially when mental illness is still considered an improper subject in Indonesia (Hartini *et al*., 2018b). Mental health problems often receive negative responses; thus, the social desirability bias (the desire to avoid embarrassment from the community) might lead to underreporting (Tourangeau and Yan, 2007).

In this study, respondents who reported ever experiencing any psychiatric disorder were also asked about their treatment experience. Medication was the most prevalent choice of treatment in this study. Not every mental health problem should receive any medications as a primary or first-line intervention (Zimmerman *et al*., 2018). The nature and severity level of mental health problems determine the need for medication, which has mostly been suggested to treat individuals with serious mental illness (Zimmerman *et al*., 2018). Although the severity of the LPD was unknown, resistance to use medication was associated with the attitude towards medication, such as the potential side effects, being dependent or experiencing withdrawal from the medication, long-term use of medication, and contemplating the efficacy profile (Asher *et al*., 2023). It could partly explain the LPD journey that those who do not receive treatment earn larger portions. Other than medication, psychotherapy is effective as an alternative or combination of modalities to reduce certain mental health disorder symptoms (Kerna NA *et al*., 2021). Psychotherapy received a good reception and is considered a popular psychiatric treatment modality (Angermeyer *et al*., 2017). There were also other options for managing mental health problems, ranging from informal approaches to formal approaches, such as self-care, community, and facility-based programs, including innovative digital interventions (Moitra *et al*., 2023). As a supplemen to modern medicine, traditional medicine was also found in Indonesian society, including traditional Chinese medicine that uses herbs, acupuncture, massage, and diet therapy (Subu *et al*., 2022).

Early detection of mental health problems can provide significant benefits to both patients and society. Preventing mental health issues and early intervention are

crucial to prevent disease advancement, hence reducing mortality and morbidity (Chanen and Thompson, 2018). Reminding us of the need to promote mental health awareness and screen mental status for better prevention and early intervention. Further research to reveal the barriers to increasing the treatment coverage in the community is needed. Some potential variables should be considered, such as attitude toward mental health treatment and mental health professionals in Indonesia; moreover, the decision towards help-seeking and receiving treatment was also important to be included. The mental health problems would be best included to identify the patients' perceptions in handling the mental health problems.

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Conclusions

This research shows that although cases of depression in Indonesia are still relatively high, most respondents do not undergo standard examinations or even seek professional help. The low rate of LPD raises concerns about many possibilities underlying the phenomenon, including the low detection rate. A range of accessible treatments should be available for patients in need of treatment. These findings warrant further research to improve mental health service coverage.

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Preservative Equipment Based on Nitrogen Doping Titanium Dioxide Photocatalyst White Oyster Mushroom In Banyumeneng

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Abstract

Oyster mushrooms easily wilt and turn brown because of bacteria and enzymatic reactions. Preservation of oyster mushrooms has been done in the freezer, which can only last 3-4 days. In addition, preservation using chemicals can cause side effects such as diarrhea to long-term cancer. The purpose of this study was to determine the shelf life of white oyster mushroom products using the innovation of making preservatives with titanium dioxide doped nitrogen (N-TiO2). The method used is the sol-gel method with TiCl4 as the precursor of TiO2 and diethylamine as the nitrogen-doped precursor. N-Doped TiO2 was characterized using FTIR, XRD, and antibacterial activity tests. The results of the FTIR spectrometer showed peaks at 518 and 678 cm-1, which indicated the presence of vibrations from TiO2. Analysis of the crystalline phase of TiO2 using XRD obtained a mixed phase in the form of anatase with peaks at 55.10 (2Ø) and rutile at 27.40 (2Ø). Anti-bacterial activity test showed that N-TiO2 was able to inhibit the growth of E. coli bacteria by 6.48±0.42 mm. The results of the organoleptic test showed that preservation using photocatalyst can extend the preservation time of oyster mushrooms, which is about 6-9 days, longer than the ideal preservation time of oyster mushrooms. This technological innovation can answer the problems of oyster mushroom farmers in Banyumeneng Village related to oyster mushroom harvests that are wasted because they are rotten and cannot be sold

Introduction

The agricultural sector is a field that is one of the livelihoods of the Indonesian people, especially oyster mushroom farmers in Banyumeneng Village. White oyster mushroom (*Pleurotus ostreatus*) is a good source of nutrition, this is because white oyster mushroom (*Pleurotus ostreatus*) contains 35% protein, 9 types of amino acids, 2.20% fat consisting of 72% unsaturated fatty acids, and carbohydrates in every 100 g(Divyasri *et al*., 2021). White oyster mushroom (*Pleurotus ostreatus*) is not only known as a delicious food mushroom and has high nutrition, but is also known as a nutraceutical ingredient because it demonstrates antimicrobial and antioxidant properties like palm sugar (Egra *et al*., 2019; Winarni *et al*., 2018). After surveying with Oyster Mushroom farmers in Banyumeneng Village, a preservation problem exists. White oyster mushrooms are a type of food that is easily damaged at room temperature, and if not packaged properly, they can only last 24 hours. Several studies have been carried out to maintain the freshness of mushrooms white oysters include storage at low temperatures(Li *et al*., 2016). During the harvest season, many farmers suffer losses because they cannot store mushrooms for more than 3 days. Damage to the fruiting body of the fungus occurs due to

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the withering process, and the colour changes to brown due to an enzymatic reaction because it reacts with oxygen. Prevention can only be done by post-harvest handling, which is through preservation technology (Sugianto & Sholihah, 2021).

One of the existing preservation technologies uses titanium dioxide (TiO_2). Titanium dioxide is an economically valuable photocatalyst substance (Daneshvar *et al.*, 2007). The working principle of the TiO_2 photocatalyst is that when nano-sized zinc oxide is exposed to UV light, it will form superoxide compounds that can eliminate harmful microbes and bacteria (Georgekutty *et al.*, 2008). TiO_2 nanoparticles have high antibacterial activity, so when TiO_2 is coated on other substances such as glass, it can kill microbes and bacteria in the surrounding environment when exposed to UV light. Because zinc oxide is a catalyst, it will never deplete and will continue to participate in the reaction. TiO_2 has a large surface area and charge transfer due to the easy enhancement of photon induction. The high surface area helps effective exposure to light and facilitates photochemical reactions on the surface, while the ease of charge transfer due to photon induction helps the photon-induced electron capture and donation process. These properties are also expected to provide benefits to nitrogen-doped TiO2 systems, so to take advantage of the superior properties of nano-sized materials, it is necessary to develop nitrogen-doped TiO2 mesoporous nanoparticles (Kay & Grätzel 1996). Titanium oxide (TiO_2) has a bandgap of 3,2 eV. This is one of the problems in the application of the TiO2-based solar spectrum because only 4 - 5% of sunlight is emitted in the UV region, so various efforts have been made to improve the response of TiO2 to visible light (Kaur & Gupta 2016). In the other situation, this is an advantage and a weakness, because titanium dioxide can act as a photocatalyst material, but is initiated by UV light (Georgekutty *et al.*, 2008). This weakness can be overcome by modifying the material using doping (Georgekutty *et al.*, 2008; Sankara Reddy *et al.*, 2013). Various studies have been conducted on the use of metal doping, ranging from alkali, alkaline earth, transition, and lanthanide elements, including metalloids such as Sb. Most of the doping does not show an increase in photo activity compared to pure TiO_2, which can be characterized that doping innovation is needed in the development of TiO_2 by using nitrogen. Nitrogen was found to be the most effective dopant because its size is not much different from that of oxygen, and its small ionization energy, which accelerates the reaction between TiO_2 and nitrogen (Sankara Reddy *et al.*, 2013; Yang *et al.*, 2021). With the above problems, the purpose of this study was to determine the shelf life of white oyster mushroom products using the innovation of making preservatives with TiO_2 and nitrogen doping as a preservative and antibacterial solution in white oyster mushrooms.

Method

The time it takes for the creation of this tool and research is five months. Activities are carried out in three places, that is, the Chemical Engineering Laboratory of Universitas Diponegoro and the Terpadu Laboratory of Universitas Diponegoro. After the mushrooms are finished harvesting, fresh mushrooms are selected and separated from mushrooms that are rotten or damp. Then, clean the roots of the mushrooms. After that, the mushrooms can be stored in our innovative storage device with a longer shelf life. Preparation of titanium dioxide (TiO_2) anatase phase was carried out by the sol-gel method with $TiCl_4$ as a precursor. The beaker containing titanium chloride ($TiCl_4$) was added $(NH_4)_2SO_4$ 0.5 M. Then reacted with NH_4OH at 70 °C and stirred at 300 rpm. The reaction product is in the form of a gel, and then washed with water to remove chlorine ions. Furthermore, the gel was dispersed into an ethanol solution to remove water and dried at 60 °C for 48 hrs to become powder.

N-TiO_2 was made based on modified Saragih's (2011) research. Next, mixing 5 g of TiO_2 with 270 mL of absolute ethanol occurred, and researchers proceeded with the process of sonication for 10 minutes. Then, researchers mixed 10 mL of absolute ethanol, 10 mL of distilled water, and 2 M HCl to achieve pH 2. Next, researchers stirred the mixture with a magnetic stirrer for 30 minutes to form a solution. Further, stirring the mixture of TiO_2 and ethanol with a magnetic stirrer for 30

minutes occurred. Researchers incorporated urea into the TiO_2 sol mixture, which was followed by stirring with a magnetic stirrer for 60 minutes. Evaporating the sol at a temperature of 70 °C under the hood for 1 hour occurred. Furthermore, heating the sol in the furnace at a temperature of 500 °C for 1 hour occurred.

Following the acquisition of N-TiO_2, the application is carried out using the system spray coating method. The spray method is designed to evenly coat the glass with N-TiO_2. A thin layer of N-TiO_2 can be formed on the glass plate using the spray method. This method can also save the use of N-TiO_2, so that this method can produce N-TiO_2-coated glass plates at a lower cost. After obtaining the TiO_2-coated N glass plate, the tool was made preservative and anti-bacterial in white oyster mushrooms with tools that have been made. To increase the lifetime of the oyster, after the photocatalyst process, put the oyster mushrooms in the vacuum container. Therefore, the use of nitrogen gas increases the time of food preservation. SEM-EDS is used to analyze the size of TiO_2 nanoparticles, with a standard size range of 400-900 cm^{-1}.

This method is used to identify the crystalline phase in the material by determining the parameters of the lattice structure and to find the particle size. An activity test of antibacterial activity was carried out on the type of E coli bacteria. Antibacterial activity test was carried whole-plate diffusion method using Nutrient Agar (NA) solid media with an incubation time of 1x24 hrs at 37 °C. This method is used to determine the effectiveness of the equipment in preserving and reducing the bacteria that are causing problems in white oyster mushrooms. The effectiveness of the tool is demonstrated by comparing preservation using the refrigerator, and our tool innovations include identifying the organoleptic analysis, including shapes, colours, and odours in white oyster mushrooms.

Result and Discussion

The initial process of making preservatives and antibacterial compounds in white oyster mushrooms begins with the synthesis process. Synthesis is carried out by the gel-sol method with the base material of *titanium tetrachloride*. The process of making nanoparticles is formed by a nanosol solution prepared with controlled hydrolyse of titanium tetrachloride in water. 5% in isopropyl alcohol (5:95) is dropped 1ml/min into 900 ml of distilled water at PH 2 (with). The mixture is stirred for 12 hrs. This solution is stable for some time. The doping with nitrogen is formed from the same sol stirred using a magnetic stirrer, followed by the addition of a diethylamine solution (to produce a nitrogen-sol 1:1 (Volume: Volume diethylamine). The solution is calcined at a temperature of 400 °C for 2 hours to produce the TiO_2 and N-TiO_2. Nano-N-doped TiO_2 obtained from this method is the basic material that will be used to coat glass plates with preservatives and antibacterial devices. After getting N-doped TiO_2 then done the manufacture of glass plates N-doped TiO_2 with a coating system using the spray method was done. This spray method is intended to make the glass covered with N-doped evenly. Here is the process of coating N-doped TiO_2 on glass. Subsequently, making a glass plate coated with N-doped TiO_2, then the manufacture of

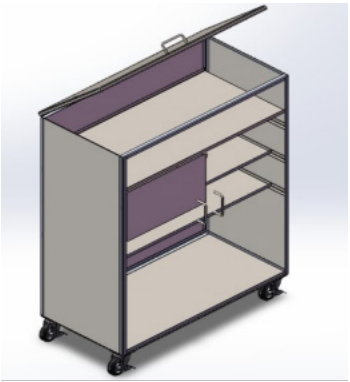

Figure 1. Equipment Design

preservatives on oyster mushrooms, designing outer equipment using metal and polymer plastic. Design of equipment made of metal and plastic so that the tool can be used for a long time. Then, TiO_2 is made on a glass plate so that it can absorb sunlight and act as a photocatalyst.

The design of this equipment is made from several parts of the process, which includes the photocatalyst process. In this case, the photocatalyst process uses nitrogen-doped TiO_2 and is placed in a vacuum chamber. In addition, the plan for this equipment is to apply white oyster nanotechnology, which is growing rapidly in Indonesia. Here are the specifications of the design of the tool that will be applied in the middle and top part (Figure 1). The preservative tool consists of 3 parts, at the top, only in use a lamp. Its main function is as a source of photons in the photocatalyst process. The middle part serves as a storage area as well as a place for the photocatalyst to take place. Then, at the bottom serves to store fresh mushrooms.

The process in the middle part of this equipment is the process of preserving oyster mushrooms, as well as the process of drying oyster mushrooms. In this equipment, there are methods of photocatalysis. The use of photocatalyst processes serves as an antibacterial in a vacuum condition. Combining the two processes is due to the lack of antibacterial ability of the photocatalyst process. In addition to improve the equipment, it can be added the hygrometer in order to check the humidity. At the top of this equipment, a lamp is used as the source of photons in the photocatalyst process (Figure 2). This preservative tool uses 2 methods, namely, photocatalyst and ozonation. Equipped with a fan and a climate control system. The Ozonization process functions as a preservative due to the antibacterial ability of the ozonation process. Then the photocatalyst process serves as an antibacterial supporting ozonation. The combination of the two processes is due to the lack of antibacterial ability of the photocatalyst process and the wasteful use of ozone.

Nano particles of TiO_2 that have been made using the sol-gel method were then performed characterization in the form of FTIR analysis to determine out oxides and

Figure 2. Equipment for the Preservation and Antibacterial Treatment of the White Oyster Mushroom

Figure 3. Result of Mushroom Preservation Using the Tools

XRD to find out the crystal form produced from the synthesis. Here are the results of the characterization of TiO_2 nanoparticles. Based on the results of the FTIR spectrometer obtained peaks were obtained at 518 and 678 cm^{-1}, which indicate the vibration of TiO_2 (Figure 3). This is following research by Silva (2013), which pinpointed peak TiO_2 in the range of 400-900 cm^{-1}(Silva *et al*., 2013). Based on Figure 4, analysis of the crystal phase TiO_2 using XRD obtained a mixed phase in the form of anatase with a peak at 55.10 (2Ø) and rutile at 27,40 (2Ø). Oyster mushroom preservatives have a power of 50 Watts from a total of 5 lamps for preservation at night. This tool also has a load of 100 kg and can store a lot quantity of oyster mushrooms. The low energy of electricity for this equipment makes the more valuable than other food preservation equipment. In addition to mold preservatives, an Ultra High Purity nitrogen tube is devoted to food packaging. Photocatalysis is a method used to inhibit the growth of bacteria, which will cause fungi to rot quickly. This process can be called a continuous oxidation process, which also functions to oxidize dyes. The continuous oxidation process occurs due to the formation of hydroxide radicals (OH), which are strong oxidizing agents that can completely mineralize organic pollutants(Faisal *et al*., 2007; Khan *et al*., 2023). TiO2 is a type of semiconductor material that is non-toxic, widely available, has good chemical stability under visible light, and is relatively cheap to manufacture. TiO2 can absorb photon energy in most of the sunlight spectrum because it has a large band gap (>3.00 eV), so TiO2 is often used in chemical reactions(Yuwono *et al*., 2011; Etacheri *et al*., 2015). The conduction band of titanium dioxide is particularly suitable for anthocyanin dyes, as it affects the injection of electrons from the dye molecules into the oxide semiconductor. TiO2 has a large surface area and charge transfer due to the easy enhancement of photon induction. The high surface area helps effective exposure to light and facilitates photochemical reactions on the surface, while the easy charge transfer due to photon induction helps the photon-induced electron capture and donation process(Narayan 2012).

Further, the photocatalyst reactions produce O_2 and OH radicals that can oxidise various bacteria with an efficiency of up to 82.47%. Technology based on this photocatalytic concept can also kill bacteria and microorganisms that cause meat decay. As a result, the use of this tool has the potential to become a white oyster mushroom. Oyster mushrooms are more durable and do not rot as easily as other mushrooms. Because ozone is a gas molecule that can kill bacteria in a vacuum system, oyster mushrooms are free of decay. An N-TiO_2 antibacterial activity test is done to find out the effectiveness in preserving oyster mushrooms. *E. coli* is one of the bacteria that cause white oyster mushrooms to rot easily. Therefore, antibacterial activity tests are carried out on types of *E. coli* bacteria. Antibacterial activity test is carried out by the well diffusion method using nutrient agar solid media (NA) with an incubation time of 1x24 hrs at a temperature of 37°C. The results obtained by N-TiO_2 can inhibit the growth of *E. coli* bacteria by 6.48±0.42 mm. Based on Wang's research (2014), N-TiO_2 can reduce bacteria by 98.70% using visible light. The mechanism of preserving oyster mushrooms with this tool is when the glass plate that has been coated with N-doped TiO_2 is illuminated by sunlight/lamp (Figure 3)(Wang & Swerdloff 2014).

Based on organoleptic observations and water content measurements in this study, it can be concluded that the effective preservation time is 6-9 days with a soft texture, water content still around 80-82%, and a slightly brown colour. The rapid decline in the quality of oyster mushrooms is caused by several factors, one of which is that the mushrooms do not have a protective cuticle, high levels of respiration, and high water content (Brennan *et al*., 2000). This damage is characterized by a change in the colour of the mushroom body to brownish due to enzyme damage, physical damage, microbiology, and shrinking of the white oyster mushroom mass (Castellanos-Reyes *et al*., 2021). The quality of mushrooms continues to decline due to the quality of temperature in this tool, which follows the high temperature conditions around the room in that area. If oyster mushrooms are stored at high temperatures, it can cause a decrease in the weight loss value of oyster mushrooms.

Fungi are protected by a thin and porous epidermis, so they are unable to prevent rapid surface dehydration. Dehydration is related to temperature, humidity, osmotic pressure, and differences in solution concentration (Murcia *et al*., 2009).

This is due to the presence of superoxide compounds (Table 1). The superoxide compound will oxidize the bacteria that are in the storage room of oyster mushrooms, so the bacteria will die. TiO_2 N-doped material is a catalyst, so the photocatalyst reaction can continue continuously(Divyasri *et al*., 2021). The slightly brownish colour obtained in the preservation data is due to the lack of temperature control in oyster mushrooms, so a temperature control tool is needed that can maintain the temperature of oyster mushroom preservation that ranges from 25-30°C. It can be concluded that preservation using photocatalysts can extend the preservation time of oyster mushrooms, which is about 6-9 days, longer than the ideal preservation of oyster mushrooms (6^{th} day).

Photocatalysts are a method of AOPs (Advanced Oxidation Processes). Characteristic of AOPs is the formation of highly active free radicals, especially hydroxyl radicals (OH) (Litter 1999). Here are the toughness of oyster mushroom preservatives: Can be used in the long term, Able to kill bacteria in oyster mushrooms, Able to preserve oyster mushrooms in a vacuum system, Effectively used by oyster mushroom farmers, Low cost, and The drying process does not depend on the weather**.** SWOT analysis is needed in the development of tools in the future. This is the SWOT analysis of this equipment (Table 2) (Silva *et al*., 2013). To achieve food self-sufficiency in the 3T region, the role of technology is needed. In this case, the focus of the problem to be discussed is increasing the potential of rural areas in the oyster mushroom agricultural sector in Banyumeneng Village. Oyster mushroom is a food commodity that is one of the main needs of people in daily life. The problem is in rural areas where there is no electricity and a refrigerator in the preservation process, which can cause big losses for farmers, that is fungi can easily rot. Therefore, the authors offer a solution in the form of photocatalyst-based oyster mushroom processing technology and

Table 1. Organoleptic Analysis

Time	Texture	Water Content	Color
0 day	Soft	90%	White
3 day	Soft	88%	Rare brown
6 day	Soft	82%	Rare brown
9 day	Soft	80%	Rare brown
12 day	Hard	60%	Brown
15 day	Very Hard	30%	Very Brown

Table 2. SWOT of the equipment

Strengths	**Weakness**
1. Environmentally friendly technology 2.Able to speed up the drying process of salty white oyster mushrooms 3.Low cost 4. Easy to use	The synthesis process must be done in the laboratory for safety 2. Still use electricity. 3. There has been no development with the relevant parties.
Opportunities	**Threats**
1. The need for renewable technology in agriculture 2. Low implementation costs. 3. Can be used long term	1. Scratched glass-coated photocatalyst Ag Doped TiO2 2. The public does not understand very well about photocatalysts and ozone technology

the presence of ozone technology as an agent in the oyster mushroom preservation process. It is hoped that the role of this technology can improve the welfare of people in coastal areas. On the other hand, this technology can be used with electricity or without electricity, that is, utilizing sunlight. The results of the FTIR spectrometer showed peaks at 518 and 678 cm-1, which indicated the presence of vibrations from TiO2. Analysis of the crystalline phase of TiO2 using XRD obtained a mixed phase in the form of anatase with peaks at 55.10 (2Ø) and rutile at 27.40 (2Ø). Anti-bacterial activity test showed that N-TiO2 was able to inhibit the growth of E. coli bacteria by 6.48±0.42 mm. The results of the organoleptic test showed that preservation using photocatalyst can extend the preservation time of oyster mushrooms, which is about 6-9 days, longer than the ideal preservation time of oyster mushrooms.

Conclusion

The use of tool design is quite effective, where there are 3 parts of the preservative that have a function in the process of preserving white oyster mushrooms. The results of the organoleptic test showed that preservation using photocatalyst could extend the preservation time of oyster mushrooms, which was about 6-9 days, 3 days longer than the ideal preservation time of oyster mushrooms. The use of ozone and photocatalyst technology is not dangerous, because both are environmentally friendly technologies and easy to apply to white oyster mushrooms. This technological innovation can answer the problem of oyster mushroom farmers in Banyumeneng Village related to the oyster mushroom harvest, which is wasted because it is rotten and cannot be sold.

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Multifactorial Risk Factors of Hypertension in Patients Aged 45-55 Years in Kota Kotamobagu: A Cross-Sectional Study

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Abstract

Hypertension in adults aged 45-55 years has a significant impact on heart health and morbidity. Hypertension is estimated to affect 1.56 billion people by 2025 and become a leading cause of death. In Indonesia, the prevalence is 18.7% in the 45-54 age group, with North Sulawesi ranking third highest. In Kotamobagu, hypertension ranks second among non-communicable diseases with 24,956 cases. This high number emphasizes the importance of prevention and control. A deep understanding of modifiable risk factors is needed to develop effective prevention strategies. This study aims to identify the primary risk factors that influence the prevalence of hypertension in the adult population of Kotamobagu City. This descriptive-quantitative study used an analytical observational study design with a cross-sectional technique. The study was conducted in Kotamobagu City, North Sulawesi Province, Indonesia, from July to August 2024. This study used an analytical observational design with a cross-sectional method, data collection using a digital sphygmomanometer to measure blood pressure, an Easy Touch GCU Meter to analyze dyslipidemia and blood sugar levels, and a questionnaire to assess physical activity, diet, salt consumption, alcohol consumption, and smoking habits. The sample consisted of 388 hypertensive patients selected using the Slovin Formula, and the statistical analysis used was chi-square. The results showed that diet, dyslipidemia, obesity, high salt consumption, alcohol, and smoking were significantly correlated with hypertension. Based on the odds ratio, the factors that had the strongest relationship with the incidence of hypertension were poor diet (OR = 1.53), dyslipidemia (OR = 1.49), and excessive salt consumption (OR = 1.46).

Introduction

Hypertension is a significant public health problem, particularly in Indonesia, where rapid urbanization has led to lifestyle changes that increase the risk of non-communicable diseases, especially hypertension (Rahut *et al*., 2023; Sivanantham *et al*., 2021). With the prevalence of hypertension having reached 12.1%, it is crucial to understand modifiable risk factors and important to develop effective prevention strategies (Hasnani *et al*., 2023; Sarma *et al*., 2019). Hypertension is one of the major health problems that urgently needs to be addressed, both in Indonesia and worldwide, due to its high prevalence and the health risks it poses (Panchanan *et al*., 2024), and the increase at a high rate among adults, ranging from 26.1% to 40% (Alfaqeeh *et al*., 2023; Defianna *et al*., 2021; Mashuri *et al*., 2022).

Hypertension is one of the NCDs whose prevalence continues to increase and is a significant risk factor for heart disease,

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kidney failure, and stroke. The high prevalence of hypertension in Indonesia exacerbates the health burden, especially in lower economic groups and urban areas, as many cases are undiagnosed, and awareness and treatment are more concentrated in higher economic groups (Adisasmito *et al*., 2020; Mashuri *et al*., 2022; Oktamianti *et al*., 2022). Adults with undiagnosed hypertension face a high risk of heart attack, atherosclerosis, heart enlargement, stroke, and kidney damage, resulting in increased morbidity and mortality rates (Debora *et al*., 2023; Wangdi & Jamtsho, 2020).

Hypertension is a leading cause of premature death, with a high prevalence across Indonesia. Identifying its contributing factors is crucial to low (Ikhlasia *et al*., 2025). It is estimated that by 2025, more than 1.56 billion people worldwide will suffer from hypertension. This will exacerbate the problem in the next few decades. Hypertension, which is one of the leading causes of death in the Western world, can also lead to stroke, kidney problems, and even kidney failure. Nearly 7.6 million people worldwide die from high blood pressure (Indonesia Health Survey, 2024). Hypertension data in Indonesia, aged 45-54 years, reaches 18.7% (78,040), dominated by females (10.5%), with the highest education level being high school. (206,812) Hypertension in North Sulawesi reaches 12.1%. North Sulawesi ranks third in Indonesia after DKI Jakarta and Yogyakarta (Ministry of Health of the Republic of Indonesia, 2019). Hypertension cases in Kotamobagu City rank second out of 10 non-communicable diseases with a total of 24,956 cases (Darmin *et al*., 2023).

Hypertension is a significant risk factor for cardiovascular disease and death, so it is essential to understand its risk factors, such as genetics, lack of physical activity, poor diet, obesity, and high salt and alcohol intake (Grau-Perez & Redon, 2020; Mills *et al*., 2020; Schiffrin, 2020; Watso *et al*., 2023). These factors, if not controlled, can lead to hypertension and worsen overall public health. Hypertension has become a significant health problem among young to middle-aged adults, contributing to the substantial burden of cardiovascular disease (CVD) and related death and disability worldwide (Liu *et al*., 2021; C. Wang *et al*., 2020; Y. Wang, 2022). This study aims to; 1) Identifying the characteristics and variable of hypertension in hypertensive patients aged 45-55 years, 2) Analyze the relationship between each factor and the incidence of hypertension in adults aged 45-55 years in the city of Kotamobagu, 3) Identify the factors that have the strongest relationship with the incidence of hypertension in patients aged 45-55 years in the city of Kotamobagu.

Method

This descriptive-quantitative research uses an analytic observational study design with a cross-sectional technique. Conducted in Kotamobagu City, North Sulawesi Province, from July to August 2024. This study was conducted by analyzing variables of predisposing factors, such as dyslipidemia (Wong *et al*., 2006), physical activity (Séogo *et al*., 2022), obesity (Majgi *et al*., 2024), diet (Sudayasa *et al*., 2020), diabetes (Whelton, 2009), excess salt consumption (Tan *et al*., 2019), alcohol consumption, and smoking (Klag *et al*., 1993). The samples were 388 hypertensive patients aged 45-55 years, according to the inclusion and exclusion criteria from a population of 15,004. Samples were taken from 7 working areas of health centers in Kotamobagu City, using the Slovin Formula. This Study period is from March to August 2024.

This study utilized various instruments to assess hypertension risk factors. Hypertension degree was measured using a digital sphygmomanometer, while dyslipidemia and diabetes mellitus (DM) were assessed with an Easy Touch GCU Meter 3-in-1. Obesity was determined using BMI calculations based on height and weight measurements. Physical activity was evaluated using the Global Physical Activity Questionnaire (GPAQ), and dietary habits were assessed with a Semi-Quantitative Food Frequency Questionnaire (SQFFQ). Smoking status, alcohol consumption, and salt intake were measured using structured questionnaires with categorical classifications. This study conducted a chi-square test to explore the relationship between hypertension and the categorized independent factors. The classical assumption test was conducted as

Table 1. Distribution of Respondent Characteristics (n = 388)

Characteristics	Total	Percentage (%)
Education		
Elementary School	1	0,26
Junior High School	2	0,54
High School	281	72,4
Undergraduate	104	26,8
Jobs		
Housewives	237	61,1
Farmers	56	14,4
Driver	25	6,4
State Civil Service	39	10,1
Private Employee	31	8
Gender		
Female	237	61,1
Male	151	38,9

Source: Primary Data 2024

a preliminary step before applying multiple linear regression, which was used to determine the effect of the independent variables on the dependent variable and identify which variables most significantly influenced the degree of hypertension. This analysis used categorical data for descriptive analysis, and numerical data (total score of respondents) was used for inferential statistical analysis.

Results and Discussion

The characteristics of respondents obtained in this study, consisting of education, occupation, and gender, the complete distribution can be presented in Table 1, as follows:

Table 1 depicts the distribution of demographic characteristics of the 388 respondents who participated in the study. Based on education level, most respondents (72.4%) had their last education at the senior high school level, followed by those who had attended university (26.8%). Only a few respondents had primary school (0.26%) and junior high school (0.54%) education. In terms of occupation, the majority of respondents were housewives (61.1%), while the rest worked as farmers (14.4%), drivers (6.4%), State Civil Apparatus (ASN) (10.1%), and private employees (8%). The composition of respondents by gender shows that the majority are women (61.1%), while men only amount to 38.9%. This data shows that the respondent population is dominated by women with a high school education who work as housewives. The variables obtained in this study consisted of: Degree of Hypertension, Dyslipidemia, Physical Activity, Obesity, Diet, Diabetes, High Salt Consumption, Alcohol Consumption, and Smoking. Complete details can be seen in Table 2 below:

Table 2. Variable distribution (n=388)

Variables	n	%
Degree of Hypertension		
	228	58,8
2nd degree	160	41,2
1st degree		
Dyslipidemia		
High (>200 mg/dL)	253	65,2
Normal (<200 mg/dL)	135	34,8
Physical Activity		
Underactivity (metabolic equivalent/week < 600)	248	63,9
Overactivity (metabolic equivalent/week ≥ 600)	140	36,1
Obesity		
Yes (BMI ≥ 30)	247	63,6
No (BMI < 30)	141	36,4
Diet		
Bad (risky food types)	254	65,5
Good (food type is not risky)	134	34,5
Diabetes		
Yes (>125 mg/dL or Fasting Blood Sugar)	177	45,6
No (90-125 mg/dL Fasting Blood Sugar)	211	54,4
Excess Salt Consumption		
Yes	252	64,9
No	136	35,1
Alcohol Consumption		
Yes (4-5 times a week with doses above 500 ml)	248	63,9
No (alcohol consumption below 200 ml or not at all)	140	36,1
Smoking		
Yes (active smoking)	246	63,4
No (never smoked)	142	36,6

Source: Primary Data 2024

Table 2 illustrates the distribution of health variables from 388 respondents, showing that most respondents had high health risk factors. Most of the respondents were in Grade 2 hypertension (58.8%) and had dyslipidemia with high cholesterol levels (65.2%). In addition, 63.9% had low physical activity (<600 METs per week), and 63.6% were classified as obese (BMI ≥30). In terms of diet, 65.5% of respondents consumed risky food types, while 45.6% had high blood sugar levels, showing signs of diabetes. Excess salt consumption was found in 64.9% of respondents, and high doses of alcohol consumption (4-5 times per week) were found in 63.9%. Smoking habits were also everyday, with 63.4% of respondents being active smokers. Overall, this data indicates a high prevalence of health risk factors in the respondents, primarily related to hypertension, dyslipidemia, obesity, risky diet, excessive salt and alcohol consumption, and smoking habits.

Table 3. Risk Factor Distribution With Hypertension (n=388)

Variables	Degree of Hypertension				Total		*p*	OR (95% CI for Exp.B)
	2nd degree		1st degree					
	n	%	n	%	n	%		
Dyslipidemia								
High (>200 mg/dL)	135		119	46,9	253	65,2	0,004*	1,49 (1,12-1,99)
Normal (<200 mg/dL)	93	24,0	42	10,8	135	34,8		
Physical Activity								
Less activity	135		113	29,1	248	63,9	0,028*	1,35 (1,03-1,78)
Overactivity	93	24,0	47	12,1	140	36,1		
Obesity								
Yes (BMI ≥ 30)	135		112	28,9	247	63,7	0,039*	1,13 (1,01-1,74)
No (BMI < 30)	93	24,0	48	12,4	141	36,4		
Diet								
Bad (risky food)	135		119	30,7	254	65,5	0,003*	1,53 (1,15-2,04)
Good (food is not at risk)	93	24,0	41	10,6	134	34,5		
Diabetes								
Yes (>125 mg/dL)	99		78	20,1	177	45,6	0,350	1,13 (0,89-1,43)
No (90-125 mg/dL)	129	33,2	82	21,1	211	54,4		
Excess Salt Consumption								
Yes	135		117	30,2	252	64,9	0,007*	1,46 (1,10-1,94)
No	93	68,4	43	31,6	136	35,1		
Alcohol Consumption								
Yes (above 500 ml, 4-5x/week	135		113	29,1	248	63,9	0,028*	1,35 (1,03-1,78)
No (below 200 ml/not at all	93	24,0	43	12,1	140	36,1		
Smoking								
Yes (current smoking)	134		112	28,9	246	63,4	0,031*	1,36 (1,03-1,78)
No (no smoking)	94	24,2	48	12,4	142	36,6		

Source: Primary Data 2024
Noted: *Significant (P = <0.05)

Table 3. The results of the analysis show that there is a significant relationship between several risk factors and the incidence of hypertension in adults aged 45-55 years in Kotamobagu City. Factors that have a significant relationship with hypertension include dyslipidemia (p = 0.004; OR = 1.49; 95% CI: 1.12-1.99), physical activity (p = 0.028; OR = 1.35; 95% CI: 1.03-1.78), obesity (p = 0.039; OR = 1.13; 95% CI: 1.01-1.74), diet (p = 0.003; OR = 1.53; 95% CI: 1.15-2.04), excessive salt consumption (p = 0.007; OR = 1.46; 95% CI: 1.10-1.94), alcohol consumption (p = 0.028; OR = 1.35; 95% CI: 1.03-1.78), and smoking (p = 0.031; OR = 1.36; 95% CI: 1.03-1.78). Patients aged 45-55 years in Kotamobagu City with a risky diet are 1.53 times more likely to experience hypertension than those who have a healthy diet. Similarly, patients with high cholesterol levels (> 200 mg / dL) are 1.49 times more at risk of hypertension than those with normal cholesterol levels. In addition, excessive salt consumption increases the risk of hypertension by 1.46 times compared to those who consume normal amounts of salt. Meanwhile, lack of physical activity, obesity,

excessive alcohol consumption, and smoking were also found to contribute to an increased risk of hypertension with varying degrees of risk. On the other hand, the results of the analysis show that diabetes mellitus has no significant relationship with the incidence of hypertension in this study (p = 0.350; OR = 1.13; 95% CI: 0.89-1.43). Although diabetes has often been associated with hypertension in various previous studies, the results obtained in this study show that the relationship is not significant. This is likely due to confounding factors or the effect of antihypertensive drugs on diabetic patients that can control blood pressure.

Based on the odds ratio (OR) value, the factor with the strongest relationship with the incidence of hypertension in this study was poor diet (OR = 1.53), followed by dyslipidemia (OR = 1.49) and excessive salt consumption (OR = 1.46). This shows that lifestyle, especially an unhealthy diet, is the main risk factor that contributes to hypertension in patients aged 45-55 years in Kotamobagu City. Therefore, hypertension prevention strategies need to focus on improving diet, such as reducing salt and saturated fat intake, increasing fiber intake, and adopting an active lifestyle to reduce the risk of hypertension. This result is in line with previous studies, which found that excessive sodium consumption and low intake of vegetables and fruits may increase the risk of hypertension (Grillo *et al*., 2019; Rust & Ekmekcioglu, 2017). In addition, these results support research showing that the DASH (Dietary Approaches to Stop Hypertension) dietary intervention effectively reduces blood pressure in various populations (Jeong *et al*., 2020; Tsioufis *et al*., 2020).

In addition, the results of this study also show that dyslipidemia and excessive salt consumption are statistically significant through the chi-square test, but not dominant enough, although both can generally be considered as risk factors for hypertension. This can be caused by several contextual factors (Bhattacharya *et al*., 2022; Imaizumi *et al*., 2017; Wu *et al*., 2020). These findings suggest that local factors, such as genetics or cultural factors, influence the body's response to dyslipidemia and high salt consumption in the context of hypertension. In this study, it was identified that cultural factors have a strong influence on the diet and health of the local community, especially in the context of hypertension. Dyslipidemia is exacerbated by the community's consumption of high-fat foods made from coconut milk. Furthermore, this poor diet is exacerbated by excessive salt consumption, coupled with the habit of serving salt at every meal, and a lack of education about the impact of excessive salt consumption and lack of attention. Thus, the cultural factors and habits of the people in this area play a large role in increasing the risk of hypertension, which shows the need for intervention and dietary changes to improve public health.

The habit of consuming foods high in fat and salt, as seen in some populations, contributes to an increased risk of hypertension. In China, for example, a diet rich in salt and fat has been linked to a higher risk of hypertension. In addition, the lack of education about the impact of excessive salt consumption exacerbates this situation, hindering the behavioral changes necessary to reduce the risk of hypertension (Mills *et al*., 2020; Wan *et al*., 2024). The consumption of oil that contains a lot of saturated fat has been proven to significantly increase total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C), both of which are risk factors for cardiovascular disease that can trigger hypertension (Dhanasekara *et al*., 2022; Jayawardena *et al*., 2020; Neelakantan *et al*., 2020). Individuals with dyslipidemia often consume more salt than is recommended, which can worsen cardiovascular risk (Guastadisegni *et al*., 2020). A poor diet pattern, including a high intake of saturated and trans fats, is common in people with dyslipidemia (Valença *et al*., 2021).

In the West African region, high consumption of fat, red meat, junk food, and alcohol was identified to contribute to a greater risk of hypertension. In contrast, consuming fruits and vegetables had a protective effect (Batubo *et al*., 2023). Meanwhile, populations in Latin America tend to have a higher genetic predisposition to hypertension, especially regarding ACE genes that interact with food consumption patterns (Zambrano *et al*., 2023). These findings reinforce the indication that genetic factors and local culture may

influence the body's response in the context of hypertension risk. Recent research has highlighted the complex relationship between lifestyle factors, cultural practices, and the risk of hypertension. The healthy lifestyle index, which combines factors such as physical activity and diet, is inversely proportional to hypertension in Sri Lanka (Fukunaga *et al*., 2020). In rural areas of northern Thailand, frequent consumption of prepared foods, eating out, and the use of MSG are associated with an increased risk of hypertension (Rusmevichientong *et al*., 2021). Cultural factors, such as the consumption of high-fat coconut milk and excessive salt intake, have been identified as contributors to the risk of hypertension (Morales & Rusmevichientong, 2020). Dietary habits show a sex-specific association with dyslipidemia in Saudi Arabia, with Turkish coffee and carbonated drinks increasing risk in men, while vegetable intake increases risk in women (Enani *et al*., 2020). These findings underscore the importance of interventions tailored to local dietary practices and cultural factors to reduce the risk of hypertension in different populations

Overall, this study addresses the research objectives by showing that poor diet, dyslipidemia, and excessive salt consumption are significant risk factors for hypertension in Kotamobagu City. It also underlines the importance of recognizing that specific conditions and local cultural adaptations strengthen the relationship between hypertension and these risk factors. Further research is expected to deepen understanding of the local factors that influence hypertension so that prevention efforts can be carried out more effectively in the local cultural and social context. The limitation of this study is that it only observes one region and does not consider genetic factors and the influence of the broader socioeconomic environment.

Conclusions

This study concluded that dyslipidemia, poor diet, and consumption of high-salt foods are the main factors closely related to higher levels of hypertension. Other factors such as low physical activity, obesity, alcohol, and smoking also show a significant relationship with hypertension. In implementing hypertension prevention and control programs, special attention should be given to middle-aged adults in areas such as Kotamobagu City. Top priority should be given to community-based interventions, such as dietary counseling, salt reduction, and promotion of a healthy lifestyle, including increased physical activity, reduced alcohol consumption, and smoking cessation, and a sustainable follow-up mechanism is needed to demonstrate the feasibility and ideal model for integrating cultural sensitivity into hypertension management programs in the 45-55 age group.

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Strategies to Improve the Performance of Medical Record Officers Through Structural Equation Model Analysis

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Abstract

This study intends to develop a performance model for hospital medical staff by analyzing the influence of work meaning and servant leadership on job performance, as well as testing the mediation role of employee gratitude and work engagement, including measuring the impact of all variables if tested simultaneously. Some previous empirical studies have stated that servant leadership has a 67% effect on improving employee performance, but other studies show the opposite. The respondents of this study were 323 medical record officers from private hospitals in Makassar City. This study uses a factorial correlation design that was tested using the Statistical Program for Social Science (SPSS) and Analysis of Moment Structure (AMOS) version 22. The study results show that employee gratitude significantly strengthens the relationship between servant leadership and job performance. In addition, work engagement has proven to be a suitable catalyst for the relationship between meaningful work and job performance. Developing dimensions and indicators of servant leadership, meaningful work, employee gratitude, work engagement, and job performance from the perspective of employee interaction with the organization is valuable in strengthening social exchange theory in the health sector. This study also suggests that hospital management should always maintain employee gratitude and employee work engagement as an effective strategy for improving the performance of hospital medical record officers.

Introduction

Hospitals function as healthcare centers responsible for patient safety and quality of life. Various studies have proven that employee performance positively impacts hospital operational efficiency in terms of accuracy of diagnosis, speed of response in emergencies, and reliability in recording and managing medical records (Ismawati *et al*., 2021; Wali *et al*., 2020). When employee performance is good, operations will be optimal to guarantee service quality. This has a real impact on patient satisfaction and the reputation of the hospital (Daraghmi *et al*., 2019). Employee performance is also critical in supporting hospital operations' sustainability amid complex work environment pressures. The healthcare sector faces severe challenges, such as high workloads, increasing patient expectations, and the demand to adhere to high service standards (Daraghmi *et al*., 2019; Wali *et al*., 2020). In these conditions, high-performing employees can handle workloads better, maintain operational stability, and ensure professional standards are met in providing services (Ismawati *et al*., 2021). This will drive cost efficiencies that are important for the financial sustainability of hospitals.

High-performing employees tend to be more engaged and motivated to contribute to developing new systems or processes. In a dynamic organization like hospitals, continuously innovating is critical in the face of changes in medical technology, health policy, and patient needs (Boonstra *et al*., 2021). Therefore,

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improving employee job performance is an operational need and an important strategy to ensure hospitals' future competitiveness and sustainability (Ismawati *et al*., 2021). In this context, servant leadership that focuses on leadership that serves and supports employees is seen as an essential factor in driving better performance (Saleem, 2022). However, studies that address the relationship between servant leadership and job performance still show inconsistencies in their findings, suggesting the need for more in-depth research to understand the mechanisms underlying the relationship. Several studies show that servant leadership positively impacts job performance because it can increase employee motivation, satisfaction, and engagement (Alahbabi *et al*., 2023; Bayangkari *et al*., 2024; Bieńkowska *et al*., 2022; Melhem *et al*., 2023; Yulihardi *et al*., 2022), while others find no significant influence (Buchori *et al*., 2023; Devi, 2022; Sriadmitum *et al*., 2023). This is the basis for this study to explore other factors in mediating the relationship, such as employee gratitude and work engagement.

In addition, studies by Song (2024) explain that good servant leadership can present employee gratitude. This is done by paying sincere attention to the needs and welfare of employees. These studies prove that gratitude strengthens emotional connections and encourages employees to work harder, show loyalty, and contribute to achieving common goals to the maximum extent (Xia, 2024). A study report by Aftab (2023) and Yao (2022) identifies work engagement as an antecedent of job performance in health services. With a strong level of engagement, employees are more motivated to achieve the best results, complete tasks efficiently, and show a high commitment to organizational goals (Aftab, 2023). Meaningful work also has a significant influence on work performance. As reported by Rabiul (2023), when individuals feel that their work has a deep meaning, they tend to be more motivated to achieve their work goals and make their best contribution. This happens because work perceived to be meaningful can provide intrinsic satisfaction, which ultimately positively impacts job performance (Ahmed, 2022). Furthermore, the study mentioned that meaningful work triggers work engagement. Individuals who feel the meaning of work will tend to be more emotionally, cognitively, and physically involved in their work. This sense of meaning strengthens their commitment to their tasks, increasing their energy, enthusiasm, and focus (Lavy, 2022; Tan, 2021).

Therefore, this study aims to test and develop a model of the influence of job performance for medical record officers in hospitals as well as test and analyze the impact of meaningful work and servant leadership on job performance, including the influence of employee gratitude and work engagement as mediation variables and to determine the influence of all variables if measured simultaneously using the social exchange theory paradigm. The modeling in this study is complex and complex and adopts an innovative approach that differentiates it from previous studies. This study explored more specific aspects and introduced new analysis methods that other researchers have not applied. Therefore, this study is expected to present new insights and enrich the scientific literature in health management.

Method

To answer the research objectives and provide a systematic overview of the research object, this study uses a quantitative approach with a descriptive type of research and a factorial correlation design (Patel & Patel, 2019). The population in this study is all 728 hospital medical record officers distributed in 35 private hospitals in Makassar City. To represent the population, the sample in each hospital was determined using the proportional random sampling method of 323 people. The data in this study were collected using a questionnaire, where each indicator was represented by one question measured by an ordinal scale. Respondents' answer options use a score range from 1 to 10. This approach is intended to minimize the potential for errors when respondents provide answers.

The model in this study consists of 5 constructions, including servant leadership, meaningful work, employee gratitude, work engagement, and job performance. The entire research construct is measured by indicators deduced from social exchange

theory. Therefore, the indicators developed are different from those of previous studies. Servant leadership measurements were synthesized from the survey with indicators such as empathetic listening, empowerment advocacy, ethical stewardship, and community building. Furthermore, meaningful work indicators are synthesized from the study form, which includes purposeful contribution, value alignment, impact awareness, and personal fulfillment. In addition, the employee gratitude indicator was measured from the synthesis of the study Hameed (2023) form, which included recognition, acknowledgment, supportive appreciation, development gratitude, and gratitude for well-being. Work engagement indicators are synthesized from the study results Zhang (2022), including vigorous involvement, cognitive absorption, emotional connection, and sustained dedication. The job performance uses indicators of the results of the synthesis of studies Ghasemy (2022): task efficiency, quality consistency, role adaptability, and proactive improvement.

The data analysis in this study uses the structural equation modeling (SEM) technique using AMOS 22 software. The selection of SEM techniques for multivariate analysis is based on several reasons: First, SEM is a multivariate analysis method that can test and display the weights and meanings of indicators simultaneously, and causal relationships in the model. Second, the SEM technique has high flexibility in model adjustment, allowing variables to simultaneously play multiple roles as exogenous, endogenous, or mediating variables. Third, SEM allows mediation and moderation analysis to be carried out in a series of integrated testing processes. Fourth, SEM techniques enable researchers to identify and measure indirect influences between variables, which is often difficult for other analysis techniques to do. Fifth, SEM techniques allow for practical and logical testing of mediation hypotheses, thus ensuring the existence of partial mediation or complete mediation. Finally, the SEM enables various types of data, including cross-sectional, longitudinal, and panel data, to provide high flexibility in its analysis (Byrne, 2016).

Result and Discussion

The respondents of this study were spread across 35 private hospitals in Makassar City, most of whom were male (90.7%), educated with Diploma 3 (64.1%), and had worked for more than 5 years (61.9%). A clear description of the research respondents can be seen in the following table 1.

The Levene test is run first on the SPSS 22 software before SEM analysis to ensure that the data is free from bias and has homogeneous properties. The test results showed that the significance of all indicators was above 0.05, so the sample data was declared homogeneous and came from the same population group. The analysis continued with a data normality test using AMOS software. The test results showed that all data were not normally distributed and were in the category of substantial negative skewness, with a CR skewness value of more than +2.58. Refer to the formula Tabanick & Fidell (2003), then the formation is carried out using the formula Lg10(K-X), where X is the normalized variable, and K is the constant. For the record, the result of the subtraction on X should still show a positive number so that the value of K = 11 corresponds to the measurement score range of 1-10. After the transformation is successfully carried out, all data is declared to have been distributed normally, and the analysis can continue. The next stage is an observation of univariate and multivariate outliers on sample data. The results showed that the z-score value was identified as < 3.0, and the value of the Mahalanobis distance shown is relatively small or on a line that follows the data distribution, so that it can be ensured that the sample data is free from univariate and multivariate outliers. The following process is to evaluate multicollinearity among exogenous variables. The analysis showed that the correlation between exogenous constructs had a coefficient of 0.752, more diminutive than 0.85, indicating no multicollinearity of exogenous variables in the model (Ghozali, 2017).

Table 1. Description of Research Respondents

Description	Frequency	Percentage (%)
Hospital	Sum	%
Jaury Academic Hospital	14	4.3
Grestelina Hospital	14	4.3
Hermina Hospital Makassar	13	4.0
Hikmah Hospital	13	4.0
Ibnu Sina Hospital Makassar	14	4.3
Faisal Islamic Hospital	12	3.7
RS Luramay	8	2.5
Mitra Husada Hospital Makassar	11	3.4
Primaya Makassar Hospital	14	4.3
Siloam Hospital Makassar	13	4.0
Stella Maris Hospital	14	4.3
East Indonesia University Tourism Hospital	9	2.8
RSIA Amanat	7	2.2
RSIA Ananda Makassar	9	2.8
RSIA Bahagia	9	2.8
RSIA Budi Mulia	9	2.8
RSIA Bunda Makassar	9	2.8
RSIA Cahaya Medika	7	2.2
RSIA Catherine Booth	9	2.8
RSIA Elim Makassar	8	2.5
RSIA Fajar Medika Nusantara	7	2.2
RSIA Gia Lestari	5	1.5
RSIA Kartini	8	2.5
RSIA Malebuh Husada	6	1.9
RSIA Masyita	9	2.8
RSIA Mutiara Aroepala	6	1.9
RSIA Paramount	10	3.1
RSIA Permata Hati	6	1.9
RSIA Prof. Dr. HM. Farid	6	1.9
RSIA Restu Makassar	7	2.2
RSIA Sayang Bunda Hertasning	7	2.2
RSIA Sentosa	10	3.1
RSIA Siti Khadijah 1	8	2.5
RSIA Siti Khadijah 3	6	1.9
RSIA Wihdatul Ummah	6	1.9
Gender	Sum	%
Man	30	9.3
Woman	293	90.7
Last Education	Sum	%
Diploma Three	207	64.1
Bachelor	116	35.9
Long Time as a Medical Records Officer	Sum	%
≤ 5 Years	123	38.1%
> 5 Years	200	61.9%

Source: Primary data, 2024

Table 2. Convergent Validity and Construct Reliability of Research Variables

Variable	Indicators	Standard Estimate	S. E	Squared Standard Estimate	Convergent Validity (>0.50)	Construct Reliability (>0.70)
Servant Leadership	Empathetic listening	0.876	0.233	0.767	0.812	0.945
		0.938	0.120	0.880		
	Ethical stewardship	0.906	0.179	0.821		
	Community building	0.883	0.220	0.780		
Meaningful Work	Purposeful contribution	0.895	0.199	0.801	0.687	0.897
	Value alignment	0.781	0.390	0.610		
	Impact awareness	0.829	0.313	0.687		
	Personal fulfillment	0.805	0.352	0.648		
Employee Gratitude	Recognition	0.718	0.484	0.516	0.516	0.810
	Support appreciation	0.695	0.517	0.483		
	Development gratitude	0.678	0.540	0.460		
	Well-being thankfulness	0.778	0.395	0.605		
Work	Vigorous involvement	0.751	0.436	0.564	0.527	0.816
	Cognitive absorption	0.697	0.514	0.486		
	Emotional connection	0.772	0.404	0.596		
	Sustained dedication	0.680	0.538	0.462		
Job	Task efficiency	0.803	0.355	0.645	0.710	0.907
	Quality consistency	0.840	0.294	0.706		
	Role adaptability	0.892	0.204	0.796		
	Proactive improvement	0.834	0.304	0.696		

Source: Primary data, 2024

After all stages were successfully implemented, the analysis continued evaluating each indicator's factorial weights using the confirmatory factor analysis (CFA) technique. The study results showed that the factorial weight value of the exogenous and endogenous variables had met the set statistical identity requirements, which was > 0.60, with a critical ratio above 1.96 at the significance probability level of <0.05. Therefore, all indicators prove to be valid representations of their variables. The results of the variable significance test and its indicators are presented in more detail in the following table.

From Table 2, all variables of this study obtained good convergent validity (>0.50), namely servant leadership (0.812), meaningful work (0.687), employee gratitude (0.516), work engagement (0.527), and job performance (0.710). The reliability measurement also meets the statistical requirements (>0.70). Each variable showed relatively high reliability, namely servant leadership (0.945), meaningful work (0.897), employee gratitude (0.810), work engagement (0.816), and job performance (0.907). Therefore, the analysis can be continued at the stage of model testing and testing of causality hypotheses. The model test in this study aims to see the overall influence of exogenous variables on endogenous variables. In addition, model testing is also intended to assess whether the built model is statistically significant (Ghozali, 2017). The main parameters in this test are the degree of the chi-square test and the degree of significance obtained. Given that the measure is difficult to achieve, the experts then developed several indices to declare the achievement of a good model (Jones, 2021). The results of the model test run in this study showed good index fulfillment and were above the required cut-off value, so the model was declared fit, as seen in the following figure and table:

The results of the full SEM test with the achievement of the index, as seen in Table 3, show that the model is well confirmed and has met the goodness of fit criteria. This means that the model developed can be tested empirically and matches existing data. In addition, the model developed is the most logical model to improve job performance for hospital medical record officers. Furthermore, observations of residual covariance from sample data were also carried out. The standardized residual covariances matrix's tolerance limit was ±2.58 with a significance level of 5%. The observation results on the output AMOS show no residual value exceeding ±2.58. Thus, it can be stated that this model qualifies as a good model (Byrne, 2016). Therefore, the analysis can be continued by testing the causality hypothesis.

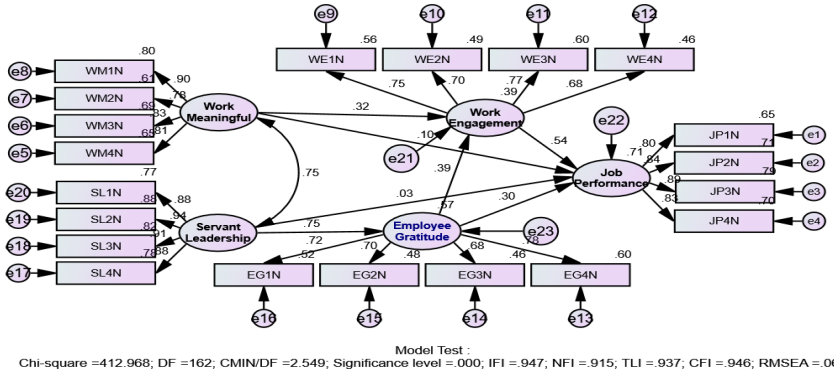

Figure 1. Model Test Results

Table 3. Model Achievement Index

Goodness of Fit Index	Cut-off Value	Result	Information
Just –Square	It is expected that the value is small	412.968	-
Significance Probability	≥ 0.05	0.000	-
CMIN/DF	≤ 2.00	2.549	-
RMSEA	≤ 0.08	0.069	Good
IFI	≥ 0.90	0.947	Good
NFI	≥ 0.90	0.915	Good
TLI	≥ 0.90	0.937	Good
CFI	≥ 0.90	0.946	Good

Source: Primary data, 2024

Each hypothesis is tested through a path coefficient with a p-value significance of less than 0.05, which indicates a significant influence. In addition, the Critical Ratio (C.R.) with a value above 1.96 strengthens the evidence of statistical significance on the path tested. The hypothesis testing in this study goes through three stages of the data processing process to ensure that all data is processed according to its respective objectives. The first stage is the analysis of confirmatory factors to identify all variables in this study. The second stage is the simultaneous testing of all hypotheses developed in the structural model, intending to ensure that each hypothesis can be tested effectively through testing the full structural model. The third stage is to test the mediation relationship formulated in this study for several mediation variables that have been previously determined. This study also developed two mediation variables in the form of employee gratitude and work engagement, which are solutions to the research gap in this research problem. This mediation test uses the bootstrapping method, a strong and accurate approach to analyzing indirect relationships (Byrne, 2016). However, the Sobel Test is still used as an additional tool and complementary analysis to confirm the mediation effect further because the Sobel Test calculates the significance directly through the z-value and displays the estimate and standard error numbers (Jones, 2021). The results of testing the causality hypothesis can be seen in the following table.

Table 4. Hypothesis Test Results

Relationship	Estimate	S.E.	C.R	P	Information
Servant Leadership → Employee Gratitude	0.633	0.051	12.443	***	Accepted
Servant Leadership → Job Performance	0.023	0.080	0.292	0.770	Rejected
Meaningful Work→ Work Engagement	0.336	0.080	4.181	***	Accepted
Meaningful Work→ Job Performance	0.103	0.068	1.518	0.129	Rejected
Employee Gratitude → Work Engagement	0.457	0.094	4.883	***	Accepted
Employee Gratitude → Job Performance	0.332	0.089	3.712	***	Accepted
Work Engagement → Job Performance	0.506	0.067	7.547	***	Accepted

Source: Primary data, 2024

Table 5. Mediation Test Results

Relationship	Mediator	C.R	S.E	P	Information
Servant Leadership → Job Performance	Employee Gratitude	3.572	0.059		Full mediation
Servant Leadership → Work Engagement	Employee Gratitude	4.526	0.064		Partial mediation
Meaningful Work→ Job Performance	Work	3.671	0.046		Full mediation
Employee Gratitude → Job Performance	Work	4.088	0.057		Full mediation

Source: Primary data, 2024

In Table 4, of the seven direct relationships tested, six hypotheses are well accepted with a CR value of > 1.96 at a significance level of < 0.05, in addition to 2 hypotheses that are declared rejected.

It can be seen in Table 5 that of the four mediation hypotheses developed, all of them show good acceptance with a CR value of > 1.96 at a significance level of < 0.05. Three show the entire mediation category, and the other 1 shows the nature of partial mediation. In principle, this study aims to examine the influence of servant leadership and work meaning on job performance and the mediation role of employee gratitude and work engagement in the relationship, and analyze the impact of all variables if measured simultaneously. Based on the analysis results, this study successfully answered the goals that had been set. The study's findings showed that of the seven direct relationships tested, five hypotheses were accepted with high significance. In addition, all mediation hypotheses tested were also accepted, with three categories of complete mediation and one partial mediation.

The results of the hypothesis test show that servant leadership is proven to increase employee gratitude significantly (Estimate = 0.633, CR = 12.443, p < 0.05). This indicates that a service-based leadership style can create high gratitude for medical record officers. Servant leaders can build positive interpersonal relationships, pay attention to employee needs, and create a supportive work environment, resulting in tremendous gratitude. As stated, these findings support previous theories and research that servant leadership contributes to increased positive emotions in the workplace. However, the direct relationship between servant leadership and job performance was insignificant (Estimate = 0.023, CR = 0.292, p = 0.770). This means that the influence of servant leadership on job performance is indirect but mediated by another variable, namely employee gratitude, as proved by Nicuță (2024) and Song (2024). Mediation analysis showed that employee gratitude could mediate this relationship (CR = 3.572, p < 0.05). In other words, servant leadership improves performance by increasing employee gratitude. These results align with research, which states that positive emotions such as gratitude bridge leadership and work results.

In addition, meaningful work significantly influenced work engagement (Estimate = 0.336, CR = 4.181, p < 0.05). These results show that the perception of meaningful work can motivate medical record officers to be more emotionally and cognitively involved. However, the direct relationship between meaningful work and job performance was insignificant (Estimate = 0.103, CR = 1.518, p = 0.129). Further analysis showed that work engagement could fully mediate this relationship (CR = 3.671, p < 0.05), meaning that meaningful work improved performance through increased engagement. These findings are consistent with studies that emphasize the importance of meaningful work in creating high work engagement.

Furthermore, employee gratitude has proven to have a significant effect on work engagement (Estimate = 0.457, CR = 4.883, p < 0.05) and job performance (Estimate = 0.332, CR = 3.712, p < 0.05). These findings reinforce the argument that gratitude is a positive emotion that encourages medical record officers to show higher commitment and perform better. This supports research Chen (2024) that reports that gratitude can improve an individual's well-

being and performance in the workplace. Work engagement was also found to significantly influence job performance (Estimate = 0.506, CR = 7.547, $p < 0.05$). This underscores the importance of work engagement as a key factor in boosting employee performance. This study proves that work engagement mediates the relationship of other variables and has a substantial direct effect on work outcomes. This fact is consistent with research stating that work engagement is the main predictor of employee performance.

In the mediation analysis, three relationships show complete mediation: Servant leadership on job performance through employee gratitude, meaningful work on job performance through work engagement, and employee gratitude on job engagement. Partial mediation is found in the relationship between servant leadership and work engagement through employee gratitude. These findings show that servant leadership has a direct influence on work engagement, as well as through the presence of employee gratitude (Hartono et al., 2021). Thus, the influence of servant leadership is complex and multidimensional, as expressed by Alahbabi et al. (2023) and Melhem et al. (2023).

Simultaneously, this analysis shows that all research variables contribute to each other in creating optimal performance. Simultaneous measurements prove that employee gratitude and work engagement are effective solutions for improving the performance of medical record officers (Baequni & Nasir, 2015; Widiarini & Nurannisa, 2022). Employee gratitude connects service-based leadership with work engagement and job performance more effectively. By increasing the grade, hospitals can create a more positive work atmosphere where officers feel valued and more motivated to perform. Gratitude can also reduce stress and improve interpersonal relationships, ultimately contributing to increased work engagement (Wijaya & Antonio, 2024). These findings support the argument of Chen (2024) that gratitude is a valuable emotional resource in the workplace.

On the other hand, work engagement significantly contributes to improving officer performance. By creating a high work engagement, medical records officers will feel more connected to their work, both emotionally and cognitively. This allows them to be more focused, proactive, and productive (Indarjo et al., 2022). Work engagement can also overcome organizational challenges such as high turnover and decreased motivation, as stated by Neuber et al. (2022), Toscano (2021), and Bizri (2021). Therefore, increasing the involvement of medical record officers in the work must be a strategic priority in hospital management. Thus, the implications of this study emphasize the importance of a holistic approach to human resource management, including the development of service-based leadership, the creation of a meaningful work environment, and the increase in employee gratitude and work engagement. These results are relevant to efforts to improve the performance of medical record officers through psychological and emotional approaches. It should be noted that the mediating variables of this study, in the form of employee gratitude and work engagement, play an important role. Therefore, hospital management can design a more targeted strategy to improve both solution variables.

Conclusion

Servant leadership has been proven to increase employee gratitude, indirectly increasing work performance. Similarly, meaningful work increases work engagement, which in turn has a positive impact on performance. This study confirms that employee gratitude and work engagement are important mechanisms bridging the relationship between other variables and are the main predictors of optimal performance. As a practical recommendation, the hospital management is advised to develop a service-based leadership training program to increase the gratitude and engagement of medical record officers. In addition, hospitals can create an emotionally and cognitively meaningful work environment and pay attention to the psychological needs of medical record officers. This effort is expected to increase their motivation, welfare, and productivity and overcome challenges such as high turnover and decreased work motivation to create a more effective and harmonious work

system.

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Organizational Factors Affecting Adoption of Electronic Medical Record (EMR) with Moderation of Openness to Experience

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Abstract

Adopting electronic medical records (EMR) in type C hospitals is essential for improving patient quality and safety. However, resistance within the healthcare industry and reluctance to accept new technologies present significant barriers. This delay in EMR implementation affects the quality of patient care and public health. This research aims to analyze the organizational factors that influence the adoption of Electronic Medical Records (EMR). There are six independent variables related to the organization, namely Management Support, Adequate Training, Patient Safety Climate, Physician's Involvement, Physician's Autonomy, and Patient Relationship. These variables are related to two mediating variables from the Technological Acceptance Model (TAM) theory, Perceived Usefulness and Perceived Ease of Use, which directly influence EMR adoption, moderating by Openness to Experience. The method used in this research was a survey of medical health workers whose work was related to EMR. Cross-sectional data were taken from 205 respondents from two type C private hospitals in December 2023. The data analysis method used was Partial Least Squares-Structural Equation Modeling (PLS-SEM). The research findings show sufficient evidence to state that all independent variables have a significant and positive influence on Perceived Usefulness and Perceived Ease of Use (P-value <0.05, CI 95%). The strongest influence was found in Patient Relationship (β=0.501) and Patient Safety Climate (β=0.404). The results of this research can provide suggestions for improving patient conditions and illnesses, thereby enhancing the quality of care and benefiting the overall health of communities through the implementation of EMR.

Introduction

The adoption of EMRs is a critical factor in enhancing healthcare delivery and improving patient outcomes. As healthcare organisations increasingly transition from paper-based systems to digital solutions, understanding the organisational factors influencing this adoption process becomes imperative (Jawhari *et al.*, 2016). This paper delves into the various organizational factors that affect the implementation and utilization of EMRs, focusing on the moderation effect of individual characteristics, specifically Openness to Experience (Zhang *et al.*, 2020). The Indonesian government actively encourages and requires the use of EMRs in health service facilities through the Indonesian Ministry of Health (Indonesian Ministry of Health, 2022). Studying the organisational factors affecting the adoption of EMRs in type C hospitals, with moderation of Openness to Experience, is crucial for several reasons. Type C hospitals often face unique challenges, such as limited financial and technical resources, which can hinder EMR adoption (Wurster *et al.*, 2023). These hospitals may face different institutional pressures compared to larger hospitals.

There is a gap in the literature regarding EMR adoption in type C hospitals (Shin *et al.*, 2021). In Indonesia, a Type C hospital must

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meet several key requirements to ensure the provision of adequate and quality healthcare services (Indonesian Ministry of Health, 2014). Firstly, these hospitals are required to offer general medical and emergency services. Additionally, they may offer other specialist services based on community needs. The infrastructure must include radiology, laboratory, pharmacy, and inpatient services, with basic medical equipment. The healthcare personnel must include general practitioners and specialists corresponding to the provided services, supported by nurses and other healthcare professionals like pharmacists, laboratory analysts, and radiographers. Meeting environmental health standards is mandatory; they need to offer a minimum of 100-200 beds. Therefore, effective management and administration systems are required, encompassing financial, human resources, and service management, along with hospital information systems that ideally include EMR (Indonesian Ministry of Health, 2014). This study can fill the gap, providing valuable data that can lead to improved strategies for EMR implementation, better healthcare outcomes, and a more comprehensive understanding of the factors influencing technology adoption in healthcare settings.

Further research is needed with data sources from medical personnel in hospitals. Therefore, a study was carried out by considering references related to the topic of EMR adoption. Several studies have been conducted on EMR adoption (Abdullah, 2023; Akwaowo *et al.*, 2022; Eden *et al.*, 2020), including research in Indonesia (Saragih *et al.*, 2020). However, only a few studies include organisational factors as independent variables. Previous research (Abdekhoda *et al.*, 2019) has highlighted the role of organization and work environment in the adoption of EMRs. These organizational factors consist of five independent variables, such as Management Support, Adequate Training, Physician's Involvement, Physician's Autonomy, and Patient Relationship. These factors are known to influence two components of TAM, namely Perceived Usefulness and Perceived Ease of Use, which have a direct impact on EMR adoption. However, this research model does not include Patient Safety, which is relevant and closely related to EMR. The study conducted by Deharja *et al.*, highlights that overall satisfaction with EMR systems is influenced significantly by user attitudes. Specifically, positive attitudes toward EMRs, such as finding the system enjoyable and useful for work, lead to higher overall satisfaction, which in turn enhances the

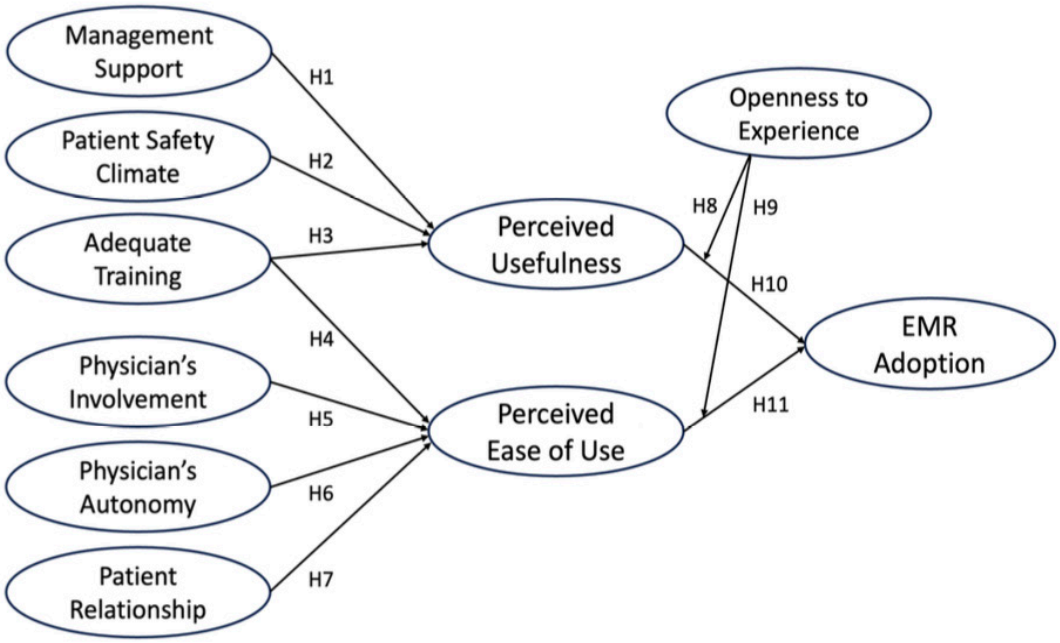

Figure 1. Conceptual Framework

perceived benefits of using the system (Deharja *et al*., 2023). This concept aligns with the role of perceived usefulness and ease of use in EMR adoption, as positive perceptions about the ease and utility of EMRs can increase overall user satisfaction. In both studies, satisfaction acts as a crucial mediator between system usage and perceived benefits, suggesting that improving user attitudes and satisfaction should be central to strategies aimed at increasing EMR adoption in type C hospitals.

The position of this research is to propose a modified research model by adding Patient Safety Climate as an independent variable that can influence Perceived Usefulness. Thus, in this model, there are six variables related to the organization, namely Management Support, Adequate Training, Patient Safety Climate, Physician's Involvement, Physician's Autonomy, and Patient Relationship. Adequate Training ensures that healthcare professionals are well-equipped with the necessary skills and knowledge to efficiently utilize EMR, thereby reducing errors and increasing efficiency. Additionally, intrinsic factors from physicians, such as their commitment to patient care and professional growth, play a critical role in the successful adoption and utilization of the EMR system (Selna *et al*., 2022). These factors will add a comprehensive understanding that can improve the delivery of patient quality of care. These six variables are related to two mediating variables derived from TAM theory, namely Perceived Usefulness and Perceived Ease of Use. These two variables have a direct influence on EMR adoption as well as mediating the influence of the independent variables. This relationship is mediated by Openness to Experience, which is one of the Five Big Personality Traits (Minbashian *et al*., 2013). Where this variable has been proven to be a significant moderating variable (Fernández-Mesa *et al*., 2020; Pagon *et al*., 2011). This model will be tested on healthcare workers at two type C hospitals whose work is related to EMR using the PLS-SEM analysis method. If the EMR adoption process takes a long time, it can hamper clinical and administrative workflows, which can result in increased workload and decreased productivity, hence reducing the quality of care given to the patients (Lloyd *et al*., 2023). Therefore, this research is important in the progress of EMR adoption in hospitals in Indonesia.

Method

This research is a quantitative cross-sectional adopts a previous research model (Donabedian, 1988) through a self-administered questionnaire distributed to healthcare workers from two type C private hospitals in Jakarta. These hospitals are owned by a group that has several hospitals in different locations and were chosen because it was recently implemented EMR in 2020. These hospitals also serve *Badan Penyelenggara Jaminan Sosial* (BPJS) and are accredited by national standards. The research population was all medical personnel who had worked for more than one year in type C private hospitals in Jakarta and whose work was related to EMR. This research used a non-probability sampling approach where individuals in the population do not have the same chance of being taken as research samples. Data were collected for 1 month in December 2023.

The survey started with an online questionnaire through Google Forms. Our study sample consisted of a total of 205 respondents who gave their informed consent and answered the questionnaire. The study received ethical approval from the Institutional Review Board of Pelita Harapan University Medical Research Council No. 026/M/EC-Nov/XI/2023. The Google Form consisted of 43 questions and was used to collect data; it was self-administered and used valid and reliable Likert-scale instruments. The survey used a questionnaire consisting of an introductory part and 2 main sections. The introductory part consisted of informed consent for this study, voluntarily, and anonymously, and will be used only for academic purposes. The first main section consisted of the respondent profile. The second main section consisted of 39 total questions with 4 questions on Adequate Training, 4 questions on EMR Adoption, 4 questions on Management Support, 3 questions on Openness to Experience, 4 questions on Patient Relationship, 4 questions on Patient Safety Climate, 4 questions on Perceived Ease of Use, 4 questions on Physician's Autonomy, 4 questions on Physician's Involvement, 4

questions on Perceived Usefulness.

EMR adoption in hospitals is based on Structure-Process-Outcome (SPO) as stated by Donabedian (Donabedian, 1988). According to the theory, hospital management can elevate organizational and environmental factors in EMR adoption to ensure high-quality patient care. Some studies stated the TAM theory of how individuals accept and use new technology or innovation (Alsyouf *et al*., 2023; Holden & Karsh, 2010; Saragih *et al*., 2020). There are 2 main key features, Perceived Usefulness and Perceived Ease of Use. Perceived Usefulness explains how individuals accept the technology if they believe that technology use will make their task easier. Perceived Ease of Use explains the user's beliefs about how easy or difficult it is to use the technology. The organizational structure and environmental factors consist of Management Support, Patient Safety Climate, Adequate Training, Physician's Involvement, Physician's Autonomy, and Patient Relationship.

This research model is a modification of previous research with 2 additions (Abdekhoda *et al*., 2019). Firstly, the Patient Safety Climate variable is included as a marker of the implementation of patient safety culture in the hospital. This variable is expected to clarify the role of the organization, especially from aspects of organizational culture related to service quality. Secondly, by placing the moderating variable Openness to Experience in predicting EMR adoption. This variable shows individuals with personalities who tend to be open to getting or learning new things (Derecho *et al*., 2024). It is hoped that the placement of this variable will help management better understand the personal background of medical personnel, which can support their performance. The data analysis method in this research was analyzed using dimensional analysis in PLS-SEM. The conceptual framework seen in Fig. 1 was regarded as a difficult research model. Therefore, the PLS-SEM approach was used since it could assess complex models in this research. When the emphasis of the investigation is on the model's explanatory and predictive qualities, PLS-SEM techniques are preferred (Hair *et al*., 2020).

Result and Discussion

This research model was conducted on two type C private hospitals in Jakarta whose work is related to EMR. There were 205 respondents, and the demographic data are presented in Table 1. The biggest percentage of respondents were 26-35 years old, followed by people 36-45 years old, whilst the smallest percentage belonged to people over 45 years old. This age data can be related to the fact that the younger generation is more exposed to information and communication technology, or is referred to as the digital generation, who are accustomed to accepting new technology, for example, the use of smartphones (Lathiifah *et al*., 2023). More than half of the respondents were Nurses, followed by General Practitioners (GP), Specialists, and Dentists. Almost half of the respondents work in the Inpatient department, while only 4 work in the Obstetric Ward. Most respondents (83%) had over three years of work experience, indicating familiarity with the hospital's organizational culture and environment. Therefore, the respondents are considered representative in providing information on organizational factors and EMR implementation in hospitals.

To assess the reliability indicator, outer loading was measured. From the results of PLS-SEM data processing, it was found that almost all outer loading values have passed the specified threshold of 0.708, except for 2 indicators. According to the guidelines for assessing outer loading results (Sarstedt, Hair, *et al*., 2022), both values can still be maintained because they are above 0.4 and their presence does not interfere with the values of the Cronbach alpha and Average Variance Extracted (AVE) variables concerned. If the outer loading value of the reflective indicator was found to be above the limit of 0.708, then the indicator was declared reliable for measuring the construct. In other words, this indicator has shown its consistency as an indicator when used repeatedly (Hair *et al*., 2020). From the internal consistency test, all constructs showed Cronbach's alpha of more than 0.7, and composite reliability is in the range of 0.7 and 0.95, indicating that the constructs' reliability in the respective models is reliable. AVE measurement determined the convergent validity. This validity check shows

Table 1. Respondent Profile

Description	Categories	Number of Respondents	Percentage (%)
Current Age	18-25 years old	40	20
	26-35 years old	78	38
	36-45 years old	52	25
	>45 years old	35	17
Total		205	100
Length of Work in the hospital	Less than 3 years	35	17
	3-5 years	55	27
	6-10 years	87	42
	More than 10 years	28	14
Total		205	100
Health Care Background	Nurse	131	64
	General Practitioner	35	17
	Dentist	7	4
	Specialist	17	8
	Other	15	7
Total		205	100
Work Unit	Inpatient	89	44
	Outpatient/ policlinic	32	16
	Emergency Department	23	11
	Intensive Care Unit (ICU)	21	10
	Operating Theatre	17	8
	Obstetric Ward	9	4
	Other	14	7
Total		205	100

Source: Primary Data (2023)

that each construct has an AVE ≥0.50, which indicates that all constructs can explain at least 50% of the item in the model, therefore establishing convergent validity (Hair *et al*., 2020). The highest AVE value is 0.808, while the lowest is 0.595. The results of the reliability and validity tests can be seen in Table 2.

The discriminant validity testing process is carried out by looking at the value of the Heterotrait-Monotrait ratio (HTMT Ratio). The interpretation of the HTMT matrix is that if the ratio value obtained is less than 0.9, it is said that the construct does not have a discriminant problem and the results are satisfactory and therefore said to be valid (Sarstedt, Radomir, *et al*., 2022). In the reporting flow of the inner model analysis results, recommendations from Hair *et al*. (2019) and Sarstedt *et al*. (2022) are followed, where, before reporting the hypothesis results, it is necessary to first evaluate the quality of the proposed research model. This is important because the goodness of fit model approach is not used in PLS-SEM (Hair *et al*., 2020). Parameters in the inner model consist of Variance Inflation Factor (VIF), R-squared (R^2), f-squared (f^2), and Q-squared predict (Q^2 predict) (Hair *et al*., 2020; Sarstedt, Hair, *et al*., 2022). Figure 2 shows the outcome of the inner model, which is the result of bootstrapping with percentile settings, a re-sample of 10.000, one-tailed, and α=0.05

Previously, common method bias, which can result from errors or biases in the measurement approach, was assessed through the inner VIF tests to check for potential multicollinearity issues. The results indicated

Table 2. Reliability And Validity Analysis

Variable	Codes	Indicators	Outer loading
Adequate Training	ADTRA1	I received the training I needed to better understand the use of electronic medical records.	0,932
	ADTRA2	Training in the use of electronic medical records is useful for me to understand how to use them properly.	0,864
	ADTRA3	Training in the use of electronic medical records made me understand new technologies that can improve the quality of patient care.	0,880
	ADTRA4	Electronic medical record training at this hospital provides new knowledge that is useful for my profession.	0,763
CA=0.887; Rho_a=0.939; Rho_c=0.920; AVE=0.743			
EMR Adoption	EMADOP1	I will continue to routinely use electronic medical records in my daily duties at this hospital.	0,772
	EMADOP2	I am willing to leave the old way and switch to using electronic medical records in this hospital.	0,846
	EMADOP3	I would also recommend the use of electronic medical records for new medical personnel working at this hospital.	0,912
	EMADOP4	I will continue to push for the use of electronic medical records in this hospital even though there are still minor errors found in the system.	0,836
CA=0.863; Rho_a=0.874; Rho_c=0.907; AVE=0.710			
	MANSU1	Implementing electronic medical records is important and a priority for top management at this hospital.	0,871
	MANSU2	So far, the process of implementing electronic medical records has been communicated effectively by the top management of this hospital.	0,876
	MANSU3	The top management of this hospital showed good intentions to assist medical personnel during the process of implementing electronic medical records.	0,816
	MANSU4	The top management of this hospital expressed their hope that I would be able to use electronic medical records according to the proposed program.	0,794
CA=0.860; Rho_a=0.863; Rho_c=0.905; AVE=0.706			
Openness to	OPTEX1	I feel like someone who enjoys learning new things in my job.	0,954
	OPTEX2	I am curious if there is a new program launched by management	0,860
	OPTEX3	I often imagine how things could be done in a different way.	0,881
CA=0.881; Rho_a=0.898; Rho_c=0.927; AVE=0.808			
Patient	PATREL1	The use of electronic medical records will not affect the credibility of doctors in the eyes of patients.	0,786
	PATREL2	With the existence of electronic medical records, patients will have more confidence in the quality of health services they receive at this hospital.	0,856
	PATREL3	The implementation of electronic medical records will not reduce the quality of communication between patients and doctors and other medical personnel.	0,624
	PATREL4	Patients will have more confidence in their doctors if electronic medical records are implemented well in this hospital.	0,799

Variable	Codes	Indicators	Outer loading
CA=0.780; Rho_a=0.829; Rho_c=0.853; AVE=0.595			
Patient Safety Climate	PATSAF1	I believe that with the presence of electronic medical records in this hospital, the treatment process with a focus on patient safety will increase.	0,880
	PATSAF2	Medical errors that can harm patients can be avoided by implementing electronic medical records in this hospital.	0,911
	PATSAF3	Electronic medical records can be used to track medical errors that occur and encourage improvements in patient safety.	0,737
	PATSAF4	Management encourages the implementation of electronic medical records to reduce the risk of medical errors occurring at this hospital.	0,840
CA=0.865; Rho_a=0.886; Rho_c=0.908; AVE=0.714			
Perceived Ease of Use	PEOUS1	In general, I feel that the electronic medical records at this hospital are easy to access and use.	0,852
	PEOUS2	I found the navigation menus in the electronic medical record easy to use.	0,865
	PEOUS3	I find it easy to understand the various menus available on the electronic medical record.	0,788
	PEOUS4	I easily got used to how to use electronic medical records at this hospital.	0,794
CA=0.845; Rho_a=0.865; Rho_c=0.895; AVE=0.681			
Physician's Autonomy	PHAUT1	Using electronic medical records will help hospital management to monitor health care and therapy provided by doctors and nurses.	0,898
	PHAUT2	The implementation of electronic medical records in this hospital will not interfere with the autonomy of doctors in assessing and making therapeutic decisions for patients.	0,917
	PHAUT3	The implementation of medical records is not intended to dictate, but will protect medical personnel from the possibility of legal claims.	0,735
	PHAUT4	I do not feel that my privacy is being disturbed by the electronic medical records at this hospital.	0,811
CA=0.862; Rho_a=0.871; Rho_c=0.907; AVE=0.711			
Physician's	PHINV1	I feel it is important to be actively involved in the process of implementing electronic medical records at this hospital.	0,837
	PHINV2	My active participation in the electronic medical record implementation process will contribute to the success of this program.	0,904
	PHINV3	I feel passionate about implementing electronic medical records in my daily work.	0,866
	PHINV4	I feel that it is my duty to support the implementation of electronic medical records in this hospital.	0,712
CA=0.851; Rho_a=0.873; Rho_c=0.900; AVE=0.694			

CA, Cronbach's Alpha; AVE, Average Variance Extracted; ADTRA, Adequate Training; EMADOP, EMR Adoption; MANSU, Management Support; OPTEX, Openness to Experience; PATREL, Patient Relationship; PATSAF, Patient Safety Climate; PEOUS, Perceived Ease of Use; PHAUT, Physician's Autonomy; PHINV, Physician's Involvement; PUSEF, Perceived Usefulness.
Source: Primary Data (2023)

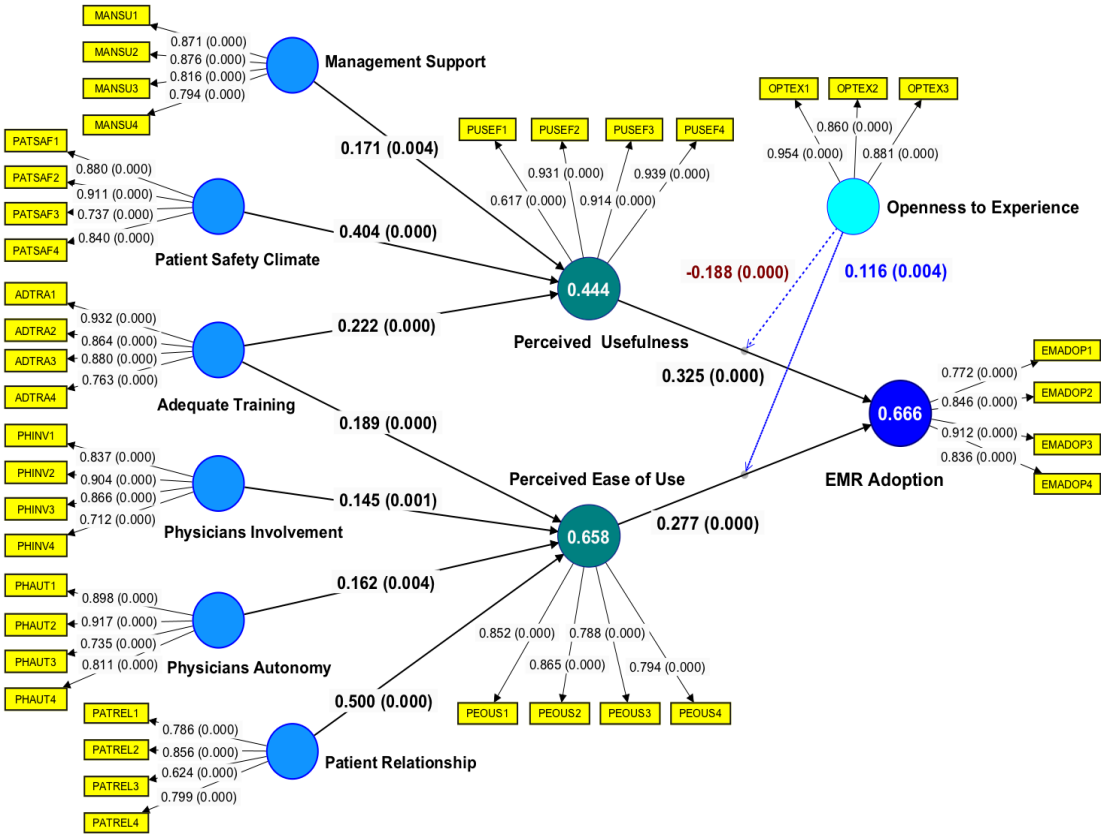

Figure 2. Inner Model

that all constructs had an inner VIF below 3, as recommended (Hair *et al.*, 2020; Sarstedt, Hair, *et al.*, 2022). Therefore, it can be concluded that there are no multicollinearity issues present in this model. The R^2 value for EMR adoption as a dependent variable is 0.666 and is therefore classified as having a moderate explanatory power category. The R^2 value for Perceived Usefulness and Perceived Ease of Use is 0.444 and 0.658, respectively. Therefore, they were classified as a moderate explanatory power category. Thus, it can be said that the respective model has a moderate explanatory capability to estimate the respective variable.

Patient Relationship has a large effect size on Perceived Ease of Use with an f^2 value of 0.398, while Patient Safety Climate shows a medium effect size, and other independent variables show a small effect size. Q^2 on EMR Adoption shows 0.611, Perceived Ease of Use shows Q^2=0.637, while Perceived Usefulness shows Q^2=0.423. Hence, EMR adoption and Perceived Ease of Use were categorized as a large predictive value (>0.5), while Perceived Usefulness was categorized as medium predictive value. From this data, it can be said that the model can be considered to have adequate predictive ability to predict EMR adoption in hospitals. The results of the comparison showed that the Average loss difference has a negative value with a p-value of 0.000, so it can be said that this model has predictive capabilities. The results of the assessment using the CVPAT method, which has predictive value, confirm that this research model is adequate in predicting EMR adoption, which is the main concern of this study.

The results of hypothesis testing with the bootstrapping feature (Table 5) showed that all hypotheses were accepted (p>0.05, Ci 5%, and CI 95% following the direction of the hypothesis). This study shows that management support has a significant positive effect on Perceived Usefulness of EMR with a coefficient of 0.171 and a P-value of 0.004, indicating that the hypothesis results are supported. These results are in line with the research of Ebnehoseini *et al*, which shows that management support is

Table 4. Cvpat

Variabel	PLS-SEM vs. *Indicator average* (IA)		PLS-SEM vs. *Linear model* (LM)	
	Average loss difference	*p-value*	*Average loss difference*	*p-value*
EMR Adoption	-0,220	0,000	0,051	0,001
Perceived Ease of Use	-0,160	0,000	0,010	0,426
Perceived Usefulness	-0,170	0,000	0,086	0,001
Overall Model	-0,183	0,000	0,049	0,000

Source: Primary Data (2023)

very important in overcoming resistance and increasing the perception of the usefulness of EMR among healthcare staff (Ebnehoseini *et al*., 2020).Strong management support facilitates the adoption of new technologies by providing the necessary resources and demonstrating the institution's commitment to EMR implementation. In addition, this study found that patient safety climate also has a significant positive effect on perceived usefulness with a coefficient of 0.404 and a P value of 0.000. This supports the findings of McAlearney *et al*, who emphasised that a positive safety environment increases the perception of EMR utility by promoting a culture of safety and reliability in healthcare practices. Thus, creating a strong safety climate can encourage the acceptance and effective use of the EMR system in type C hospitals (McAlearney *et al*., 2015).

The results of this study indicate that adequate training has a significant positive effect on Perceived Ease of Use with a coefficient of 0.189 and a P-value of 0.000. This indicates that proper training can improve nurses' ability to use EMR, which is consistent with the findings of Kipturgo *et al*., who emphasized the importance of training in increasing technology adoption (Kipturgo *et al*., 2014). In addition, physician involvement also has a positive effect on perceived ease of use with a coefficient of 0.145 and a p-value of 0.001. These results indicate that support and active involvement from physicians can help nurses feel more comfortable using EMR, supporting the research of Kalayou *et al*., which states that physician involvement is a key factor in the successful implementation of health technology (Kalayou *et al*., 2021).

Physicians' Autonomy and Patient Relationship also showed a positive effect on perceived ease of use, with coefficients of 0.162 and 0.500, respectively. These results indicate that physicians who have greater autonomy in decision-making and good relationships with patients can increase the ease of use of EMR by nurses. This finding is in line with the study by Jedwab *et al*., which found that physician autonomy and positive interactions with patients contributed to the perception of ease of use of health technology (Jedwab *et al*., 2021). The new contribution of this study, based on the Technology Acceptance Model (TAM) theory developed by Davis, is the emphasis on the importance of adequate training, physician involvement, physician autonomy, and patient relationships as critical factors in increasing the perception of ease of use of EMR. These findings broaden the understanding of the determinants influencing the adoption of health technology in private type C hospitals in Indonesia, which has previously been underexplored in this context (Schorr, 2023).

This study found that openness to experience moderates the relationship between perceived usefulness and EMR adoption with a coefficient of -0.188 (P value 0.000), indicating that openness to experience weakens this relationship. This indicates that individuals who are more open to new experiences may be more critical of the usefulness of EMR and need more reasons to adopt it. This study also found that openness to experience strengthens the relationship between perceived ease of use and EMR adoption with a coefficient of 0.116 (P value 0.004). This means that more open individuals tend to be more receptive to EMR if they feel the technology is easy to use. This finding is consistent with previous research by Svendsen *et al*., which showed that individuals with high levels of openness tend to be more critical but also more adaptive to easy-to-use technology (Svendsen *et al*., 2013). This study

extends the TAM theory by showing that personality characteristics such as openness to experience can influence technology adoption. This highlights the importance of considering personality factors in EMR implementation strategies to increase adoption rates and user satisfaction.

This study found that perceived usefulness has a significant positive effect on EMR adoption with a coefficient of 0.325 (P value 0.000), indicating that the perception of usefulness of EMR increases the adoption of this technology among nurses in type C hospitals. In addition, perceived ease of use is also proven to have a significant positive effect on EMR adoption with a coefficient of 0.277 (P value 0.000), which means that the ease of use of EMR also encourages its adoption. This finding is consistent with Davis's TAM theory, which identifies perceived usefulness and perceived ease of use as the main factors influencing technology acceptance(Schorr, 2023). A study by Alaa and Ramayah showed similar results where perceived usefulness and perceived ease of use contributed significantly to the adoption of health information systems in various clinical settings(Alaa & Ramayah, 2023). The novel contribution of this study lies in the specific context of type C hospitals in Indonesia, strengthening the external validity of the TAM theory by confirming that these factors remain relevant in different settings and highlighting the importance of these two constructs in EMR implementation strategies to increase adoption rates in type C hospitals.

This study adds one variable, namely

Table 5. Hypothesis Test Results

Hypothesis		*Standard -ized Coefficient*	P-*values*	*Confidence Interval* (CI 95%)		f^2	Result
				Lower 5.0%	*Upper* 95.0%		
H1	*Management Support -> Perceived Usefulness*	0,171	0,004	0,068	0,281	0.035	Hypothesis Supported
H2	*Patient Safety Climate -> Perceived Usefulness*	0,404	0,000	0,299	0,505	0.188	Hypothesis Supported
H3	*Adequate Training -> Perceived Usefulness*	0,222	0,000	0,105	0,322	0.059	Hypothesis Supported
H4	*Adequate Training -> Perceived Ease of Use*	0,189	0,000	0,107	0,272	0.066	Hypothesis Supported
H5	*Physicians' Involvement -> Perceived Ease of Use*	0,145	0,001	0,066	0,228	0.043	Hypothesis Supported
H6	*Physicians Autonomy -> Perceived Ease of Use*	0,162	0,004	0,060	0,258	0.053	Hypothesis Supported
H7	*Patient Relationship -> Perceived Ease of Use*	0,500	0,000	0,383	0,619	0.398	Hypothesis Supported
H8	*Openness to Experience x Perceived Usefulness -> EMR Adoption*	-0,188	0,000	-0,262	-0,120	0.070	Hypothesis Supported
H9	*Openness to Experience x Perceived Ease of Use -> EMR Adoption*	0,116	0,004	0,043	0,186	0.026	Hypothesis Supported
H10	*Perceived Usefulness -> EMR Adoption*	0,325	0,000	0,240	0,409	0.198	Hypothesis Supported

Hypothesis		*Standard -ized Coefficient*	P-*values*	*Confidence Interval* (CI 95%)		f^2	Result
				Lower 5.0%	*Upper* 95.0%		
H11	*Perceived Ease of Use -> EMR Adoption*	0,277	0,000	0,185	0,369	0.124	Hypothesis Supported

Source: Primary Data (2023)

Openness to Experience, from the Big Five Personality Traits is argumentatively more relevant and important as a moderator of the relationship between TAM and EMR adoption than the other four personality traits because openness to experience is directly related to the tendency to accept and adapt to new technologies. Individuals with high levels of openness are more likely to explore, understand, and adopt new technologies, including EMR, compared to individuals with high levels of conscientiousness, extraversion, agreeableness, or neuroticism (Devaraj *et al*., 2008). Psychological theory suggests that openness to experience fosters creativity and innovation, which are critical in responding to technological change. Research by Svendsen *et al*., confirmed that openness to experience influences how individuals integrate new technologies into their work practices, strengthening the relationship between perceived ease of use and perceived usefulness with technology adoption(Svendsen *et al*., 2013). Thus, openness to experience provides a more comprehensive framework for understanding the dynamics of EMR adoption through TAM.

From the analysis results, it is known that this research model has moderate explanatory power (R^2), but in segment analysis (PLS-POS), it can increase to strong explanatory power. Furthermore, this research model is known to have large predictive relevance (Q^2_predict) for the EMR adoption variable. The overall predictive ability of this model is confirmed by the results of the cross-validated prediction ability test (CVPAT). Thus, it can be concluded that the proposed research model is adequate to explain and predict EMR adoption in type C private hospitals. So this model can also be recommended for use in further research.

This study's novel contribution is to demonstrate a new independent variable on Organizational factors, namely Patient Safety Climate, and a new moderation variable, namely Openness to Experience, between perceived usefulness and perceived ease of use to EMR adoption from one of the Big Five Personality Traits. This study reveals how individual characteristics that are open to new experiences can influence EMR adoption. These findings can be used by healthcare institutions to design training programs and more personalized approaches to implementing health technology, thereby increasing the acceptance and effective use of EMR. With better implementation of EMR, the quality of care and patient safety can be improved, and medical errors can be reduced. This finding also aligns with a study conducted by Fitriani *et al*., that states that clinical governance, as measured by five dimensions and mediated by a patient safety culture, significantly impacts the quality of care (QOC) in hospitals. The study emphasizes that proactive risk management, integrated quality improvement, training and development, and a positive safety climate all contribute to improving QOC (Fitriani *et al*., 2024). The adoption of EMR systems may also be improved by focusing on factors such as training and supportive management, which facilitate ease of use and perceived usefulness, similar to how patient safety culture mediates the impact of clinical governance on care quality. Both research pieces underscore the importance of a structured and supportive work environment to drive successful technology adoption and improve healthcare outcomes. A study conducted by Sutanto *et al*., highlights the critical role of organizational culture and training in influencing healthcare outcomes. Factors like management support and adequate training are key in shaping perceived usefulness and ease of use, which can enhance EMR adoption. Similarly, fostering a safety culture

through empowerment can facilitate EMR adoption, as empowered healthcare personnel are more likely to embrace and effectively use digital health technologies (Sutanto *et al*., 2024).

The previous study conducted by Dewi and Mahyuni showed that there is a genuine demand for digital healthcare services driven by both necessity and hedonic factors (Dewi & Mahyuni, 2024). The findings highlight the need for developers to enhance usability and create appealing interfaces to improve the acceptance of digital healthcare. Additionally, it suggests that addressing user feedback by improving ease of use and increasing advertising efforts will help in broader adoption. In this study, organizational factors such as adequate training and patient safety climate are crucial for fostering positive attitudes toward EMR, and usability and ease of use are key in enhancing the adoption of digital health solutions. Both of these research findings correlate the critical role of user satisfaction and positive experiences in ensuring the successful adoption of healthcare technologies. Furthermore, understanding the role of personality in technology adoption can help hospital policy makers in developing strategies that are more adaptive to the characteristics of healthcare workers, thereby accelerating digital transformation in the healthcare sector that directly benefits the wider community, which has an impact on healthcare services and public health in general. The next limitation is that the results of the latent class analysis with PLS-POS of this study obtained unobserved heterogeneity, so it is recommended that this finding be followed up in further research to identify what attributes exist in the respondent segment or what factors differentiate the segment. This is needed to obtain homogeneous response data with certain criteria so that the model's predictive ability can be more adequate. Another limitation of this study is that there may be other Big 5 personality traits that influence EMR adoption that cause the data to be insignificant, so I suggest that data moderation other than openness to experience, such as Consciousness, can be conducted in research on EMR adoption for healthcare workers.

Conclusion

This study revealed that management support, patient safety climate, and adequate training had a significant positive effect on perceived usefulness and perceived ease of use of EMR, which is consistent with previous studies. Strong management support and positive safety climate encourage EMR adoption by providing resources and promoting a safety culture. Adequate training and physician involvement also increase EMR ease of use. Openness to Experience was found to negatively moderate the relationship between perceived usefulness and EMR adoption, but strengthen the relationship between perceived ease of use and EMR adoption, indicating that individuals with high levels of openness tend to be more critical but also more adaptive to new technologies. These findings extend the TAM theory by emphasizing the importance of personality factors in EMR implementation strategies. This study also confirms the relevance of perceived usefulness and perceived ease of use in EMR adoption in type C hospitals in Indonesia, strengthening the external validity of the TAM theory.

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Organizational Factors Affecting Adoption of Electronic Medical Record (EMR) with Moderation of Openness to Experience

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Abstract

Adopting electronic medical records (EMR) in type C hospitals is essential for improving patient quality and safety. However, resistance within the healthcare industry and reluctance to accept new technologies present significant barriers. This delay in EMR implementation affects the quality of patient care and public health. This research aims to analyze the organizational factors that influence the adoption of Electronic Medical Records (EMR). There are six independent variables related to the organization, namely Management Support, Adequate Training, Patient Safety Climate, Physician's Involvement, Physician's Autonomy, and Patient Relationship. These variables are related to two mediating variables from the Technological Acceptance Model (TAM) theory, Perceived Usefulness and Perceived Ease of Use, which directly influence EMR adoption, moderating by Openness to Experience. The method used in this research was a survey of medical health workers whose work was related to EMR. Cross-sectional data were taken from 205 respondents from two type C private hospitals in December 2023. The data analysis method used was Partial Least Squares-Structural Equation Modeling (PLS-SEM). The research findings show sufficient evidence to state that all independent variables have a significant and positive influence on Perceived Usefulness and Perceived Ease of Use (P-value <0.05, CI 95%). The strongest influence was found in Patient Relationship (β=0.501) and Patient Safety Climate (β=0.404). The results of this research can provide suggestions for improving patient conditions and illnesses, thereby enhancing the quality of care and benefiting the overall health of communities through the implementation of EMR.

Introduction

The adoption of EMRs is a critical factor in enhancing healthcare delivery and improving patient outcomes. As healthcare organisations increasingly transition from paper-based systems to digital solutions, understanding the organisational factors influencing this adoption process becomes imperative (Jawhari *et al.*, 2016). This paper delves into the various organizational factors that affect the implementation and utilization of EMRs, focusing on the moderation effect of individual characteristics, specifically Openness to Experience (Zhang *et al.*, 2020). The Indonesian government actively encourages and requires the use of EMRs in health service facilities through the Indonesian Ministry of Health (Indonesian Ministry of Health, 2022). Studying the organisational factors affecting the adoption of EMRs in type C hospitals, with moderation of Openness to Experience, is crucial for several reasons. Type C hospitals often face unique challenges, such as limited financial and technical resources, which can hinder EMR adoption (Wurster *et al.*, 2023). These hospitals may face different institutional pressures compared to larger hospitals.

There is a gap in the literature regarding EMR adoption in type C hospitals (Shin *et al.*, 2021). In Indonesia, a Type C hospital must

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meet several key requirements to ensure the provision of adequate and quality healthcare services (Indonesian Ministry of Health, 2014). Firstly, these hospitals are required to offer general medical and emergency services. Additionally, they may offer other specialist services based on community needs. The infrastructure must include radiology, laboratory, pharmacy, and inpatient services, with basic medical equipment. The healthcare personnel must include general practitioners and specialists corresponding to the provided services, supported by nurses and other healthcare professionals like pharmacists, laboratory analysts, and radiographers. Meeting environmental health standards is mandatory; they need to offer a minimum of 100-200 beds. Therefore, effective management and administration systems are required, encompassing financial, human resources, and service management, along with hospital information systems that ideally include EMR (Indonesian Ministry of Health, 2014). This study can fill the gap, providing valuable data that can lead to improved strategies for EMR implementation, better healthcare outcomes, and a more comprehensive understanding of the factors influencing technology adoption in healthcare settings.

Further research is needed with data sources from medical personnel in hospitals. Therefore, a study was carried out by considering references related to the topic of EMR adoption. Several studies have been conducted on EMR adoption (Abdullah, 2023; Akwaowo *et al.*, 2022; Eden *et al.*, 2020), including research in Indonesia (Saragih *et al.*, 2020). However, only a few studies include organisational factors as independent variables. Previous research (Abdekhoda *et al.*, 2019) has highlighted the role of organization and work environment in the adoption of EMRs. These organizational factors consist of five independent variables, such as Management Support, Adequate Training, Physician's Involvement, Physician's Autonomy, and Patient Relationship. These factors are known to influence two components of TAM, namely Perceived Usefulness and Perceived Ease of Use, which have a direct impact on EMR adoption. However, this research model does not include Patient Safety, which is relevant and closely related to EMR. The study conducted by Deharja *et al.*, highlights that overall satisfaction with EMR systems is influenced significantly by user attitudes. Specifically, positive attitudes toward EMRs, such as finding the system enjoyable and useful for work, lead to higher overall satisfaction, which in turn enhances the

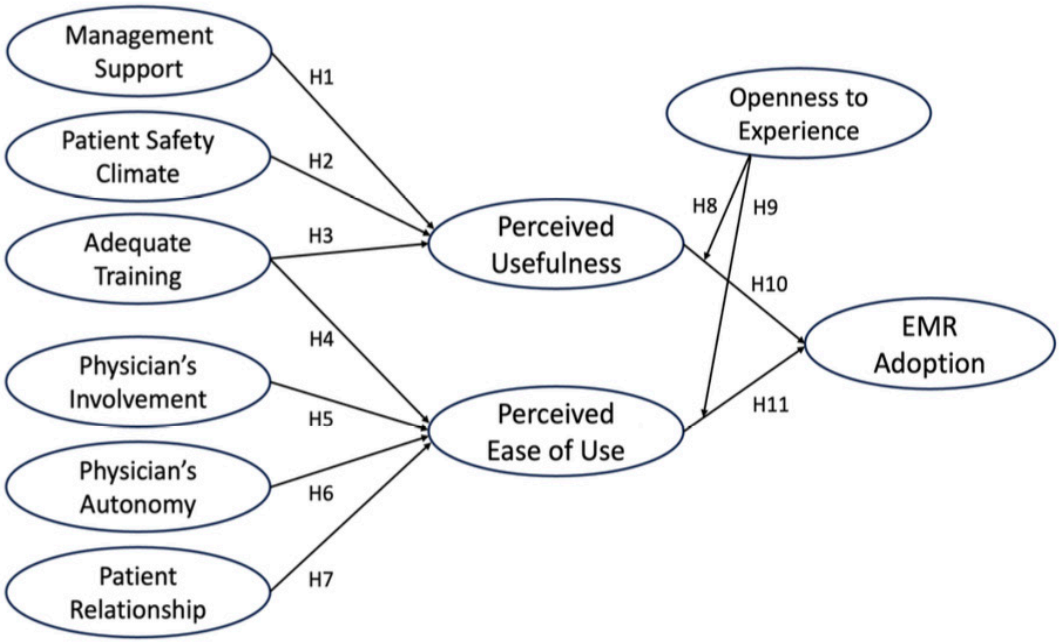

Figure 1. Conceptual Framework

perceived benefits of using the system (Deharja *et al*., 2023). This concept aligns with the role of perceived usefulness and ease of use in EMR adoption, as positive perceptions about the ease and utility of EMRs can increase overall user satisfaction. In both studies, satisfaction acts as a crucial mediator between system usage and perceived benefits, suggesting that improving user attitudes and satisfaction should be central to strategies aimed at increasing EMR adoption in type C hospitals.

The position of this research is to propose a modified research model by adding Patient Safety Climate as an independent variable that can influence Perceived Usefulness. Thus, in this model, there are six variables related to the organization, namely Management Support, Adequate Training, Patient Safety Climate, Physician's Involvement, Physician's Autonomy, and Patient Relationship. Adequate Training ensures that healthcare professionals are well-equipped with the necessary skills and knowledge to efficiently utilize EMR, thereby reducing errors and increasing efficiency. Additionally, intrinsic factors from physicians, such as their commitment to patient care and professional growth, play a critical role in the successful adoption and utilization of the EMR system (Selna *et al*., 2022). These factors will add a comprehensive understanding that can improve the delivery of patient quality of care. These six variables are related to two mediating variables derived from TAM theory, namely Perceived Usefulness and Perceived Ease of Use. These two variables have a direct influence on EMR adoption as well as mediating the influence of the independent variables. This relationship is mediated by Openness to Experience, which is one of the Five Big Personality Traits (Minbashian *et al*., 2013). Where this variable has been proven to be a significant moderating variable (Fernández-Mesa *et al*., 2020; Pagon *et al*., 2011). This model will be tested on healthcare workers at two type C hospitals whose work is related to EMR using the PLS-SEM analysis method. If the EMR adoption process takes a long time, it can hamper clinical and administrative workflows, which can result in increased workload and decreased productivity, hence reducing the quality of care given to the patients (Lloyd *et al*., 2023). Therefore, this research is important in the progress of EMR adoption in hospitals in Indonesia.

Method

This research is a quantitative cross-sectional adopts a previous research model (Donabedian, 1988) through a self-administered questionnaire distributed to healthcare workers from two type C private hospitals in Jakarta. These hospitals are owned by a group that has several hospitals in different locations and were chosen because it was recently implemented EMR in 2020. These hospitals also serve *Badan Penyelenggara Jaminan Sosial* (BPJS) and are accredited by national standards. The research population was all medical personnel who had worked for more than one year in type C private hospitals in Jakarta and whose work was related to EMR. This research used a non-probability sampling approach where individuals in the population do not have the same chance of being taken as research samples. Data were collected for 1 month in December 2023.

The survey started with an online questionnaire through Google Forms. Our study sample consisted of a total of 205 respondents who gave their informed consent and answered the questionnaire. The study received ethical approval from the Institutional Review Board of Pelita Harapan University Medical Research Council No. 026/M/EC-Nov/XI/2023. The Google Form consisted of 43 questions and was used to collect data; it was self-administered and used valid and reliable Likert-scale instruments. The survey used a questionnaire consisting of an introductory part and 2 main sections. The introductory part consisted of informed consent for this study, voluntarily, and anonymously, and will be used only for academic purposes. The first main section consisted of the respondent profile. The second main section consisted of 39 total questions with 4 questions on Adequate Training, 4 questions on EMR Adoption, 4 questions on Management Support, 3 questions on Openness to Experience, 4 questions on Patient Relationship, 4 questions on Patient Safety Climate, 4 questions on Perceived Ease of Use, 4 questions on Physician's Autonomy, 4 questions on Physician's Involvement, 4

questions on Perceived Usefulness.

EMR adoption in hospitals is based on Structure-Process-Outcome (SPO) as stated by Donabedian (Donabedian, 1988). According to the theory, hospital management can elevate organizational and environmental factors in EMR adoption to ensure high-quality patient care. Some studies stated the TAM theory of how individuals accept and use new technology or innovation (Alsyouf *et al*., 2023; Holden & Karsh, 2010; Saragih *et al*., 2020). There are 2 main key features, Perceived Usefulness and Perceived Ease of Use. Perceived Usefulness explains how individuals accept the technology if they believe that technology use will make their task easier. Perceived Ease of Use explains the user's beliefs about how easy or difficult it is to use the technology. The organizational structure and environmental factors consist of Management Support, Patient Safety Climate, Adequate Training, Physician's Involvement, Physician's Autonomy, and Patient Relationship.

This research model is a modification of previous research with 2 additions (Abdekhoda *et al*., 2019). Firstly, the Patient Safety Climate variable is included as a marker of the implementation of patient safety culture in the hospital. This variable is expected to clarify the role of the organization, especially from aspects of organizational culture related to service quality. Secondly, by placing the moderating variable Openness to Experience in predicting EMR adoption. This variable shows individuals with personalities who tend to be open to getting or learning new things (Derecho *et al*., 2024). It is hoped that the placement of this variable will help management better understand the personal background of medical personnel, which can support their performance. The data analysis method in this research was analyzed using dimensional analysis in PLS-SEM. The conceptual framework seen in Fig. 1 was regarded as a difficult research model. Therefore, the PLS-SEM approach was used since it could assess complex models in this research. When the emphasis of the investigation is on the model's explanatory and predictive qualities, PLS-SEM techniques are preferred (Hair *et al*., 2020).

Result and Discussion

This research model was conducted on two type C private hospitals in Jakarta whose work is related to EMR. There were 205 respondents, and the demographic data are presented in Table 1. The biggest percentage of respondents were 26-35 years old, followed by people 36-45 years old, whilst the smallest percentage belonged to people over 45 years old. This age data can be related to the fact that the younger generation is more exposed to information and communication technology, or is referred to as the digital generation, who are accustomed to accepting new technology, for example, the use of smartphones (Lathiifah *et al*., 2023). More than half of the respondents were Nurses, followed by General Practitioners (GP), Specialists, and Dentists. Almost half of the respondents work in the Inpatient department, while only 4 work in the Obstetric Ward. Most respondents (83%) had over three years of work experience, indicating familiarity with the hospital's organizational culture and environment. Therefore, the respondents are considered representative in providing information on organizational factors and EMR implementation in hospitals.

To assess the reliability indicator, outer loading was measured. From the results of PLS-SEM data processing, it was found that almost all outer loading values have passed the specified threshold of 0.708, except for 2 indicators. According to the guidelines for assessing outer loading results (Sarstedt, Hair, *et al*., 2022), both values can still be maintained because they are above 0.4 and their presence does not interfere with the values of the Cronbach alpha and Average Variance Extracted (AVE) variables concerned. If the outer loading value of the reflective indicator was found to be above the limit of 0.708, then the indicator was declared reliable for measuring the construct. In other words, this indicator has shown its consistency as an indicator when used repeatedly (Hair *et al*., 2020). From the internal consistency test, all constructs showed Cronbach's alpha of more than 0.7, and composite reliability is in the range of 0.7 and 0.95, indicating that the constructs' reliability in the respective models is reliable. AVE measurement determined the convergent validity. This validity check shows

Table 1. Respondent Profile

Description	Categories	Number of Respondents	Percentage (%)
Current Age	18-25 years old	40	20
	26-35 years old	78	38
	36-45 years old	52	25
	>45 years old	35	17
Total		205	100
Length of Work in the hospital	Less than 3 years	35	17
	3-5 years	55	27
	6-10 years	87	42
	More than 10 years	28	14
Total		205	100
Health Care Background	Nurse	131	64
	General Practitioner	35	17
	Dentist	7	4
	Specialist	17	8
	Other	15	7
Total		205	100
Work Unit	Inpatient	89	44
	Outpatient/ policlinic	32	16
	Emergency Department	23	11
	Intensive Care Unit (ICU)	21	10
	Operating Theatre	17	8
	Obstetric Ward	9	4
	Other	14	7
Total		205	100

Source: Primary Data (2023)

that each construct has an AVE ≥0.50, which indicates that all constructs can explain at least 50% of the item in the model, therefore establishing convergent validity (Hair *et al*., 2020). The highest AVE value is 0.808, while the lowest is 0.595. The results of the reliability and validity tests can be seen in Table 2.

The discriminant validity testing process is carried out by looking at the value of the Heterotrait-Monotrait ratio (HTMT Ratio). The interpretation of the HTMT matrix is that if the ratio value obtained is less than 0.9, it is said that the construct does not have a discriminant problem and the results are satisfactory and therefore said to be valid (Sarstedt, Radomir, *et al*., 2022). In the reporting flow of the inner model analysis results, recommendations from Hair *et al*. (2019) and Sarstedt *et al*. (2022) are followed, where, before reporting the hypothesis results, it is necessary to first evaluate the quality of the proposed research model. This is important because the goodness of fit model approach is not used in PLS-SEM (Hair *et al*., 2020). Parameters in the inner model consist of Variance Inflation Factor (VIF), R-squared (R^2), f-squared (f^2), and Q-squared predict (Q^2 predict) (Hair *et al*., 2020; Sarstedt, Hair, *et al*., 2022). Figure 2 shows the outcome of the inner model, which is the result of bootstrapping with percentile settings, a re-sample of 10.000, one-tailed, and α=0.05

Previously, common method bias, which can result from errors or biases in the measurement approach, was assessed through the inner VIF tests to check for potential multicollinearity issues. The results indicated

Table 2. Reliability And Validity Analysis

Variable	Codes	Indicators	Outer loading
Adequate Training	ADTRA1	I received the training I needed to better understand the use of electronic medical records.	0,932
	ADTRA2	Training in the use of electronic medical records is useful for me to understand how to use them properly.	0,864
	ADTRA3	Training in the use of electronic medical records made me understand new technologies that can improve the quality of patient care.	0,880
	ADTRA4	Electronic medical record training at this hospital provides new knowledge that is useful for my profession.	0,763
CA=0.887; Rho_a=0.939; Rho_c=0.920; AVE=0.743			
EMR Adoption	EMADOP1	I will continue to routinely use electronic medical records in my daily duties at this hospital.	0,772
	EMADOP2	I am willing to leave the old way and switch to using electronic medical records in this hospital.	0,846
	EMADOP3	I would also recommend the use of electronic medical records for new medical personnel working at this hospital.	0,912
	EMADOP4	I will continue to push for the use of electronic medical records in this hospital even though there are still minor errors found in the system.	0,836
CA=0.863; Rho_a=0.874; Rho_c=0.907; AVE=0.710			
	MANSU1	Implementing electronic medical records is important and a priority for top management at this hospital.	0,871
	MANSU2	So far, the process of implementing electronic medical records has been communicated effectively by the top management of this hospital.	0,876
	MANSU3	The top management of this hospital showed good intentions to assist medical personnel during the process of implementing electronic medical records.	0,816
	MANSU4	The top management of this hospital expressed their hope that I would be able to use electronic medical records according to the proposed program.	0,794
CA=0.860; Rho_a=0.863; Rho_c=0.905; AVE=0.706			
Openness to	OPTEX1	I feel like someone who enjoys learning new things in my job.	0,954
	OPTEX2	I am curious if there is a new program launched by management	0,860
	OPTEX3	I often imagine how things could be done in a different way.	0,881
CA=0.881; Rho_a=0.898; Rho_c=0.927; AVE=0.808			
Patient	PATREL1	The use of electronic medical records will not affect the credibility of doctors in the eyes of patients.	0,786
	PATREL2	With the existence of electronic medical records, patients will have more confidence in the quality of health services they receive at this hospital.	0,856
	PATREL3	The implementation of electronic medical records will not reduce the quality of communication between patients and doctors and other medical personnel.	0,624
	PATREL4	Patients will have more confidence in their doctors if electronic medical records are implemented well in this hospital.	0,799

Variable	Codes	Indicators	Outer loading
CA=0.780; Rho_a=0.829; Rho_c=0.853; AVE=0.595			
Patient Safety Climate	PATSAF1	I believe that with the presence of electronic medical records in this hospital, the treatment process with a focus on patient safety will increase.	0,880
	PATSAF2	Medical errors that can harm patients can be avoided by implementing electronic medical records in this hospital.	0,911
	PATSAF3	Electronic medical records can be used to track medical errors that occur and encourage improvements in patient safety.	0,737
	PATSAF4	Management encourages the implementation of electronic medical records to reduce the risk of medical errors occurring at this hospital.	0,840
CA=0.865; Rho_a=0.886; Rho_c=0.908; AVE=0.714			
Perceived Ease of Use	PEOUS1	In general, I feel that the electronic medical records at this hospital are easy to access and use.	0,852
	PEOUS2	I found the navigation menus in the electronic medical record easy to use.	0,865
	PEOUS3	I find it easy to understand the various menus available on the electronic medical record.	0,788
	PEOUS4	I easily got used to how to use electronic medical records at this hospital.	0,794
CA=0.845; Rho_a=0.865; Rho_c=0.895; AVE=0.681			
Physician's Autonomy	PHAUT1	Using electronic medical records will help hospital management to monitor health care and therapy provided by doctors and nurses.	0,898
	PHAUT2	The implementation of electronic medical records in this hospital will not interfere with the autonomy of doctors in assessing and making therapeutic decisions for patients.	0,917
	PHAUT3	The implementation of medical records is not intended to dictate, but will protect medical personnel from the possibility of legal claims.	0,735
	PHAUT4	I do not feel that my privacy is being disturbed by the electronic medical records at this hospital.	0,811
CA=0.862; Rho_a=0.871; Rho_c=0.907; AVE=0.711			
Physician's	PHINV1	I feel it is important to be actively involved in the process of implementing electronic medical records at this hospital.	0,837
	PHINV2	My active participation in the electronic medical record implementation process will contribute to the success of this program.	0,904
	PHINV3	I feel passionate about implementing electronic medical records in my daily work.	0,866
	PHINV4	I feel that it is my duty to support the implementation of electronic medical records in this hospital.	0,712
CA=0.851; Rho_a=0.873; Rho_c=0.900; AVE=0.694			

CA, Cronbach's Alpha; AVE, Average Variance Extracted; ADTRA, Adequate Training; EMADOP, EMR Adoption; MANSU, Management Support; OPTEX, Openness to Experience; PATREL, Patient Relationship; PATSAF, Patient Safety Climate; PEOUS, Perceived Ease of Use; PHAUT, Physician's Autonomy; PHINV, Physician's Involvement; PUSEF, Perceived Usefulness.
Source: Primary Data (2023)

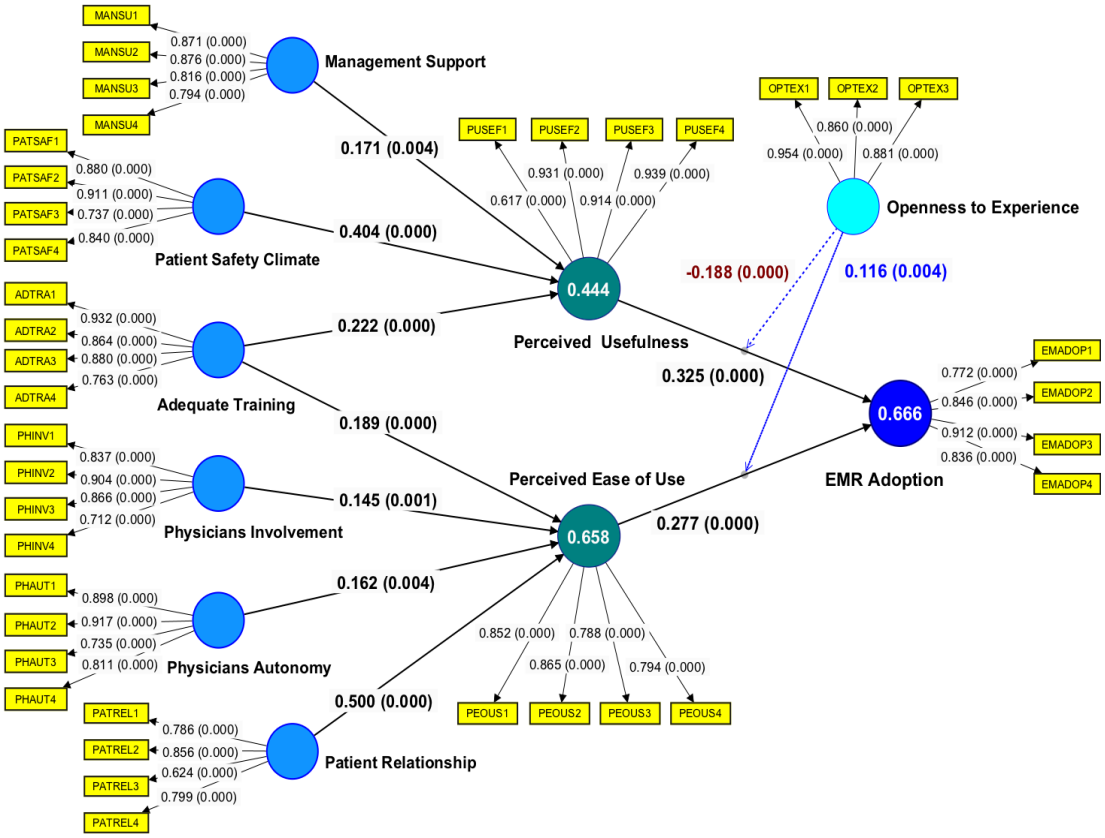

Figure 2. Inner Model

that all constructs had an inner VIF below 3, as recommended (Hair *et al.*, 2020; Sarstedt, Hair, *et al.*, 2022). Therefore, it can be concluded that there are no multicollinearity issues present in this model. The R^2 value for EMR adoption as a dependent variable is 0.666 and is therefore classified as having a moderate explanatory power category. The R^2 value for Perceived Usefulness and Perceived Ease of Use is 0.444 and 0.658, respectively. Therefore, they were classified as a moderate explanatory power category. Thus, it can be said that the respective model has a moderate explanatory capability to estimate the respective variable.

Patient Relationship has a large effect size on Perceived Ease of Use with an f^2 value of 0.398, while Patient Safety Climate shows a medium effect size, and other independent variables show a small effect size. Q^2 on EMR Adoption shows 0.611, Perceived Ease of Use shows Q^2=0.637, while Perceived Usefulness shows Q^2=0.423. Hence, EMR adoption and Perceived Ease of Use were categorized as a large predictive value (>0.5), while Perceived Usefulness was categorized as medium predictive value. From this data, it can be said that the model can be considered to have adequate predictive ability to predict EMR adoption in hospitals. The results of the comparison showed that the Average loss difference has a negative value with a p-value of 0.000, so it can be said that this model has predictive capabilities. The results of the assessment using the CVPAT method, which has predictive value, confirm that this research model is adequate in predicting EMR adoption, which is the main concern of this study.

The results of hypothesis testing with the bootstrapping feature (Table 5) showed that all hypotheses were accepted (p>0.05, Ci 5%, and CI 95% following the direction of the hypothesis). This study shows that management support has a significant positive effect on Perceived Usefulness of EMR with a coefficient of 0.171 and a P-value of 0.004, indicating that the hypothesis results are supported. These results are in line with the research of Ebnehoseini *et al*, which shows that management support is

Table 4. Cvpat

Variabel	PLS-SEM vs. *Indicator average* (IA)		PLS-SEM vs. *Linear model* (LM)	
	Average loss difference	*p-value*	*Average loss difference*	*p-value*
EMR Adoption	-0,220	0,000	0,051	0,001
Perceived Ease of Use	-0,160	0,000	0,010	0,426
Perceived Usefulness	-0,170	0,000	0,086	0,001
Overall Model	-0,183	0,000	0,049	0,000

Source: Primary Data (2023)

very important in overcoming resistance and increasing the perception of the usefulness of EMR among healthcare staff (Ebnehoseini *et al*., 2020).Strong management support facilitates the adoption of new technologies by providing the necessary resources and demonstrating the institution's commitment to EMR implementation. In addition, this study found that patient safety climate also has a significant positive effect on perceived usefulness with a coefficient of 0.404 and a P value of 0.000. This supports the findings of McAlearney *et al*, who emphasised that a positive safety environment increases the perception of EMR utility by promoting a culture of safety and reliability in healthcare practices. Thus, creating a strong safety climate can encourage the acceptance and effective use of the EMR system in type C hospitals (McAlearney *et al*., 2015).

The results of this study indicate that adequate training has a significant positive effect on Perceived Ease of Use with a coefficient of 0.189 and a P-value of 0.000. This indicates that proper training can improve nurses' ability to use EMR, which is consistent with the findings of Kipturgo *et al*., who emphasized the importance of training in increasing technology adoption (Kipturgo *et al*., 2014). In addition, physician involvement also has a positive effect on perceived ease of use with a coefficient of 0.145 and a p-value of 0.001. These results indicate that support and active involvement from physicians can help nurses feel more comfortable using EMR, supporting the research of Kalayou *et al*., which states that physician involvement is a key factor in the successful implementation of health technology (Kalayou *et al*., 2021).

Physicians' Autonomy and Patient Relationship also showed a positive effect on perceived ease of use, with coefficients of 0.162 and 0.500, respectively. These results indicate that physicians who have greater autonomy in decision-making and good relationships with patients can increase the ease of use of EMR by nurses. This finding is in line with the study by Jedwab *et al*., which found that physician autonomy and positive interactions with patients contributed to the perception of ease of use of health technology (Jedwab *et al*., 2021). The new contribution of this study, based on the Technology Acceptance Model (TAM) theory developed by Davis, is the emphasis on the importance of adequate training, physician involvement, physician autonomy, and patient relationships as critical factors in increasing the perception of ease of use of EMR. These findings broaden the understanding of the determinants influencing the adoption of health technology in private type C hospitals in Indonesia, which has previously been underexplored in this context (Schorr, 2023).

This study found that openness to experience moderates the relationship between perceived usefulness and EMR adoption with a coefficient of -0.188 (P value 0.000), indicating that openness to experience weakens this relationship. This indicates that individuals who are more open to new experiences may be more critical of the usefulness of EMR and need more reasons to adopt it. This study also found that openness to experience strengthens the relationship between perceived ease of use and EMR adoption with a coefficient of 0.116 (P value 0.004). This means that more open individuals tend to be more receptive to EMR if they feel the technology is easy to use. This finding is consistent with previous research by Svendsen *et al*., which showed that individuals with high levels of openness tend to be more critical but also more adaptive to easy-to-use technology (Svendsen *et al*., 2013). This study

extends the TAM theory by showing that personality characteristics such as openness to experience can influence technology adoption. This highlights the importance of considering personality factors in EMR implementation strategies to increase adoption rates and user satisfaction.

This study found that perceived usefulness has a significant positive effect on EMR adoption with a coefficient of 0.325 (P value 0.000), indicating that the perception of usefulness of EMR increases the adoption of this technology among nurses in type C hospitals. In addition, perceived ease of use is also proven to have a significant positive effect on EMR adoption with a coefficient of 0.277 (P value 0.000), which means that the ease of use of EMR also encourages its adoption. This finding is consistent with Davis's TAM theory, which identifies perceived usefulness and perceived ease of use as the main factors influencing technology acceptance(Schorr, 2023). A study by Alaa and Ramayah showed similar results where perceived usefulness and perceived ease of use contributed significantly to the adoption of health information systems in various clinical settings(Alaa & Ramayah, 2023). The novel contribution of this study lies in the specific context of type C hospitals in Indonesia, strengthening the external validity of the TAM theory by confirming that these factors remain relevant in different settings and highlighting the importance of these two constructs in EMR implementation strategies to increase adoption rates in type C hospitals.

This study adds one variable, namely

Table 5. Hypothesis Test Results

Hypothesis		*Standard -ized Coefficient*	P-*values*	*Confidence Interval* (CI 95%)		f^2	Result
				Lower 5.0%	*Upper* 95.0%		
H1	*Management Support -> Perceived Usefulness*	0,171	0,004	0,068	0,281	0.035	Hypothesis Supported
H2	*Patient Safety Climate -> Perceived Usefulness*	0,404	0,000	0,299	0,505	0.188	Hypothesis Supported
H3	*Adequate Training -> Perceived Usefulness*	0,222	0,000	0,105	0,322	0.059	Hypothesis Supported
H4	*Adequate Training -> Perceived Ease of Use*	0,189	0,000	0,107	0,272	0.066	Hypothesis Supported
H5	*Physicians' Involvement -> Perceived Ease of Use*	0,145	0,001	0,066	0,228	0.043	Hypothesis Supported
H6	*Physicians Autonomy -> Perceived Ease of Use*	0,162	0,004	0,060	0,258	0.053	Hypothesis Supported
H7	*Patient Relationship -> Perceived Ease of Use*	0,500	0,000	0,383	0,619	0.398	Hypothesis Supported
H8	*Openness to Experience x Perceived Usefulness -> EMR Adoption*	-0,188	0,000	-0,262	-0,120	0.070	Hypothesis Supported
H9	*Openness to Experience x Perceived Ease of Use -> EMR Adoption*	0,116	0,004	0,043	0,186	0.026	Hypothesis Supported
H10	*Perceived Usefulness -> EMR Adoption*	0,325	0,000	0,240	0,409	0.198	Hypothesis Supported

Hypothesis		*Standard -ized Coefficient*	P-*values*	*Confidence Interval* (CI 95%)		f^2	Result
				Lower 5.0%	*Upper* 95.0%		
H11	*Perceived Ease of Use -> EMR Adoption*	0,277	0,000	0,185	0,369	0.124	Hypothesis Supported

Source: Primary Data (2023)

Openness to Experience, from the Big Five Personality Traits is argumentatively more relevant and important as a moderator of the relationship between TAM and EMR adoption than the other four personality traits because openness to experience is directly related to the tendency to accept and adapt to new technologies. Individuals with high levels of openness are more likely to explore, understand, and adopt new technologies, including EMR, compared to individuals with high levels of conscientiousness, extraversion, agreeableness, or neuroticism (Devaraj *et al*., 2008). Psychological theory suggests that openness to experience fosters creativity and innovation, which are critical in responding to technological change. Research by Svendsen *et al*., confirmed that openness to experience influences how individuals integrate new technologies into their work practices, strengthening the relationship between perceived ease of use and perceived usefulness with technology adoption(Svendsen *et al*., 2013). Thus, openness to experience provides a more comprehensive framework for understanding the dynamics of EMR adoption through TAM.

From the analysis results, it is known that this research model has moderate explanatory power (R^2), but in segment analysis (PLS-POS), it can increase to strong explanatory power. Furthermore, this research model is known to have large predictive relevance (Q^2_predict) for the EMR adoption variable. The overall predictive ability of this model is confirmed by the results of the cross-validated prediction ability test (CVPAT). Thus, it can be concluded that the proposed research model is adequate to explain and predict EMR adoption in type C private hospitals. So this model can also be recommended for use in further research.

This study's novel contribution is to demonstrate a new independent variable on Organizational factors, namely Patient Safety Climate, and a new moderation variable, namely Openness to Experience, between perceived usefulness and perceived ease of use to EMR adoption from one of the Big Five Personality Traits. This study reveals how individual characteristics that are open to new experiences can influence EMR adoption. These findings can be used by healthcare institutions to design training programs and more personalized approaches to implementing health technology, thereby increasing the acceptance and effective use of EMR. With better implementation of EMR, the quality of care and patient safety can be improved, and medical errors can be reduced. This finding also aligns with a study conducted by Fitriani *et al*., that states that clinical governance, as measured by five dimensions and mediated by a patient safety culture, significantly impacts the quality of care (QOC) in hospitals. The study emphasizes that proactive risk management, integrated quality improvement, training and development, and a positive safety climate all contribute to improving QOC (Fitriani *et al*., 2024). The adoption of EMR systems may also be improved by focusing on factors such as training and supportive management, which facilitate ease of use and perceived usefulness, similar to how patient safety culture mediates the impact of clinical governance on care quality. Both research pieces underscore the importance of a structured and supportive work environment to drive successful technology adoption and improve healthcare outcomes. A study conducted by Sutanto *et al*., highlights the critical role of organizational culture and training in influencing healthcare outcomes. Factors like management support and adequate training are key in shaping perceived usefulness and ease of use, which can enhance EMR adoption. Similarly, fostering a safety culture

through empowerment can facilitate EMR adoption, as empowered healthcare personnel are more likely to embrace and effectively use digital health technologies (Sutanto *et al*., 2024).

The previous study conducted by Dewi and Mahyuni showed that there is a genuine demand for digital healthcare services driven by both necessity and hedonic factors (Dewi & Mahyuni, 2024). The findings highlight the need for developers to enhance usability and create appealing interfaces to improve the acceptance of digital healthcare. Additionally, it suggests that addressing user feedback by improving ease of use and increasing advertising efforts will help in broader adoption. In this study, organizational factors such as adequate training and patient safety climate are crucial for fostering positive attitudes toward EMR, and usability and ease of use are key in enhancing the adoption of digital health solutions. Both of these research findings correlate the critical role of user satisfaction and positive experiences in ensuring the successful adoption of healthcare technologies. Furthermore, understanding the role of personality in technology adoption can help hospital policy makers in developing strategies that are more adaptive to the characteristics of healthcare workers, thereby accelerating digital transformation in the healthcare sector that directly benefits the wider community, which has an impact on healthcare services and public health in general. The next limitation is that the results of the latent class analysis with PLS-POS of this study obtained unobserved heterogeneity, so it is recommended that this finding be followed up in further research to identify what attributes exist in the respondent segment or what factors differentiate the segment. This is needed to obtain homogeneous response data with certain criteria so that the model's predictive ability can be more adequate. Another limitation of this study is that there may be other Big 5 personality traits that influence EMR adoption that cause the data to be insignificant, so I suggest that data moderation other than openness to experience, such as Consciousness, can be conducted in research on EMR adoption for healthcare workers.

Conclusion

This study revealed that management support, patient safety climate, and adequate training had a significant positive effect on perceived usefulness and perceived ease of use of EMR, which is consistent with previous studies. Strong management support and positive safety climate encourage EMR adoption by providing resources and promoting a safety culture. Adequate training and physician involvement also increase EMR ease of use. Openness to Experience was found to negatively moderate the relationship between perceived usefulness and EMR adoption, but strengthen the relationship between perceived ease of use and EMR adoption, indicating that individuals with high levels of openness tend to be more critical but also more adaptive to new technologies. These findings extend the TAM theory by emphasizing the importance of personality factors in EMR implementation strategies. This study also confirms the relevance of perceived usefulness and perceived ease of use in EMR adoption in type C hospitals in Indonesia, strengthening the external validity of the TAM theory.

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Anemia in Pregnancy Based on Rural and Urban Areas

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Abstract

From 2013 to 2018, the proportion of anemia in pregnant women in urban and rural areas increased from 37.1% to 48.9%. This study aims to analyze the differences in determinants of anemia in pregnancy based on place of residence. Research was conducted in 2024. The research sample in rural areas was 39 pregnant women with anemia, and in urban areas was 31 pregnant women with anemia. Ratio scale data, including nutritional intake, is tested for normality with the Kolmogorov-Smirnov test, then tested using the t-independent test. Other variables are tested using the Mann-Whitney test. Regarding the various determinant factors studied, including the age of pregnant women, nutritional status, and gravida status, there is no significant difference (p-value > 0.05) in pregnant women with anemia in rural and urban areas. There is a significant difference (p-value < 0.05) between nutritional knowledge, food expenditure, and nutritional intake in pregnant women with anemia in rural and urban areas. Based on the determinant factors of anemia in pregnancy studied, food expenditure, nutritional knowledge of pregnant women, protein, iron, and vitamin C intake in pregnant women with anemia in rural and urban areas differ significantly.

Introduction

Anemia is a worldwide public health issue that impacts people of all ages in both developed and developing nations (Geta *et al*., 2022). Worldwide, the prevalence of anemia during pregnancy is reported to be 29.9%. Despite efforts to lower the occurrence of anemia, particularly in developing nations, it remains commonplace worldwide and, if left untreated, can have serious health effects (Abd Rahman *et al*., 2022). Unfavorable pregnancy-related events may increase if anemia is present. Anemia during pregnancy can raise the risk of postpartum hemorrhage, cesarean sections, and gestational hypertension. Anemia during pregnancy is also linked to an increased risk of gestational hypertension, fetal distress, preterm birth, cesarean section, postpartum hemorrhage, and newborn hypoxia (Detlefs *et al*., 2022; Zhao *et al*., 2022).

Anemia risk was considerably increased in low-socioeconomic pregnant women, first-trimester pregnant women, multipara pregnant women, and pregnant women who did not receive dietary education (El-Kholy *et al*., 2023). The country has reduced anemia among pregnant women by implementing a national nutrition program and a micronutrient deficiency prevention and control strategy (Woldegebriel *et al*., 2020). The prevalence of anemia was higher in rural than in urban areas (Ayensu *et al*., 2020). Pregnancy anemia is associated with residing in rural areas, but it is also related to the multiparity factor (Nuru Yesuf & Agegniche, 2021). Women in rural areas with low levels of household wealth are more likely to suffer from anemia (Abate *et al*., 2021).

According to research, mothers who live in rural regions are less likely to have a cesarean section but more likely to experience anemia, preterm birth, post-term pregnancies, LBW,

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requirement for neonatal resuscitation, and NICU hospitalization (Mehrnoush *et al*., 2023). Variation in anemia prevalence across urban and rural areas suggests that interventions should be focused on particular locations. 40,9% of people were anemic overall. Compared to urban people (20.1%), rural dwellers (46.6%) had a greater rate of anemia (Tesfaye *et al*., 2020). Pregnant women's anemia was a moderate public health concern in an urban area. Anemia was found to be substantially correlated with several factors, including low income, larger families, higher parity, longer menstrual cycles, and bleeding during pregnancy (Alreshidi & Haridi, 2021).

The most significant risk variables for anemia were maternal and dietary features, but the most significant risk factor for iron deficiency during pregnancy was dietary. Numerous nutrient deficits sometimes coexist with the development of anemia and iron deficiency (Kangalgil *et al*., 2021). Pregnancy anemia is related to the level of knowledge, the nutritional status, and the economy of pregnant women (Rahayu *et al*., 2023). The variables that showed a statistically significant correlation with the prevalence of anemia were residence, educational status, monthly family income, occupation, gestational age, iron folic acid supplementation, dietary habits of avoiding meat and animal products, green leafy vegetables, and drinking tea and coffee right after meals (Bansal *et al*., 2020). Based on the differences in characteristics between rural and urban areas, the author examines the determinants of anemia in pregnancy based on rural and urban areas. This study aims to analyze the differences in determinants of anemia in pregnancy based on place of residence.

Method

This research is quantitative research with a comparative method. The research design used is cross-sectional, where researchers conduct observations or measurements of variables at one time. This study involved two locations, namely rural areas conducted in the working area of the Kesamben Kulon Health Center, Gresik Regency, and urban areas conducted in the working area of the Jemursari Health Center, Surabaya City. Data collection was carried out for three months, namely January-March 2024. The population in this study was all pregnant women in the working area of Jemursari Health Center, Surabaya City, totaling 56 people, and all pregnant women in the working area of Kesamben Kulon Health Center, Gresik Regency, totaling 61 people. The inclusion criteria in this study were: pregnant women with anemia with hemoglobin levels < 11 g/dL; and pregnant women who were willing to be respondents by signing an informed consent. Sampling is included in nonprobability sampling using purposive sampling techniques. The research sample in rural areas was 39 pregnant women with anemia, and in urban areas was 31 pregnant women with anemia.

The independent variables in this study are residences covering rural and urban areas. The dependent variables include nutritional intake (protein, Fe, vitamin C); knowledge of pregnant women; parity status; age of pregnant women; nutritional status; and food expenditure of pregnant women. The nutritional intake studied included protein, Fe, and vitamin C intake consumed by pregnant women during the last month. The study used the semi-quantitative food frequency questionnaire (SQ-FFQ) method. The list of food ingredients listed in the SQ-FFQ questionnaire was obtained from the Indonesian food composition table (TKPI, 2020).

Pregnant women's knowledge about anemia was studied using a questionnaire taken from previous research (Gustiana *et al*., 2021). Knowledge of pregnant women was assessed using a questionnaire with 10 questions. Pregnant women who answered "correctly" were given a score of "+1" and pregnant women who answered "incorrectly" were given a score of "0". Pregnant women who scored more than or equal to the average score of the total knowledge assessment questions were considered to have good knowledge. Meanwhile, pregnant women who scored less than the average score of the total knowledge assessment questions were considered to have poor knowledge (Balcha *et al*., 2023).

The nutritional status of pregnant women is assessed based on the circumference of the upper arm. Pregnant women are considered to have chronic energy deficiency if they have an upper arm circumference of

<23.5 cm (Kementerian Kesehatan RI, 2014). The instrument used to study food expenditure is a questionnaire containing questions about family income and expenditure (Dipa, 2022). The percentage of food expenditure is classified as low if < 60% and is classified as high if > 60%. The higher the food expenditure, the lower the food security of a household (Manyullei & Arundhana, 2021).

Data collection begins with screening pregnant women for anemia by conducting hemoglobin examination using a digital Hb checker, namely the Easy Touch GCHb. The examination is carried out by an enumerator. Data collection method with direct measurement and interview. The collected data is analyzed after editing, coding, and tabulating have been carried out. Ratio scale data, including nutritional intake, is tested for normality with the Kolmogorov-Smirnov test, then tested using the t-independent test. Other variables are tested using the Mann-Whitney test with a 95% confidence level. Data collection was carried out after obtaining an ethical feasibility letter from the Research Ethics Committee of Universitas Nahdlatul Ulama Surabaya with number 0363/EC/KEPK/UNUSA/2023.

Result and Discussion

The characteristics of respondents in this study included the degree of anemia in pregnant women, nutritional status before pregnancy in mothers, education, employment, nutritional information, and consumption of iron supplementation in pregnant women. Classification of anemia in pregnant women according to the World Health Organization (WHO), namely mild anemia (10-10.9 g/dL), moderate anemia (7-9.9 g/dL), and severe anemia (< 7 gr/dL) (Shi *et al*., 2022). The nutritional status of mothers before pregnancy based on body mass index is classified according to World Health Organization, namely underweight (< 18,5); normal (18.5-22.9); overweight (23-24.9); and obesity (≥ 25) (Inciong *et al*., 2020).

The education level of pregnant women is classified based on their last level of education, namely elementary school, high school, and college (Pratiwi, 2020). Characteristics of pregnant women's work include whether the mother works or is a housewife. While nutritional information means whether the pregnant woman has ever received information about nutrition for pregnant women or not. Consumption of iron supplementation is based on whether the pregnant woman consumes iron supplementation during pregnancy or not. The distribution of respondent characteristics will be explained in the table below.

Table 1. Distribution of Characteristics of Pregnant Women with Anemia

Variable	Urban	Rural	Total	p value
Anemia				
Mild anemia	36 (92.3%)	27 (87.1%)	63 (90%)	0.474
Moderate anemia	3 (7.7%)	4 (12.9%)	7 (10%)	
Severe anemia	0	0		
Nutritional Status				
Underweight	7 (17.9%)	4 (12.9%)	11 (15.7%)	0.464
Normal	18 (46.2%)	13 (41.9%)	31 (44.3%)	
Overweight	5 (12.8%)	6 (19.3%)	11 (15.7%)	
Obesity	9 (23.1%)	8 (25.9%)	17 (24.3%)	
Education				
Elementary school	3 (7.7%)	0	3 (4.3%)	
Junior high school	14 (35.9%)	2 (6.5%)	16 (22.9%)	0.000
Senior high school	18 (46.1%)	15 (48.4%)	33 (47.1%)	
College	4 (10.3)	14 (45.1%)	18 (25.7%)	

Work				
Work	11 (28.2%)	16 (51.6%)	27 (38.6%)	0.047
Not Working	28 (71.8%)	15 (48.4%)	43 (61.4%)	
Nutritional information				
Ever received	15 (38.5%)	26 (83.8%)	41 (58.6%)	0.000
Never received	24 (61.5%)	5 (16.2%)	29 (41.4%)	
Consumption of iron supplementation				
Consumption				
Not consumption	11 (28.2%)	26 (83.8%)	37 (52.8%)	0.000
	28 (71.8%)	5 (16.2%)	33 (47.2%)	

Source: primary data (2024)

Based on the table above, it is known that most (90%) of pregnant women with anemia in rural and urban areas experience mild anemia. Based on the statistical results, it is known that there is a difference (0.474) between the levels of anemia in rural and urban areas. As many as 44.3% of pregnant women with anemia in rural and urban areas have normal nutritional status before pregnancy. There is No. significant difference (0.464) between the nutritional status before pregnancy in pregnant women with anemia in rural and urban areas.

Characteristics of pregnant women with anemia based on education, more pregnant women with anemia in urban areas (45.1%) have a college education compared to pregnant women in rural areas (10.3%). In rural areas, there are no pregnant women with anemia with elementary school education. In urban areas (7.7%), there are pregnant women with anemia with elementary school education. There is a significant difference (0.000) between the education level of pregnant women with anemia in rural and urban areas. There is a difference (0.047) between the working status of pregnant women with anemia in rural and urban areas. Pregnant women with anemia in rural areas are mostly unemployed (71.8%), while in urban areas, most (51.6%) of pregnant women with anemia work.

Most (61.5%) of pregnant women with anemia in rural areas have never received information about pregnancy nutrition. In contrast, in urban areas, most (83.8%) of pregnant women with anemia have received information about pregnancy nutrition. There is a significant difference (0.000) between nutritional information on pregnant women with anemia in rural and urban areas. There is a difference (0.000) between the consumption of iron supplementation in pregnant women with anemia in rural and urban areas. Most (71.8%) of pregnant women with anemia in rural areas do not consume iron supplementation, while most (83.8%) of pregnant women with anemia in urban areas consume iron supplementation during pregnancy.

Of the 39 pregnant women with anemia, 51.3% of pregnant women with anemia in rural areas are included as high risk because they are aged < 20 years and > 35 years. In urban areas, pregnant women with anemia who are included in high-risk age groups are smaller than in rural areas (45.2%). Most (54.8%) of the 31 pregnant women with anemia have ages that are not included in high-risk. There was no significant difference (0.613) between the age of pregnant women with anemia in rural and urban areas. The nutritional status of pregnant women is measured based on the results of upper-arm circumference measurements in pregnant women with anemia. In rural areas, those who experienced chronic energy deficiency because they had an upper arm circumference < 23.5 cm were 28.2%. While in urban areas, it was higher, namely 41.9% of pregnant women with anemia in urban areas experienced chronic energy

Table 2. Determinant Factors of Anemia in Pregnancy

Variable	Rural	Urban	P value
Age			
Not high risk	19 (48.7%)	17 (54.8%)	0.613
High risk	20 (51.3%)	14 (45.2%)	
Upper arm circumference			
Not chronic energy deficiency	28 (71.8%)	18 (58.1%)	0.233
Chronic energy deficiency	11 (28.2%)	13 (41.9%)	
Gravida			
Primigravida	10 (25.6%)	11 (35.5%)	0.375
Multigravida	29 (74.4%)	20 (64.5%)	
Knowledge			
Good	4 (10.3%)	18 (58.1%)	0,000
Less	35 (89.7%)	13 (41.9%)	

Source: primary data (2024)

deficiency. There was no significant difference (0.233) between the nutritional status based on the upper arm circumference of pregnant women with anemia in rural and urban areas.

For pregnant women with anemia in rural areas, most (74.4%) are included in multigravida pregnancies. Similarly, for pregnant women with anemia in urban areas, most (64.5%) are included in multigravida pregnancies. There is no significant difference (0.375) between the gravida status of pregnant women with anemia in rural and urban areas. The knowledge of pregnant women with anemia studied includes knowledge about nutrition during pregnancy. Knowledge was studied using a questionnaire, and the results showed that knowledge of pregnant women with anemia in rural areas was mostly (89.7%) less, in contrast to urban areas, where most (58.1%) pregnant women with anemia had good knowledge. The results of the data analysis showed that there was a significant difference (0.000) between the knowledge of pregnant women with anemia in rural and urban areas.

Other determinant factors include food expenditure and nutritional intake. Food expenditure on pregnant women with anemia is greater in rural areas than in urban areas. The average food expenditure on pregnant women with anemia in rural areas is 52.69%, greater than the average food expenditure on pregnant women with anemia in urban areas of 45.45%. There is a significant difference (0.018) between food expenditure on pregnant women with anemia in rural and urban areas. Nutritional intake studied in pregnant women with anemia includes protein, iron, and vitamin C intake. Where the nutritional intake is related to anemia in pregnant women. Nutritional intake in pregnant women was studied using SQ-FFQ, with the average result of protein intake in pregnant women with anemia in rural areas of 22.95%. The average protein intake in pregnant women in rural areas is higher, namely 27.57%. Based on statistical tests, it was found that there was a significant difference (0.000) between protein intake in pregnant women with anemia in rural and urban areas.

Table 3. Determinant Factors of Anemia in Pregnancy

Variable	Rural	Urban	P value
Food expenditure (%)	52.69	45.45	0.018
Protein intake (g)	42.06	49.68	0.000
Fe intake (mg)	22.95	27.57	0.000
Vitamin C intake (mg)	45.94	64.21	0.000

Source: primary data (2024)

Similarly to Fe intake, the Fe intake in pregnant women with anemia in rural areas is lower than in urban areas. The average Fe intake in pregnant women with anemia in rural areas is 42.06 grams per day, while in urban areas it is 27.57 grams per day. Based on these data, it was found that there is a significant difference between Fe intake in pregnant women with anemia in rural and urban areas. The average intake of vitamin C in pregnant women with anemia in rural areas is 45.94 mg/day. The average intake of vitamin C in pregnant women with anemia in urban areas is 64.21 mg/day. In line with protein and Fe intake, vitamin C intake in pregnant women with anemia in urban areas is greater than in rural areas. Based on data analysis, it was found that there was a significant difference between vitamin C intake in pregnant women with anemia in rural and urban areas.

The prevalence of anemia in pregnant women in Tanzania in 2015-2016 in urban areas reached 53.6%, slightly higher than the prevalence of anemia in pregnant women in rural areas reached 58.6%. Women between the ages of 15 and 19 are more likely than those between the ages of 20 and 34 to have a higher prevalence (Sunguya *et al*., 2021). This study shows that pregnant women with non-high-risk ages are also likely to experience anemia, even with a higher rate than pregnant women with high-risk ages. Similar research results state that pregnant women of teenage age are more likely to experience anemia during pregnancy than mothers of older age (Liyew *et al*., 2021).

In rural areas, the age of pregnant women are at a higher risk, while in urban areas, pregnant women are at a lower risk. This is related to the higher maternal mortality rate in rural areas than in urban areas (Merkt *et al*., 2021). Pregnant women with chronic energy deficiency are at twice the risk of developing anemia. There is an increase in the volume of fluid and red blood cells and a decrease in the concentration of nutrient-binding protein in the blood. So pregnant women with nutritional problems are at risk of developing anemia (Azmi & Puspitasari, 2022). The results of this study show that the number of chronic energy deficiencies in pregnant women is higher in rural areas than in urban areas. This is different from research conducted by (McKay *et al*., 2020) that rural areas are more susceptible to nutritional problems because there is food insecurity in rural areas.

Research by (Veile *et al*., 2022) also states that people in rural areas are more susceptible to nutritional problems, especially malnutrition, compared to people in urban areas. While in urban areas, they are more susceptible to overweight or obesity than in rural areas. The number of birth histories is related to the occurrence of anemia in pregnant women (Sharma, 2020). The more often a woman is pregnant and gives birth, the greater the risk of developing anemia, because anemia drains iron reserves in the body (Astriana, 2017). The results of this study are that there is no difference between the gravida status of pregnant women with anemia in rural and urban areas. This is in line with research by (Wulandari *et al*., 2021), that the distribution of gravida in pregnant women in rural and urban areas is not much different. Knowledge of pregnant women is related to the behavior of mothers, where mothers who have good knowledge of pregnancy nutrition can meet nutritional needs during pregnancy well. So that pregnant women can avoid nutritional problems during pregnancy (Karyuni *et al*., 2020). Knowledge affects behavior, where eating behavior will influence nutritional status during pregnancy (Nashih *et al*., 2024).

The results of this study are that the

knowledge of mothers in urban areas is better than that of mothers in rural areas. This is in line with research (Aljassim & Ostini, 2020) that the majority of studies found that in developing countries, the level of health literacy of urban residents is higher than that of rural residents. Different results stated that there was no difference between the knowledge of rural and urban residents (Chen & Chen, 2020). Food security is the state in which all people have physical and economic access to sufficient food to fulfill their dietary needs to live a productive and healthy life. Household food security status related to protein intake levels in pregnant women (Sudaryati *et al*., 2021). Pregnant women with nutritional problems are associated with lower household expenditure. Food security and higher levels of household food expenditure will affect nutritional problems in pregnant women (Dewi *et al*., 2020).

Engel's Law states that low-income households tend to spend most of their income on necessities. Conversely, high-income households tend to spend only a small portion of their total expenditure on necessities (Nicholson, 1995). Poverty in rural areas results in the level of food expenditure of rural residents being much higher than in urban areas (Lagakos, 2020). Anemia is a serious public health problem among pregnant women. Inadequate dietary diversity coupled with inadequate daily food intake are eating habits that cause anemia in pregnant women (Gibore *et al*., 2021). Anemia in pregnancy can be caused by iron deficiency, low vitamin B12, and low vitamin C intake (Atanu & Bhadra, 2020).

Differences in nutritional knowledge among rural and urban residents are related to the food intake they consume (Egg *et al*., 2020). Living in rural areas tends to have low levels of education which is a factor in low nutritional literacy and unhealthy eating habits (Scalvedi *et al*., 2021). In addition to knowledge and education, rural residents tend to shop more for food at less healthy stalls and shops (Lacko *et al*., 2020). Compared to women from urban regions, the prevalence of protein deficiencies was much greater in women from rural and semi-urban areas (Gómez-Cantarino *et al*., 2020).

Conclusion

Based on the results of the study, it can be concluded that from the various determinant factors studied, including the age of pregnant women, nutritional status, and gravida status, there is no significant difference in pregnant women with anemia in rural and urban areas. In contrast, there is a significant difference between nutritional knowledge, food expenditure, and nutritional intake in pregnant women with anemia in rural and urban areas. Suggest to health workers in every region, especially in rural areas, to be able to provide nutritional information to every pregnant woman from the beginning of pregnancy. Providing nutritional education can improve the nutritional behavior of pregnant women, so that pregnant women can meet their nutritional needs properly. That way, there are no nutritional problems during pregnancy. Although urban areas have better health outcomes, the problem of anemia still exists, so it is necessary to study the risk factors that cause anemia in pregnant women, both in urban and rural areas, so that interventions can be provided that follow each problem. Economic equality also needs to be carried out both in rural and urban areas, so that people do not have difficulty in meeting their food needs, and food expenditure can be reduced in each family.

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Sociodemographic Factors and Adolescent Attitudes Towards Family Planning Programs Related to Adolescent Marriage in Bali Province

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Abstract

Adolescent marriages in Bali Province are reported to be increasing. Sociodemographic factors and adolescents' attitudes toward family planning programs are suspected to be related to adolescent marriage. Therefore, this study aims to analyze the relationship between demographic factors of adolescents' attitudes toward family planning programs and the ideal age of marriage for adolescents. This study uses secondary data from the Program Performance and Accountability Survey of the National Population and Family Planning Agency of Bali Province in 2019. Cross-sectional studies were conducted among adolescents aged 10-24 years. The probability of selecting 668 adolescents for this study was determined using the proportional-to-size method. An adolescent's marriage is determined based on the adolescent's perceptions of the age of marriage before 21 years. Logistic regression tests were conducted to determine the relationship between access to information and the perception of marriage among adolescents. It was found that 87.9% of the adolescents perceive the age of marriage for women as≥ 21 years. Based on the results of the multivariate analysis, gender, rural residence, and access to information on family planning programs, adolescents' attitudes toward FPPs and attitudes toward marriage before 21 years of age were associated with adolescents' marriage. Factor demographic factors and adolescent attitudes increased the perception of the ideal age for marriage among adolescents. This finding suggests that demographic factors should be considered to increase the ideal age for adolescent marriage to further prevent the incidence of health and social problems resulting from child marriages

Introduction

Marriage during adolescence adversely affects the individual and their social life (Urquia *et al*., 2022). Adolescent marriages force teenagers, especially girls, to stop attending school (Fan & Koski, 2022). Furthermore, terminating school opportunities for adolescent girls can hinder their development and impede gender equality (Parsons & McCleary-Sills, 2014). Low educational levels also impoverish married adolescents (Sagalova *et al*., 2021). Additionally, marrying at a young age allows for a large number of children, increases the risk of domestic violence incidents, and tends to result in poor mental health status (Aggarwal *et al*., 2023; Belachew *et al*., 2022; Yoosefi Lebni *et al*., 2023). Early marriage refers to one conducted under the age of 18 (Elnakib *et al*., 2022). To date, the incidence of teenagers marrying at an early age has remained high. Globally, 115 million teenage boys are married. Of these, one in five teenagers, or as many as 23 million, got married before the age of 15 years old (UNICEF, 2019, 2023). High rates of child marriages have

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also been reported among teenagers in South Asia. Approximately 45% of approximately 290 million Syrian refugee children in southern Lebanon are married and under 18 years old (UNICEF, 2023). Marriages have even been conducted among 10-year-old children, with girls accounting for 32.56% (Elnakib *et al*., 2022).

The rate of child marriages in Indonesia is still high. Accordingly, it is feared that the country will not be able to achieve its sustainable development target by 2023 (Unicef Indonesia, 2020). Early marriages in Indonesia are ranked 37th globally and second in Asia after Cambodia (UNICEF, 2023). In 2010, the proportions of marriages among 10-14- and 15–19-year-olds in Indonesia were 4.8% and 41.9% respectively. Meanwhile, NBHR data in 2013 showed that the proportions of first-time married adolescents aged less than 15 years and those aged 15-19 years were 2.6% and 23.9% respectively (Kementerian Kesehatan RI, 2018). Data from the 2017 Indonesian Demographic and Health Survey showed that the child marriage rate decreased slightly to 11.2% in 2018 and continued declining to 10.4% and 9.2% in 2020. However, the number of child marriages remained below the target number. The number of child marriages is targeted to be less than 8.7% in 2024 and 6.9% in 2030 (Kementrian Kesehatan RI, 2018).

Based on the concept of behavior, early marriage is influenced by several factors. Planned behavior theory by Fishbein and Ajzen (1975) describes behavior controlled by intention. The intention effect of attitude, individual subjective norms, perceptions of how other people perceive behavior, and perceptions of behavioral control. Attitude follows attitudes toward behavior. Additionally, behavior is implemented if other people accept it as a normative belief. Furthermore, one cannot entirely control the behavior under the control of that individual. Internal and external factors influence behavioral control. Internal factors such as skills, will, and information, among others, come from within. In contrast, external factors originate from the environment. Environmental factors include sociodemographic environments, such as rural or urban areas (Anggreni *et al*., 2023).

Various studies on the factors related to teen marriages show mixed results. One study found that adolescent marriage rates are associated with being rural residents, being uneducated, attending only primary school, having parents decide when to marry, being poor, and having the poorest wealth status (Aychiluhm *et al*., 2021). Another study conducted at the Indonesian Tertiary Center found a link between living in rural areas, low-income families, low educational levels, and early marriage (Indarti *et al*., 2020). Moreover, different results were found among adolescents in Injibara, Ethiopia, where a factor associated with adolescent marriage was a low level of non-formal education among adolescent fathers (Paige D Martin, 2003). Based on the results of the literature review, it was found that, in addition to social demographic factors, there are other influencing factors such as ethnicity, religion, and mass media exposure (Anggreni *et al*., 2023).

Socialization efforts regarding the ideal age for marriage have been made; however, the results have not been optimal. The Indonesian Government created the Marital Age Maturity Program (MAMP) via the National Population and Family Planning Board (NPFPB). The MAMP was an attempt to increase the age limit for first marriage to reach the minimum age of marriage, which was 21 years for women and 25 years for men (Direktorat Bina Remaja Badan Kependudukan dan Keluarga Berencana Nasional., 2019). Since the program was run down, the number of adolescent girl marriages seems to decrease gradually. The National Census Survey in 2018 reported that one in nine (11.1%) adolescent girls were married, and approximately 1.220.900 women aged 20-24 years got married before 18. Most adolescents (83%) know about MAMP within a suitable category (Rulistyana, 2017). Meanwhile, 60.7% of teenagers in the Loksado subdistrict of South Hulu Sungai Regency, South Kalimantan, Indonesia, have a positive attitude toward child marriages (Husna *et al.,* 2017). This situation was worrying enough to achieve the failure of child marriages targeted by 2024 and 2030 (Unicef Indonesia, 2020).

Teenagers' perceptions of the ideal age for marriage still vary. Most adolescents believe the

ideal age for marriage is 19-24 and 25-30 years for women and men, respectively (Subranmiam *et al*., 2015). Some teenagers agree to marry at the age of 16 (Kohno *et al*., 2020). However, on average, they marry at an age younger than the perceived ideal age for marriage (Mardi *et al*., 2018). Based on the results, these factors were found to be related to the perception of the ideal age for marriage among adolescents. Physical and mental maturity, social norms, insecurity, family honor, preference for young brides, and leniency in enforcing the minimum age for marriage were found to influence perceptions (Islam *et al*., 2021). Other related factors include lack of awareness, absence of marriage certificate requirements, social norms, and lack of marriage registration (Kumari *et al*., 2022). Child marriages in Indonesia are related to the educational background and income of the relevant head of the family (Rhena, 2020). Accordingly, economic factors negatively affect early marriage among adolescents in Bangladesh and Ghana (Saleheen *et al*., 2021).

The relationship between demographic factors and the perception of the ideal age for adolescent marriage remains limited. One of the existing studies conducted in Bangladesh, Ghana, and Iraq evaluated sociodemographic factors using secondary data from 2017 through 2019 (Kumari *et al*., 2022). Another study was conducted using the Behavioral Risk Factor Surveillance System to identify adults > 18 years old living in rural and urban areas in the U.S. from 2018 through 2019 (Kyalwazi *et al*., 2022). The NPFPB conducted Program Performance and Accountability Surveys (PPAS) in 2019 to photograph program achievements listed in the 2015-2019 National Medium-Term Program Plan, and was designed to produce estimates of national- and provincial-level parameters, including Bali Province. Perceptions of early marriage were among the parameters evaluated in this survey. To the best of our knowledge, publications related to the relationship between demographic factors and adolescents' perceptions of the ideal age for marriage in Bali Province using PPAS data from 2019 have not been conducted. Therefore, this study aims to identify the role of demographic factors in enhancing the perception of the ideal age for marriage among adolescents in Bali Province using PPAS data.

Method

This study uses secondary data on the PPAS from the NPFPB Bali Province in 2019. Cross-sectional studies were conducted among adolescents aged 10-24 years from 34 Indonesian provinces. The probability of selecting adolescents in this study was proportional to the size (PPS) method. The number of successfully interviewed teenagers was 41.582, including 22.124 boys and 19.458 girls. A total of 668 unmarried adolescents in Bali Province aged 10-24 years were sampled. The timing of data collection varied between the provinces, from June 10 to September 10, 2019. Structured interviews were conducted to collect data. The collected data included adolescents' characteristics, perceptions of the ideal age for marriage, knowledge about family planning programs (FPPs), sources of population information, and attitudes toward FPPs and marriage before 21 years.

Data were analyzed using univariate, bivariate, and multivariate analyses. The data analyzed in this study were based on the characteristics, knowledge, attitudes toward FPPs, and perceptions of the ideal age for marriage for adolescent girls. Characteristics included age, education level, sex, and residential region. Data related to adolescent knowledge consisted of a knowledge index on population issues, adolescent reproductive health (ARH), effects of early marriage, FPPs, information sources on reproductive health, and exposure to information from youth generation programs (YGP). Data on age are categorized into "10-14 years old", "15-19 years old", and 20-24 years old. "Sex" includes "male" and "female". Education level is categorized into "without education", "Primary school", "Junior High School", "Senior High School", and "College". In comparison, residential areas are categorized into "urban" and "rural". The perception of the ideal age for marriage is categorized into a marriage age < 21 years and a marriage age ≥ 21 years. Attitudes are categorized into "positive", "neutral", and "negative". Knowledge is categorized into "good", "sufficient", "lacking", "knowing", "not knowing", or "ever hearing/seeing/reading information", and "never hearing/seeing/

reading information". A univariate analysis was conducted to obtain an overview of the frequency distribution of the ideal marriage age for adolescent attitudes toward FPPs. A bivariate analysis was conducted using the chi-square test to obtain trends in adolescents' ideal age for marriage based on their characteristics, knowledge, and attitudes. A multivariate logistic regression analysis was conducted to determine the factors associated with marital age among adolescents.

Results and Discussion

Bali Province is one of the provinces in Indonesia with an area of 5,590.15 km². The administrative structure of Bali Province consists of 9 districts and 1 city (Badan Pusat Statistik Provinsi Bali, 2025). Culturally, Balinese people mostly embrace Hinduism and adhere to the patrilineal system. The rights and position of men are valued higher than the position of women in the patrilineal system (Fahrurrozhi & Kurnia, 2024). The people of the island of Bali consist of 2 main groups, namely Bali Aga and Bali Majapahit, or modern Bali. The Bali Aga are a group native to the island of Bali who tend to maintain their traditions and customs from generation to generation. This group tends to be more closed to outside cultures and settles in mountainous areas. Meanwhile, the Balinese Majapahit or Modern Balinese group is more open to outside civilization and lives in urban areas. The culture of freedom is a Western culture brought by tourists to the island of Bali and has created cultural dynamics that affect the behavior of the community, including teenagers in Bali (Fahrurrozhi & Kurnia, 2024). Table 1 shows that most adolescents were aged 10-14 years (44.8%), male (54.4%), with a high school education level (34.0%), and living in Urban Areas (63.9%).

TABLE 1. Respondent Caracteristics

Demography Characteristic (n=668)		Frequency	%
Age (years)	10-14	300	44.8
	15-19	254	38.0
	20-24	115	17,2
Sex	Male	364	54.4
	Female	305	45.6
Education level	Without education	3	0.5
	Primary school	173	25.9
	Junior high school	184	27.5
	Senior high school	227	34.0
	College	81	12.1
Living area	Urban	427	63.9
	Rural	242	36.1

Source: PPAS from the NPFPB Bali Province in 2019

TABLE 2. Frequency Distribution of Perception, Attitude, Knowledge Level, And Programmatic Factors of Adolescents About The Ideal Age for Marriage

Variable		Frequency	%
Marriage age for women (n= 588)	< 21 years old	80	12.0
	≥ 21 years old	507	87.9
Attitude toward FPPs	Positive	215	32.2
	Neutral	228	34.0
	Negative	226	33.7

Attitude toward marriage before 21 years of age	Positive	503	75.3
	Neutral	122	18.2
	Negative	44	6.5
Knowledge of family planning	Less	81	12.2
	sufficient	309	46.2
	Good	279	41.7
Knowledge about the consequences of child marriage	Yes	406	60.7
	No	263	39.3
Knowledge of modern family planning methods	Good	8	1.1
	sufficient	164	24.6
	Less	497	74.3
Exposure to information on YGP	Yes	128	19.2
	No	540	80.8
Exposure to information on CIC for adolescence	Ever	95	14.2
	Never	573	85.8
Knowledge about information related to adolescents' reproductive health	Ever	635	94.9
	Never	34	5.1
Knowledge about information related to the youth generation	Ever	128	19.2
	Never	540	80.8
Media Source of YGP (n=128)	At least one of the media sources	116	90.6
	None of the media sources	12	9.4
Information source from a staff of YGP (n=128)	At least one of the staff	116	90.6
	No one staff	12	9.4

Source: PPAS from the NPFPB Bali Province in 2019

Table 2. shows that most teenagers' perception of the ideal marriage age, especially for adolescent girls, is greater than or equal to 21 years (87.9%), with a positive attitude toward marriage before 21 years of age (75.3%), knowing the consequences of early marriage (60.7%), with low-level knowledge of modern family planning devices (74.3%), and without exposure to YGP (80.8%) dan Center of Information and Counseling (CIC) for adolescents (85.8%).

Table 3 shows that there are significant proportion differences in the ideal age for marriage for women based on age, education level, residential area, attitude toward marriage age before 21 years old, and attitude toward FPPs ($p< 0.05$)

Table 4 shows the result of a logistic regression test, which found that the factors related to adolescents' perceptions of the ideal age for marriage include gender (AOR=1.757; CI= 1.053-2.932;p=0.031); residential area (AOR=0.578; CI=0.350-0.955; p=0.032); having heard, seen, or read information about YGP (AOR=0.471; CI= 0.257 – 0.864; p= 0.015); adolescents' attitude toward FPPs (AOR=1.449, CI= 1.067-1.967;p=0.018); and attitude toward marriage before 21 years of age (AOR=0.432; CI=0.298-0.628;p=0.000).

This study shows that sex was associated with the age of marriage for teenagers. Adolescent girls were 1.7 times more likely to perceive the ideal age for marriage as ≥21 years compared with adolescent boys. Meanwhile, based on the bivariate analysis, the differences in the proportion of perception of the ideal age for marriage between ages ≥21 years old between adolescent girls and boys are 83.7%

TABLE 3. Cross Tabulation Among Characteristics, Knowledge Level, and Attitude of Adolescents

Variable	The Ideal Age for Marriage for Women				x	p
	< 21 years		**≥ 21 years**			
	f	**%**	**f**	**%**		
Age (years)					7.713	0.021
10-14	42	18.4	186	81.6		
15-19	28	11.3	220	88.7		
20-24	10	8.9	102	91.1		
Sex					4.115	0.053
Male	51	16.3	262	83.7		
Female	21	6.2	246	93.8		
Education level					9.697	0.046
Without education	0	0	3	100		
Primary school	25	20.2	99	79.8		
Junior high school	26	19.4	134	80.6		
Senior high school	24	10.8	198	89.2		
College	6	0.7	74	99.3		
Living area (n=588)					6.084	0.018
Urban	40	10.9	327	89.1		
Rural	40	18.1	181	81.9		
Knowledge about the effects of early marriage					0.112	0.799
Yes	56	12.4	397	87.6		
No	25	11.6	191	88.4		
Knowledge about the possibility of getting pregnant after engaging in sexual intercourse only once					2.082	0.353
Can be pregnant	46	15.4	252	84.6		
Cannot be pregnant	14	10.2	122	89.8		
Knowledge about ARH						0.447
Yes	80	13.8	496	86.2		
No	1	50.0	1	50.0		
Knowledge about YGP					1.321	0.244
Yes	21	16.9	103	83.1		
No	60	12.9	404	87.1		
Attitude toward marriage before 21 years of age					29.559	0.000
Positive	55	11.8	411	88.2		
Neutral	11	12.3	78	87.7		
Negative	15	45.0	18	54.6		
Media Source of ARH					0.002	0.965

At least from one media source	78	13.9	484	86.1		
None	2	14.3	12	85.7		
Information source from ARH staff					0.864	0.369
At least one staff	74	13.5	476	86.5		
No staff	5	20.0	20	80.0		
Media Source of YGP					0.614	0.426
At least from one media source	18	16.1	94	83.9		
None	3	25.0	9	75.0		
Attitude toward FPPs					7.838	0.020
Positive	38	16.1	199	83.9		
Neutral	18	8.7	188	91.2		
Negative	25	22.1	201	77.9		
Exposure to CIC for adolescence					0.118	0.744
Yes	14	14.9	80	85.1		
No	67	13.6	427	86.4		
Knowledge about modern family planning methods					1.253	0.534
Good	2	25.0	6	75.0		
Sufficient	24	14.8	138	85.2		
Insufficient	54	0.2	364	99.8		
Knowledge about family planning					0.025	0.903
Yes	49	13.9	302	86.1		
No	32	13.5	205	86.5		

Source: PPAS from the NPFPB Bali Province in 2019

TABLE 4. Factors Related to Adolescents' Perception of The Ideal Marriage Age

Variable	AOR	Confidence Interval		p
		Lower	Upper	
Age	1.303	0.794	2.140	0.295
Education level	1.365	0.940	1.982	0.102
Sex	1.757	1.053	2.932	0.031
Living area	0.578	0.350	0.955	0.032
Have you heard, seen, or read information about YGP?	0.471	0.257	0.864	0.015
Attitude toward FPPs	1.449	1.067	1.967	0.018
Attitude toward being married before 21 years of age	0.432	0.298	0.628	0.000

Source: PPAS from the NPFPB Bali Province in 2019

*Variables that do not meet p value < 0.25 are not continued for the next multiple regression model

and 93.8%, respectively, with p-value = 0.053. These results are consistent with those of a study conducted on adolescents in Kozovar, which found that adolescents' perceptions of marriage were associated with their gender, age, level of parental education, number of siblings, education level, and financial income (Hyseni *et al*., 2020). Adolescent girls often experience reproductive health problems; therefore, women seek more information regarding disease prevention and treatment. Compared with boys, adolescent girls were reported to be three times more likely to undergo early marriage. Most sexual relations occur during marriage among adolescent girls and outside marriage among adolescent boys (Singh *et al*., 2023). Based on this, socialization about the ideal age for marriage for adolescent boys needs to be considered, considering that adolescent boys also play a role in early marriage.

The residential area was also associated with the age for marriage among adolescents (AOR=0.578; CI=0.350-0.955; p=0.032). The proportion of women who were married before 20 years was significantly higher in rural than in urban areas, at 45.5% and 27.8%, respectively (Talukder *et al*., 2020). A factor known to be associated with early marriage is the low educational level of young women and their parents. The same research in Amhara regional state results were noted among adolescents living in the village as a predictor factor for early marriage (AOR = 4:33; 95% CI=2.17, 8.64) (Aychiluhm *et al*., 2021; Radwan *et al*., 2021). This is made possible by the taboo culture embraced by teenagers. Although it still requires confirmation, education levels are not linear with a taboo culture in adolescents. The influence of taboo culture will limit them from talking about intimate or inappropriate issues related to reproductive health, such as sex issues, sex education, and contraception (Lindawati *et al*., 2022).

Moreover, teenagers living in urban areas generally have easy access to information and education, allowing them to better understand the adverse effects of marriage during adolescence. In this study, 19.2% had heard information about YGP. Women exposed to good information tend not to marry at an early age compared with those not exposed to media (Abera *et al*., 2020; Aychiluhm *et al*., 2021). Women with low education levels or those who did not finish primary school were more likely to marry in adolescence than women in high school (Berliana *et al*., 2021). In this study, the proportion of adolescents with a higher level of education was lower than that with secondary education. Most adolescents had a high school education level (34.0 %); only a small percentage had a higher education level (12.1 %), and only a small percentage did not attend school (0.5 %). However, the parents' educational levels were not evaluated in this study.

Adolescent attitudes toward FPP were significantly associated with the age to marry in adolescence. Adolescents' positive attitudes towards FPP were 1.4 times more likely to marry at the age of ≥21 compared to adolescents with negative attitudes. These results are consistent with the attitude of adolescents in Loksado District. Most teenagers in the Loksado District are optimistic about early marriage. Positive attitudes toward early marriage are more common among adolescent boys and those with a high school education (Husna *et al.,* 2017). Only about one-third of U.S. teens express a positive attitude toward premarital sex, and the majority indicate that they will have sex before marriage. Adolescents' attitudes towards FPP may be related to cultural factors. In addition, some cultures consider the use of contraception to be contrary to religious values (Najib *et al*., 2020). In general, marriage is a stage in the life cycle. Until now, customary law has not set an ideal age for marriage. A limitation that is often used in a woman's eligibility to marry is the menstrual cycle. Marriage is allowed if a woman has experienced menstruation, which indicates that the woman's uterus is ready to get pregnant (Mahendra *et al*., 2019). Cultural factors are also a reason for parents to marry their daughters before the age of 20 to avoid the stigma of "old virgins". In addition, parents will feel proud if their child is married.

Decision-making about the ideal marriage age on the island of Bali is also inseparable from cultural factors. The people of the island of Bali consist of 2 main groups, namely Bali Aga and Bali Majapahita, or modern Bali. The Bali Aga are a group native to the island of Bali who tend to maintain their

traditions and customs from generation to generation. This group tends to be more closed to outside cultures and settles in mountainous areas. Meanwhile, the Balinese Majapahit group is more open to outside civilization and lives in urban areas. The culture of freedom is a Western culture brought by tourists to the island of Bali has created a cultural dynamic (Fahrurrozhi & Kurnia, 2024).

Cultural factors may also influence adolescents' attitudes about the age of marriage (Saudah *et al*., 2023). In this study, it was found that most adolescents (87.9%) consider the ideal age to marry to be ≥21 years for women. This figure is higher than the proportion of positive attitudes of adolescents about the ideal age of marriage from other studies, which ranges from 35-77% (Taufik *et al*., 2018). Adolescents' perceptions of the ideal age for marriage are also reported to vary across countries, namely 14 years old in rural Niger (Tomar *et al*., 2021), < 18 years old in Mozambique and Ethiopia (Jones *et al*., 2020; Packer *et al*., 2020), and age 23 in Bhutan (UNICEF & UNFPA, 2019). In addition, a lack of knowledge about reproductive health has led to increasing teenage marriage (Rizqi *et al*., 2022). Adolescents are exposed to information about YGP related to the ideal age for marriage. In this study, 19.2% had heard information about YGP. Based on the bivariate analysis, there was no significant difference in the proportion of good perceptions about the ideal age for marriage among adolescents who had exposure (83.1%) and never had exposure to information regarding YGP (87.1%), with a p-value = 0.244. This assessment is also inseparable from limitations related to the use of secondary data; therefore, it has limitations in analysing variables related to perception. The analysed variables were adjusted for the availability of data. The possibility of bias in the data collection is also attributed to the use of secondary data. The data collection method used in this study follows the data collection method of the owner of NPFPA Bali Province.

Conclusion

Sociodemographic factors, such as gender, place of residence, having heard/seen/read information related to gender, and adolescents' attitudes towards family planning programs related to teen marriage. This research contributes to an increasing understanding of the role of sociodemographic factors and adolescent attitudes toward adolescent marriage. Based on this, it is recommended to expand the reach of education about reproductive health in rural areas and involve adolescent boys and girls.

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Strategies for Child Marriage Prevention in Indonesia: A Case Study

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Abstract

Early marriage is a complex social problem, with many girls marrying before the age of 18. In Indonesia, child marriage data in 2021 increased by 30%. This figure indicates that early marriage remains a significant challenge in Indonesia, in terms of education and health. This study aims to explore perceptions about child marriage and provide insight into the dynamics of decision-making around child marriage in Dlingo and Dukun, Indonesia. Qualitative research methods were used to ensure an in-depth understanding of the reasons and processes behind child marriage. Data were collected through 12 focus group discussions (FGD), 20 in-depth interviews (IDI), and 6 semi-structured key interviews (KII) informants. The instrument used a semi-structured guideline, using individual interview techniques. Data analysis used Nvivo version 12. This study concluded that families use child marriage as a protection strategy in response to economic insecurity. In addition, this program is also used as a means to protect young women from sexual exploitation and prevent consensual sex before marriage. Early marriage is associated with the vulnerability of pregnancy complications, while the recommendation is to provide comprehensive education to adolescents about reproductive health and the dangers of early marriage.

Introduction

In Indonesia, child marriage has been increasing annually by 18% among young women and 4.7% among young men under the age of 18. Meanwhile, the incidence rate in Central Java was 9.75%, while in Yogyakarta it was 84% (Statistics of Indonesia). This trend is shaped by cultural norms and perspectives among those under 18, which restrict educational opportunities, particularly for young women, and negatively impact health and empowerment due to the risks associated with early pregnancy (UNFPA-UNICEF, 2020; Weny, 2024). Additionally, some communities resort to early marriage as a means of protecting children from premarital relationships and sexual abuse, as well as preserving family honor. In Southeast Asia, including Indonesia, child marriage is also seen as a strategy to alleviate family economic hardships (Hüseyin, 2021; Kuygun, 2020). Daughters from households with lower levels of education and income are particularly vulnerable to child marriage, often arranged by their parents (Allassad, 2020; Duran, 2019). Furthermore, the availability of suitable grooms who belong to specific castes and religions, possess economic assets, and hold high educational qualifications, as well as the availability of dowry funds, serve as significant driving factors.

Local customs play a significant role in promoting the occurrence of child marriage (John, 2019). Child Marriage Restriction Law recommended a national minimum age of 16

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years for women and 18 years for men. In 2020, the marriage age for women was raised from a minimum of 18 to 19 years in Yogyakarta province. According to the Demographic and Health Survey (2021), 18.29% of women aged 29–49 years were married at 18 years, while 12.7% of 15–19-year-old women in Bantul were reported to be married. Child marriage reached 13.5% of total cases in 2020–2021 (Lo, 2019), attributed to the poor implementation of legal restrictions and contextual factors such as economic constraints and climate change (Indraswari, 2023; Nurlaily, 2025). In Indonesia, 66–78% of marriages are adapted to local culture, where a pair of siblings is exchanged between two households (Lo, 2019).

Young women are also commonly considered subordinate to young men, possessing limited decision-making power, education, and knowledge regarding sexual and reproductive rights as well as health (Ali TS, 2011; Chandra-Mouli, 2018; Handayani 2024; Azinar, 2024). For example, a study conducted in the urban slums of Lahore showed that 13 out of 19 interviewed women were unaware of the negative impacts of child marriage and satisfied with parental decision to become engaged before the age of 18 (Lo, 2019). Mengjia (2021) interviewed five married 13 to 19-year-old women in the Dlingo Bantul area, as well as another five in Dukun Magelang, and found that the victims lacked adequate initial preparation because of limited knowledge. Furthermore, the victims believed that higher knowledge would help to achieve sufficient preparation for future lives (Raj, 2019; Hermawan, 2024; Fitriahadi, 2024).

Lahore and Indonesia both have strong cultures and traditions that influence the practice of early marriage. Factors such as social norms, community pressures, and religious beliefs are often key drivers. While there are differences in cultural details, these basic patterns provide commonalities that can be used for analysis and comparison. The early marriage data from Lahore has significant relevance to the Indonesian context, particularly in socio-cultural, economic, and educational aspects. Despite geographic and demographic differences, similar patterns can be identified and used to understand the root causes and design more effective solutions. International collaboration and knowledge exchange can be a critical step towards addressing this issue more comprehensively (Raj, 2019; Hermawan, 2024).

Only 34% of young women were surveyed and consulted. Parents were the primary decision-makers in choosing partners and marriage dates (Yount, 2018). Understanding the decision-making dynamics surrounding marriage is crucial for developing specific and effective interventions in cultural contexts. The primary objective of the mentoring program (2020–2021) conducted in Bantul is to enhance the reproductive health knowledge of younger generations, as well as reduce child marriage and early pregnancies. It includes implementation of the 'in-school approach' (Vanwesenbeeck, 2016; Sekine, 2017), dialogues with community leaders, and economic empowerment activities in certain districts. Specifically, the program develops an individual or private mentoring model consisting of cadres, midwives, young children, and parents who are trained to understand reproductive health and raise awareness concerning child marriage through community campaigns from one household to another. Based on collected data, this study aims to explore community perceptions about child marriage among youths aged 15-24 years and provide insights into the associated decision-making dynamics in Dlingo and Dukun, Indonesia. Research contribution to children's health related to reproductive health in women who marry early. Contribution to the government in developing intervention programs to delay the age of marriage, such as women's economic empowerment or community-based advocacy programs. This research can provide significant contributions to understanding the phenomenon of early marriage more deeply and offer solutions to reduce its negative impacts.

Methods

Qualitative methods were applied in this study as a critical part of a broader investigation aimed at clarifying the child marriage assistance program conducted in Dlingo and Dukun. The assistance program was implemented collaboratively by the Bantul Regency government, community leaders, and Aisyiyah

cadres, with the Aisyiyah community in Dlingo as a research partner. In addition, data collection was conducted in September 2021 in Central Java and Yogyakarta Provinces. Both Dlingo and Dukun are identified as predominantly poor rural areas with large Muslim populations, especially Dlingo, which experiences the highest poverty intensity in Bantul Regency, Yogyakarta. Dlingo has elementary schools and only a few high schools. Elementary school graduation rates for young men and women are 52% and 38% in Bantul and 57% and 26% in Magelang, respectively (Tenkorang, 2019). In addition, the labor force participation of 30% men in Dlingo is associated with the practice of recruiting around 700,000 children as casual laborers, mostly from Muslim families. Tenancy relationships are often inherited, and all family members, including women and children, are expected to be involved in field work (Weny, 2024; Paul, 2019). Previous investigations reported that 30% and 25%, and 40% and 13% of women and men aged 18 to 24 in Dukun and Dlingo, respectively, were married before the age of 18. According to Statistics Indonesia (2022), 11.2% of women aged from 15 to 19 gave birth early in Dlingo. Therefore, this study uses qualitative methods to provide in-depth insights into 'why' and 'how' child marriage occurs (Busetto, 2020). Data were collected through 12 focus group discussions (FGD), 20 in-depth interviews (IDI), and 6 semi-structured key informant interviews (KII).

FGD and IDI were conducted with adolescent girls and boys aged 15–24 years and their parents or caregivers. Other IDIs were conducted with health workers, religious leaders, Aisyiyah cadres, and government staff, while KII were conducted with policymakers, legislators, and NGO staff at the district level. Each FGD session was attended by 6 to 8 participants and was arranged simultaneously with all interviews in a closed setting, such as the home of the participant or Aisyiyah cadre. The research team consisted of a lead scientist and four assistants, including two women and two men. The assistants were midwifery students at Universitas Aisyiyah Yogyakarta who had relate experience in qualitative investigations and were initially trained on research objectives, sampling methods, tools, and ethics before data collection. In addition, guidelines for the FGD, IDI, and KII were developed by the team in collaboration with program partners. Purposive sampling was adopted to select participants based on age, gender, and marital status.

The qualitative research instrument used a semi-structured guideline, using individual interview techniques. The interview guideline was piloted before the interview was conducted to ensure that it functioned well and was in line with the research objectives. In addition, the observation checklist form uses primary and secondary data. For quantitative research, a questionnaire was used to assess respondents' knowledge of the impact of early marriage on children. The questionnaire refers to previous research, which had previously undergone validity and reliability tests. The validity of the questionnaire was confirmed at 100%, and its reliability, as measured using Cronbach's Alpha, was 0.809, exceeding the threshold of 0.50. Thus, the questions in the questionnaire are reliable.

Interviews were subsequently audio-recorded with the consent of participants, and assistants prepared field notes. The process of FGD was carried out for about 1.5 hours, and interviews were performed over a period of 1 hour. One of the scientists supervised and supported the assistant team to ensure the quality of the collected data. After each session, the study team conducted debriefings to assess the quality and progress of data collection and discuss associated challenges. The team regularly contacted the authors virtually to discuss the challenges and opportunities encountered during data collection. All data were transcribed verbatim and translated into English, followed by the implementation of random testing checks on the transcripts. Thematic content analysis was also performed using Nvivo version 12, and a generic coding framework was developed based on current and relevant literature as well as the results from the baseline data collected in 2018. Themes identified from the data were discussed among the team and added to the coding framework. The coding helped identify patterns, including similarities or differences, in the responses of participants from the two sub-districts. Narratives were written based on primary

themes and sub-themes, and then the study team explained the objectives, potential risks, and benefits as part of the consent process.

The right to withdraw consent during the interview without any penalties was reiterated, and informed consent forms adapted to the local Indonesian language were provided to participants. Verbal consent was obtained when participants felt uncomfortable disclosing names or signing the consent form. In the case of minors, consent from parents or caregivers had to be obtained, along with the minors' consent. This study adhered to strict qualitative research standards to ensure data validity and trustworthiness (Johnson, 2020), using various strategies to maintain high data quality throughout the research process. Data validity in qualitative research is assessed through trustworthiness, which includes aspects such as transferability, confirmability, dependability, and credibility. Repeated checking and review of transcripts by other researchers further ensured reliability, with NVivo 12 used for data storage and organization. Moreover, the child marriage assistance protocol was approved by the Research Ethics Committee of Universitas Aisyiyah Yogyakarta (1873/KEP-UNISA/VIII/2021).

Results and Discussion

Sample demographic characteristics, including the participants' gender, are presented in Table 1. In this study, both married and unmarried young people were recruited as participants, showing varying levels of education, with some lacking formal education. Most interviewed fathers received a relatively good education and were predominantly engaged in farming, while all interviewed mothers had no formal education and solely remained as homemakers. Similarly, all interviewed grandmothers lacked formal education and were aged 50 years. Among the two religious leaders (Muslim) assessed, one held a bachelor's degree. Health workers from both sub-districts were over 40 years old and found to possess a Diploma III education. Interviewed Aisyiyah cadres had higher education degrees, and all key informants were Muslim men over 40 years old.

From the exploration of perceptions and driving factors, many young people and some adult participants acknowledged the social value attributed to child marriage. But the victims did not recognize any benefit from the practice. Some young and adult participants believed that child marriage was justified due to various economic benefits for households during childbirth, spousal benefits for in-laws, and the perceived 'protection' provided to young women. It was also speculated to offer opportunities for young women to express personal rights, thereby fulfilling imposed societal expectations. Young people, particularly women, are seen as burdens, with the discourse revolving around the perception of children as financial burdens. According to a young woman (FGD, 15–19 years old):

"Parents consider them [daughters] as burdens, hence, they marry early. And we [daughters] really relieve our parents of responsibility [when they marry early]."

Additionally, the financial burden of raising a daughter who will at some point marry and move into the house of in-laws was mentioned by an Aisyiyah cadre and several young people. A young man (IDI, 20–24 years old) summarized this statement by saying parents tend to save expenses through the early marriage of daughters. A mother and a young woman (FGD, 15–19 years old) discussed the pressure on young men to meet the expected responsibilities of providing for families. A young woman (IDI, 15–19 years old) referred to an unmarried son as a (potential) 'burden' to the family, while a married son could be independent. Child marriage is seen as protecting young women from premarital sex and sexual harassment. Some members of the community viewed child marriage as an appropriate strategy to prevent young women from consensual premarital sex and harassment. For young men (IDI, 20–24 years old), marriage was speculated to be a safeguard against 'bad habits'. A young woman from a youth organization stated that community members believed marriage would liberate the victims from negativity. This sentiment was elaborated by a grandmother based on the belief about a young woman having a boyfriend. The

fear of the daughter eloping with the boyfriend prompted parents to arrange a marriage with another man to prevent such an occurrence. Moreover, the same grandmother clearly distinguished between the behavior of educated and uneducated young women. The uneducated who remained unmarried at 18 were ridiculed by presuming that the situation would increase the chances for young women to start dating men. But it was not considered an issue for their educated counterparts. A key informant from an NGO described child marriage as a strategy to protect the victims from sexual harassment.

The motivation behind child marriage explains why younger generations marry early despite preferring to engage above the age of 18. Marriage, children, and household chores are part of life. Some young people mentioned that society considered child marriage beneficial because young brides would take care of the in-laws of the husband and assist with household chores. For a young woman (IDI, 15–19 years old), marriage is a social order constituting a crucial aspect of life, where a daughter will marry, go to the house of in-laws to provide care, and help with household chores. A young man (FGD, 20-24 years old) reported that, supposing the couple is "settled" (has a stable income and clear living arrangements), there will be no negative impact from child marriage. Another young man reiterated that young couples could bear children early to gain support in the future. A young woman and two adults discussed early marriage as a normal phenomenon. Other benefits of child marriage include introducing an infant into the family and learning how to live responsibly in society.

The exploration of decision-making dynamics showed that in most cases, a premature marriage is the parent decision. Young people, specifically women, lack the option to make this decision, while the educational status of parents and children influences the tendency toward child marriage in households. Additionally, this study obtained community ideas about consent, where some young people could reject getting married and intervene in other marriages. The stated refusal attitude is particularly true when confronted with or trained through assistance programs. The majority of participants reported parents as the main decision-makers regarding child marriage. Two key informants explained that fathers play the most significant role in making this decision due to the patriarchal nature of society. Other relatives (men) were mentioned as decision-makers by young men (FGD, 15–19 years old) and a grandmother (IDI) in a context where most marriages were only recorded in religious offices. Some young people, including those who have participated in assistance programs, felt the necessity for children to make personal decisions and reported that more parents solicit the consent of children before arranging marriages. A young woman (FGD, 15–19 years old) associated these changes with increased awareness of the negative impacts of child marriage. Most young people and all parents explained that children would not be forced into marriage. However, a father in FGD still estimated that only 10% of parents asked for the opinions of children. Some participants reiterated the influence of education and agreed that educated parents offer children more freedom and options in making marriage-related decisions.

"In some communities, children are not consulted about marriage, as parents make the decisions and set the wedding date. Even before marriage, they cannot meet each other [referring to the couple], but in educated communities, the situation is different."

In educated communities, the desires of daughters for marriage are considered, and the right to make marriage decisions is acknowledged. In the Indonesian environment, 50% of the community accepts the rights of children, and 50% do not.

"A young woman from the youth group (20 years old, IDI) stated that conscious people respect the rights."

According to a father (FGD), children should primarily decide when to marry while still considering the opinion of parents. Most fathers interviewed in FGD were highly educated and working as teachers, which might influence some opinions. Some fathers stated that there would be no negative consequences in case a son refused to marry. Another father realized that

providing opportunities for partner selection to children would make daughters confide in parents and not run away from home. It was mentioned that when an absconding daughter received stigma and embarrassed the family. FGD conducted with mothers possessing a more diverse background and level of education compared to fathers added some differences to these results. According to a particular report, mothers are often consulted, and children can inform parents in case of disagreement. But the father has the right to make the final decision in such matters. For a healthcare worker from the IDI category, parental education does not automatically guarantee the consideration of the children's consent. This participant stated:

"I have seen some people who get children's consent for marriage, even though they have low education. But many educated people also ignore children's expectation".

Young people do not have sufficient opportunities to make decisions about marriage. Many young people reported the lack of ability to make decisions about marriage and the need to obtain permission from their fathers. A policymaker reiterated the influence of gender norms and mentioned the discourse about young women as 'burdens' by stating the expectation of future marriage, which affects the nurturing pattern used for women. This participant declared that:

"They [parents] consider them [daughter] as burdens, not responsibilities. First, they educate their children, then marry them without being asked, let alone the daughters." According to young people (FGD, 15–19 years old), there is a significant difference between the decision-making capacity and freedom provided to young women and men."

Furthermore, a young woman (IDI, 20–24 years old) reported that when a daughter refused to marry, the parent was pitied. A teacher advised daughters not to refuse marriage:

"Parents are the ones who make decisions. If a son denies his parents' decision, he can be expelled from the house. Parents call the son misbehaving. However, the daughter cannot deny their parents' decision."

Most mothers subjected to IDI and FGD had different opinions about whether sons have more chances to make decisions than daughters. One mother argued that although some parents ask for the consent of sons, this does not occur with daughters. Similar to educated parents, educated younger generations show more voice in decision-making. According to a grandmother, an educated young woman would be respected by the community and not married off before reaching the age of 18. A father (FGD) stated that an educated daughter would have greater bargaining power in marriage. Some young and adult participants discussed potential income (to be earned after education) and economic security as benefits of educating young women who are not married. It was also mentioned in the context of vocational training or skill development opportunities capable of generating employment and preventing child marriage. An NGO participant subjected to KII stated that

"If a young woman becomes a doctor or a teacher, her parents will not marry her off at a young age because she is a source of income, she earns a living, and supports her parents; hence, why would they marry her off early? In the village, the situation is different, where acceptance of women's education is limited, hence; they are married off".

While discussing decision-making regarding marriage, the extent of consent of women is considered crucial. The participation of young women in decision-making seems limited to giving consent, and only in some cases involve selecting a partner. Some young women (IDI, 15–19 years old, and FGD, 15–19 years old) reported that marriage would not last long without mutual consent and understanding, and could lead to divorce. One key informant questioned the ability of younger generations to offer meaningful consent. According to an NGO participant (KII),

"If you see a 12 or 13-year-old child about to get married, it would not hurt to ask for their

consent. They sometimes do not even know what marriage is; hence, they also do not know what decision-making is, and they do not know what responsibilities they should take on. It is just moving from one house to another".

Some young people rejected and intervened in existing child marriage, and this study found certain cases of refusal, which occasionally led to the stopping of the marriage. The majority of participants reported that with increasing awareness, there is a change in the attitudes of parents and society toward child marriage. As expressed by a young woman from the youth organization, increased awareness and knowledge enable society to reject child marriage. When discussing the role of a group of adolescents, a young woman (FGD, 15–19 years old) testified to the influence of mentoring programs on stopping child marriage:

"Yes, they [youth clubs] prepare younger generations a lot; now young people are aware and can voice their rights. I refused when my parents arranged my marriage when I was still in the first year of high school. I told them that it was not my time to get married. I am still a child and do not know what marriage means. My father wanted to marry me off because he was not healthy, and his financial condition was not good."

Additionally, education plays a crucial role in rejecting child marriage. A grandmother subjected to IDI stated that *"Educated young women and men can also reject that decision and make the final decision"*. According to a young man (IDI, 20–24 years old), child marriage can be stopped by informing parents that it is a crime. The study discussion section consistently referred to the influence of education on child marriage tendency. Education levels among younger generations, specifically young women and parents, play a role in delaying child marriage. There is insufficient presence of higher education institutions in both sub-districts, and gender norms describe women as burdens, leading to limited mobility. Due to these situations, only 1 of 4 young women in Dlingo and Dukun pursue specific education. Education particularly allows young women to be considered 'valuable' family members rather than 'burdens' and married off as children in a context of severe economic insecurity. A study in India found that limited education and poverty remained the most influential factors in child marriage. Empowerment through education and economics would be a safe strategy to address this issue (Paul, 2019).

Raj (2019) stated that even though secondary education reduced the tendency of early marriage for young women, the impact was not significant because many engaged at older ages. Additionally, the effect of limited education in contexts consisting of unequal gender norms (Bandiera, 2020) was identified. It is relevant in the patriarchal context of Indonesia, where the median marriage age for women (25–49 years) is 20.4 years. In India, promising marriage proposals were found to outweigh the potential benefits of future education. In the context of food insecurity, bonded child labor, poverty, weak education systems, and limited job opportunities, methods for preventing child marriage should be multifaceted. There is a need to advocate for education for young women and expand available career choices while striving to effect broader social norm changes. This study found that the benefits of education apply to parents where parental education and aspirations are related to delaying marriage, as also observed in Senegal, Ethiopia, and India (Marchetta, 2016; McDougal, 2018; Singh, 2016; Singh, 2018).

A different study reported that parents remained skeptical about the ability of young people to make decisions despite possessing the necessary rights. Parents in Indonesia typically direct major decisions in the children's lives. Particularly, young women (Sarfo, 2020). Other investigations observed that when parents solicit the consent of daughters before marriage, it is often superficial (Crivello, 2018; Van Veen, 2018). This study showed that a few parents who requested their daughters' consent often discussed the readiness to marry and rarely asked questions related to the choice of partners. However, parents soliciting the consent of children regarding timing might indicate progress in the context of most arranged marriages. This study found no young women selecting partners, while increased

levels of education among young women have been associated with an elevated tendency of partner selection in arranged marriages (Sarfo, 2020; Kistiana, 2025).

Crivello (2018) found that young women often agree to marriage to gain family support in case of possible future marital problems. When younger generations are expected to obey elders, engaging parents in adult peer education and intergenerational dialogue, along with the promotion of alternative parenting styles, helps to delay marriage (Bhan, 2019; Semra, 2022; Robert, 2019). This study found that community engagement programs need to involve parents to bridge the generational gap, particularly while consistently addressing sensitive topics. To counter harmful gender norms limiting young women to domestic roles as well as restricting educational and career choices, interventions focusing on social norms can offer opportunities for substantial change (Sarfo, 2020; Canan, 2021).

The perception that child marriage serves as a protection and prevention strategy against forced and premarital sexual activities also shows the taboo surrounding the sexuality of young women and reproductive health. It suggests the need for consistent inquiry during data collection due to the limited chances commonly available for self-expression among children. However, this study identified some cases of resistance occurring when young people, particularly in Dukun community, intervened in child marriage. The ability of families to carry out intervention can be associated with empowerment and knowledge-based training received as part of mentoring programs. The training comprises raising awareness on reproductive health issues, including gender equality and child marriage, developing skills in self-expression, engaging with community members, and intervening in cases of child marriage. It provides an opportunity for educated women who postpone marriage to become role models, a situation equally relevant for young men.

Conclusion

In conclusion, the results showed that child marriage was used by families as a protective strategy in the context of economic insecurity. Additionally, it was implemented to prevent young women from exploitation and premarital consensual sexual relationships. Young people, specifically women, were found with limited freedom for decision-making about marriage due to strict norms requiring obedience to elders and restricting victims from giving birth and performing household roles. Although the requests by parents for child marriage approval tended to be simply superficial, it might signify progress in a context

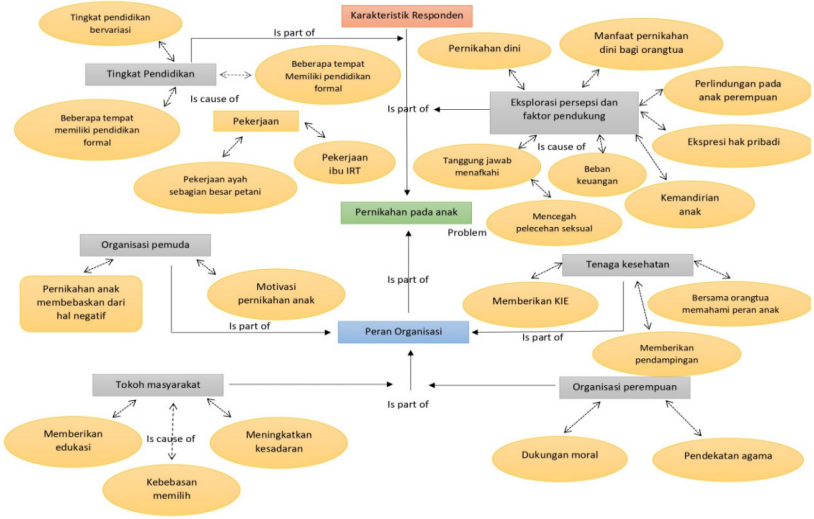

Figure 2. Problems and Models of Assistance in Preventing Child Marriage (Qualitative Analysis in Bahasa).

featuring commonly arranged marriages. Moreover, education was perceived and used, both by young people and adults, to negotiate decisions in families and reject societal norms to delay marriage. The results showed that advocating for the education of women and expansion of available career choices should be the primary and ongoing focus while striving to effect social norm changes by involving parents, Aisyiyah cadres, and empowering younger generations.

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Families at Risk of Stunting and the Prevalence of Stunting in Indonesia: An Ecological Study

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Abstract

Abstract: Stunting remains a critical public health challenge in Indonesia, impacting child growth, cognitive development, and long-term productivity. The government has prioritized interventions targeting families at risk of stunting to reduce its prevalence. This study examines the relationship between families at risk of stunting and stunting prevalence in Indonesia by an ecological study design. Data were analyzed at the district/city level using correlation analysis to assess key risk factors. The findings indicate that inadequate access to safe drinking water, poor sanitation, substandard housing, and reproductive health risks among women of reproductive age are significantly correlated with higher stunting prevalence ($p<0.05$). The correlation coefficients for these factors are 0.14, 0.19, 0.17, and 0.33, respectively. Furthermore, a one percent reduction in families at risk of stunting is associated with a 0.19 percent decrease in stunting prevalence (R^2 = 16%). These results highlight the need for comprehensive interventions addressing environmental, socio-economic, and maternal health factors. Strengthening policies that improve access to clean water, sanitation, and maternal health services is crucial to accelerating stunting reduction efforts in Indonesia. Prioritizing families at risk can enhance the effectiveness of government strategies in achieving national stunting decrease targets.

Introduction

Stunting remains a significant public health concern in Indonesia, marked by chronic malnutrition affecting children's growth and development. In 2023, the stunting prevalence was 21.5%, showing only a slight decrease from 21.6% in 2022, highlighting persistent challenges and the need for effective interventions (Ministry of Health the Republic of Indonesia, 2024). Stunting impairs not only physical growth but also has lasting impacts on cognitive development, educational outcomes, and economic productivity. Stunting is driven by various factors, including child-specific factors like low birth weight, frequent diarrhea, and poor dietary diversity (Berhe *et al.*, 2019; Woldeamanuel & Tesfaye, 2019). Family factors, such as maternal education, height, BMI, household wealth, and family size, also play a role (Berhe *et al.*, 2019; Mulyaningsih *et al.*, 2021). Environmental factors, including limited access to clean water, sanitation, and electricity, further contribute to the issue(Mulyaningsih *et al.*, 2021; Yani *et al.*, 2023). Nutrition-specific and -sensitive interventions, such as poverty reduction, improved food access, sanitation,

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and education, are crucial for reducing stunting (Siswati *et al*., 2022). In India, enhanced health services, household assets, and sanitation led to a 47% reduction in stunting, supported by political stability and community engagement (Kohli *et al*., 2020). In Sub-Saharan Africa, stunting decreased significantly over the last decade, with faster reductions among disadvantaged groups, although disparities in diet quality and healthcare access remain (Baye *et al*., 2020).

Effective interventions should improve maternal education and nutrition, increase dietary diversity, reduce diarrheal infections, and strengthen community infrastructure (Eshete *et al*., 2020; Herawati & Sunjaya, 2022). The Indonesian government has prioritized preventive strategies for families at risk of stunting. Such families, often characterized by low socioeconomic status, insufficient parental education, limited access to healthcare, and poor dietary practices, are considered key contributors to the high prevalence of stunting in the country (Ahmad *et al*., 2023; Headey *et al*., 2020; Kwami *et al*., 2019). This study aims to evaluate the relationship between families at risk of stunting and the prevalence of stunting in Indonesia. The findings of this study will provide insights into the most effective interventions and policy measures needed to address stunting, thereby contributing to the ongoing efforts to reduce stunting prevalence in Indonesia.

Method

This research is an observational study with an ecological approach aimed at examining the relationship between families at risk of stunting and the prevalence of stunting at the district/city level. The dependent variable in this study is the prevalence of stunting at the district/city level, derived from the Indonesian Health Survey (Survei Kesehatan Indonesia - SKI) conducted in 2023. The independent variable in this study is families at risk of stunting, measured based on aggregated data from the 2023 update of Indonesian family data. According to Indonesia's National Action Plan for Accelerating Stunting Reduction (RAN PASTI), families at risk of stunting are those that possess one or more risk factors associated with stunting. These factors include having family members who are adolescent girls, brides-to-be, pregnant women, or children aged 0–23 months and 24–59 months, belonging to poor households, having parents with low educational attainment, living in environments with inadequate sanitation, and lacking access to safe drinking water. The measurement of this variable involves aggregating the total number of families meeting these risk criteria at the district/city level, providing a comprehensive overview of the distribution of at-risk families across Indonesia's 514 districts/cities. This approach allows for the analysis of the relationship between the prevalence of stunting and the concentration of at-risk families in each area.

To explore the relationships between these variables, a correlation analysis approach was employed. This method will help determine the strength and direction of the association between family risk factors and stunting prevalence across various regions. By identifying the key risk factors and their impact on stunting, the findings of this study aim to provide valuable insights for more effective interventions and policies to address stunting, thereby contributing to ongoing efforts to reduce stunting prevalence in Indonesia. This study has obtained ethical approval from the Faculty of Public Health, Universitas Indonesia, with the ethical approval number Ket-678/UN2.F10.D11/PPM.00.02/2024.

Result and Discussion

According to the 2023 Indonesian Health Survey, the national average stunting prevalence stands at 21.5%. However, this progress has yet to meet the target set in the National Medium-Term Development Plan 2020-2024, which aims to reduce it to 14% by 2024. Among Indonesia's 38 provinces, 15 provinces have a stunting prevalence below the national average. The three provinces with the highest stunting rates are Papua Tengah (39.4%), Nusa Tenggara Timur (37.9%), and Papua Pegunungan (37.3%). An in-depth analysis of stunting prevalence across the country's 514 districts and cities reveals considerable variation. In 277 districts/cities, the prevalence exceeds the national average of 21.5%, signaling the need

for focused interventions in these areas. On the other hand, 222 districts/cities have managed to keep stunting prevalence below the national average, suggesting the effectiveness of local health initiatives or differing socio-economic conditions. Data collection gaps in 15 districts/cities, due to low response rates, hinder an accurate assessment, highlighting the need for more robust data gathering efforts. Notably, 65 districts/cities have already achieved a stunting prevalence of less than 14%, meeting the 2024 target set by the Presidential Regulation. These regions offer valuable insights into successful strategies that could potentially be applied to other areas. These findings underscore the importance of region-specific approaches in reducing stunting and achieving broader public health goals across Indonesia.

The identification of families at risk of stunting is based on screening specific target families, including families with women of reproductive age (15-49 years), pregnant women, infants aged 0-23 months (baduta), and toddlers aged 24-59 months (balita). These families are assessed for risk factors such as lacking access to safe drinking water, inadequate sanitation, and the "4 Too" conditions: having children too young (under 20 years), being too old to have children (over 35 years), having closely spaced children (less than 2 years apart), or having more than two children. Families not using modern contraception are also flagged as at risk. If a family meets even one criterion, they are categorized as being at risk of stunting. Environmental factors significantly contribute to stunting, particularly access to safe drinking water. Unsafe water and inadequate sanitation heighten the risk of infections-like diarrhea, a key cause of malnutrition, especially during the first 1,000 days of a child's life (Ahmad *et al*., 2023). The highest proportion of target families without access to safe drinking water is in Papua Pegunungan Province, where 68.71% (70,797 out of 103,032 households) lack access. Conversely, DKI Jakarta has the lowest proportion, with only 0.30% (3,004 out of 995,792 households) lacking safe water access.

Adequate sanitation is also crucial for stunting prevention. Poor sanitation promotes infectious diseases. Further, increasing stunting risks (Kwami *et al*., 2019). Across Indonesia, many target families lack proper sanitation, with Papua Pegunungan Province again having the highest proportion—72.12% (74,308 out of 103,032 households) without adequate facilities. DI Yogyakarta has the lowest, with just 5.92% (30,696 out of 518,449 households) lacking sanitation. This geographic variation emphasizes the need to address both water and sanitation to reduce stunting. Reproductive health is another key factor, specifically the "4 Too" conditions: having children too young, too old, too closely spaced, or too many. In the second semester of 2023, approximately 43% of target families were identified as meeting one or more of these criteria. Addressing these conditions through targeted interventions is critical to reducing stunting prevalence.

Table I. Stunting Prevalence and Risk Factors for Families at Risk of Stunting Across Indonesian Provinces 2023

Province	Prev.	Target Families	%Poor Drinking Water	% Poor Sanitation	% Families with High-Risk WRA	% Risk of Stunting
Aceh	29.4	802,499	5.6	16.3	51.4	34.3
Sumatera Utara	18.9	1,862,441	8.3	16.4	54.3	36.3
Sumatera Barat	23.6	738,445	5.9	24.2	52.7	38.9
Riau	13.6	958,885	14.7	14.3	50.3	35.4
Jambi	13.5	621,290	12.3	15.5	44.2	30.9
Sumatera Selatan	20.3	1,329,298	11.0	17.3	46.2	32.4
Bengkulu	20.2	335,560	7.5	12.4	44.8	25.1
Lampung	14.9	1,335,818	6.6	10.4	42.7	24.0
Kep. Bangka Belitung	20.6	250,470	2.5	7.2	43.4	16.9
Kepulauan Riau	16.8	308,936	3.2	13.5	48.5	35.3
Dki Jakarta	17.6	995,792	0.3	9.1	45.8	32.9
Jawa Barat	21.7	7,811,477	4.0	18.5	41.7	29.7
Jawa Tengah	20.7	5,777,687	4.7	11.7	38.6	23.8
DI Yogyakarta	18	518,449	5.0	5.9	36.1	20.6
Jawa Timur	17.7	6,154,287	3.6	14.9	36.1	24.6
Banten	24	1,879,648	2.6	10.6	42.8	21.9
Bali	7.2	587,840	4.6	11.7	40.9	24.6
Nusa Tenggara Barat	24.6	945,553	3.7	17.8	43.4	30.4
Nusa Tenggara Timur	37.9	638,837	20.1	36.3	56.4	60.3
Kalimantan Barat	24.5	706,347	44.4	22.5	46.1	59.8
Kalimantan Tengah	23.5	382,085	16.9	21.3	43.3	36.5
Kalimantan Selatan	24.7	639,992	10.1	18.1	41.5	29.8
Kalimantan Timur	22.9	523,012	3.9	9.1	47.9	25.9
Kalimantan Utara	17.4	85,887	10.8	16.6	52.3	40.5
Sulawesi Utara	21.3	326,325	4.2	17.2	40.2	29.6
Sulawesi Tengah	27.2	454,224	7.1	24.0	48.3	39.0
Sulawesi Selatan	27.4	1,214,817	3.9	11.2	49.0	26.1
Sulawesi Tenggara	30	389,763	5.9	15.9	53.5	35.8
Gorontalo	26.9	201,670	2.7	26.7	42.4	35.7
Sulawesi Barat	30.3	205,011	12.1	23.2	51.6	44.8
Maluku	28.4	204,077	8.3	23.0	55.9	48.4
Maluku Utara	23.7	160,544	6.5	19.4	50.8	36.4
Papua	28.6	91,301	18.4	23.7	49.7	54.9
Papua Barat	24.8	93,683	22.9	24.1	52.4	55.6
Papua Selatan	25	51,406	26.4	39.3	50.9	61.9
Papua Tengah	39.4	87,298	37.2	56.4	38.8	74.9
Papua Pegunungan	37.3	103,032	68.7	72.1	32.1	92.4

WRA=women of reproductive age

Table I below provides detailed information on stunting prevalence and families at risk of stunting at the provincial level.

Stunting prevalence is influenced by a complex mix of socio-economic and environmental factors. Access to safe drinking water and sanitation is critical, as poor water quality and inadequate facilities increase the risk of diseases like diarrhea, leading to chronic malnutrition and stunting (Astuti *et al.*, 2025; Najib *et al.*, 2024). Families lacking these services face higher risks due to repeated infections and poor nutrient absorption in children. Socio-economic conditions, such as income, education, and healthcare access, also play a significant role, with lower-income families often unable to provide adequate nutrition for proper child growth. Reproductive health practices, particularly closely spaced pregnancies (as seen in WRA 4T), further raise stunting risks. Mothers with little recovery time between pregnancies may experience nutritional depletion, impacting both their health and that of their children. These factors collectively make children more vulnerable to stunting, highlighting the need for comprehensive interventions that address both nutritional needs and the wider socio-economic and environmental conditions.

Access to safe drinking water is a critical factor in stunting. Unsafe water increases the risk of diseases like diarrhea, which contributes to malnutrition in children, particularly within the first 1,000 days of life—a key period for growth (Najib *et al.*, 2024). Figure 1 shows a positive correlation between stunting prevalence and the percentage of families

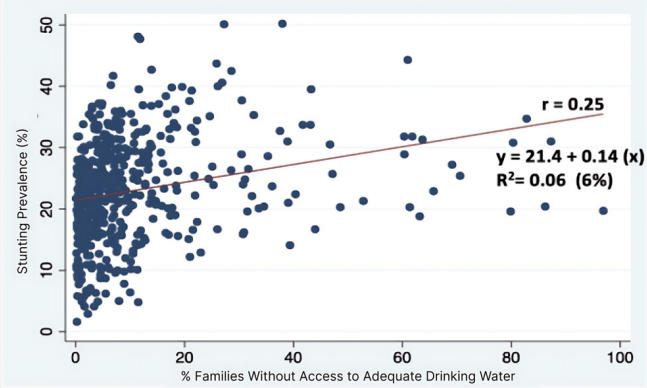

Figure 1. Correlation of Stunting Prevalence and the Percentage of Families with Inadequate Access to Safe Drinking Water

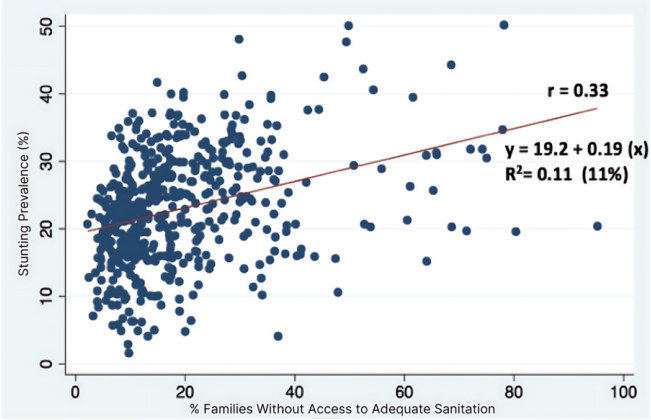

Figure 2. Correlation of Stunting Prevalence and the Percentage of Families with Inadequate Sanitation

without access to safe water. The regression line indicates that as the percentage of families lacking safe water rises, so does the prevalence of stunting.

Figure 1 illustrates a positive relationship between the percentage of families without access to safe drinking water and the prevalence of stunting in Indonesia. This relationship is depicted by the regression line with a positive slope, indicating that as the percentage of families without access to safe drinking water increases, the stunting prevalence tends to rise as well. However, this relationship is relatively weak, with a correlation coefficient (r) of 0.25. The R^2 value of 0.06 suggests that only 6% of the variation in stunting prevalence is explained by access to safe drinking water, implying that other factors play a more significant role. Therefore, while improving access to safe water is important, broader efforts are needed to address various other determinants of stunting. The condition of adequate sanitation in Indonesia is a crucial factor in preventing stunting in children. Adequate sanitation encompasses access to clean water, proper toilet facilities, and good hygiene practices. In many parts of Indonesia, particularly rural areas, access to such sanitation remains a challenge. This lack of adequate facilities contributes to the spread of diseases like diarrhea, which significantly affects children's nutritional status and overall health. Therefore, improving sanitation infrastructure is vital for reducing stunting and promoting better health outcomes for children across the country.

Figure 2 shows the correlation between the percentage of families without access to adequate sanitation and the prevalence of stunting in Indonesia. A positive relationship is evident, as stunting prevalence tends to rise with an increase in families lacking proper sanitation. The regression line's positive slope confirms this association. The correlation coefficient (r) of 0.33 indicates a moderately strong relationship, stronger than the one observed between stunting and lack of safe drinking water. The R^2 value of 0.11 reveals that 11% of the variation in stunting prevalence can be explained by access to adequate sanitation, highlighting that while sanitation plays a role, other significant factors also contribute to stunting.

Stunting, a chronic condition affecting children's physical and cognitive development, is influenced by multiple factors, including maternal health and reproductive patterns. One significant indicator associated with stunting risk is the presence of women of reproductive age with four high-risk factors, commonly referred to as 4T: women who are too young, too old, have closely spaced pregnancies, or have too many children (Najib *et al.*, 2024). These high-risk reproductive factors contribute to stunting risk in children and highlight the importance of maternal health in addressing stunting prevalence. The figure below will

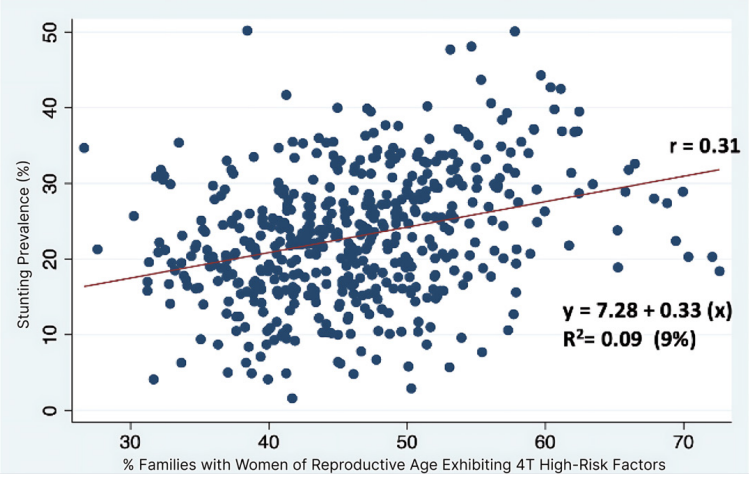

Figure 3. Correlation of Stunting Prevalence and Families with Women of Reproductive Age with High-Risk Factors

further explain the relationship between stunting prevalence and the percentage of women of reproductive age with these high-risk factors.

Figure 3 presents a linear regression analysis examining the relationship between stunting prevalence and the percentage of women of reproductive age (WRA) experiencing 4T, and the figure below illustrates this relationship. A positive correlation was found, with a regression coefficient of 0.336, indicating that for every one-unit increase in WRA with 4T, the stunting prevalence rises by 0.33 units. This finding is statistically significant, as evidenced by a very low p-value (0.000), underscoring the strong likelihood that this relationship is not due to chance. The model's R^2 value of 0.0977 and adjusted R^2 of 0.0959 suggest that around 9.59% of the variability in stunting prevalence can be explained by the percentage of WRA experiencing 4T. While this indicates a notable influence, the majority of variability in stunting prevalence remains unexplained, pointing to the presence of other contributing factors.

Families identified as "at risk of stunting" are characterized by specific risk factors, such as inadequate access to safe drinking water, poor sanitation, and the presence of high-risk reproductive behaviors among women of reproductive age, known as WRA 4T (too young, too old, closely spaced pregnancies, or having too many children). These risk factors not only affect maternal health but also create conditions that increase the likelihood of stunting in children. Understanding the relationship between at-risk families and stunting prevalence is crucial for developing targeted interventions to lower stunting rates. The following analysis explores how these risk factors contribute to stunting prevalence, emphasizing the need for comprehensive strategies to address this issue.

Figure 4 illustrates the correlation between stunting prevalence and the percentage of families at risk of stunting in Indonesia for 2023. Regression analysis reveals a significant relationship, with a regression coefficient of 0.1969 ($p < 0.0001$), indicating that for every 1% increase in families at risk, the stunting prevalence rises by 0.1969 units. The model's intercept is 15.84 ($p < 0.001$), representing the baseline stunting prevalence when no families are at risk. The R-squared value of 0.1644 implies that 16.44% of the variability in stunting prevalence is explained by this model, while the adjusted R-squared value of 0.1627 confirms model consistency. Despite the significant positive relationship, the low R-squared suggests that most variations in stunting prevalence are influenced by other factors not captured in this model.

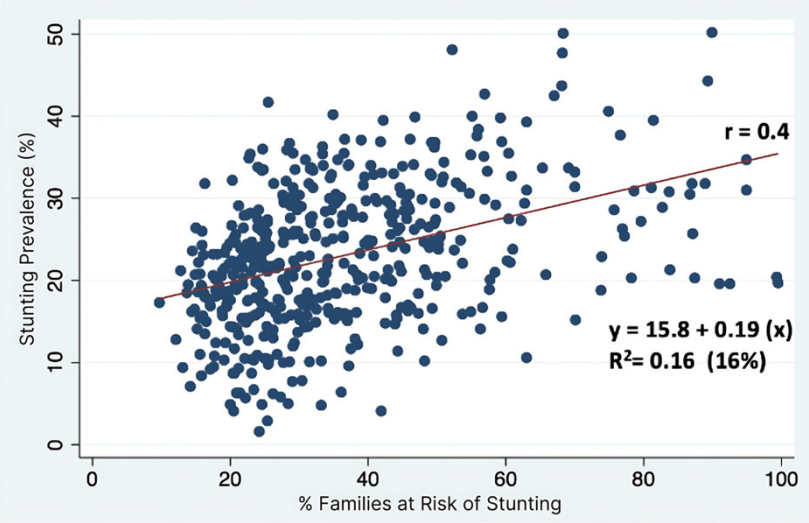

Figure 4. Correlation of Stunting Prevalence and Families at Risk of Stunting in Indonesia

Preventing stunting in children is far more effective than attempting to treat stunted growth after it has occurred. Stunting has long-term implications for a child's health, cognitive abilities, and future productivity. If not addressed early, it can lead to lower economic productivity in adulthood and place a greater burden on healthcare systems. Thus, focusing on prevention can not only improve individual well-being but also produce wider social and economic benefits, including creating a healthier, more productive workforce (Robinson & Dinh, 2023). Preventive interventions are particularly crucial during the first 1,000 days of a child's life—a critical period for growth and development. Research indicates that interventions targeting nutrition during this time frame significantly improve child linear growth and can reduce stunting by as much as 10.2% by 24 months of age. These early interventions establish a strong foundation for lifelong health and development, underlining the importance of timely action in combating stunting (Soofi *et al*., 2022).

A multisectoral approach has been proven to be more effective in preventing stunting than isolated interventions. By involving various sectors, such as health, education, sanitation, and social protection, comprehensive programs can provide a supportive environment for child growth and development. Addressing multiple factors that contribute to stunting through a collaborative approach ensures that children receive holistic care, leading to improved immediate health outcomes and enhanced long-term well-being. These integrated efforts maximize the effectiveness of interventions and are crucial for sustainable stunting reduction (Kim *et al*., 2020). Key areas such as improved sanitation, access to clean water, and health education are crucial components of these programs, as they collectively reduce the risk factors associated with stunting. Additionally, investments in stunting prevention generate substantial economic benefits. Economic analyses describe that every dollar spent on stunting prevention yields an average return of 18 dollars, as children who are not stunted tend to perform better academically, are more productive in their future careers, and have higher lifetime earnings. This highlights the long-term societal and economic gains from investing in preventive measures, going beyond individual health improvements to create broader benefits for communities and economies (Aguilera & Daher, 2019; Galasso & Wagstaff, 2018; Nasser *et al*., 2022).

To effectively address stunting, it is essential to identify families at high risk of this condition. Stunting, a consequence of chronic malnutrition, can severely impair a child's growth, cognitive development, and future productivity. By leveraging data on families at risk, governments and health organizations can develop targeted interventions to mitigate these risk factors. Such data often encompasses nutritional status, dietary habits, access to healthcare, and socio-economic conditions, enabling more precise strategies to tackle the underlying causes of stunting (Victora *et al*., 2021). Immediate interventions informed by this data can deliver nutritional support, health education, and improved access to medical services to the most vulnerable populations. For example, food and vitamin supplementation programs can be specifically directed at pregnant women and young children in high-risk families. Additionally, educating caregivers on proper feeding practices and hygiene can significantly reduce the risk of infections contributing to stunting. These targeted, data-driven approaches ensure that resources are efficiently allocated and interventions are more likely to decrease stunting prevalence (Suratri *et al*., 2023).

The role of the family is critical in preventing stunting, as it is the primary unit influencing a child's growth and development. Families play a vital role in providing adequate nutrition, balanced diets, and a supportive environment for optimal growth. Research has shown that family-centered interventions, such as education on proper feeding practices, can significantly decrease the risk of stunting. Engaging families in prevention efforts helps foster healthier habits that support children's well-being and growth (Yani *et al*., 2023). Mothers, in particular, play a crucial role in ensuring proper nutrition during the first 1,000 days of life—a period critical for both physical and cognitive development. Adequate nutrition during this window supports brain

development and establishes the groundwork for future health outcomes (Brar *et al*., 2020; Kwami *et al*., 2019).

Environmental factors like inadequate sanitation, unsafe water, and hygiene practices significantly contribute to stunting. A study by Torlesse *et al*. identified a strong relationship between household sanitary facilities, water treatment methods, and child stunting (Torlesse *et al*., 2016). The risk of stunting was over three times higher in households using unimproved latrines and consuming untreated water, emphasizing the importance of access to safe water and sanitation. Stewart *et al*. demonstrated that environmental factors like infection, inflammation, and undernutrition are critical in determining child growth and development (Stewart *et al*., 2013). Globally, contaminated water and poor sanitation account for approximately 5.4 billion diarrhea cases and 1.6 million deaths annually (Hutton & Haller, 1994). Addressing these challenges requires comprehensive interventions that focus on improving access to clean water, sanitation, and hygiene practices.

The impact of inadequate water, sanitation, and hygiene (WASH) practices remains substantial, contributing to over 1,000 child deaths daily worldwide. While strides have been made in reducing mortality rates, diarrheal diseases continue to pose a significant burden, with around 1.7 billion cases annually. Chronic diarrheal episodes can lead to undernutrition, stunted growth, and cognitive deficits in children. In addition, inadequate WASH conditions contribute to environmental enteropathy, a chronic form of intestinal inflammation that exacerbates malnutrition and developmental issues in children (Prüss-Ustün *et al*., 2019; Waddington *et al*., 2023). These conditions represent significant health risks and underscore the importance of global efforts to improve WASH practices as a preventive measure against stunting. Inadequate access to safe water, poor sanitation, and hygiene practices are dominant global health risks contributing to diarrhea and stunting. These factors are especially critical in low-income settings, where diarrheal diseases significantly add to disability-adjusted life years (DALYs) and are closely linked to stunted growth (Karambizi *et al*., 2021). Practices like using unprotected water sources and poor sanitation facilities facilitate the faecal-oral transmission of pathogens, leading to diarrhea, which can result in undernutrition and stunted growth. These health issues are associated with impaired cognitive development and reduced intellectual capacity, leading to long-term physical and cognitive deficits in children (Girma *et al*., 2024; Stürchler, 2023).

Stunting is closely related to the "4 Too" conditions among reproductive-age individuals. Young mothers, especially under 20, face a higher risk of giving birth to stunted children due to biological immaturity, often resulting in complications like low birth weight (Adugna, 2022; Qi *et al*., 2022). Older maternal age (above 35) is also associated with adverse pregnancy outcomes, increasing the risk in offspring (Jacobson *et al*., 2023; Scime *et al*., 2020). Short interpregnancy intervals deplete maternal nutrition, affecting child growth, while having more than two children can strain family resources, impacting adequate nutrition and care (Petersen *et al*., 2021; Wang *et al*., 2022). Targeted public health interventions, including family planning and maternal health education, are essential to address these "4 Too" conditions and reduce stunting prevalence (Mengesha *et al*., 2021). Socioeconomic status is a significant determinant of stunting. Low-income families often struggle to provide nutritious food and access to healthcare services essential for child growth and development. Poor economic conditions also lead to inadequate access to clean water and sanitation, key factors in preventing stunting. Children from economically disadvantaged backgrounds face a higher risk of chronic malnutrition and recurrent infections, which contribute to stunted growth (Shibre *et al*., 2021; Soekatri *et al*., 2020; Widyaningsih *et al*., 2022).

Conclusion

In conclusion, preventing stunting is a multifaceted challenge that requires timely, data-driven interventions and a multisectoral approach involving health, education, sanitation, and social protection. The critical role of families, especially mothers, in ensuring proper nutrition and care during

the first 1,000 days of a child's life cannot be overstated. Targeted programs that address high-risk families, improve access to clean water, sanitation, and healthcare, and promote health education are essential in reducing stunting rates. Furthermore, the economic benefits of stunting prevention—both in terms of individual well-being and broader societal gains—underscore the importance of continued investment in these efforts. By addressing the root causes of stunting and adopting a holistic approach, it is possible to foster a healthier, more productive generation and significantly reduce the long-term impacts of stunting.

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Menopause: Mental Health, Health Issues, and Coping Strategies. A Qualitative Study

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Abstract

Menopause marked a transformative phase in many women's lives, often accompanied by complex physical, emotional, and social challenges. This study aimed to explore how women in Yogyakarta experienced and managed menopause, shedding light on their unique coping strategies and support systems. A qualitative design employed purposive sampling to recruit women aged 45 to 55, ensuring diverse and relevant experiences. In-depth, face-to-face interviews were conducted and analyzed thematically to uncover underlying patterns and meanings. Four major themes emerged: physical and emotional changes, adaptation strategies, social support dynamics, and shifts in sexuality. Women reported symptoms such as sleep disruption, fatigue, and mood instability, and adapted by seeking information and modifying their lifestyles, although resources were often insufficient. Family and community support provided essential emotional relief, while changes in intimacy required communication and adjustment. These findings highlighted the need for holistic menopause management that integrates physical, emotional, and relational support.

Introduction

Menopause is not merely a biological milestone but a main life transition that affects millions of women worldwide (Meeta *et al*., 2021). It represents a natural phase in aging, yet it often carries profound implications for women's physical, emotional, and social well-being. Typically occurring between the ages of 45 and 55, menopause is marked by the cessation of menstruation due to hormonal changes. These changes often lead to symptoms such as hot flashes, night sweats, sleep disturbances, mood swings, and decreased libido (Gur *et al*., 2004). The severity and interpretation of these symptoms, however, can vary significantly. While some women manage menopause with minimal disruption, others experience distress that interferes with daily life (Prajapati, 2020). This variation is shaped by personal, cultural, and environmental factors that influence how menopause is perceived and managed (Prajapati, 2020).

In many societies, menopause is still surrounded by stigma, silence, or misinformation. Such cultural taboos can prevent open conversations about symptoms and support, both at the community level and within healthcare systems. As a result, many women navigate this transition without adequate information or guidance (Achmad & Agustina, 2025). To cope with menopause, women often adopt diverse strategies. These

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range from hormone replacement therapy (HRT) to natural remedies, such as diet modifications, exercise, and mindfulness practices (Prajapati, 2020). Emotional support from family members, especially spouses, as well as peer or community groups, plays a crucial role in enhancing resilience (Prajapati, 2020). However, much of the existing research continues to focus on biomedical or symptom-based approaches, neglecting the lived experiences of women (Cronin *et al*., 2025; Wood *et al*., 2025). These subjective, day-to-day experiences are essential to understanding how menopause is actually navigated in real life, especially in many cultural contexts. A study in Central Java, Indonesia, found that physical symptoms during premenopause and menopause significantly affect women's quality of life, highlighting the importance of addressing these domains in Indonesian settings (Marni & Husna, 2023).

In Indonesia, and particularly in Yogyakarta, such qualitative perspectives remain underexplored. Factors such as social expectations, local beliefs, and healthcare access can significantly influence how women perceive menopause and decide whether to seek help. Understanding these influences is crucial to creating effective and culturally appropriate support systems. This study aims to address that gap by exploring the lived experiences of menopausal women in Yogyakarta. Through a qualitative lens, it seeks to understand how women interpret their symptoms, what coping strategies they find efficacious, and what forms of support they consider meaningful, ultimately contributing to more responsive and empathetic health interventions.

Methods

This study uses a qualitative approach to gain an in-depth understanding of women's menopause experiences. This approach aims to capture participants' subjective perspectives, allowing researchers to understand the experiences, coping strategies, and social support deemed most effective by women experiencing menopause. This study employs a qualitative approach along with a case study method, allowing for an in-depth analysis of the menopause phenomenon through detailed interviews with several participants. The population for this study consisted of menopausal women aged 45 to 55 residing in the Special Region of Yogyakarta, covering four administrative regencies. This region was selected due to its cultural and social diversity, which can shape the menopausal experience, and its inclusion of both urban and rural communities to apprehend a wide range of perspectives. Participants were selected using purposive sampling, a non-probability technique commonly used in qualitative research to identify individuals with direct and relevant experience related to the study topic. This method was chosen to ensure that the participants could provide rich, reflective, and meaningful accounts of their menopausal experiences, coping mechanisms, and sources of social support.

The study aimed to recruit approximately four participants. While this may seem small, the intention was to conduct an in-depth exploration using a case study design. In qualitative research, the focus is on depth rather than breadth, and smaller sample sizes are acceptable when they allow for detailed, contextually grounded analysis. This approach enables researchers to closely examine the unique narratives of each individual. Furthermore, in many qualitative studies, a small sample size is considered sufficient when data saturation is reached, that is, when no new significant insights emerge from additional participants. This study has received ethical approval from the Ethics Committee of Aisyiyah University Yogyakarta with number 2853/KEP-UNISA/V/2023. All participants will be given clear information about the research's objectives, the process involved, and the potential risks and benefits. Participation consent will be documented through signed consent forms. Participants' confidentiality and anonymity are strictly maintained, and the data collected will be used solely for the purposes of this study.

The analysis in this study is conducted using a thematic approach, where the data obtained from in-depth interviews will be identified and categorized into main themes that reflect the experiences, coping strategies, and social support relevant to menopause. This

analysis process involves several stages. Starting with the verbatim transcription of the interviews, followed by repeated readings to recognize the overall content. Subsequently, the data will be analyzed to identify significant patterns, themes, and subthemes. The researchers will use qualitative data analysis software to help organize and categorize the data, allowing for a deeper and more meaningful understanding of women's menopause experiences. The findings from this analysis will be compared with existing literature to identify similarities or differences with previous research.

Results and Discussion

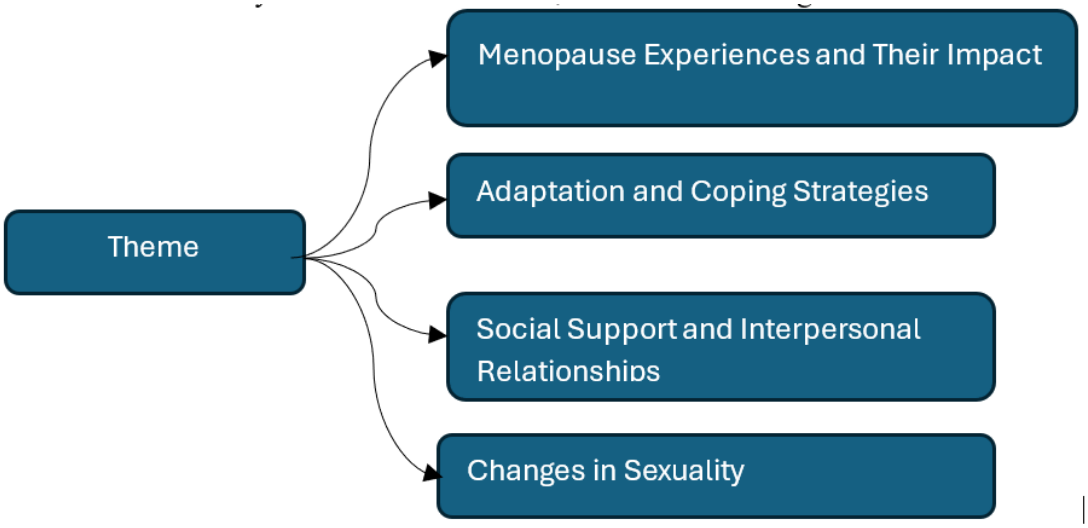
This study identified four themes, as illustrated in Figure 1.

Menopause experiences often involve significant physical and emotional challenges. Participants described various physical and emotional aspects they encountered during this transition period.

Physical: One of the most apparent signs of menopause is the cessation of the menstrual cycle, as one participant noted, "It's been about three years since my last period (P. 1)." Sleep disturbances were also a common complaint, with another participant stating, "It's hard to sleep (P. 2)." Fatigue was another frequently mentioned symptom, "I get tired easily. Even lifting something simple feels too much (P. 3)," highlighting how menopause can affect daily energy levels.

Emotional: Emotional sensitivity increases during menopause, with participants saying, "I feel more sensitive (P. 4)." This heightened sensitivity often leads to irritability, "I get angry quickly (P. 4)." Concerns about personal and social changes were also prominent, as expressed in the quote, "I'm worried that those who know me will notice these changes (P. 5)."

Menopause is a natural phase in a woman's life but is often accompanied by challenges that can significantly impact daily life (Cowell *et al.*, 2024). Participants in this study reported various physical symptoms such as sleep disturbances and fatigue, which reflect studies showing that hormonal changes during menopause can cause significant sleep disruptions and overall energy decline (Anurogo, 2023; Hestiantoro *et al.*, 2019; Zhang & Cheng, 2024). Emotionally, women often experience increased sensitivity and mood (Barko *et al.*, 2019; Gordon *et al.*,



Theme 1. Menopause Experiences and Their Impact

2021; Schweizer-Schubert *et al*., 2021). These emotions can contribute to interpersonal challenges and feelings of isolation. Studies indicate that these mood changes are related to hormonal fluctuations that also affect neurotransmitters in the brain associated with mood regulation (Hestiantoro *et al*., 2019; Zhang & Cheng, 2024). Further research to identify and address the psychosocial impacts of menopause is crucial, especially in enhancing effective coping strategies and support systems for women going through this phase. Better education and resources can help women navigate the complexities of menopause more effectively (Munn *et al*., 2022; Warke, 2021).

Theme 2: Adaptation and Coping Strategies

To cope with the changes during menopause, participants developed various coping strategies.

Coping: Information was a primary need, with participants seeking knowledge from online sources, "I sometimes browse on Google (P. 6)." However, the information found was often inadequate, highlighting the need for more reliable and in-depth sources.

Lifestyle Adjustments: Changes in diet and exercise were necessary to manage symptoms. "I eat more vegetables. At night, I only consume fruits (P. 7)." The use of supplements was also frequent as part of their adjustment strategy, "I take some kind of vitamin, but I can't remember the name (P. 8)."

Coping strategies used by women during menopause vary widely. From seeking information online to lifestyle changes like diet and exercise (Alazawa *et al*., 2023). Research indicates that women who proactively seek information and implement lifestyle changes tend to experience better symptom relief (Annisa *et al*., 2022). However, challenges remain, particularly regarding the quality and accuracy of available information. Women often feel frustrated with inadequate resources or misleading information. Studies suggest that more effective health education and access to valid information are needed to help women manage menopause symptoms more effectively (Backonja *et al*., 2021; Nguyen *et al*., 2020). Additionally, integrating professional support, such as counseling or therapy, can be a valuable addition to existing coping strategies. This multidisciplinary approach can provide further support for women to manage menopause in a healthy and effective manner (Li *et al*., 2023).

Theme 3: Social Support and Interpersonal Relationships

Support from family, friends, and the community helped participants manage the menopause transition.

Social: Communication with spouses was crucial, with one participant noting, "It's fine with my husband. No problem (P. 1)." However, participation in community activities was sometimes limited. "For the PKK, I participate as a cadre, particularly in health activities in the village (P. 2)."

Social support plays a crucial role in helping women manage the menopause transition. Positive social interactions with family and friends can provide significant emotional benefits and help reduce feelings of isolation during menopause (Cowell *et al*., 2024; Patel *et al*., 2023). It aligns with studies in Indonesia demonstrating that social support can reduce depression levels among the elderly (Kamila *et al*., 2024). The role of husbands or partners is also crucial, where open communication about needs and changes during menopause can strengthen relationships and ensure women feel supported by their closest ones. Studies have shown that emotional support from partners has a significantly positive impact on how women experience menopause (Edwards *et al*., 2021; Khalesi *et al*., 2020). Moreover, family support has been shown to reduce stress levels in women during critical reproductive periods. Increasing access to support groups and communities that understand menopause can also provide additional channels for support and experience exchange, helping women find collective solutions to challenges faced during menopause (Edwards *et al*., 2021; Khalesi *et al*., 2020).

Theme 4: Changes in Sexuality

Menopause also affects sexuality, including libido, satisfaction, and intimate relationships.

Sexuality: A decrease in libido was

acknowledged by participants, "I feel lazy or have no desire…. (P. 3)," and sexual satisfaction often diminished, "I feel less satisfied, and I feel it's not enough (P. 4)." Intimate relationships underwent significant changes, "But because of my husband's demands, I still comply (P. 5)," indicating adaptations in relationship dynamics.

Menopause often brings significant changes in sexuality, including decreased libido and changes in sexual satisfaction (Cagnacci *et al*., 2020). It is a vital aspect of the menopause experience that affects both the physical and psychological aspects of women's intimate lives. Research indicates that hormonal changes during menopause can directly affect sexual arousal and physical response, leading to decreased satisfaction in sexual activity (Mernone *et al*., 2019). Participants in this study also indicated the need for adaptation in intimate relationships to accommodate these changes. Couples who can communicate openly about needs and changes during menopause tend to have more satisfying sexual experiences despite the challenges. It highlights the importance of sexual education and couples therapy in addressing sexual issues that arise during menopause (Meeta *et al*., 2021).

Furthermore, studies suggest that a holistic approach to managing sexual changes during menopause should include medical aspects, such as consulting with healthcare professionals about hormone replacement therapy (HRT) to help reduce some physical symptoms affecting sexual life (Cameron *et al*., 2023). This approach should also involve emotional and psychological support to help women and their partners understand and navigate these changes (Garg & Robinson, 2021). To provide a comprehensive understanding of the study findings, a schematic overview was developed to illustrate the interconnectedness of the themes identified in this research. The diagram summarizes how physical and emotional experiences during menopause lead to the adoption of various coping strategies, influenced by the availability of social support, and how these processes collectively impact

Table 1. Schematic Overview of Study Findings on Menopause Experiences Among Women in Yogyakarta

Main Themes	Categories	Sub-Categories	Relational Explanations
1. Menopause Experiences and Impact	Physical	• Cessation of Menstruation • Sleep Disturbances	Triggers the need for adaptation and social support
	Emotional	• Heightened Sensitivity • General Worries	Affects interpersonal relationships and coping strategies
2. Adaptation and Coping Strategies	Information Seeking	• Browsing Online • Independent Reading	Helps understanding, but information often insufficient
	Lifestyle Adjustments	• Diet and Exercise • Supplement Use	Efforts to reduce physical and emotional symptoms
3. Social Support and Relationships	Social	• Communication with Husband • Community Activities	Provides emotional support and reduces isolation
4. Changes in Sexuality	Libido	Decreased Libido	Affects intimate relationships with partner
	Satisfaction	Reduced Sexual Satisfaction	Requires communication and partner adaptation
	Intimacy	Adjustments in Intimate Relations	Impacts couple's quality of relationship during menopause

changes in sexuality. This schematic underlines the progression from menopause experiences to adaptation and the critical role of community and family support in shaping women's well-being during this transition. It serves as a visual guide to better comprehend the multifaceted nature of menopause as experienced by women in Yogyakarta, reinforcing the need for holistic, culturally sensitive approaches in supporting women through menopause.

Conclusion

This study reveals that menopause is a multifaceted experience involving significant physical, emotional, and social challenges. Women face symptoms such as cessation of menstruation, sleep disturbances, fatigue, heightened emotional sensitivity, mood swings, and changes in libido. Coping strategies range from seeking information online to making lifestyle adjustments, but the need for reliable resources is evident. Social support from family, friends, and the community plays a crucial role in alleviating isolation and providing emotional relief. Addressing changes in sexuality through open communication and professional guidance is also vital. A holistic approach to menopause management, incorporating comprehensive physical, emotional, and social support, is essential for enhancing women's quality of life during this transition. This study recommends improving menopause education and support by providing accurate information and fostering community-based networks, including support groups and digital platforms, to help women access guidance and share experiences, enhancing their quality of life during menopause.

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Hypertension in Pregnancy: A Nested Case-Control Study

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Abstract

Hypertension during pregnancy is the leading cause of maternal and neonatal morbidity and mortality. In Indonesia, 30 % of deaths are caused by hypertension. This study was conducted to analyze the risk factors for hypertension in pregnancy in mothers with high pregnancy risk. A nested case-control study design was employed, with data sourced from secondary records of obstetric medical documents from Gondosari Health Centre, Kudus Regency, Central Java Province, Indonesia, for the years 2021, 2022, and 2023. The number of hypertension cases was 46, and the number of controls was 92. The technique for collecting case data was based on reviewing the medical records of mothers with hypertension. In contrast, control data was taken by random sampling from mothers with high risk but who did not have hypertension. Statistical analysis used the chi-square (bivariate) and logistic regression (multivariate) tests. The study's results stated that significant factors for hypertension in pregnancy were gestational age of 20 weeks, obesity, and primigravida with p 0.037, p 0.044, and p 0.010. Pregnant women > 20 weeks have a risk of 2.267 times to experience pregnancy hypertension, obesity has a risk of 4.288 times to experience hypertension in pregnancy, and non-primigravida status is at a higher risk of hypertension in pregnancy than primigravida mothers by 0.252 times. Mothers who have these three factors together have a probability of 80.79% of experiencing hypertension during pregnancy. This study concluded that gestational age > 20 weeks, obesity, and non-primigravida were related to the risk of hypertension in pregnancy at the study site; mothers who had gestational conditions > 20 weeks, obesity, and non-primigravida had the highest likelihood of developing hypertension in pregnancy

Introduction

Hypertension during pregnancy is the leading cause in the world (WHO, 2023). Hypertension during pregnancy results in the deaths of 70,000 women each year, including half a million births and neonatal deaths, the majority of which occur in developing countries (WHO, 2023). According to the World Health Organization, hypertension disorders during pregnancy cause 14.5% of maternal deaths in Southeast Asia (Say *et al*., 2014). In Indonesia, 30% of the deaths are caused by hypertension (Kemenkes, 2021). Hypertension during pregnancy (HDP) is classified into three types. First, chronic hypertension occurs 20 weeks before pregnancy. Hypertension in pregnancy

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occurs after 20 weeks of pregnancy, and pre-eclampsia occurs after 20 weeks of pregnancy, accompanied by signs of proteinuria, thrombocytopenia, increased transaminase levels, renal insufficiency, pulmonary edema, or new-onset headache (Khadegi & Bello, 2021; Narkhede & Karnad, 2024). According to the available evidence, hypertension during pregnancy is related to blood type O, multiple pregnancies (Jilo *et al*., 2024), primary, having previous HDP, family history of hypertension, low level of maternal education (Meazaw *et al*., 2020), older gestational age, family history of Diabetes Mellitus (DM), Body Mass Index (BMI) > 25, alcohol consumption, lack of counseling nutrient consumption during antenatal, lack of fruit consumption, and vegetable consumption (Tesfa *et al*., 2020).

HDP is one of the conditions for women with high-risk pregnancies (Jordan & Murphy, 2009; Kipnis *et al*., 2022), and is associated with obstetric complications in the form of intrauterine growth retardation, prematurity, and intrauterine death (Regitz-Zagrosek *et al*., 2018; Wilson *et al*., 2024), stroke and ischemic heart disease (Ray *et al*., 2005; Sheehy *et al*., 2023), chronic kidney failure (Watanabe *et al*., 2020), and cognitive decline (Mielke *et al*., 2023). Complications that occur due to hypertension during pregnancy are usually found late, which happens due to inadequate health care-seeking behavior (Syairaji *et al*., 2024; Suparji *et al*., 2024). Therefore, early discovery through early detection solves the high pregnancy risk (Tjandraprawira & Ghozali, 2019). Early detection behaviors correlated with increased knowledge, finding that mothers who had a good understanding of pregnancy red flags were 6.657 times more likely to be worried about risky pregnancies earlier than those who did not understand them (Mardiyanti *et al*., 2019). It was also found that women who understood the danger signs of pregnancy were 3.470 times more likely to visit antenatal services (Belayhun *et al*., 2021). This proves that pregnant women have a sense of caution about the danger signs that cause maternal death.

In 2023, the Maternal Mortality Rate in Indonesia was recorded at 305/100,000 live births. And in 2024, the Indonesian government made the Maternal Mortality Rate (MMR) the third "Major Project" of national development, with an MMR target of 183/100,000 live births. Towards the Sustainable Development Goals (SDGs) target in 2030, efforts continue to be made nationally. Although Indonesia is expected to achieve more than the SDGs target, reaching the MMR target of below 70 per 100,000 live births takes hard work (Syairaji *et al*., 2024). Indonesia must make several efforts to reduce MMR. An increased understanding of pregnancy danger indicators is needed to help women become more aware of potential threats and to seek medical help immediately. Therefore, efforts are required to find more appropriate risk factors to help increase public awareness in recognizing the risks of pregnancy and childbirth hazards in Indonesia. The findings of high-risk pregnancies can be known through early detection and appropriate predictors, so that women can detect high-risk pregnancies early on their own through community case studies that have a high-risk incidence rate. Indonesia has the 4th largest population and birth rate in the world, located between the United States and Australia, and has 17,508 islands. Java is one of the provinces on the island of Java, with the 3rd highest population density in Indonesia. Kudus Regency is one of 29 districts in Central Java with a high population density of 2,014 people per square kilometer (BPS, 2023). Therefore, this study aims to analyze the determinants of hypertension during pregnancy among pregnant women who have a high risk of pregnancy in the community primary services (Gondosari Health Center).

Method

The research design employed is a nested case-control study, a type of research where case and control data are collected from the cohort population over time (Saefurrohim *et al*., 2022). The place of this research is at the Gondosari Health Center, which is the health center with the highest cases of high risk of pregnancy in the Kudus Regency area in 2021, 2022, and 2023 respectively in 2021 (24.93%), 2022 (29.59%), and 2023 (41.07%) (DDK Kudus, 2021), (DDK Kudus, 2022), (DDK Kudus, 2023). The data used in this study were secondary data collected retrospectively from a database of obstetric

service documents, specifically the Monitoring of the Maternal and Child Health Local Area (PWS KIA) of the Gondosari Health Center, Kudus Regency, Central Java, Indonesia, in 2021, 2022, and 2023.

The population of this study was 1119 high-risk pregnant women at the Gondosari Health Centre in 2021, 2022, and 2023. The number of cases in this study is pregnant women who experience hypertension in pregnancy, a total of 46 respondents. While the control in this study is pregnant women who have a high risk of pregnancy but do not experience hypertension in pregnancy which amounted to 1073 respondents, control data collection was carried out by random sampling technique based on numbers using the excel format "RANBETWEEN", several ratios of 1: 2 = 46: 92 respondents were taken, the control was also matched based on commute time for health, gestational age, age of pregnant women, interval between pregnancies, number of children, pregnant status, nutritional status, the history of SC, anemia status, history of abortion and status of diabetes. Selection of a 1:2 ratio based on considerations, Susan Lewallen, MD (1998) (Lewallen, 1998), which states control of more than two for each case in the case control study, statistically does not provide meaningful information. Figure 1 shows the flow of research respondents.

The independent variables in this study include; travel time to health services (categorized to be > 30 minutes and 30 minutes); pregnancy (categorized into > 20 weeks and < 20 weeks); age of pregnant women (categorized by age < 20 years >35 and ages 20 – 34); interval between pregnancies, (categorized < 2 years and > 2 years); number of children (categorized into ≥4 and <4); gravidity (categorized into primigravida and non-primigravida); nutritional status (categorized as obesity and non-obese); the history of Section Caesaria (SC) (categorized as having a history of SC and not having a history of SC); anemia status (categorized as anemia and non-anemia); the history of abortion (categorized as having a history of abortion and not having a history of abortion); Diabetes Mellitus status (categorized as DM and non-DM); the bound variables in this study are hypertension in pregnancy (categorized as hypertension in pregnancy and non-hypertension in pregnancy). The data was analyzed using bivariate analysis with chi-square or Fisher, p-value<0.05. and multivariate with logistic regression on variables that meet the p-value <0.25 criteria. Based on the result of the logistic regression, the regression equation can be formulated as follows: y (hypertension in pregnancy) = - 0.838 (gestational age > 20 weeks) + 1.456 (Nutritional status of obesity) + -1.402 (gravidities primigravida). The above equation can be used to calculate the probability of hypertension in pregnancy using the formula:

$$p = \frac{1}{1 + \exp(-(y))}$$

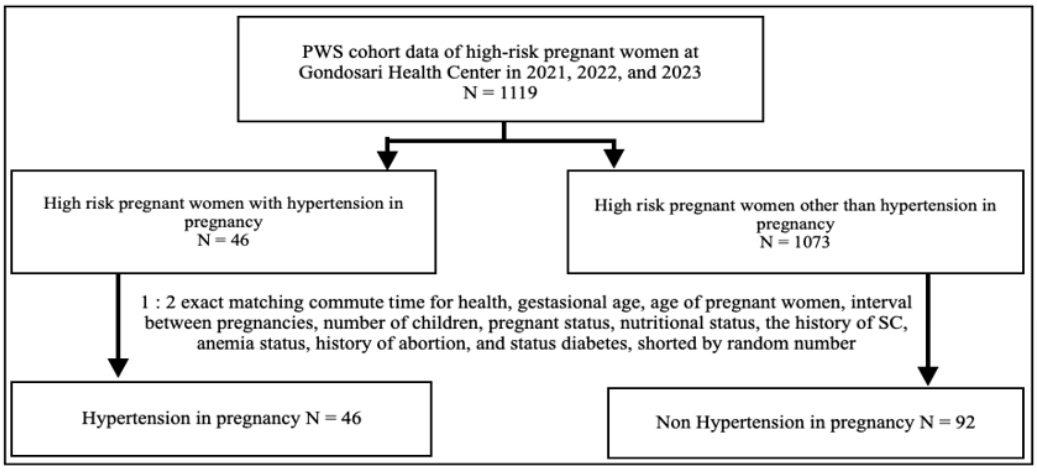

FIGURE 1. Flow Chart Sampling Process

Result and Discussion

The characteristics of respondents of those at risk and those not at risk of hypertension in pregnancy are presented in Table 1. Hypertension cases of 33.33%, Commute time for health> 30 minutes 11.59%, Gestational age > 20 weeks 34.78%, Age of pregnant women <21 year and >35 year 31.88%, Interval between pregnancies < 24 months 9.42%, Number of children ≥4 person 14.49%, Pregnant status; primigravida 25.36%, Nutritional status; obesity 7.25%, The history of Section Caesaria (SC); having history of SC 11.59%, Anemia status; anemia 8.70%, History of abortion; having history of SC 11.59%, Diabetes Mellitus (DM) 4.35%. The results of bivariate analysis are also shown in Table 1, where the significant variables for HDP are gestational age and gravida status with hypertension (p<0.05), with an unadjusted odds ratio at gestational age 2.327 (95% CI 1.115 – 4.854) and Gravida Status 0.252 (95% CI 0.90 – 0.703). Multivariate analysis was carried out on candidate variables with a p < of 0.25, and the results of the study are shown in Table 2, gestational age variables, nutritional status and gravidity were significant to HDP with a p value of < 0.05, the most dominant risk factor for HDP occurred in the nutritional status variable (obesity) with an OR of 4,288 (95% CI 1,038 - 17,711). There is also a protective factor in HDP, gravidity (non-primigravida), with an OR of 0.246 (0.084 - 0.717). Results of probability calculation (Table 3) showed some probability of HDP occurring: First, mothers with >20 weeks of gestation, obesity, and primigravida are likely to experience HDP of 50.87%.

TABLE 1. Characteristics of the Study Population and Case-Control Bivariate Analysis Results

Variable	Total Population		Hypertension (Case)		No Hypertension (Control)		P-value
	N=136	%	N=46	%	N=92	%	
Hypertension							
yes	46	33.33					
no	92	66.67					
Commute time for health							
>30 minutes	16	11.59	6	13.0	10	10.87	0.925
≤30 minutes	122	88.41	40	87.0	82	89.13	
Gestational age							
>20 weeks	48	34.78	22	47.8	26	28.26	0.037*
<20 weeks	90	65.22	24	52.2	66	71.74	
Age of pregnant women							
<21 year and >35 year	44	31.88	16	34.8	28	30.43	0.747
21-35 years	94	68.12	30	65.2	64	69.57	
Interval between pregnancies							
< 24 months	13	9.42	5	10.9	8	8.70	0.760
≥ 24 months	125	90.58	41	89.1	84	91.30	
Number of children							
≥4 person	20	14.49	7	15.2	13	14.13	1.000
<4 person	118	85.51	39	84.8	79	85.87	
Pregnant status							
Primigravida	35	25.36	5	10.9	30	32.61	0.010*
Non primigravida	103	74.64	41	89.1	62	67.39	
Nutritional status							
Obesity	10	7.25	6	13.0	4	4.35	0.084
Non obese	128	92.75	40	87.0	88	95.65	

Variable	Total Population		Hypertension (Case)		No Hypertension (Control)		P-value
	N=136	%	N=46	%	N=92	%	
The history of Section Caesaria (SC)							
Having a history of SC	16	11.59	7	15.2	9	9.78	0.511
Not having a history of SC	122	88.41	39	84.8	83	90.22	
Anemia status							
Anemia	12	8.70	1	2.2	11	11.96	0.061
Not anemia	126	91.30	45	97.8	81	88.04	
History of abortion							
Have had an abortion	19	13.77	7	15.2	12	13.04	0.930
Never had an abortion	119	86.23	39	84.8	80	86.96	
Diabetes Mellitus (DM)							
DM	6	4.35	2	4.3	4	4.35	1.000
Non-DM	132	95.65	44	95.7	88	95.65	

*p<0,05; considered statistically significant.

TABLE 2. Multivariate Analysis of Hypertension During Pregnancy Results

Variable	P-value	95% CI		
		AOR	Lower Bound	Upper Bound
Gestational age	0.037*	2.267	1.051	4.889
Nutritional status	0.044*	4.288	1.038	17.711
Pregnant status	0.010*	0.246	0.084	0.717
Constan	0.002	0.433		

Abbreviations: AOR, Adjusted Odds Ratio; CI, Confidence Interval
*p<0,05; considered statistically significant

TABLE 3. Result of Probability Calculation in Several Scenarios of Hypertension During Pregnancy (HDP) (N = 138)

SR	GA	NS	*G*	*y*	*(-)y*	*exp (-y)*	*1+exp (-y)*	*p*	*HDP Probability (%)*
A	1	1	1	0.035	-0.035	0.965605	1.965605	0.509	50.87
B	1	1	0	1.437	-1.437	0.23764	1.23764	0.808	80.79
C	1	0	0	-0.019	0.019	1.019182	2.019182	0.495	49.52
D	0	0	0	-0.838	0.838	2.311739	3.311739	0.302	30.19
E	1	0	1	-1.421	1.421	4.14126	5.14126	0.195	19.45
F	0	1	1	-0.784	0.784	2.190216	3,190216	0.313	31.34
G	0	0	1	-2.24	2.24	9.393331	10.39333	0.096	9.62
H	0	1	0	0.618	-0.618	0.539021	1.539021	0.650	64.97

Abbreviations: SR, Scenario respondents; GA, Gestational age; NS, Nutritional status; G, Gravidity
Gestational age: 1 = > 20 weeks, 0 = ≤ 20 weeks; Nutritional status: 1 = obesity, 0 = non obese; Gravidity: 1 = primigravida, 0 = non primigravida; *p<0,05; considered statistically significant

The findings of this study showed that maternal factors such as time to health services, maternal age, birth distance, number of children, parity, cesarean history, anemia, abortion history, and diabetes status do not show a significant relationship with HDP, only the variables of gestational age, nutritional status and gravidity have significance and are predictors of HDP (Table 2). The gestational age variable > 20 weeks in this study was significant

with HDP p value 0.019 OR 2.267 (95% CI 1.051 - 4.889), which means that in this study, mothers with a gestational age > 20 weeks were 2,267 times more likely to experience HDP than mothers with a gestational age of 20 weeks. Gestational age is the number of days or weeks from the first day of the last normal menstrual period in women with regular menstrual cycles (Marc & Vangeenderhuysen, 2015). Sibai (2002) states that during normal pregnancy, there is an increase in metabolism, increasing cardiac output of 30-50%, accompanied by a decrease in systemic vascular resistance and an increase in plasma volume. Khedagi & Bello (2021) explained that in the second trimester of pregnancy (14 to 27 weeks) there is excessive sympathetic activity after 20 weeks of pregnancy, this condition is related to the risk of gestational hypertension or preeclampsia, due to a decrease in systemic vascular resistance, relaxin decreases to intermediate values after the circulation of the uterocente is formed, so that the absorption of vascular resistance becomes low. In addition, arterial pressure reaches the nadir during the second trimester, while cardiac output increases to 45% above the start at 24 weeks. Pregnancy hypertension occurs in mothers with a gestational age of 19 – 23 weeks, based on research by Gibbone *et al* (2021), caused by functional changes in the heart that then progress to preeclampsia in the following weeks. A previous study corroborates these findings in 1345 pregnancies with a gestation age of 24 weeks in which respondents were identified as having early or advanced preeclampsia; the results of the study found an increase in left ventricular mass and a higher diastolic functional index compared to those whose pregnancies were uncomplicated (Valensise *et al*., 2008). The findings of this study are inconsistent with previous studies in Southern Ethiopia that did not find a relationship between gestational age and hypertension in pregnancy (Jilo *et al*., 2024), but consistent with research Mwanri *et al* (2015) in Tanzania which declared a gestational age > 20 weeks significant with hypertension in pregnancy with an OR of 1,10 (95% CI 1,02 - 1,20). Another finding that causes gestational hypertension in pregnant women > 20 weeks is the existence of predictors in the form of plasma levels of SERPINC1, SERPINA5, CFHR5, clusterin, CK18, and HRG in the plasma of pregnant women who experience gestational hypertension after gestational age > 20 weeks, where these plasma levels are not found in pregnant women without hypertension (Zhou *et al*., 2024).

The obesity variable in this study is at risk of experiencing an increase in HDP. A study by Ali *et al*. (2020) showed that the majority of housewives in Central Java are either pre-obese or obese, with overweight individuals following in number. Previous studies showed that due to the excess adipose tissue owned by obese women, this tissue is rich in pro-inflammatory cytokines and complementary proteins. Systemic inflammation during pregnancy due to excess adiposity impacts the development of the placenta, thus giving rise to antiangiogenic factors. This condition explains why obesity contributes to the pathogenesis of HDP (Schiavone *et al*., 2024). Another study in Soppeng, South Sulawesi, also showed a significant relationship between nutritional status and the incidence of hypertension with p-value<0.05 (Maria *et al*., 2023). The results of this study are that obesity contributes to an increase in HDP with a p value of 0.044 OR 4.288 (95% CI 1.038 – 17.711). This means that obese mothers have a total of 4,288 times the risk of experiencing HDP compared to non-obese mothers. The results of this study are in line with previous research which stated that obesity is at risk for HDP by OR=3.77 (95% CI 3.45 – 4.13) (Sun *et al*., 2024), research in China and Sweden also stated obesity as a risk factor for HDP with OR 5.12 dan 3,49 (Yang *et al*., 2021).

The status of gravida primigravida in this study is a variable that contributes to an increase in the risk of HDP p value 0,010 OR 0,246 (95% CI 0.084 – 0.717), OR<1 is defined as a protective risk factor, which means that mothers with non-primigravida are more at risk of developing hypertension in pregnancy than mothers with primigravida. Previous research that is not in line with this study, namely a study at Abbotabad Hospital on 134 patients with gestational hypertension, found that hypertension in pregnancy is more experienced by primigravida mothers

by 76% with a gestational age of > 20 weeks compared to non-primigravida mothers (Faiza *et al*., 2023). Also, the findings of another study stated that primigravida mothers were more at risk of developing HDP compared to mothers with non-primigravida status (Meazaw *et al*., 2020; Zhou *et al*., 2024; Hinkosa *et al*., 2020). The study, which is in line with the findings of this study, is a study in Ghana of 500 pregnant women, found that mothers with multigravida are more at risk of developing HDP with OR 4,53 (95% CI 1,42–14,42) compared to mothers with primigravida (Boachie-Ansah *et al*., 2023). A study that corroborates the occurrence of HDP in non-primaries is the result of a survey in eight health facilities in seven Nigerian states, which found that about 61.2% of hypertension disorders do not resolve after childbirth (Ishaku *et al*., 2021). This can be interpreted that when hypertension does not heal in the first pregnancy, it can lead to chronic hypertension in the subsequent pregnancy, thus increasing the cumulative burden on the mother and multigravida.

Table 3 showed that mothers with a gestational age of> 20 weeks, obese but not primigravida, are likely to experience HDP of 80.79%. Mothers with a gestational age of > 20 weeks, who are not obese and who are not primigravida, are likely to experience HDP of 49.52%. Mothers with a gestational age of 20 weeks, not obese, and not primigravida are likely to experience HDP of 30.19%. Mothers with a gestational age of > 20 weeks, who are not obese and primigravida, are likely to experience HDP of 19.45%. Mothers with 20 weeks of gestation, obesity, and primigravida are likely to experience HDP of 31.34 %. Mothers with a gestational age of 20 weeks, not obese, and primigravida are likely to experience HDP of 9.62%. Mothers with a gestational age of 20 weeks, obesity, and non-primigravida are likely to experience HDP of 64.97%. The strength of our study was the use of a cohort with a period of 3 years in the highest high-risk group in the population. We also matched the hypertension group in pregnancy and the control group at a ratio of 1:2 to commute time for health, gestational age, age of pregnant women, interval between pregnancies, number of children, pregnant status, nutritional status, the history of SC, anemia status, history of abortion, and status of diabetes in at-risk groups. This is done to evaluate whether the findings are consistent in individuals with different characteristics. The limitation of this study is that the data used, namely secondary data, misses some variables that are relevant to socio-demographic factors, such as maternal education level, maternal height, maternal smoking status, religion, occupation, family history of hypertension, and antenatal care history, as well as pre-pregnancy blood pressure.

Conclusion

Women with HDP have a greater risk of morbidity and mortality than women who have normal blood pressure. Gestational age >20, obesity, and non-primigravida are risk factors for HDP, and the highest probability occurs if the mother has these three risk factors. Based on the findings of this study, recommendations that can be given are screening, counseling, and education in pre-conception care services to prevent hypertension before pregnancy, and during pregnancy, strengthening antenatal care services with counselling and treatment of complications from the beginning of pregnancy.

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Maternal Characteristics, Malnutrition, and Pregnancy Complications with the Incidence of Low Birth Weight in an Industrial Environment

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Abstract

Low Birth Weight is one of the leading causes of under-five deaths during the neonatal period. In Indonesia, the infant mortality rate is in the top 7 in the world. The industrial environment, where air pollution is high, is one of the factors causing LBW. The study aimed to identify the factors that influence the incidence of LBW in an industrial environment. Using data from a cohort of pregnant women in 2023, the study used a nested case-control design at Bergas Community Health Centre. The study population included all mothers who delivered live infants in 2023, totalling 832 respondents. Data from the study were analysed using Chi-Square for bivariate analysis and logistic regression for multivariate analysis. The results showed a relationship between maternal age, parity, maternal nutritional status, hypertension, preeclampsia, and anaemia with the occurrence of LBW with $p < 0.0001$. The multivariate analysis indicated a significant relationship between maternal age (OR 3.233, 95% CI 1.557 – 6.714), parity (OR 2.567, 95% CI 1.382 – 4.767), maternal nutritional status (OR 7.905, 95% CI 3.472 – 17.998), preeclampsia (OR 28.090, 95% CI 9.894 – 84.468), and maternal hemoglobin levels (OR 10.883, 95% CI 5.736 – 20.649) with the incidence of LBW. The most influential factor in LBW is the occurrence of preeclampsia in mothers.

Introduction

Low birth weight (LBW) infants weigh less than 2,500 grams. The most severe risks for LBW infants include death and disability (Osuchukwu & Reed, 2024; UNICEF & WHO, 2019, 2020; WHO, 2011, 2022). It is estimated that around two million neonatal deaths occur, with approximately two million attributed to low birth weight. Infants with LBW face higher risks of mortality, growth delays, lower intelligence levels, and chronic diseases in adulthood (UNICEF & WHO, 2019). In addition to mortality, about a million LBW infants live with long-term disabilities, including cerebral palsy and cognitive delays. Besides the risks of death, disabilities, and long-term illnesses, families with infants weighing less than 2,500 grams are at increased risk of experiencing psychological and long-term financial issues (UNICEF & WHO, 2020).

Some research found that very preterm birth, defined as a gestational age of less than 32 weeks and very low birth weight (< 1,500 grams), had several effects, including a higher risk of experiencing conception or fertility problems, complications during pregnancy, three times the risk of developing pregnancy-related hypertension, lower IQ levels, and poorer physical health quality in early adulthood. This can cause issues with vision, mobility, dexterity, and cognition as well, compared to term infants, and weighing 2500 grams or

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more (Bolbocean *et al*., 2023; Eves *et al*., 2021; Van Der Pal *et al*., 2021). Premature babies are also prone to experiencing difficulties in oral motor skills, breathing, and fulfilling their nutritional needs (Mauliza *et al*., 2023). Infants with very low birth weight are more vulnerable to metabolic syndrome later on. Very low birth weight also predisposes individuals to coronary heart disease because these infants are small and thin at birth, followed by a rapid growth spurt during childhood and an increased risk of type 2 diabetes, resulting from an accelerated growth phase in the first year of life (Barker *et al*., 2009; Eriksson, 2006, 2011, 2016; Jebasingh & Thomas, 2022).

The infant mortality rate in Indonesia was the 7th highest in the world in 2020. The trend in infant mortality rates for deaths of toddlers in Indonesia in 2023 experienced improvement compared to 2022, and death is the most common in the neonatal age. The three reasons for death are Respiratory and Cardiovascular (1%), LBW (0.7%), and congenital abnormalities (0.3%). The causes of neonatal deaths in Central Java are the highest at 38.44% LBW. LBW infant trends for those born in Central Java for 4 years keep increasing, with an incidence of 5.2% in 2023. Semarang Regency occupies ranking 7th rank in Central Java in the incidence of LBW, namely by 6.6%, and the Bergas Health Community Centre is ranked first in the incidence of LBW in Semarang Regency in 2023, namely 8.89% of total deliveries alive. LBW babies who experience complications until they die by 8.1%. Various efforts have been made in the Semarang district for the management of LBW from the start of pregnancy until management when it is born, but LBW incidents continue to increase (BPS Kabupaten Semarang, 2024). Characteristics of female workers in Semarang Regency are in the processing sector or laboring by 41.15%. This is because the education level is still low and medium, as well as the number of factories in the Semarang area (BPS Kabupaten Semarang, 2022). The Bergas sub-district is a densely populated area with industries, which causes many mothers to become industrial workers. This environment can also affect mothers' nutritional patterns and consumption habits, as they usually prefer fast food with minimal nutritional content. Industrial environments are also very susceptible to air pollution related to low birth weight (Trerotoli *et al*., 2021).

One of the attempts to reduce LBW is pregnancy mentoring for mothers at risk. Effective mentoring needs the existence of study-related factors that affect LBD incidence. Prior research stated that the determinants of BBLR include sociocultural factors, such as family income, education, location of residence, and the number of family members (3-4 people). Maternal factors consist of age at delivery, height, maternal illness during pregnancy, maternal BMI, weight gain of less than 6.5 kg during TM 2 and TM 3, consumption of iron tablets of less than 180 during pregnancy, the distance between pregnancies, regularity of antenatal care (ANC) visits, and a bicornuate uterus (Helmizar *et al*., 2024). Environmental factors include distance from home to health services, use of firewood for cooking, washing hands with water only, and kitchen space within the house, which are related to air pollution, one factor causing LBW. Factors of the female fetus, factor placenta, the incidence of premature rupture of membranes, gestational hypertension, dental health in the last 1-3 years, working hours more than 6 hours, passive smokers, and consumption of peanut oil. Factors that can prevent LBW or are protective include weight gain in pregnant women, daily milk consumption, and folic acid supplementation (Demelash *et al*., 2015; Khayati *et al*., 2016; Shen *et al*., 2019). This research aimed to identify the factors causing LBW in the work area of Bergas Community Health Centre in 2023, based on cohort data from mothers. The variables studied in this study were gender of the baby, the mother's age, the mother's parity, the distance of pregnancy, the mother's nutritional status, hypertension, haemoglobin status, diabetes, hepatitis, and preeclampsia (Aini & Kurniawan, 2023; Oktriyanto *et al*., 2022).

Methods

The study used the Nested Case-Control design and was implemented at Bergas Community Health Centre. Mothers who delivered live infants recorded at the Bergas Community Health Centre in 2023 were

involved in this study, with 832 participants. The current study used recorded respondent data from cohort mothers at village midwives. Then, it was reported and documented at the community health centre. The measurement used documentation results from the cohort mothers and matched the available data from the midwives and the community health centre. The data collection was compiled using a master table. The retrieval sample in this study used total sampling. This study has been declared ethically feasible by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Negeri Semarang, with number 206/KEPK/FK/KLE/2024. The characteristics of the respondents were analysed using univariate analysis with frequency distribution. Bivariate analysis was carried out using Chi-Square or alternative tests. Multivariate analysis was performed using logistic regression with IBM SPSS 25.0 version. The results of the multivariate analysis were then used to calculate the probability of low birth weight (LBW) using the formula:

$$p = \frac{1}{(1 + exp^{(-y)})}$$

Results And Discussion

The Maternal Characteristics Of Respondents In This Study, Presented In Table 1, Showed That Out Of 832 Respondents, 74 (8.9%) Gave Birth To Low-Birth-Weight Infants. Mothers Who Delivered Female Infants Totalled 386 Respondents (46.4%), At Risk Due To Age (Under 20 And Over 35 Years) Amounted To 99 Respondents (11.9%), And With High Parity (Primipara) Were 251 Respondents (30.2%). The Number Of Respondents With A Risky Pregnancy Interval (Less Than 2 Years) Was 4 (0.5%), With Chronic Energy Deficiency (Ced) Totalled 46 Respondents (5.5%), Experienced

Table 1. Maternal Characteristics of Respondents, Bergas 2023

Variable	Frequency (N)	Percentage (%)
Low Birth Weight		
Yes	74	8.9
No	758	91.9
Baby gender		
Woman	386	46.4
Man	446	53.6
Mother's age		
At risk	99	11.9
No risk	733	88.1
Maternal parity		
At risk	251	30.2
No Risk	581	69.8
Pregnancy interval		
At risk	4	0.5
No Risk	828	99.5
Maternal nutritional status		
Chronic Energy Deficiency	46	5.5
Good	786	94.5
Maternal Hypertension		
Yes	36	4.3
No	796	95.7
Maternal Anaemia		

Variable	Frequency (N)	Percentage (%)
Yes	94	11.3
No	738	88.7
Maternal Diabetes Mellitus		
Yes	2	0.2
No	830	99.8
Yes	6	0.7
No	826	99.3
Preeclampsia		
Yes	22	2.6
No	810	97.4
Job		
Laborer	538	64.7
Unemployed	169	20.3
Trader	26	3.1
Teacher	72	8.7
Civil Servant	20	2.4
Doctor	1	0.1
Farmer	6	0.7

Hypertension 36 Respondents (4.3%), With Anaemia Were 94 Respondents (11.3%), With Diabetes Were Two Respondents (0.2%). Those With Hepatitis Were Six Respondents (0.7%). Those Who Experienced Preeclampsia And Eclampsia Were 22 Respondents (2.6%).

Maternal Characteristics With Low Birth Weight (Lbw) At Bergas Community Health Centre Are Shown In Table 2. Out Of 10 Variables, Six Are Associated With Lbw, Including Mothers Aged Less Than 20 Years And More Than 35 Years (Or: 3.742; 95% Ci: 2.156-6.494); Primiparous Mothers (Or: 2.701; 95% Ci: 1.667-4.376); Chronic Energy Deficiency (Ced), (Or: 17.906; 95% Ci: 9.364-34.238); Hypertension (Or: 6.810; 95% Ci: 3.287-14.111); Preeclampsia And Eclampsia (Or: 17.736; 95% Ci: 7.290-14.149); And Anemia (Or: 16.527; 95% Ci: 9.663-28.226). The Results Of Bivariate Analysis Were Presented In Table 2.

Table 2. Maternal Characteristics with Low Birth Weight

Variables	Birth Weight				p	OR (CI 95%)
	LBW		BBLN			
	n	%	n	%		
Baby gender [b]						
Woman	34	45.9	352	46.4	1.000	0.980
Man	40	54.1	406	53.6		(0.607-1.583)
Mother's age [b]						
Less than 20 and more than 35 years	22	29.7	77	10.2		3.742
20-35 years	52	70.3	681	89.8		(2.156-6.494)
Maternal parity [b]						
Nulliparous	38	51.7	213	28.1		2.701
Multipara	36	48.6	545	71.9		(1.667-4.376)

Pregnancy interval [a]						
<2 years	1	1.4	3	0.4	0.312	3.447
>2 years	73	98.6	755	99.6		(0.354-33.567)
Maternal nutritional statu[s] a						
Chronic Energy Deficiency	25	33.8	21	2.8		17.906
Good	49	66.2	737	97.2		(0.354-33.567)
Maternal Hypertension [a]						
Yes	13	17.6	23	3.0		6.810
No	61	82.4	735	97.0		(3.287-14.111)
Preeclampsia [a]						
Positive	13	17.6	9	1.2		17.736
Negative	61	82.4	749	98.8		(7.290-14.149)
HB mother [b]						
Anaemia	41	55.4	53	1.2		16.527
No anaemia	33	44.6	705	98.8		(9.663-28.266)
Maternal Diabetes [a]						
Yes	0	0	2	1.8	1.000	1.099
No	74	100	756	99.7		(1.076 – 1.123)
Maternal Hepatitis [a]						
Yes	2	2.7	4	0.5	0.093	5.236
No	72	97.3	754	99.5		(0.943-29.081)

[a]Analyzed using Fisher's Exact
[b] Analyzed using Chi-Square
*Statistically significant at p=0.05

Table 3. Relationship between Age, Parity, Nutritional Status, Preeclampsia, and Anaemia with the incidence of LBW

Variables	**B**	**Wald**	**p**	**OR (CI 95%)**
Mother's Age	1.174	9.912	0.002	3.233 (1.557 – 6.714)
Mother's Parity	0.943	8.913	0.003	2.567 (1.382 – 4.767)
Maternal Nutritional Status	2.067	24.252	<0.0001	7.905 (3.472 – 17.998)
Preeclampsia	3.364	37.816	<0.0001	28.090 (9.894 – 84.468)
Anaemia	2.387	53.362	<0.0001	10.883 (5.736 – 20.649)
Constant	-4.047	200.097	<0.0001	0.017

Multivariate Analysis With Logistic Regression Was Conducted To Determine The Risk Factors For Lbw, The Result Of Which Was Presented In Table 3. Preeclampsia Was The Most Influential Factor In The Incidence Of Lbw, With An Or Of 28,090 (95% Ci: 9,894-84,468). It Indicated That Mothers With Preeclampsia Had An Increased Risk Of Giving Birth To Lbw By 28 Times Compared To Mothers Without Preeclampsia Table 3.

Analyzed Using Multiple Logistic Regression. The Effect Of Each Variable Is Adjusted For The Effect Of The Other Variables. Using The Results Of Multivariate Logistic Regression, The Probability Of Lbw Could Be Calculated Using The Formula As Follows.

Y= -4.047+1.174 (Mother's Age < 20 Years Old And > 35 Years Old) + 0.943 (Parity

Table 4. Results of Probability Calculations in Several Scenarios

Respondent	Mother's age	Parity	Nutritional status	Pree clam psia	Anaemia	Probability of LBW Incident (%)
Respondent A	<20 and >35 Years	Multigravida	Good	No	No	5,352
Respondent B	20-35 years	Primipara	Good	No	No	4,292
Respondent C	20-35 years	Multigravida	Chronic Energy Deficiency	No	No	12,134
Respondent D	20-35 years	Multigravida	Good	Yes	No	33,560
Respondent E	20-35 years	Multigravida	Good	No	Yes	15,978
Respondent F	20-35 years	Multigravida	Good	No	No	1,718
Respondent G	<20 and >35 Years	Primipara	Chronic Energy Deficiency	Yes	Yes	99,723
Respondent H	<20 and >35 Years	Primipara	Chronic Energy Deficiency	Yes	No	97,070
Respondent I	<20 and >35 Years	Primipara	Chronic Energy Deficiency	No	Yes	92,578
Respondent J	<20 and >35 Years	Primipara	Good	Yes	Yes	97,855
Respondent K	<20 and >35 Years	Multigravida	Chronic Energy Deficiency	Yes	Yes	99,292
Respondent L	20-35 years	Primipara	Chronic Energy Deficiency	Yes	Yes	99,110

Nulliparous Mothers) + 2,067 (Chronic Energy Deficiency (Ced) Mothers) + 3,364 (Preeclampsia Mothers) + 2,387 (Anemic Mothers).

Based On The Probability Calculations, Mothers Aged 20-35 Yo, Multigravida, With Good Nutritional Status, No Preeclampsia, And No Anemia Had A Chance Of Giving Birth To Lbw Infants Of 1.718%. In Comparison, Mothers Who Were Less Than 20 Years Old And More Than 35 Years Old, With Primipara, Chronic Energy Deficiency, Preeclampsia, And Anemia, Had A Chance Of Giving Birth To An Lbw Baby Of 99.723%. The Results Of Several Scenarios Were Presented In Table 4.

Mothers With Solely An Age-Related Risk Would Have A 5.352% Probability Of Delivering Low Birth Weight Infants. This Was More Likely Than The 4.292% Possibility For Mothers Who Were Only At Risk Of Parity. The Highest Chance Of Delivering Lbw Infants Was 3.560% For Mothers Who Had Pre-Eclampsia. Mothers With Preeclampsia Would Have Disorders Of Uteroplacental Blood Circulation That Would Interfere With The Supply Of Fetal Needs And Result In Stunted Fetal Growth. Our Study Found That Mothers Who Gave Birth In Bergas In 2023 Mostly Worked As Labourers (64.7%). There Were Many Factories In The Bergas Area And The Lowlands Of Community Education (Bps Kabupaten Semarang, 2022). Working As A Labourer Results In Limited Family Income, Leading To Low Socio-Economic Status, Which Causes Low Birth Weight (Mishra Et Al., 2021). Labour Workers With High Workloads And Low-Wage Incomes Use Their Nutritional Purchasing Power To The Fullest Rather Than Considering Its Nutritional Content. Short Rest Periods Also Make Labour Workers Buy Food Available Around The Factory, Which, On Average, Is Low In Nutritional Content. This Happens Every Day, Therefore Increasing The Incidence Of Malnutrition And Anaemia.

Our Research Findings Indicated That Preeclampsia Was The Highest Risk For Delivering Low Birth Weight Infants, With An Or Of 28.09. This Signified That Mothers With Preeclampsia Possess A 28 Times Greater Chance Of Giving Birth To An Lbw Infant Compared To Mothers Without Preeclampsia. This Study Supported Prior Research Indicating That Low Birth Weight Results From Childbirth

Complicated By Preeclampsia (Shulman Et Al., 2017). Research That Has Been Conducted In Ethiopia Also Found That Maternal Preeclampsia And Hiv Increased The Incidence Of Lbw (Ekubagewargies Et Al., 2019). The Condition Of Mothers With Preeclampsia Impaired Uteroplacental Blood Circulation, Resulting In Fetal Growth Abnormalities. Anaemia Status Was Also One Of The Factors That Would Result In Lbw Pregnancy Outcomes In This Study; The Results Obtained Were Or 10.883 (95% Ci: 5.736 - 20.649). This Means That Mothers Who Experience Anaemia Have A 10.88 Times Higher Risk Of Delivering Lbw Infants Compared To Mothers Who Are Not Anaemic. During Pregnancy, There Is An Increased Need For Hb For Fetal Growth And Preparation For Blood Loss During Childbirth. Fetal Growth Will Be Hampered If The Mother Is Anaemic (Anil Et Al., 2020; Chandran & Kirby, 2021). In Developing Countries, Lbw Is Often Caused By What Kind Of Status (Bhowmik Et Al., 2019). Anaemia In The Mother Greatly Influences The Incidence Of Lbe, Which Is Related To Fetal Growth In The Womb (Figueiredo Et Al., 2019).

Our Study Found That Mothers With Chronic Energy Deficiency (Ced) Status Have A Risk Of Giving Birth To Lbw Babies 7.9 Times Compared To Mothers With Good Nutrition, With Or 7.905 (95% Di: 3.472 - 17.998). A Mother's Nutritional Status Intake Pregnancy During Pregnancy Can Determine The Outcome Of Pregnancy, Namely The Infant. The Mother's Nutritional Status Before Pregnancy Greatly Influences The Outcome Of Pregnancy, One Of Which Is The Weight Of The Fetus (Retnakaran Et Al., 2021). During Pregnancy, The Health Of The Fetus Depends On The Mother; If The Mother Is Malnourished, The Fetus In The Womb Will Also Experience Malnutrition, Which Will Result In Lbw. The Results Of The Study Showed That The Poor Nutritional Status Of The Mothers Was 31.7 Times More At Risk Of Lbw (Mohamed Et Al., 2022). The Nutritional Status Of The Mother Before Pregnancy And Weight Gain During Pregnancy Are Related To The Incidence Of Lbw (Bhowmik Et Al., 2019). Maternal Malnutrition, Both Past And Present, Increases The Risk Of Lbw (Gokhale & Rao, 2020). Underweight Mothers Are At Risk Of Delivering Lbw Infants. Some Attempts To Overcome It Are Monitoring And Improving Nutritional Status During Pregnancy To Increase Fetal Weight And Have It Born With A Normal Weight (He Et Al., 2018). Women Who Experience Malnutrition During Pregnancy, Aged Less Than 20 And More Than 35 Years, And Have Low Parity Are At Greater Risk Of Having A Pregnancy Outcome With Lbw. To Prevent The Occurrence Of Labour With Lbw Babies, Regular Prenatal Checkups Are Necessary To Monitor The Baby's Growth And Improve The Nutritional Status Of The Mother During Pregnancy. Maternal Age And Parity Are The Causes Of Lbw (Kaur Et Al., 2019). The Results Of This Study Showed That Maternal Age At Risk, Namely Less Than 20 Years And More Than 35 Years, Could Increase The Risk Of Giving Birth To An Lbw Baby By 3,233 Times Compared To Maternal Age 20-35 Years With

Conclusion

The factors related to the incidence of LBW were maternal age, maternal parity, maternal nutritional status, preeclampsia, and maternal HB Status. Preeclampsia had the most influence on the incidence of LBW. It is advisable to implement stringent treatment and oversight of pregnancies in mothers who are either very young or older, primiparous, have chronic energy deficiency, are experiencing preeclampsia, or are afflicted with anaemia to reduce the incidence of low birth weight (LBW).

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Minimum Initial Service Package Readiness Assessment (MRA) for Reproductive Health in the Disaster Situation of Mount Merapi Eruption in Magelang Regency

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Abstract

The Minimum Initial Service Package Readiness Assessment (MRA) was a comprehensive tool used to evaluate a region's preparedness in delivering priority reproductive health services during emergencies, as outlined in the MISP. In Indonesia, the MRA had only been implemented in four provinces, including Central Java. This study was the first research conducted in Magelang Regency. It aimed to describe the implementation of the Minimum Initial Service Package (MISP) for reproductive health during the Mount Merapi eruption disaster in Magelang Regency. A qualitative approach with a case study design was employed, involving 10 informants from government agencies, non-governmental organizations, and evacuation site managers. Data were collected through observation, in-depth interviews, and document review, with data validity ensured through triangulation of techniques and data sources. The data analysis included data reduction, data display, and conclusion drawing. The data were analyzed using the Atlas.ti software. The findings indicated that MISP implementation in Magelang Regency during the Mount Merapi eruption disaster remained suboptimal, particularly due to the absence of a dedicated reproductive health sub-cluster. Despite good coordination among government agencies, awareness and understanding of MISP among policymakers remained limited. Village midwives played a crucial role in health service provision at evacuation sites. However, socio-cultural constructs that perceived reproductive health issues during disasters as sensitive posed significant challenges

Introduction

The Disasters can disrupt health services, particularly reproductive health services, which are often overlooked (Amiri *et al.*, 2020; Ayuningtyas *et al.*, 2021). The need for reproductive health services tends to increase during health crises caused by disasters (Hermawan, Widyaningrum, Lee, Nugroho, Indarjo, Raharjo, *et al.*, 2023; Kementrian Kesehatan Republik Indonesia, 2021). Therefore, it is essential to integrate reproductive health services into primary healthcare during emergencies. The Mount Merapi eruption has provided various lessons, particularly regarding access to reproductive health services for vulnerable groups. Several reproductive health-related cases have occurred in evacuation shelters following the eruption. Previous studies have revealed several social phenomena in Mount Merapi evacuation sites that indicate the vulnerability of displaced populations, particularly women. These include instances of premarital sexual activity, some of which have led to unreported cases of sexual violence; unintended pregnancies due to limited access to family planning services; sexual harassment in bathroom areas; and sexual intercourse occurring in open spaces due to a lack of privacy. A preliminary study conducted by the researcher found that designated private booths, known as *bilik mesra*, were available for couples of reproductive age at evacuation sites, although their number remained limited. This indicates a certain degree of attention to

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reproductive health needs in displacement settings (Nuruniyah, 2016). Furthermore, the researcher's preliminary study on refugees from the 2010 Merapi eruption reported a childbirth case at the TEA Deyangan evacuation site that had to be referred to a hospital due to inadequate equipment, potentially increasing the risk of maternal and neonatal complications. Therefore, the provision of family planning services, antenatal care, and skilled birth assistance by trained midwives is essential among displaced populations (Balinska *et al*., 2019).

Reproductive health services in emergency disaster situations are implemented through a program developed by the Indonesian Ministry of Health, namely the Minimum Initial Service Package (MISP) for reproductive health in health crises (Kementrian Kesehatan Republik Indonesia, 2021). The implementation of MISP in buffer villages plays a crucial role in mitigating the impact of disasters on reproductive health. MISP implementation in these areas aims to ensure accessibility to reproductive health services for affected communities, particularly vulnerable groups (Hermawan, Widyaningrum, Lee, Nugroho, Indarjo, & Raharjo, 2023; Nugroho *et al*., 2025). The program has the potential to reduce maternal and child mortality rates, as well as to minimize the risks of sexual violence, the transmission of sexually transmitted infections (STIs), including HIV/AIDS, unintended pregnancies, and various other reproductive health issues that tend to increase during disasters (Kementrian Kesehatan Republik Indonesia, 2021; Myers *et al*., 2018; Nabulsi *et al*., 2021). Based on the aforementioned description, it is evident that reproductive health services in the context of disasters have not yet become a priority and are often overlooked. Therefore, this study is urgent in examining the implementation of the components of the Minimum Initial Service Package (MISP) for reproductive health during the Mount Merapi eruption in Magelang Regency.

Method

This study employed a qualitative research design using a case study approach to explore a social reality that is subjective, complex, and dynamic. The research was conducted in Magelang Regency, Central Java Province, from February to April 2025. A total of 10 informants were selected using the snowball sampling technique. Among them, three informants represented government agencies, three were from buffer village management, and four represented organizations or non-governmental organizations (NGOs).

Table 1. Characteristic of Research Informant

Informant	Affiliate
Informant 1 (B)	Manager of the Sister Village Program, Tamanagung Village
Informant 2 (JP)	Manager of the Sister Village Program, Deyangan Village
Informant 3 (NA)	Volunteer Corps of the Indonesian Red Cross, Magelang Regency
Informant 4 (HK)	Head of Networking and Cooperation Division, Muhammadiyah Disaster Management Center (MDMC), Magelang Regency
Informant 5 (MA)	Treasurer, Muhammadiyah Disaster Management Center (MDMC), Magelang Regency
Informant 6 (AR)	Head of Disaster Prevention Division, Regional Disaster Management Agency (BPBD), Magelang Regency
Informant 7 (IK)	Head of Family Health and Maternal and Child Health (MCH) Division, Magelang District Health Office
Informant 8 (ES)	Secretary of the Community-Based Disaster Risk Management Organization, Pucungrejo Village
Informant 9 (EM)	Coordinating Midwife, Borobudur Public Health Center
Informant 10 (LM)	Coordinating Midwife, Muntilan 2 Public Health Center

Primary data were collected through in-depth interviews with informants using a semi-structured interview guide. Secondary data were obtained through observation (by directly observing the research setting and gathering information from informants) as well as through document reviews, which served to support and validate the findings from interviews and observations. Triangulation of research findings was conducted by comparing interview results across informants and performing cross-verification with observation and documentation data to enhance the credibility of the study.

Data processing and presentation were carried out by compiling all relevant and representative information. Once the data were collected, the analysis was conducted through three main stages: data reduction, data display, and conclusion drawing. The processed data were presented in narrative form. The researchers used software tools to assist in extracting meaning units, codes, and categories from the verbatim transcripts. RNA performed the initial coding independently. Conclusions were drawn after the results were discussed with AAN, SF, and EN. An example of the coding process is presented in Table 2. Written informed consent was obtained from all informants before they participated in the study. This research received ethical clearance from the Health Research Ethics Committee of Universitas Negeri Semarang (Approval No. 664/KEPK/FK/KLE/2024).

Table 2. Example of the Coding Process

Theme	**Sub-theme**	**Interpretation of Findings**
General Coordination	Well-Structured coordination	Coordination is led by the Regional Disaster Management Agency (BPBD) in collaboration with nine other government departments in disaster management.
	Absence of a reproductive health sub-cluster	The reproductive health sub-cluster has not been established, limiting the operational implementation of MISP.
Prevention of sexual violence and survivor response	Limited reporting of sexual violence cases	No reports of sexual violence have been recorded; however, there is a possibility that unreported cases exist.
	Availability of facilities to meet sexual needs	*Bilik asmara* (intimacy booths) are available at evacuation sites, though limited in number and utilization.
Prevention of HIV and other STIs	HIV/STI transmission prevention	No HIV/STI cases were identified; prevention strategies include education, family-based shelter separation, and the provision of contraceptives for those in need.
	Access to and cultural approaches toward contraceptives	Condoms are available, but their use remains limited due to a lack of information and inadequate socialization efforts in the evacuation sites.
		Religious values play an important role in the prevention of HIV and other STIs.
Prevention of maternal and neonatal mortality	Maternal-neonatal monitoring and referral system	Pregnant women and infants are monitored from an early stage, and referrals are made to health facilities in the event of emergencies.
	Special facilities for vulnerable groups	Dedicated spaces and essential supplies are available for pregnant women and newborns, although in limited quantities.
Prevention of unintended pregnancy	Availability and access to family planning services	Basic contraceptives (oral pills, injectable contraceptives, and condoms) are available at the health posts in evacuation sites.
Adolescent reproductive health	Limited attention to adolescents	Adolescents are not yet considered a priority group in disaster response at evacuation sites.
Minimum health services for children	Emergency education services and psychosocial support	Temporary schools are held in shifts; informal activities such as trauma healing sessions are also conducted.
	Availability and quality of child-friendly spaces	Child-friendly spaces are limited and not well-organized; toy donations are available in some evacuation posts.

Minimum health services for the elderly	Physical health services and psychosocial support for the elderly	Routine health check-ups are available for elderly individuals; they are also involved in various evacuation activities
Integration of comprehensive reproductive health services into basic health services	Limited service availability and human resource capacity	Reproductive health services remain limited; only one out of ten informants had received training on reproductive health in emergencies.

Result and Discussion

The Minimum Initial Service Package (MISP) is a reproductive health service program for disaster situations, implemented across Indonesia since 2008, and developed by the Ministry of Health of the Republic of Indonesia (Kementrian Kesehatan Republik Indonesia, 2021).

General Coordination

The designated coordinator of MISP is, by definition, the coordinator or head of the reproductive health sub-cluster (Chaudhary *et al*., 2017). However, field findings in Magelang Regency indicate a structural gap, as the reproductive health sub-cluster has not yet been established.

"...there isn't one yet, we only have disaster nutrition..." (IK)

"...as for the team, it doesn't seem to be structured yet..." (LM)

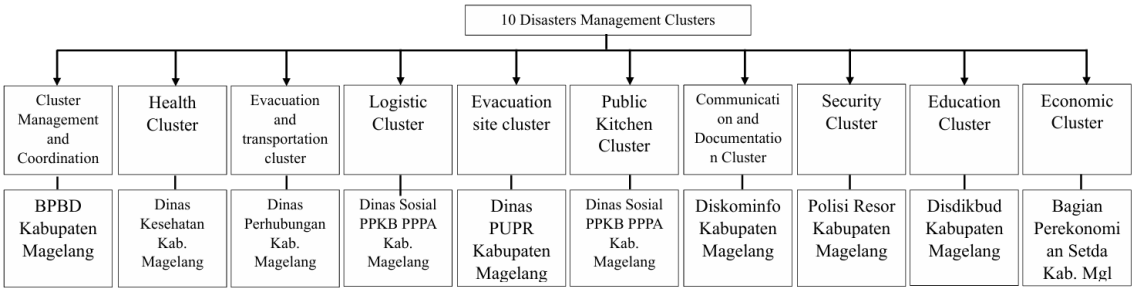
The Regional Disaster Management Agency (BPBD) of Magelang Regency has performed its coordination function with the support of nine related departments. Nevertheless, the absence of a reproductive health sub-cluster has resulted in poorly directed reproductive health services. This aligns with the findings (Onyango *et al*., 2013; Tanabe *et al*., 2022) which revealed the lack of designated individuals or organizations responsible for MISP or health sub-cluster coordination, leading to an absence of clear planning in its implementation.

The evacuation coordination process in Magelang Regency demonstrates an organized structure, with a flow led by the Regional Disaster Management Agency (BPBD) of Magelang and supported by nine other relevant departments. This reflects the existence of a collaborative framework involving multiple stakeholders, contributing to an effective evacuation response and ultimately reducing disaster-related risks (Nugroho *et al*., 2025).

Prevention of Sexual Violence and Response to Survivors' Needs

Following the 2010 Mount Merapi eruption, disaster management efforts experienced significant improvements, including the establishment of the "sister village" program, which fosters partnerships between affected villages and buffer villages. This synergy has contributed to a sense of safety and comfort among evacuees during their stay in evacuation sites. Moreover, it has had a positive impact in minimizing reported cases of sexual violence during the emergency response phase.

"...no reports yet, there hasn't been such



Picture 1. 10 Disaster Management Clusters

an incident of sexual violence..." (JP)

"...well, if it wasn't reported to us directly, we wouldn't know..." (HK)

As a preventive measure, structured reporting and response mechanisms for sexual violence cases have been made accessible to evacuees through both evacuation posts and direct reporting channels to camp coordinators. Evacuation sites with organized mechanisms tend to have higher awareness of the importance of protection, as well as clear planning stages for implementing protective measures (Onyango *et al*., 2013). Additionally, various risk-reduction strategies have been applied, such as separating shelter units by family, providing gender-segregated toilets, and ensuring adequate lighting. Previous studies also emphasize that disaster-resilient shelters and evacuation posts that are gender-sensitive are critical for protecting survivors in emergency contexts (Murphy *et al*., 2023; Nuriana *et al*., 2020; Yoshihama, 2021).

The findings indicate that the provision of intimacy booths or private spaces for couples of reproductive age (PUS) in evacuation sites following the 2020 Mount Merapi eruption has been initiated, although it remains a service that receives limited attention in disaster emergency settings. This reflects a recognition of evacuees' sexual needs, but also highlights that the realization of such support is still far from ideal. Informant statements are consistent with previous studies (Milawaty, 2021), which emphasizes the urgent need for intimacy booths to allow married couples to fulfill their sexual needs.

"...reproductive health services such as intimacy booths have been provided, but they are still limited..." (NA)

"...there used to be a 'bilik cinta..." (EM)

"...we have already provided space for sexual needs, especially for married couples..." (ES)

Prevention of Transmission and Reduction of Morbidity and Mortality due to HIV and Other STIs

Research findings indicate that, based on available reports, HIV and other sexually transmitted infections (STIs) have not emerged as prominent health issues within the evacuation settings. Although no HIV cases were reported, a referral system to more comprehensive health facilities for further diagnostic testing has been established for evacuees showing clinical symptoms of HIV or other STIs (Onyango *et al*., 2013; Roxo *et al*., 2019; Widjaja *et al*., 2023). This reflects the readiness of the health system to manage potential HIV/STI cases through a referral mechanism, ensuring that evacuees with symptoms or at risk receive appropriate care (UNAIDS, 2021).

"...our guiding principle is religion, that's our strength, it helps us stay disciplined..." (HK)

One of the key strategies in preventing HIV and other STIs involves the integration of faith-based approaches, recognizing that religion and culture in Indonesia generally do not support premarital sexual relations. This approach is considered effective, as religious leaders and communities play an essential role in preparedness, response, and recovery efforts during disasters, particularly in ensuring protection for vulnerable groups (Tambunan *et al*., 2021; UNAIDS & UNHCR, 2007). Field data underscore that access to contraceptive services, particularly condoms, was adequately available in evacuation shelters following the Mount Merapi eruption in Magelang Regency.

"...for contraception issues, it's been addressed through collaboration with the Family Planning Field Officers (PLKB) and the social services agency..." (IK)

"...condoms are available, but there's no HIV testing..." (LM)

Although contraceptives were available, their utilization remained limited. This was primarily due to the lack of outreach and information dissemination to displaced populations, as well as prevailing cultural taboos surrounding reproductive health issues during emergencies. Displaced individuals often lacked access to HIV prevention programs, and basic HIV-related support frequently received insufficient attention. Furthermore, cultural considerations significantly influenced the availability and acceptance of condoms in evacuation settings (Onyango *et al*., 2013; UNAIDS & UNHCR, 2007). In the context of a public health crisis, condoms play a critical role as the only contraceptive method proven to be effective in reducing the risk of HIV and other sexually transmitted infections (STIs) (Cooper

et al., 2020; Dambre *et al*., 2022; Kementrian Kesehatan Republik Indonesia, 2021).

Prevention of Unintended Pregnancies

The provision of free condom access is a core objective of the Minimum Initial Service Package (MISP), and it falls under the responsibility of the public health sector, which includes adequate emergency and post-disaster response services related to reproductive health (Pearson *et al*., 2023; Svallfors & Scholar, 2024; UNAIDS, 2010).

"...usually pills and condoms are already available..." (ES)

"...besides condoms, there are birth control pills and injections, that's all..." (IK)

In addition to condoms, other available contraceptive methods included oral contraceptive pills and injectable contraceptives. These services aim to prevent unintended pregnancies during an emergency (Yulianti *et al*., 2022). Village midwives served as coordinators for displaced persons in need of contraceptive services. Disasters can elevate the demand for contraception as a preventive measure against unintended pregnancies (Elimian *et al*., 2024; M *et al*., 2016; Nugroho *et al*., 2025). The repositioning of contraception within the MISP framework reflects a growing recognition of its importance in preventing unintended pregnancies during crises (Foster *et al*., 2017; Gyan & Marhefka-Day, 2021; Mbachu *et al*., 2021).

Prevention of Increased Maternal and Neonatal Morbidity and Mortality

Pregnant women are categorized as a priority vulnerable group (Helmizar *et al*., 2024). Health teams conduct initial assessments of displaced individuals, which include collecting medical histories, particularly for pregnant women and newborns, enabling timely and appropriate emergency interventions when necessary.

"...the health team, of course, conducts initial assessments (for pregnant women)..." (JP)

The data collection and mapping of pregnant women, women in labor, and newborns are carried out as part of the information-gathering process led by those responsible for maternal and neonatal health components (Dhital *et al*., 2019; Pusat Krisis Kesehatan Kementerian Kesehatan RI, 2023).

"...we also have 24-hour standby ambulances, both from the village and the health office, to handle emergencies such as labor or contractions..." (B)

A 24-hour referral system must be in place at evacuation sites to facilitate both transportation and communication from shelters to health care facilities (Casey *et al*., 2015; Pusat Krisis Kesehatan Kementerian Kesehatan RI, 2023). This system is part of the public health sector's responsibility to provide adequate emergency response infrastructure during disasters (Beek *et al*., 2021; Sajow *et al*., 2021). Moreover, the contribution of midwives to disaster response and risk reduction is critical. This is supported by the WHO's recognition of the importance of addressing the health needs of mothers, newborns, and women during crises (Ku Carbonell *et al*., 2024; Lordfred *et al*., 2021). Protective measures for these vulnerable groups include the provision of adequate and comfortable shelter, placement in areas with improved access to sanitation and ventilation, and centralized accommodations to facilitate the delivery of comprehensive health services (Purno *et al*., 2023; Zhang *et al*., 2024).

Adolescent Reproductive Health and Youth Engagement

Adolescence is a distinct phase of human development (Prabamurti *et al*., 2024; Raharjo *et al*., 2019). Findings from this study reveal that adolescents were not identified as a vulnerable group in the planning and implementation of emergency response efforts. Informants' statements indicate a perception that adolescents are capable of functioning independently without the need for targeted intervention.

"...there were no specific programs for adolescents in 2020, they were still able to carry on with their activities there..." (B)

In disaster contexts, adolescents are often perceived as adaptable, energetic individuals with the capacity to manage stress on their own. As a result, they are frequently overlooked in protection schemes and the provision of basic services in evacuation shelters (Casey, 2015; Pusat Krisis Kesehatan Kementerian Kesehatan RI, 2023). This study also found that there were no youth-friendly spaces established in the

evacuation sites. This highlights a significant gap in the availability of facilities specifically designed to address the social and psychological needs of adolescents in displacement settings.

Minimum Health Services for Children Under Five

Findings from this study highlight that several evacuation sites successfully facilitated educational activities through the establishment of emergency schools, which were implemented in two main schemes: formal and informal education.

"...so the emergency school used the same facility as the one in Pucung villagerefugee children used it in the afternoon, while local students attended in the morning..." (ES)

"...the elementary school children were temporarily enrolled in our existing school..." (JP)

"...for informal education, we had morning and afternoon sessions as part of psychosocial support services..." (HK)

The formal education scheme was carried out through two approaches: Class integration, where students from affected villages were incorporated into existing classes in host community schools. Classes comprised students from both communities, and teachers from the disaster-affected villages assisted with the learning process; Rotational (shift-based) scheduling, whereby classrooms were used by local students in the morning and refugee children in the afternoon. Meanwhile, informal education took place in temporary tents or open yards and was facilitated by external volunteers under psychosocial support services. Education is not only a fundamental right but also serves as a critical protective mechanism during emergencies, offering physical, psychosocial, and cognitive safeguards that can save and sustain lives (Bhadra, 2016; Ramezankhani & Sabouri, 2023; Zhong *et al*., 2021).

Some informants reported the presence of adequately functioning and supportive child-friendly spaces that contributed positively to children's psychosocial well-being. Safe play areas for children are recommended in psychosocial and mental health support guidelines as essential for receiving or mobilizing psychosocial support (Atazadeh *et al*., 2022; Bhadra, 2016; Burkhart *et al*., 2023). In addition, psychosocial support services were implemented through trauma healing programs aimed at helping children return to normal daily activities.

Minimum Health Services for the Elderly

The study revealed that the elderly population received particular attention in evacuation sites due to their heightened vulnerability to both physical and mental health issues.

"...we continue to monitor health services and conduct regular check-ups for the elderly in the shelters..." (B)

Older adults often face significant barriers in accessing health care, including limited physical access to health facilities, inappropriate or inadequate medical services tailored to their needs, insufficient supply of medications and care, and unaffordable medical costs (Abi Chahine & Kienzler, 2022; Boetzelaer *et al*., 2024). In addition to medical services, basic psychosocial support was also provided to enhance comfort and reduce potential stress among the elderly (Sri-on *et al*., 2019; Ye *et al*., 2022). This support involved actively engaging older adults in daily activities such as cooking, cleaning the environment, and meal preparation. Activity planning for the elderly must adhere to the principle of "not harm," meaning it should avoid exposing them to additional risks while ensuring appropriate protective measures are in place (Bausch *et al*., 2021; HelpAge International, 2013). The treatment of the elderly as a vulnerable group in evacuation settings reflected two distinct approaches. Some evacuation sites established dedicated spaces for the elderly, aiming to create a more comfortable, secure, and age-appropriate environment tailored to their specific needs (Perdamaian *et al*., 2020; Pusat Krisis Kesehatan Kementerian Kesehatan RI, 2023; Ye *et al*., 2022).

"…yes, based on vulnerable groups, the waste bank area is allocated for the elderly and toddlers, and the community health post (PKD) also serves toddlers because it has medical equipment..." (ES)

"…they remained within their family clusters because they felt more comfortable. There's the wife, the children, if they were separated, it would cause more stress. So sleeping arrangements were still organized by family

units..." (LM)

This form of clustering is intended to reduce stress and health problems associated with overcrowded evacuation conditions. The provision of dedicated spaces for the elderly thus represents an effort to protect their rights and well-being during disaster situations. Beyond physical arrangements, ongoing accompaniment also plays a crucial role in providing psychosocial support, helping to maintain the mental health of older adults amid the stress and uncertainty brought on by displacement (Nasar *et al*., 2022; Yarmohammadian *et al*., 2023).

Planning for Comprehensive Reproductive Health Services Integrated into Basic Health Services

Interviews with several informants revealed that the availability of reproductive health services in evacuation settings remained limited and had only reached a minimally adequate level.

"…so far, it's still not optimal, there is still a strong need for more facilities to support those services..." (NA)

This indicates a gap between displaced individuals' rights to comprehensive reproductive health services and the reality of service provision on the ground. The integration of reproductive health services into every health-related disaster response is expected to better meet service demands (Özvarış *et al*., 2024). By embedding reproductive health services within all aspects of health emergency response, service needs can be more adequately addressed (Fouad *et al*., 2023; Tran *et al*., 2020). The integration of reproductive health services into basic emergency health care is highly dependent on the capacity and expertise of health workers involved (Nugroho *et al*., 2025). Possessing specific competencies for delivering reproductive health care during crises is essential. However, findings indicate that the number of health personnel trained specifically in providing reproductive health services in emergency settings remains limited. This underscores a significant gap in the readiness of human resources to deliver reproductive health services that are both comprehensive and responsive to the needs of displaced populations.

Conclusion

The implementation of the Minimum Initial Service Package (MISP) in Magelang Regency during the Mount Merapi eruption revealed significant gaps between field needs and the application of global standards. Key challenges included the absence of a reproductive health sub-cluster, limited understanding among health personnel, inadequate privacy facilities, and suboptimal mechanisms for reporting sexual violence. Nevertheless, the active roles of village midwives, volunteers, and local institutions served as critical strengths in supporting the delivery of essential services. A collaborative and adaptive approach remains necessary to ensure reproductive health protection for vulnerable groups in crises. The study recommends the formal establishment of a reproductive health sub-cluster and the integration of MISP into regional planning documents to ensure the legal and sustainable implementation of disaster responseparticularly in the area of reproductive health.

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Gender-Based Violence against Men and Women

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Abstract

Based on data from the Indonesian National Commission on Violence Against Women (INCVAW/Komnas Perempuan) from 2007 to 2019, there was a very significant increase in cases of Gender-Based Violence (GBV), reaching eightfold (792%). The majority of GBV victims are women, but men can also be potential victims. However, most research on GBV focuses only on women. Gender-based violence has short-term and long-term impacts on physical and mental health. Female victims of GBV usually experience anxiety, depression, post-traumatic stress disorder (PTSD), and even suicidal thoughts. This study aims to provide an overview of GBV that occurs in both men and women. This study is based on data on reported cases of violence obtained from the Women's Empowerment and Child Protection Service (WECPS/DP3A) of Sleman Regency, Yogyakarta, for the period 2020-2024. Of the 1,001 reported GBV cases, 817 (81.6%) victims were women and 184 (18.4%) were men. The majority of female victims of GBV are of reproductive age (19-44 years), while the majority of male victims are adolescents (11-18 years). There is a significant relationship between gender, location of the incident, and the type of violence experienced. Currently, both men and women experience violence in the public sphere (50.5% and 53.2%, respectively). Psychological violence is the most common experience for both sexes. Men mostly experience neglect, exploitation, and other forms of violence. Meanwhile, women mostly experience physical, sexual, and human trafficking violence. Innovation in reporting forms that are easily accessible to the public is also needed to facilitate victims seeking help.

Introduction

Globally, gender-based violence remains a serious public health and human rights issue and requires special attention (Bhattacharjee *et al*., 2020; Nguefack-Tsague *et al*., 2024)**.** Unequal gender power dynamics in relationships, male control over women, including decision-making, rigid gender roles, and weak negotiation skills in girls and women, as well as gender inequality and social norms, are some of the factors associated with gender-based violence (GBV) (Bhattacharjee *et al*., 2020). Given women's vulnerability to GBV, GBV is often referred to as violence against women and girls, although GBV can also occur in men. According to the World Bank (2019), approximately 200 million women experience the painful practice of female genital mutilation/cutting. Globally, approximately 35% of women have been victims of physical and/or sexual violence, and 38% of female homicides worldwide are perpetrated by intimate partners (World Bank, 2019). In developing countries, the prevalence of domestic violence (DV) remains slightly high, ranging from 29.4% to 73.78% (Christaki *et al*., 2023).

According to data from the National Commission on Violence Against Women

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(Komnas Perempuan), in Indonesia, between 2007 and 2019 (12 years), there was a very significant increase in GBV cases, reaching eightfold (792%) (Komnas Perempuan, 2020). In 2022, there were 339,782 reports of GBV cases against women, with 336,804 cases (99%) being violence in the personal sphere (Komnas Perempuan, 2023). The actual number of cases in the field is likely much higher than reported. Based on complaints received by Indonesian National Commission on Violence Against Women (INCVAW), the most dominant type of violence experienced by women in 2022 was sexual violence (38.21%), followed by psychological violence (35.72%) (Komnas Perempuan, 2023). Violence in any form has serious health consequences. Gender-based violence impacts physical and mental health, both in the short and long term. Female victims of GBV often experience anxiety, depression, post-traumatic stress disorder (PTSD), and even suicidal ideation (Hossain *et al*., 2021; Patel *et al*., 2021). Women who previously had no mental health problems showed increased rates of general mental disorders and suicidal tendencies within one and five years. The onset of PTSD is very common in the early years following the incident.

Poor health status, risk of injury and disability, chronic pain, substance abuse, various health problems such as reproductive disorders, urinary tract infections, cardiovascular problems, chronic pelvic pain, and sleep disorders are also some of the impacts associated with GBV (Chandan *et al*., 2020; El-Serag & Thurston, 2020), and in some cases, violence has even resulted in the death of the victims (Tobin-Tyler, 2023). Children exposed to domestic violence have physical and mental health problems that are difficult to recover from (Doroudchi *et al*., 2023). Impaired memory development, behavior, cognitive function, and verbal skills have also been reported in children exposed to domestic violence Impaired memory development, behavior, cognitive function, and verbal skills have also been reported in children exposed to domestic violence (Berthelon *et al*., 2020; Mueller and Tronick, 2019). The significant impact of violence on victims is inversely proportional to the limited access to assistance and reporting of the violence they experience. Access to timely GBV services is crucial in addressing GBV. But unfortunately, these services are not fully utilized by victims. Research in 24 countries shows that of all female victims of GBV who reported to official sources, in Somalia, only 53.6% accessed GBV services (Muuo *et al*., 2020), Even in Uganda, only 31.9% of female victims of GBV accessed GBV services (Ssanyu *et al*., 2022). Negative stigma within the family and community, victims' fear that the perpetrator will commit further violence, feelings of insecurity and helplessness, and rejection by service providers are barriers to accessing GBV services (Muuo *et al*., 2020). Although several previous studies have described the characteristics of victims of violence (Bhattacharjee *et al*., 2020; Mingude & Dejene, 2021; Murphy *et al*., 2021; Workye *et al*., 2023), the majority of these studies focused only on women and did not include victims who reported to official institutions. Several other similar studies have focused more on domestic violence and sexual violence. Therefore, this research aims to provide an overview of gender-based violence incidents that occur against both men and women, in both the public and domestic spheres.

Method

This research is a secondary study based on reported cases of violence from the Women's Empowerment and Child Protection Service (WECPS) of Sleman Regency, Yogyakarta Special Region, from 2020 to 2024. The study is a descriptive design by analyzing secondary data from the Women's Empowerment and Child Protection Service (WECPS) of Sleman Regency, Yogyakarta, from 2020 to 2024. The population in this study was 1,001 victims of violence from 2020 to 2024. The research sample was selected using total sampling. The analysis test used frequency distribution to describe five-year trends, regional distribution, and characteristics of victims by gender. Bivariate correlation tests were conducted using the chi-square and Spearman Rank. This research has received an ethics letter from the Ethics Committee of Aisyiyah University of Yogyakarta, number 2870/KEP-UNISA/V/2023.

Results And Discussions

The research team analyzed 1,001 cases of gender-based violence reported to the (WECPS) of Sleman Regency, Yogyakarta Special Region, between 2020 and 2024. We categorized all reporting characteristics from different gender perspectives, namely male and female. The trend in the incidence of violence cases is shown in Figure 1, where during the 2020-2024 period, there was a decrease in reported GBV cases from 120 to 119 cases. However, throughout the 2021-2024 period, there was a very significant increase in reported cases, reaching 63.86%, from 119 cases to 297 cases in 2024. There are several possible reasons. It could be due to the increasing number of GBV cases, or it could also be due to increased public awareness of GBV, so that they are brave enough to report these GBV cases.

The distribution of violence cases in Sleman Regency by sub-district is presented in Figure 2. Over the past five years, the highest number of cases occurred in Depok sub-district with 129 cases (12.8%), followed by Mlati sub-district with 124 cases (12.3%). It could be because the Depok sub-district has the highest population density, with 3,699 people per square kilometer in 2022. Areas with high population density tend to experience more intense social interactions between individuals. Conflicts between individuals or groups can occur more frequently due to limited physical distance and greater social contact. Furthermore, denser areas often have higher crime rates. Factors such as inadequate social oversight and economic inequality can exacerbate the situation.

Documenting, reporting, preventing, and addressing gender-based violence (GBV) are primary challenges today. The number of reported GBV cases in developing countries is like the "tip of the iceberg," not yet reflecting the full number of cases of violence that occur in the field Govender, (2023). Violence is difficult to uncover because it is difficult to get victims to talk or report the violence they have experienced. Cases of domestic violence in

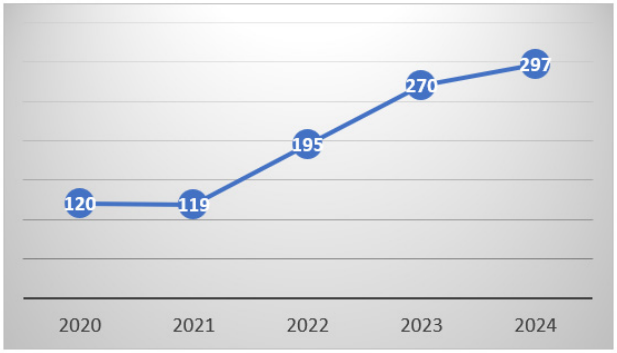

Image 1. Incidents of Violence in Sleman Regency during the 2020-2024 period

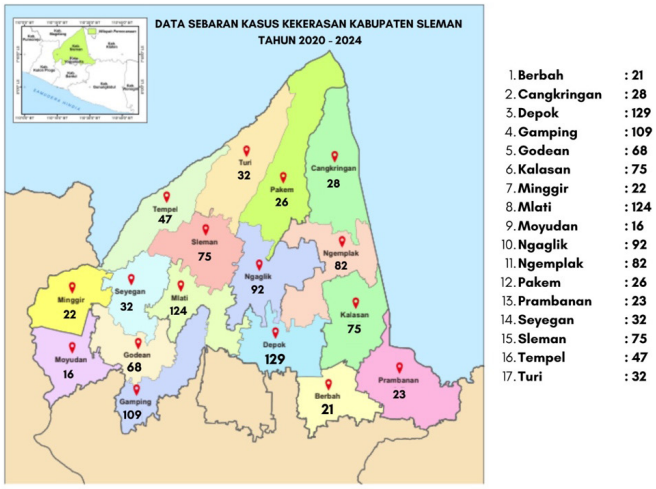

Image 2. Data on the Distribution of Violence Cases in Sleman Regency

some countries are even considered a domestic matter that must be covered up (Arisukwu *et al*., 2021).

Research in Uganda shows that only 31.9% of victims report GBV (Ssanyu *et al*., 2022). Financial dependence on the perpetrator, feelings of low self-esteem and shame, negative stigma in society, ignorance about services and access to them, a culture that normalizes violence, lack of social support, fear of retaliation from the perpetrator, threats of losing children, and distrust of health care professionals are some of the barriers to reporting GBV cases (Heron and Eisma, 2021; Ssanyu *et al*., 2022). These barriers make it difficult to find appropriate treatment for victims and minimize their risks. In Indonesia, where patriarchal norms are strong, incidents of violence, especially domestic violence, are often considered taboo to share with others. Consequently, many victims of domestic violence choose not to report their experiences and receive help late. Given this phenomenon, it is not surprising that domestic violence is often considered a "silent killer," especially for women (Arisukwu *et al*., 2021; Tobin-Tyler, 2023). Although both men and women have the potential to become victims of GBV, in fact, women are more often victims of GBV. Data from the Indonesian Child Protection Agency (ICPA) shows that GBV is experienced more often by women than by men, at 81.6% and 18.4%, respectively. The tendency for women to become victims of violence occurs due to several factors, including social and cultural support. The beliefs and actions of people in society are influenced by their culture (Saaida, 2023). Therefore, a culture that supports, legalizes, and perpetuates violence against women and girls can be an obstacle to eradicating violence or harassment perpetrated by men in society.

Violence against women is an actualization of long-standing gender inequality between men and women, giving rise to discrimination and male domination of women. Patriarchal culture supports male domination over women in society and is a contributing factor to gender-based violence (Mshweshwe, 2020; Sikweyiya *et al*., 2020). This culture creates the subordination of women, forcing women to accept their position as always being below men, which is considered normal. Therefore, women are educated to be fearful, shy, unable to make their own decisions, and

Table 1. Overview of Gender-Based Violence Incidents Against Men and Women

	Man		Woman	
Characteristics	**n**	**%**	**n**	**%**
Type of Violence				
Psychic	61	33,2	277	33,9
Physique	59	32,1	260	31,8
Sexual	19	10,3	201	24,6
Neglect	24	13,0	44	5,4
Exploitation	14	7,6	19	2,3
Human Trafficking	1	0,5	2	0,2
Other Violence	6	3,3	14	1,7
Total	184	100	817	100
Age				
1-5 years	23	12,5	25	3,1
6-10 years	66	35,9	84	10,3
11-18 years	94	51,1	193	23,6
19-44 years	1	0,5	415	50,8
45-59 years	0	0	90	11,0
65-74 years	0	0	10	1,2

Characteristics	Man		Woman	
	n	%	n	%
Total	184	100	817	100
Scene				
Domestic	91	49,5	382	46,8
Non Domestic	93	50,5	435	53,2
Total	184	100	817	100
Disability Status				
Non-disabled	181	98,4	797	97,6
Mental Retardation	2	1,1	9	1,1
Speech impaired	0	0	1	0,1
Deaf	0	0	2	0,2
Deaf and Speech Impaired	1	0,5	4	0,5
Blind, Deaf, and Speech Impaired	0	0	1	0,1
Physical and mental disabilities	0	0	3	0,4
Total	184	100	817	100

Source: Secondary Data 2020-2024

Table 2. Correlation Test of Types of Gender-Based Violence

Gender	Type of Violence								Total	P-value
	Psychic		Physique		Sexual		Others			
	n	%	n	%	n	%	n	%		
Man	23	2.4	51	5.4	15	1.6	42	4.4	131	0,000
Woman	173	18.2	362	38.2		21.1	82	8.6	817	
	196	20.7	413	43.6		22.7	124	13.1	948	

Source: Secondary Data 2020-2024

Table 3. Correlation test of locations of gender-based violence incidents

Gender	Location				Total	P-Value
	Domestic violence		Non Domestic Violence			
	n	%	n	%		
Man	53	5.6	78	8.2	131 (13.8)	0,000
Woman	387	40.8	430	45.4	817 (86.2)	
Total	440	46.4	508	53.6	948 (100)	

Source: Secondary Data 2020-2024

inferior to men, especially husbands (Arisukwu *et al*., 2021; Sultana *et al*., 2023).

In addition to patriarchy, male masculinity is also considered a contributing factor to GBV. Men control and subjugate women using their masculinity. Men objectify women sexually to serve themselves, without considering women's needs and desires as human beings (Arisukwu *et al*., 2021). Traditionalist societies largely accept violence as a means to maintain men's superior position in marriage, while pragmatists view violence as undesirable but sometimes necessary to improve women's behavior. Research in Uganda shows that nearly half of female victims of domestic violence (48.1%) consider wife beating to be normal under certain circumstances (Ssanyu *et al*., 2022).

Based on Table 1, the types of violence experienced by both male and female victims varied, including physical violence, psychological violence, sexual violence,

neglect, exploitation, human trafficking, and other forms of violence. Psychological violence was the most common form of violence experienced by both male (33.2%) and female (33.9%). In this study, no male reported cases of human trafficking. Males experienced more violence in the form of neglect, exploitation, and other forms of violence. This picture is reinforced by the results of the correlation test in Table 2, which found a significant relationship between gender and the type of violence experienced.

Data from the National Commission on Violence Against Women, during 2022, showed that the type of violence against women in the personal sphere was mostly psychological violence (35.72%), while in the public sphere, the majority was sexual violence (38.21%) (Komnas Perempuan, 2023). According to the National Commission on Violence Against Women (2023) several forms of psychological violence that are often reported are: 1) coercion and pressure (threats of being hurt, threats of murder); 2) Emotional violence (infidelity, verbal violence, neglect, specifically violence in dating, emotional violence in the form of broken marriage promises); 3) isolation (cutting off communication). Physical violence that is often experienced is in the form of being slapped, abused, having objects thrown at them, being hit, choked, kicked, hair pulled, punched, pushed, and injuries to body parts (Komnas Perempuan, 2023).

The development of information and communication technology has resulted in sexual violence not only occurring offline (rape, verbal and physical sexual harassment, including forced abortion), but also online, better known as technology-facilitated sexual violence (TFSV). Some reported forms of TFSV include online sexual harassment, receiving sexually explicit images, comments, emails/text messages, threats, or the distribution of sexually explicit photos/videos, and cyberstalking (Powell and Henry, 2019; Snaychuk and O'Neill, 2020; Zagloul *et al*., 2022). Several platforms frequently used to perpetrate TFSV include social media and messaging apps (Facebook, YouTube, Twitter, Instagram, Snapchat, WhatsApp) Several platforms frequently used to perpetrate TFSV include social media and messaging apps (Facebook, YouTube, Twitter, Instagram, Snapchat, WhatsApp) (Salerno-Ferraro *et al*., 2021; Zagloul *et al*., 2022). The impact of psychological violence differs from other forms of violence because its impact is often less visible to the naked eye, unlike sexual and physical violence. However, the handling of psychological violence requires special attention, because physical violence, especially sexual violence, also impacts the victim's psyche. Several previous studies have shown that the psychological impacts of GBV include: loss of interest, anxiety, sadness, restlessness, hopelessness, depression, feelings of worthlessness, sometimes accompanied by somatic symptoms such as headaches, insomnia (Rikhotso *et al*., 2023; Sewalem and Molla, 2022), and sometimes even suicidal thoughts and behaviors in some GBV victims (Patel *et al*., 2024; Rasmussen *et al*., 2023).

In terms of age, both genders (men and women) experience violence from infancy through adulthood. The majority of female GBV victims are of reproductive age (19-44 years), while the majority of male GBV victims are adolescents (11-18 years), at 50.8% and 51.1%, respectively. An interesting finding is that violence against the elderly was only reported by women; no male elderly person reported experiencing violence. It suggests that throughout the life cycle, women are more likely to be victims of violence than men. Violence experienced throughout a woman's life cycle can be seen starting from: 1). the prenatal life cycle in the form of sex-selective abortion (Channon *et al*., 2021; Regmi *et al*., 2024), violence during pregnancy (Maciel *et al*., 2019; Román-Gálvez *et al*., 2021), forced pregnancy (Ameyaw *et al*., 2019; Keegan *et al*., 2023); 2). the life cycle of babies and toddlers in the form of acts of violence such as infanticide and neonaticide (Greenwood *et al*., 2023; Milia and Noonan, 2022); 3). the life cycle of childhood in the form of child marriage (Lami *et al*., 2023; Pourtaheri *et al*., 2023); 4). adolescent life cycle in the form of dating violence (Redondo *et al*., 2024; Villanueva-Blasco *et al*., 2023), sexual violence and assault (Banvard *et al*., 2020; Bentivegna and Patalay, 2022), prostitution and trafficking of adolescent

girls (Lindahl *et al*., 2023), sexual harassment (Bonsaksen *et al*., 2024; Norcott *et al*., 2021); 5). The life cycle of adulthood/reproductive age in the form of domestic violence (Rashedi *et al*., 2019; Sardinha *et al*., 2022), marital rape (Agarwal *et al*., 2022; Ogunwale and Afolabi, 2022), sexual harassment in the work environment (Hardies, 2023; Mohammed *et al*., 2024); 6). the life cycle of the elderly in the form of neglect (Dasbas and Isikhan, 2019), and domestic violence (Meyer *et al*., 2020).

Based on the location of the violence in Table 1, we found that both genders, both men and women, experienced violence in the domestic/personal (household) sphere, amounting to 49.5% and 46.8%, respectively. According to the National Commission on Violence Against Women Komnas Perempuan, (2023), during 2022, violence against women in the domestic sphere consisted of Violence Against Ex-Boyfriends (34%), Violence Against Wives (30%), and Violence in Dating (20%). A strong patriarchal culture and a lack of socialization of policies on domestic violence have resulted in attitudes that legalize violence and consider it normal as a form of education, especially for women. The negative stigma from society that considers domestic conflict as inappropriate, shameful, and private, and does not require outside intervention (Svegel, 2023) further exacerbates this condition. The majority of Indonesians strongly believe this stigma, resulting in many cases of domestic violence going unreported, perhaps even unknown to the victim's relatives. Domestic violence is something that is very close or covered up, because it is considered shameful or taboo.

In addition to the domestic sphere, public spaces such as schools, public places, workplaces, and the homes of perpetrators and victims, as well as boarding houses, have not been safe spaces, especially for women. Data from the National Commission on Violence Against Women (Komnas Perempuan, 2024). Based on the correlation test results in Table 3, a significant relationship was found between gender and the location of the incident. However, our findings indicate that men and women currently experience more violence in the public sphere, at 50.5% and 53.2%, respectively. Patriarchal culture, masculinity, and negative stigma about violence likely contribute to this condition. The high number of GBV cases against men in public spaces is likely also influenced by men's greater activity in public spaces. Men tend to be bolder in public spaces than women. Erkan & Sevin Topçu, (2021) found that women tend to limit their time in public spaces due to fear of crime. Fear of being in dark, lonely places, and fear of verbal and physical harassment also contribute to women feeling unsafe in public spaces. The less women spend time in public spaces, the lower their risk of violence.

Gender-based violence does not only occur to those without disabilities. Double discrimination occurs against people with disabilities, especially women and girls, due to gender inequality and their disabilities. The dependence of people with disabilities on others for assistance in their daily lives makes them more vulnerable to GBV (Namatovu *et al*., 2019). Women with disabilities report fear of being targets of violence, tend to tolerate violence, and rarely report the violence they experience. (Namatovu *et al*., 2019). We found that 21 women with disabilities experienced violence, the majority experiencing physical violence (44.4%), psychological and sexual violence (22.2% each), and other violence (11.1%). Women with intellectual disability were the group most frequently experiencing violence, with 66.7% of the violence being sexual. Research in Uganda and Bangladesh shows that compared to women without disabilities, women with disabilities are at higher risk of experiencing physical, sexual, and emotional violence (Valentine *et al*., 2019). In Indonesia, in 2023, cases of violence against women with disabilities were in the domestic/personal sphere, including violence against wives, children, and girlfriends (Komnas Perempuan, 2023).

Given the enormous impact of GBV, GBV is no longer considered a personal issue but has become a public health issue. The Indonesian government has issued several regulations that can serve as a legal umbrella for GBV victims and witnesses who report it, including: Law No. 23/2004 concerning the Elimination of Domestic Violence; Law No. 13/2006 concerning Protection of Witnesses

and Victims; Law No. 21/2007 concerning the Crime of Human Trafficking; Law No. 35 of 2014 concerning Amendments to Law No. 23 of 2002 concerning Child Protection; Regulation of the Minister of Education, Culture, Research, and Technology No. 30 of 2021 concerning the Prevention and Handling of Sexual Violence in Higher Education Environments; Law No. 12 of 2022 concerning Criminal Acts of Sexual Violence. The existence of these regulations is expected to increase the public's courage to report acts of GBV to the authorities. In addition, socialization and campaigns about GBV need to be carried out on various platforms, especially social media, to increase public awareness in order to prevent and handle GBV.

Conclussions

Women and men have the same potential to become victims of violence, but the number of cases of violence against women is higher than that of men. Women experience more violence throughout their life cycle, from childhood to old age. Most female victims of GBV are of reproductive age (19-44 years), while the majority of men are in adolescence (11-18 years). Currently, both men and women experience violence in the public sphere. Psychological violence is the most common violence experienced by both sexes. Neglect, exploitation, and other violence are often experienced by men. Women experience more physical violence, sexual violence, and human trafficking. Women with disabilities are at risk of experiencing sexual violence, although not many report incidents. The majority of perpetrators of violence are people close to the victim, such as husbands and parents.

This research encourages policymakers to conduct various outreach and education programs about GBV, particularly through digital platforms, which can encourage victims to report and access assistance, as well as increase the utilization of available support services. Community leaders, such as religious and community leaders, must be empowered with information and resources to effectively support GBV survivors in their communities, as they are often the first point of contact for survivors. Innovation in reporting forms that are easily accessible to the public is also needed to make it easier for victims to seek help.

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Digital Therapy Versus Traditional Care for Maternal Mental Health: Meta-Analysis of Psychotherapy RCTs

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Abstract

Perinatal mental health issues, particularly depression and anxiety, pose critical challenges to maternal and children's well-being. It has been reported that psychological distress affects approximately 20.7% of prenatal and 17% of postnatal mothers, attributed to multifaceted emotional, physiological, social, and interpersonal transitions during the perinatal period. Accessibility of digital technologies has increased, prompting innovative approaches to prevention and treatment. This study aims to evaluate the effectiveness of digital psychotherapy interventions compared to traditional care in addressing perinatal mental health outcomes. A comprehensive literature search conducted between September and October 2023 across Scopus, PubMed, and Web of Science databases yielded eleven eligible randomized controlled trials (2017-2023). Meta-analytic findings using Review Manager 5.4 demonstrated significant reductions in anxiety (SMD: -0.41; 95% CI: -0.67 to -0.15; $p = 0.002$) and depressive symptoms (SMD: -0.41; 95% CI: -0.54 to -0.27; $p < 0.00001$) through digital interventions compared to traditional care. Future research directions should prioritize developing engaging interventions, possibly incorporating animation and virtual environments, while considering population-specific factors and optimal intervention duration.

Introduction

Maternal mental health disorders, particularly depression and anxiety, pose significant challenges during pregnancy and up to one year postpartum. These conditions affect maternal well-being and have profound implications for child development and family dynamics (Cimino, 2023). In developing countries, the prevalence of maternal mental health problems is high, with approximately 15.6% of cases occurring during childbirth and 19.8% postpartum (WHO, 2016). According to Mahajan, prevalence rates vary between 10-15% in different countries, depending on assessment techniques and regional factors (Mahajan., 2019). Meta-analyses have revealed that the incidence of depression during pregnancy is approximately 20.7% and 17% of cases occur in the postnatal period (Shorey *et al.*, 2018; Yin *et al.*, 2021). These statistics underline the magnitude of perinatal mental health problems and their potential to affect the well-being of both mother and child significantly.

Prenatal depression is associated with severe perinatal complications, including intrauterine growth retardation, preterm birth, low birth weight, and increased risk of infectious diseases in infants (Gelaye *et al.*, 2016; Roy *et al.*, 2022). In addition, untreated maternal depression can lead to dire consequences, including the risk of suicide and infanticide (Cimino, 2023). Despite the

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severity of these problems, the prevention and treatment of perinatal depression is often delayed or inaccessible. This gap in care is due to a variety of factors, including insufficient ability to recognize and analyze symptoms of perinatal mental health problems, lack of interest or capacity to seek professional help, and prevailing stigma and mistrust among perinatal women and within communities (Daehn *et al.*, 2022). In addition, prenatal stress may be exacerbated by cultural and linguistic background, weak partner support, and a history of childhood abuse (Khanlari *et al.*, 2019).

Traditionally, primary health care has been the main approach to maternal mental health. This approach includes regular check-ups, counseling, and pharmacological interventions. However, these traditional approaches often face challenges related to accessibility and affordability (Webb *et al.*, 2023). In light of these challenges, digital technologies have emerged as a promising medium for mental health interventions, offering potential benefits such as increased accessibility, flexibility, and cost-effectiveness. Digital interventions, particularly those incorporating psychological components such as cognitive behavioral therapy (CBT), are effective in treating a range of mental health problems, including depression, anxiety, substance abuse, and personality disorders (Sarkhel, Singh and Arora, 2020).

Recent studies have demonstrated the effectiveness of web- or app-based therapy interventions in managing postpartum depression (Sun *et al.*, 2019; Qin *et al.*, 2022). Meta-analyses have also assessed the efficacy of digital therapy interventions based on specific objectives, intervention type(Siobhan A. Loughnan *et al.*, 2019), and study quality (Bright *et al.*, 2019; Siobhan A. Loughnan *et al.*, 2019; Miura *et al.*, 2023). Despite the growing body of research on both traditional care and digital therapy interventions for maternal mental health, a comprehensive comparison of these approaches is lacking. To date, no meta-analyses have systematically compared the effectiveness of digital therapy interventions with traditional primary care for maternal mental health, focusing specifically on psychotherapeutic approaches. Therefore, this meta-analysis aimed to compare the effectiveness of digital therapy interventions with traditional primary care in improving maternal mental health outcomes and to identify potential moderating factors that influence the effectiveness of these treatment approaches.

Method

This meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines, conducting a comprehensive search across Scopus, PubMed, and Web of Science databases from September to October 2023. The study focused on randomized controlled trials (RCTs) evaluating digital-based psychotherapy interventions for perinatal maternal mental health, specifically examining Generalized Anxiety Disorder-7 (GAD-7) scores for anxiety symptoms and Edinburgh Postnatal Depression Scale (EPDS) scores for depression symptoms. Data search utilizing the PICOS framework (Participants, Interventions, Comparisons, Outcomes, and Study design framework) (Page *et al.*, 2021).

The search strategy incorporated keywords related to perinatal, prenatal, and postnatal mothers exhibiting anxiety or depression symptoms. Intervention keywords encompassed various digital psychotherapy approaches, including Cognitive Behavioral Therapy and mindfulness applications. The comparison keyword "treatment as usual" represented standard maternal primary health care, while outcome keywords focused on GAD-7 and EPDS scores. The Study design keyword used is Randomized Controlled Trials (RCT). The combination of keywords used in this study were "Mother perinatal" OR "Mother prenatal" OR "Mother Postpartum" AND "Digital psychotherapy intervention" OR "Cognitive Behavioral Therapy" OR "Cognitive Therapy" OR "Behavior Therapy" OR "mindfulness application" AND "Treatment as usual" AND "GAD-7 score" OR "EPDS score" AND "Randomized Controlled Trials". Details of the search strategy are shown in Appendix 1.

Eligibility criteria included full-text, English-language publications published in the last ten years, and targeting perinatal women

aged over 18 years, from early pregnancy to one year postpartum. The analysis focused on perinatal psychotherapeutic interventions delivered via websites and mobile applications compared to standard perinatal care. Studies were excluded from the analysis if the study design was not an RCT, did not present outcome data in the form of Me±SD, did not analyze symptoms of maternal perinatal stress and anxiety, or the form of intervention was not digital, either via a website or a mobile application. The description of the eligibility criteria is shown in Figure 1.

Data extraction was performed independently and included characteristics such as study location, design, objectives, population details, intervention specifics, and outcomes (mean±SD). The results of the data extraction are presented in Appendix 2. The quality assessment used the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2), evaluating six domains of potential bias (Sterne *et al.*, 2019). The quality assessment of the trials is provided in Appendix 3. The meta-analysis used a random effects model to assess clinical heterogeneity. Data were processed as continuous variables using standard mean differences (SMDs) and 95% confidence intervals, presented in visual inspection of forest plots. Review Manager version 5.4 facilitated data analysis and provided a robust review of the effectiveness of digital psychotherapy for perinatal maternal mental health.

Result and Discussion

The literature search identified 433 studies potentially relevant to the effectiveness of digital education and removed 25 duplicates. Screening of titles and abstracts resulted in 223 studies being included in the full-text review. After evaluation based on eligibility criteria, 11 studies were identified for this meta-analysis. Table 1 shows RCT studies conducted between 2017 and 2023 in Singapore, Sweden, Australia, China, Taiwan, Norway, the United States, Portugal, and the Netherlands. The studies included 6555 perinatal women aged ≥18 years, including 3121 prenatal women and 3434 postnatal women. The sample sizes ranged from 42 to 1342, and the duration of intervention ranged from 28 days to 12 months. The attrition rate of the study ranged from 1.9% to 32.4%.

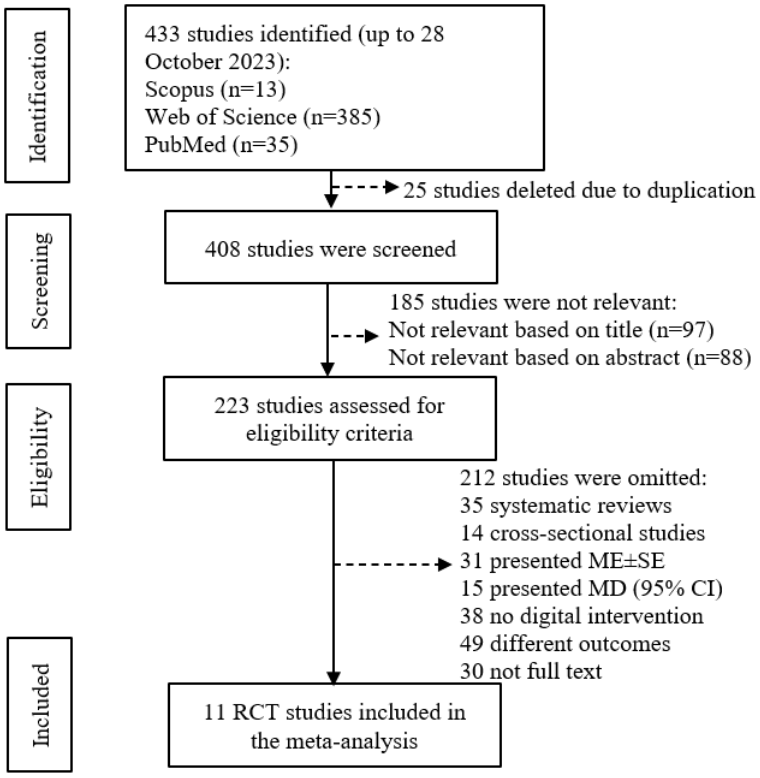

FIGURE 1. Flow Chart of Study Selection

Table 1. Study Characteristics

Author	Country	Years of Study	Population	Age (Mean ±SD)	Intervention	Comparator	Size Sample	Intervention Time	Attrition
(Forsell *et al.*, 2017)	Sweden	2017	Prenatal (10-28 weeks), 95 participants	≥18 years	ICBT	TAU	I: 22; K: 20	Maternity treatment by ICBT for 10 weeks	7.1%
(Haga *et al.*, 2019)	Norwegia	December 2013-February 2015	Prenatal (21-25 weeks), 1590 participants	≥18 years	Mamma Mia	TAU	I: 678; K: 664	Intervention was 44 sessions for 11.5 months	16.8%
(Siobhan A Loughnan *et al.*, 2019)	Australia	2019	Postnatal (<12 months postpartum), 383 participants	≥18 years	MUMentum Pregnancy	TAU	I: 43; K: 44	Intervention during 6 weeks	5.2%
(Heller *et al.*, 2020)	Belanda	March 2014 to January 2017	Prenatal (≤ 30 weeks), 349 participants	≥18 years	MamaKits online	TAU	I: 79; K: 80	Intervention during 5 weeks (1 module/ week)	17.6%
(Liu *et al.*, 2022)	Taiwan	2022	Prenatal (36–38 weeks), 130 participants	20-40 years	We'll App	TAU	I: 65; K:65	Application intervention 3 times a week for 8 weeks	26.6%
(Qin *et al.*, 2022)	China	2022	Postnatal (0-3 postnatal), 112 participants	31.9 ±3.6 years	Application of the CareMom program	TAU	I: 57; K: 55	Intervention during 28 days	6.3%
(Carona *et al.*, 2023)	Portugal	25 January 2019-30 January 2021	Postnatal (≤ 3 months), 1980 participants	18-45 years	Be a Mom	TAU	I: 542;	Intervention 8 weeks	32.4%

(Shorey *et al.*, 2023)	Singapura	February 2020 until July 2022	Prenatal (> 24 weeks), 349 participants	≥21 years	Supportive Parenting App (SPA)	TAU	I: 100;	Interventions during pregnancy and follow-up were extended to 12 months	27.5%
(Suharwardy *et al.*, 2023)	United States	January-May 2019	Postnatal (≤ 12 bulan), 467 participants	≥18 years	Woebot application and TAU	TAU	I: 96; K:96	Intervention for 2 weeks and 4 weeks of follow-up	20.8%
(X. Zhang *et al.*, 2023)	Australia	December 2020 until April 2021	Prenatal (12-20 weeks), 608 participants	≥18 years	Application-based ISP and TAU	TAU	I: 80; K: 80	Interventions 6 weeks and follow-up to 6 months	1.9%
(Y. Zhang *et al.*, 2023)	China	May 2020 until March 2021	Postnatal (≤ 6 months), 492 participants	≥18 years	Application-based ISP and TAU	TAU	I: 118;	Intervention 3 months and follow-up 3 months	3.4%

ICBT: Internet-Delivered Cognitive Behavioural Therapy; ISP: Internet-Based Support Program; PST: Problem-Solving Treatment; TAU: Treatment as Usual

Sumber: (Forsell *et al.*, 2017; Haga *et al.*, 2019; Siobhan A Loughnan *et al.*, 2019; Heller *et al.*, 2020; Liu *et al.*, 2022; Qin *et al.*, 2022; Carona *et al.*, 2023; Y. Zhang *et al.*, 2023; Shorey *et al.*, 2023; Suharwardy *et al.*, 2023; X. Zhang *et al.*, 2023)getting treatment is of the utmost importance. A guided internet self-help intervention may help to provide more women with appropriate treatment. Objective: This study aimed to examine the effectiveness of a guided internet intervention (MamaKits online

Figure 2 presents the intervention studies analyzed were generally of high quality, with the randomized sequences generated from 11 studies rated as low risk of bias for, the randomization process (n= 9), departures from the intended interventions (n= 9), missing outcome data (n= 9), measurement of the outcome (n= 9), selection of the reported outcome (n= 7), and overall bias (n= 6). The risk of bias was unclear in 11 studies for allocation concealment, randomization process (n= 2), deviations from the intended interventions (n= 2), measurement of the outcome (n= 1), selection of the reported outcome (n= 2), and overall bias (n= 2).

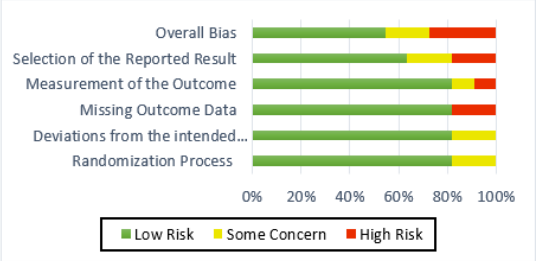

FIGURE 2. Analysis of Risk of Bias in Included Studies
Sumber: (Forsell *et al.*, 2017; Haga *et al.*, 2019; Siobhan A Loughnan *et al.*, 2019; Heller *et al.*, 2020; Liu *et al.*, 2022; Qin *et al.*, 2022; Carona *et al.*, 2023; Y. Zhang *et al.*, 2023; Shorey *et al.*, 2023; Suharwardy *et al.*, 2023; X. Zhang *et al.*, 2023

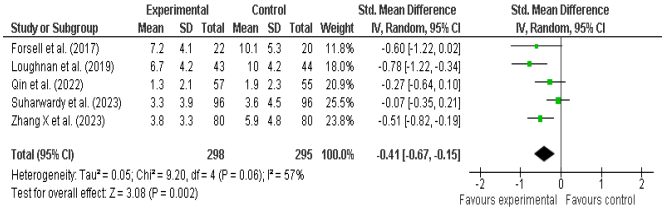

FIGURE 3. Forest Plot Effectiveness of Digital Psychotherapy Intervention on Perinatal Anxiety Symptoms
Source: Revman's analysis from the study (Forsell et al., 2017; Siobhan A Loughnan et al., 2019; Qin et al., 2022; Suharwardy et al., 2023; X. Zhang et al., 2023)

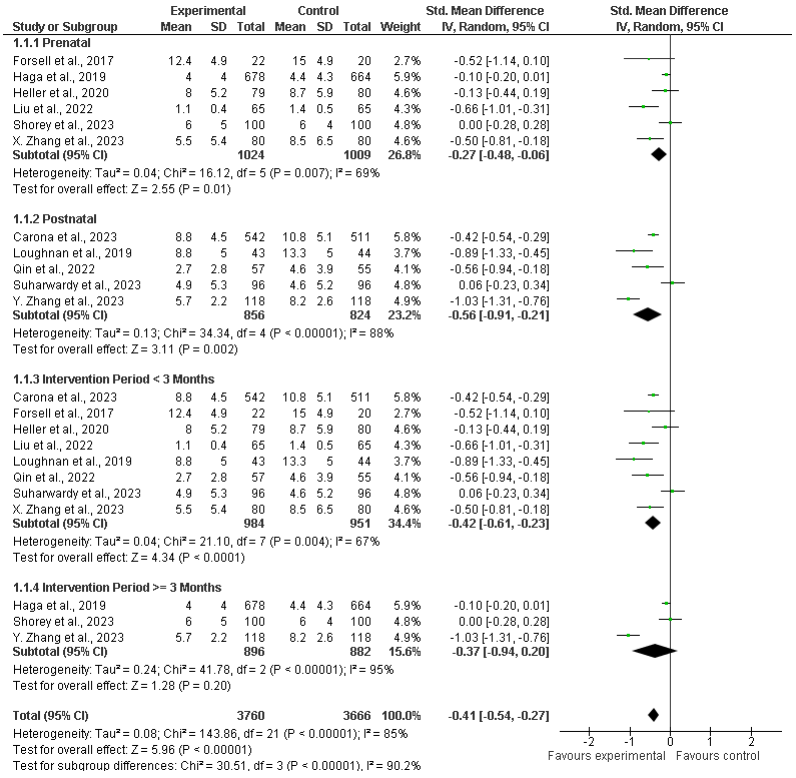

FIGURE 4. Forest Plot of Comparison Effectiveness of Digital Psychotherapy Interventions on Perinatal Depression Symptoms Based on Research Population and Period Intervention
Source: Revman's analysis from the study (Forsell et al., 2017; Haga et al., 2019; Siobhan A Loughnan et al., 2019; Heller et al., 2020; Liu et al., 2022; Qin et al., 2022; Carona et al., 2023; Y. Zhang et al., 2023; Shorey et al., 2023; Suharwardy et al., 2023; X. Zhang et al., 2023)a

Figure 3 shows the statistically significant effect (p = 0.002, from five studies) of digital psychotherapy interventions on reducing perinatal maternal anxiety symptoms. The analysis reveals a small to moderate effect size (SMD: -0.41; 95% CI: -0.67 to -0.15), with consistency across studies despite moderate heterogeneity (I^2 = 57%, Chi^2 = 9.20, p = 0.06). This heterogeneity suggests variability in intervention efficacy across different contexts or populations. Based on the study analysis indicates that two studies had medium to large effect sizes. Loughnan *et al.* (SMD: -0.78; 95% CI: -1.22 to -0.34) and Forsell *et al.* (SMD: -0.60; 95% CI: -1.22 to 0.02) reported the highest values. Interestingly, both Forsell and Loughnan's studies employed Internet-delivered cognitive behavioral therapy (ICBT) as their intervention paradigm, albeit with distinct target populations (Forsell *et al.*, 2017; Siobhan A. Loughnan *et al.*, 2019). Forsell *et al.* focused on pregnant women (n = 42) over a 10-week intervention period, whereas Loughnan *et al.* targeted postpartum women (n = 131) with six-week programs. It is worth noting the differential completion rates: 85.7% in Forsell *et al.*'s study compared to 68.1% in Loughnan *et al.*'s investigation (Forsell *et al.*, 2017; Siobhan A. Loughnan *et al.*, 2019). These differences in population characteristics, intervention duration, and adherence may contribute to the observed heterogeneity and warrant future research to optimize digital psychotherapy interventions for perinatal anxiety.

The analysis forest plot in Figures 4 and 5 shows digital psychotherapy interventions'

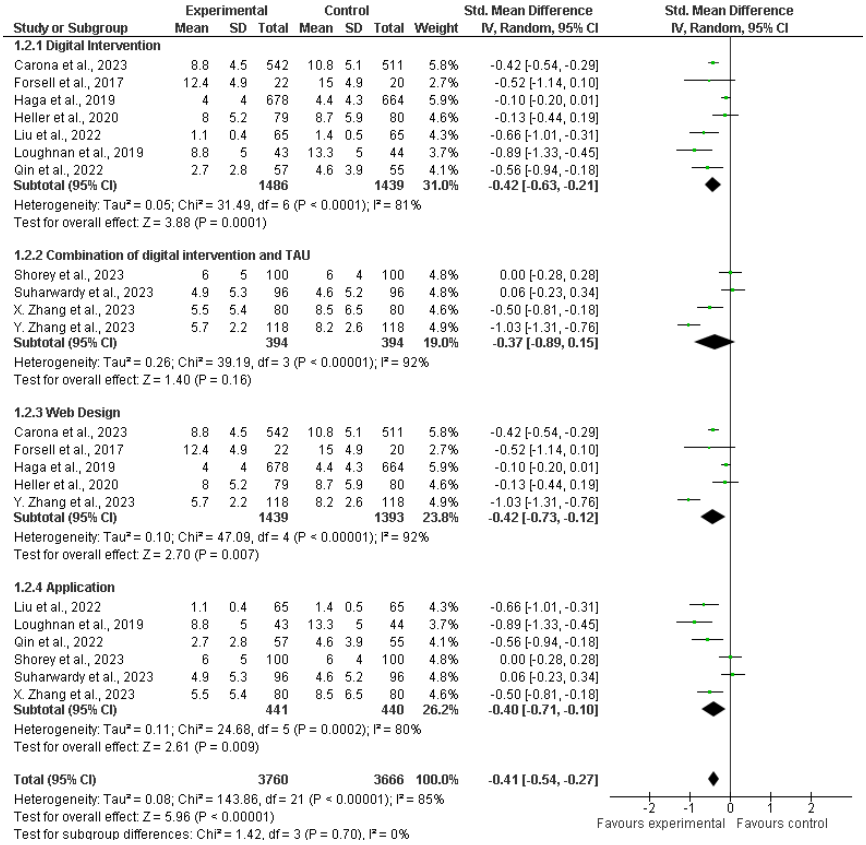

FIGURE 5. Forest Plot of Comparison Effectiveness of Digital Psychotherapy Interventions on Perinatal Depression Symptoms Based on Intervention Type and Digital Media

Sumber: (Forsell et al., 2017; Haga et al., 2019; Siobhan A Loughnan et al., 2019; Heller et al., 2020; Liu et al., 2022; Qin et al., 2022; Carona et al., 2023; Y. Zhang et al., 2023; Shorey et al., 2023; Suharwardy et al., 2023; X. Zhang et al., 2023)

a new app-based cognitive behavioral therapy program, on reducing the depressive symptoms of mothers during the very early postpartum period via a pilot randomized controlled study. The participants were recruited during birth hospitalization (within 3 days after giving birth

effectiveness in improving perinatal depression symptoms ($p < 0.0001$ from 11 studies). The analysis reveals a small to moderate effect size (SMD: -0.41; 95% CI: -0.54 to -0.27). However, the heterogeneity observed was very high ($I^2 = 85\%$, $Chi^2 = 143.86$, $p < 0.00001$). This indicates substantial variability in intervention effects across studies, potentially attributable to differences in populations, intervention types, use of digital media, and intervention periods.

Based on the analysis shown in Figure 4, the timing of intervention implementation (prenatal or postnatal) and intervention duration (long-term or short-term) may affect the effectiveness of perinatal depression treatment. Meta-analysis results indicate that interventions in prenatal populations (SMD: -0.27; 95% CI: -0.48 to -0.06), postnatal populations (SMD: -0.56; 95% CI: -0.91 to -0.21), and short-term interventions (<3 months) (SMD: -0.56; 95% CI: -0.91 to -0.21) significantly reduced depressive symptoms. Meanwhile, the long-term intervention (≥3 months) showed no significant differences between experimental and control groups (three studies, p=0.2). This study suggests the highest intervention effectiveness was observed in the postnatal population. This finding aligns with Finlayson *et al*. research regarding the effectiveness of postnatal interventions in reducing depressive symptoms (Finlayson *et al.*, 2020). This may be influenced by the complexities of adapting to parenthood roles and changing family dynamics during the perinatal phase. However, postnatal maternal care often receives insufficient attention regarding service standardization and individualization (Beňová *et al.*, 2023), given that maternal health systems prioritize antenatal and intrapartum care. This emphasizes that the specific needs of both populations need to be considered when optimizing perinatal mental health services.

In the short-term intervention, Loughnan et al.'s study demonstrated the highest intervention effect (SMD: -0.89; 95% CI: -1.33 to -0.45), involving 131 postnatal mothers for six weeks of intervention and four weeks of follow-up, with a low attrition rate of 3.4% (Siobhan A Loughnan *et al.*, 2019). Conversely, although not reaching statistical significance, the long-term intervention by Zhang *et al*. resulted in the highest measure of effectiveness in the subgroup (SMD: -1.03; 95% CI: -1.31 to -0.76). The study involved 236 three-month postnatal mothers and a three-month follow-up, with an attrition rate of 5.2% (Y. Zhang *et al.*, 2023). The duration of both the intervention and follow-up periods appears to be a crucial determinant of application use dropout rates. Linardon's research suggests that a significant decline in app usage correlates with the duration of use, whether measured in minutes, days, or hours (Linardon, 2023). This observation highlights the importance of considering engagement strategies and optimal intervention duration when designing and implementing digital psychotherapy interventions for perinatal depression. These findings emphasize the importance of considering the optimal duration of interventions in perinatal depression intervention management. Although postnatal and short-term interventions tend to provide more consistent and significant results, long-term interventions also deserve further exploration, considering the potential unidentified in current studies.

The forest plot in Figure 5 shows the variation in effectiveness by intervention type (digital intervention and combination of digital intervention with TAU) and delivery platform (web modification and app) in perinatal depression management. Meta-analytic findings revealed statistically significant intervention effectiveness in depression symptom reduction across digital interventions (SMD: -0.42; 95% CI: -0.63 to -0.21), web-based modifications (SMD: -0.42; 95% CI: -0.73 to -0.12), and mobile applications (SMD: -0.40; 95% CI: -0.71 to -0.10). Although the combination of digital intervention with TAU showed a positive trend, it was not statistically significant (SMD: -0.37; 95% CI: -0.89 to 0.14, $p = 0.16$). The substantial heterogeneity observed in this subgroup analysis ($I^2 = 92\%$) indicates considerable inter-study variability in intervention efficacy. In a subgroup analysis of digital interventions, the MUMentum Pregnancy application, evaluated by Loughnan *et al*., demonstrated the highest effectiveness. This application adapted Internet-based Cognitive Behavioural Therapy (ICBT) with content condensed through comic-style illustrated narratives, achieving a 60.3%

completion rate over a 4-week follow-up period (Siobhan A Loughnan *et al.*, 2019). Protocol adherence was monitored through sequential lesson access, regulated by an automated five-day interval restriction mechanism. These findings align with Chua and Shorey's systematic review, which showed the promising potential of mobile application-based interventions in enhancing overall perinatal well-being (Chua and Shorey, 2022). Their research also recommended incorporating animation and virtual reality technologies to provide experiential learning opportunities for parents.

Regarding web-based platforms, Zhang Y *et al.*'s evaluation of an integrated digital intervention and TAU approach utilizing an Internet-based Support Programme (ISP) scored the highest, although the overall analysis of studies in this subgroup was not significant. This may have been influenced by the limited number of studies analyzed. Participants achieved 96.6% compliance over a three-month follow-up period, as measured by login frequency and duration (Y. Zhang *et al.*, 2023). Variability in attrition and completion rates may have affected the intervention outcomes (Sterne *et al.*, 2019), with enhanced protocol adherence correlating with stronger treatment-seeking intentions. Multiple factors influence the implementation and success of these interventions, particularly in combined approaches. Barriers to traditional mental health services include stigma, lack of awareness, and limited access (Atif *et al.*, 2023), which are particularly prevalent in low- and middle-income countries (Sun *et al.*, 2021). Furthermore, delays in accessing mental health services are often due to a lack of qualified professionals to facilitate psychological interventions and financial constraints (Mitchell *et al.*, 2023). Improving the effectiveness of interventions depends on the full integration of user preferences, accessibility, and context-specific perinatal healthcare systems.

Conclusion

This meta-analysis investigates the effectiveness of digital therapies versus traditional treatments for maternal mental health, focusing on randomized controlled trials (RCTs) of psychotherapy. The study provides important insights into technology-based interventions to address maternal mental health issues, particularly depression and anxiety. Findings indicate that digital interventions are most effective for the postnatal population when implemented for less than three months. The analyzed studies were generally of high methodological quality and predominantly conducted in high-income countries, which limits the generalizability of results to low- and middle-income settings. A notable limitation is that fewer studies measured anxiety symptoms, which limits our understanding of the effectiveness of interventions for antenatal and postnatal anxiety. While the analyzed study's strength lies in its sample size and attrition rate, results should be interpreted cautiously. Further research is needed to validate these findings and explore the role of digital technologies in improving the accessibility and effectiveness of psychological interventions in different clinical and cultural contexts.

Acknowledgment

We sincerely thank the researchers whose randomized controlled trials (RCTs) were included as supplementary data in this meta-analysis. Their rigorous studies contributed significantly to the depth and validity of our findings, enabling a comprehensive synthesis of evidence on digital therapies for maternal mental health.

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Building a Culture of Patient-Centered Care and Its Impact on Hospital Performance

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Abstract

The objective of this research is to examine the connection between hospital performance and customer centricity, focusing on the adoption of Patient-Centered Care (PCC) practices. This study explores how customer-centric approaches influence key performance indicators (KPIs) in healthcare organizations to highlight the benefits of fostering a patient-centered care culture. A mixed-methods approach combines qualitative case studies with quantitative data analysis. Data were collected through questionnaires and interviews with patients, administrators, and healthcare providers from selected hospitals. The quantitative aspect involved statistical analysis of financial performance, readmission rates, and patient satisfaction scores. The qualitative component included in-depth interviews capturing the perspectives of those implementing PCC. Findings reveal a significant positive correlation between hospital performance and customer-centric strategies. Hospitals that actively adopted PCC had lower readmission rates, higher satisfaction scores, and better financial outcomes. Qualitative insights further underscore the importance of organizational culture, staff development, and leadership commitment in successful PCC implementation. The research concludes by offering specific strategies healthcare organizations can adopt to enhance customer-centricity and achieve improved performance outcomes

Introduction

The delivery of exceptional, patient-centered care has emerged as a pivotal imperative for hospitals, as they seek to elevate the quality of patient experiences and optimize clinical outcomes (Epstein & Street, 2011). This approach places patients at the core of healthcare, emphasizing respect for their preferences, needs, and values while ensuring that their voices guide all clinical decisions. As healthcare systems worldwide confront rising patient expectations, increasing competition, and regulatory pressures, patient-centered care has become synonymous with high-quality healthcare delivery. To achieve this paradigm shift, hospitals are adopting a multifaceted strategy that integrates technological advancements, process improvements, and a culture of empathy and responsiveness. For instance, electronic health records (EHRs) and patient portals empower patients with easy access to their health information, enhancing transparency and enabling informed decision-making (Bates & Bitton, 2010). Moreover, telemedicine and mobile health applications have revolutionized patient engagement, providing convenient access to care and fostering continuous patient-provider communication (Kruse *et al*., 2017).

In the ever-evolving healthcare landscape, the concept of patient-centered care has gained significant traction as a critical driver of hospital performance. The growing emphasis on delivering exceptional patient experiences has prompted healthcare organizations to delve deeper into understanding the intricate relationship between customer centricity and organizational outcomes, a fundamental

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priority that has become increasingly crucial in today's dynamic healthcare environment. The notion of patient-centered care is not merely a passing trend, but rather a strategic imperative that has profoundly transformed the way healthcare services are planned, delivered, and evaluated. As healthcare leaders grapple with the challenges of implementing and sustaining a patient-centric culture, they must navigate the nuances of balancing the needs and expectations of patients, physicians, and employees – the three key stakeholders whose collective experiences shape the quality of the healthcare service (Werft, 2024). Currently, a large number of the most significant healthcare providers, legislators, regulatory agencies, research organizations, and funders in the business have adopted patient-centered care. This significant change in focus might be attributed to a 2001 Institute of Medicine report that included patient-centered care as one of six interconnected components of high-quality healthcare. This established the patient-centered care approach as a cornerstone for the delivery of high-quality treatment as well as a means of improving the patient experience.

Healthcare systems are transforming from the traditional volume-based model of healthcare to a value-based model of healthcare. Value generation in healthcare is about emphasizing the health outcomes achieved by patients and organizations while maintaining an optimal relationship with costs (Fernández-Salido *et al*., 2024). Patient and family-centered care is a philosophy, a process, and a practice that can transform the care experience and bolster quality and safety. The key principles of this approach, which are dignity and respect, information sharing, participation, and collaboration, empower patients as active partners in their care. Patients, as experts in their own diagnoses and healthcare journeys, possess invaluable insights that can inform meaningful, actionable changes to the physical and experiential dimensions of care delivery (Purcărea, 2016). To harness the power of patient-centricity, hospitals must foster a culture of open innovation, which encourages collaboration with diverse stakeholders, including patients, to drive continuous improvement. By establishing robust partnerships with patients and involving them in the value-creation process, hospitals can leverage patient knowledge, participation, and responsibility to enhance the quality, safety, and affordability of care.

Carilion Clinic's ongoing evolution as an integrated delivery system, along with its participation in national collaborations to enhance care, exemplifies the transformative potential of patient-centered, innovation-driven approaches (Agee, 2020). The issue of disparity and inequity in healthcare access, as well as the quality of care and performance, is a prominent concern within the Indonesian healthcare system. The imbalance discussed below has a direct impact on the burden borne by the general people, notably in the context of hospital care. Indonesia's healthcare system faces a complex set of challenges, including a significant disease burden, limited hospital resources, and uneven access to quality care. Despite the government's efforts to expand universal healthcare coverage, hospitals in Indonesia continue to grapple with issues of efficiency, utilization, and patient-centered care (Hutapea, 2019; Handayani *et al*., 2014).

Indonesia possesses a publicly funded healthcare system alongside an emerging private healthcare sector. The oversight of the public healthcare system falls under the purview of the Ministry of Health, with funding primarily provided by the government. A diverse range of medical facilities, including hospitals, clinics, and health centers, is available nationwide to offer healthcare services to the public. Nevertheless, there exists significant variation in the quality of healthcare and the accessibility of resources, contingent upon geographical location and the specific type of healthcare facility. Not only with the differentiation between the public and private, in Indonesia, but the distribution of hospitals can also be categorized based on the urban-rural divide, wherein larger cities tend to possess more sophisticated infrastructure and more skilled personnel compared to their rural counterparts. The healthcare system in Indonesia is widely regarded as subpar in comparison to neighboring countries within the area, primarily attributable to insufficient financing and a scarcity of healthcare personnel. The healthcare system in Indonesia exhibits

notable diversity, encompassing a combination of state and private hospitals.

The healthcare strategy prioritizes that referred to "patient-centered care", prioritizes the central role of the patient in the delivery of treatment, emphasizing the consideration of the patient's choices, values, and requirements as primary factors in the decision-making process. The concept of patient-centered care has been established for a considerable duration, although in recent times, it has garnered increasing prominence to enhance the quality of healthcare and the outcomes experienced by patients. The concept of "hospital performance" pertains to the evaluation of a hospital's efficacy in delivering high-quality care, attaining positive patient outcomes, and efficiently managing resources. The Institute of Medicine (IOM) delineated the key dimensions of quality care, encompassing efficacy, safety, patient-centeredness, timeliness, efficiency, and equity. The studies published by the Institute of Medicine (IOM) have generated significant interest in the measurement of hospital performance as a method for assessing the efficacy of quality improvement initiatives and finding areas for improvement.

One key aspect of improving hospital performance in Indonesia is the strengthening of collaborative relationships between healthcare providers. By fostering cooperation and coordination, hospitals can leverage their collective resources and expertise to enhance the quality and timeliness of care delivered to patients. Additionally, the implementation of innovative payment models, such as the Indonesia Case-Based Groups (INA-CBG) system, has the potential to incentivize hospitals to focus on patient-centered care and improve overall healthcare outcomes (Nilasari *et al*., 2023). However, the path to achieving this goal is not without its obstacles. Factors such as medical tourism, high out-of-pocket payments, and the patronage of traditional medical practitioners contribute to the paradox of low hospital bed utilization and high disease burden in Indonesia (Awofeso *et al*., 2013). To address these challenges, a multifaceted approach is required, one that combines strategic planning, effective financial management, and a commitment to fostering a culture of collaboration and innovation within the healthcare system (Jonny, 2016). By addressing these challenges and prioritizing patient-centered care, hospitals in Indonesia can play a vital role in improving the overall quality and accessibility of healthcare services, ultimately benefiting the well-being of the Indonesian population (Handayani *et al*., 2014).

Various organizations have since developed frameworks for assessing hospital performance. The key areas of focus in this study were financial performance, client (patient) satisfaction, internal procedures, and development and learning. The assessment of the hospital's financial performance is conducted from a financial standpoint, whereas the evaluation of customer happiness and experience is conducted from a customer-centric perspective. The hospital's capacity for innovation and expansion is assessed through the lens of learning and growth, while the efficiency and efficacy of the hospital's care delivery are evaluated from the perspective of internal processes. Based on the previous description of the problematics, phenomenon, one of the objectives of this research is to determine whether open innovation would play an important role in the sustainability of hospital performance that can be implemented on a managerial level, where patient-centered care can achieve hospital performance that highly sustainable through hospital collaboration.

Method

An online survey will be administered to Indonesian hospital managers with varying levels of professional experience. To capture their attitudes, viewpoints, and perceptions on the focal social issue, the instrument employs a 6-point Likert scale—an even-numbered format that intentionally omits a neutral option and nudges respondents to indicate a clear position. This choice aligns with methodological guidance, as Taherdoost (2019) concludes that while a 7-point scale is generally optimal, a 6-point scale is most suitable when researchers "*need to have respondents directed to one side*," thereby reducing midpoint bias and yielding more discriminating attitudinal data. Minimum sample size requirements in Partial Least Squares Structural Equation Modeling

(PLSSEM) can be determined a priori with analytic formulas—namely the inverse squareroot and gammaexponential methods—providing researchers with an objective basis for deciding whether their sample is large enough before data collection" (Kock & Hadaya, 2018).

The number of samples must be more than the number of indicators being assessed, according to the theoretical framework. The calculation to determine the number of samples involves multiplying the total number of indicators by ten. The number of samples is equal to ten times the number of indicators, or the value of the variable "n". The algorithm concludes that a minimum sample size of 290 respondents is needed for analysis based on the inclusion of 29 indicators and 5 variables in this study. Type A, B, and C hospitals in Indonesia are included in the study. However, all hospitals in Indonesia are included. There are reportedly 2290 hospitals in this demographic overall (Ditjen Yankes, 2024). There are 290 participants in the research sample who are all field managers with at least a year of work experience under their belts. Less than a year of experience will be excluded from the sample, and only individuals with such experience will be included in the analysis. The IMPPI (*Ikatan Manager Pelayanan Pasien Indonesia*) organization distributed the primary data, which was collected through the face-to-face administration of a questionnaire.

Class A hospitals are teaching hospitals with cutting-edge facilities and advanced medical services that are located in well-known metropolitan locations. The hospital is manned by highly qualified medical professionals and equipped with modern medical equipment. Class B hospitals are medical facilities that provide basic healthcare services and are usually located in areas that are under the district level. The company offers a variety of services, such as inpatient care, outpatient therapy, and emergency care. Class C hospitals are medical facilities located in rural areas that provide basic medical services. The facility offers basic medical services, which include immunizations, maternity and child health services, and outpatient care. Class D hospitals are medical establishments that provide basic healthcare services and are usually located in remote areas. The organization offers a variety of services, such as vaccinations, maternity and child health care, and outpatient treatment.

In addition, it is important to remember that Class A, B, and C specialist hospitals do exist. The medical facilities provide specialized care in areas such as neurology, cardiovascular care, and cancer therapy. It is important to recognize that Indonesia has both public and private healthcare systems. Private hospitals are owned and run by non-governmental organizations, while public hospitals are governed and administered by the government. Modern conveniences and cutting-edge medical technology are more likely to be found in private hospitals than in public ones, albeit the former may come at a higher price. There are many different kinds of health facilities in every Indonesian district, including hospitals, clinics, and health posts. Hospitals are divided into numerous categories based on the variety of services they provide and the caliber of treatment they provide. Choosing a hospital that meets your needs and is conveniently located near your place of employment or residence is very important. In light of the many hospital classifications in Indonesia, it is imperative to categorize the hospital types for this research.

It is evident from the results that 81% of the participants are connected to general hospitals, while the remaining participants are connected to specialist hospitals. No. Permenkes. According to Act 56 of 2014, hospitals are divided into two categories: general hospitals, which provide comprehensive healthcare services for a variety of illnesses, and special hospitals, which primarily concentrate on offering specialized services in a particular field or disease type. These categories are based on disciplines, age groups, organs, diseases, or other particular criteria. The study's possible participants include everyone connected to general hospitals, including department heads, hospital administrators, and medical professionals who actively participate in interdisciplinary teamwork. In-depth knowledge of the interdepartmental dynamics in a hospital context and possible partnerships between the hospital and outside healthcare providers are the goals of this research. Medical professionals, surgeons, and researchers who

Table 1. Validity and Reliability Test

Observed Variable	Average Variant Extracted	Cronbach's Alpha
PCC	0.649	0.727
HP	0.692	0.955

actively collaborate in their various fields of expertise will make up the majority of study participants. In order to provide complete healthcare services, it could also form cooperative alliances with general hospitals or other specialty hospitals. Convergent validity, as determined by the loading factor and average variance extracted (AVE) parameter, will be used to test the outer model. All of the variables had values larger than 0.5 when the AVE (Average Variance Extracted) values are examined. When evaluating discriminant validity, the Fornell-Larcker Criterion cross-loading parameter is usually utilized.

Subsequently, the researchers tested the Cronbach's Alpha coefficient and composite reliability. Since every variable has a coefficient greater than 0.7, the variable is considered to have excellent reliability. Every variable has a Cronbach's Alpha value greater than 0.7.

Path coefficient output, which frequently contains statistics like the mean, standard deviation, and t-values, is used in hypothesis testing. If the t-statistic value from the table is more than 1.96 and the p-value is less than 0.05, the hypothesis about the link between the variables under examination is accepted. When the t-statistic's absolute value is less than 1.96 and the p-value is more than the significance level of 0.05, the null hypothesis is rejected. The impact of each exogenous variable on the endogenous variable can be evaluated using the route's coefficient value. The sample mean (M) is 0.061, while the original sample (O) gets a score of 0.058. For this sample, the Standard Deviation (STDEV) is 0.021. The value of T-statistics (|O/STERR|) is 3.395, suggesting a noteworthy deviation from the null hypothesis. The sample in question has a P-value of 0.001, which provides additional evidence against the null hypothesis. Thus, based on the facts provided, it may be concluded that the hypothesis is supported. The model could account for 54.5% of HP, according to the R Square Values of HP (0.544).

Result and Discussion

Patient-centered care (Patient Centered Care) represents a break from traditional disease-centric paradigms and is grounded in the principles of holistic healthcare (Epstein, 2000). During the 1970s, patient-centered care started to experience a surge in popularity, and in recent times, it has acquired significant traction due to endorsements from medical, public, and other organizations. The importance of defining and measuring patient-centered care (Patient Centered Care) outcomes is growing due to the increased interest in Patient Centered Care. The concept of Patient Centered Care is determined by the locations and perspectives that are depicted. It also highlights the importance and impact of social, mental, emotional, and spiritual needs apart from diagnosis, physical, and medical needs (Kumar & Chattu, 2018).

A comprehensive examination of the existing literature revealed the identification of four distinct sources that provide definitions of Patient Centered Care. Measuring patient-centered care outcomes requires a multidimensional framework that captures patient experience, health outcomes, economic impact, and policy context, reflecting the diverse perspectives stakeholders hold regarding care quality. The perspectives encompassed in this category consist of patient perspectives, therapeutic perspectives, economic perspectives, and perspectives on public policy. The study conducted by the Picker Institute and Harvard Medical School (Picker, n.d.) highlights the significance of eight elements of Patient-Centered Care, which are considered to be of utmost importance to patients respect for patients' values, preferences, and expressed needs, coordination and integration of care, information and education, physical comfort, emotional support and alleviation of fear and anxiety, involvement of family and friends, continuity and transition, and access to care. Consider the patient's perspective to understand patient centricity.

Patient-centered care (Patient Centered Care) has not yet been established, but patient preferences for healthcare interactions have. Patient care priorities include respect, civility, capability, efficacy, patient input in decision-making, treatment duration, availability, and information. Excellent communication and comprehensive research are needed for patient therapy (Tucker *et al*., 2011). For psychiatric and symptomatic patients, communication, relationships, and health promotion were the most important primary care preferences. Patients prefer polite and competent care and knowledge, according to (Little *et al*., 2001). This highlights the need for patient-centered care.

Patient-centered care (PCC) has emerged as a fundamental approach in modern healthcare systems, emphasizing the active involvement of patients in their care and the tailoring of services to their individual needs and preferences (Pelzang, 2010). Proponents have described patient-centered care as that which honors patients' preferences, needs, and values, applies a biopsychosocial perspective rather than a purely biomedical perspective, and forges a strong partnership between patient and clinician (Greene *et al*., 2012). Until recently, most research on patient-centered care and its impact focused on the patient's relationship with their clinician or care team (Greene *et al*., 2012). However, the patient experience extends beyond the in-office visit, encompassing interactions with a range of healthcare providers and technologies, as well as the broader context in which care is delivered (Greene *et al*., 2012).

The implementation of patient-centered care can be hampered by a lack of a clear definition and methods of measurement. It is increasingly important for healthcare providers to understand the core elements of patient-centered care, which include respecting patients' values, providing coordinated and integrated care, ensuring physical comfort, emotional support, and involvement of family and friends, as well as ensuring the continuity of care (Pelzang, 2010). The clinician's or team's ability to provide patient-centered care is affected by the context in which they operate, such as the size and structure of the healthcare organization (Greene *et al*., 2012). Implementing a patient-centered model of care has profound implications for the way care is planned, delivered, and evaluated, requiring a significant commitment and organizational adjustments from healthcare leaders (Cliff, 2012). Before 2001, healthcare leaders often identified barriers to the widespread adoption of patient-centered practices, such as resistance to change, perceived resource constraints, and a lack of clarity on how to initiate and maintain a culture change (Cliff, 2012). Organizational culture and leadership commitment are pivotal in embedding patient-centered care practices. Supporting this, Fiorio *et al*. (2018) quantitatively demonstrate a significant improvement in efficiency and effectiveness following the implementation of a patient-centered hospital model, affirming that organizational change aligned with the principles of PCC yields tangible operational benefits (Fiorio *et al*., 2018).

The shift towards patient-centered care has been driven in part by the recognition that it can lead to improved health outcomes. Providing patient-centered care has been identified by the Institute of Medicine as one of the central means by which the quality of health care can be improved. Patient-centeredness directly correlates with patient satisfaction and hospital performance metrics (Price *et al*., 2015). Specifically, patient-centered care has been linked to increased patient satisfaction, better adherence to treatment recommendations, and improved clinical outcomes (Ward, 2004). In patient-centered care, the preferences of the patient are given priority. In order to get the greatest outcomes, this technique places a strong emphasis on patient participation and doctor-patient collaboration. The management is full of ideas for patient-centered treatment. Patient-centered care fosters better communication, which leads to improved trust, adherence to treatment, and overall patient outcomes (Thomas & Jayakumar, 2017).

Managers, be sensitive to the needs and experiences of your patients. To make sure healthcare team members communicate effectively with patients and with one another, management must pay attention to patients and their families and communicate honestly

and openly. Clear communication, devoid of medical jargon, and in-depth explanations of medical data are required for this. Supervisors ought to promote patients' involvement in their care. Since patients frequently require ongoing care, it is essential to respect their preferences and values, involve them in decision-making, and give them the knowledge and tools they need to make wise choices. When patients need to move between care venues and providers, managers should assist them. In conclusion, patient-centered care has become a central focus in healthcare, with growing recognition of its potential to enhance the patient experience and improve health outcomes. However, its implementation requires a significant commitment from healthcare leaders and organizations to overcome the historical barriers and cultivate a culture that truly prioritizes the needs and preferences of patients. The following empirical results further substantiate these findings. Based on the SEM-PLS analysis of 306 respondents from hospitals in Indonesia:

The t-statistic value of 3.395 is greater than the critical value of 1.96, indicating statistical significance. Additionally, the P-value of 0.001 is less than the significance level of 0.05, further supporting the conclusion that there is a substantial influence of Patient-Centered Care on HP. The coefficient value of 0.058 indicates a positive relationship between Patient Centered Care and HP. In order to establish the acceptance of the hypotheses, it is necessary to demonstrate that the Pearson correlation coefficient (Patient Centered Care) exerts a positive and statistically significant impact on the dependent variable, namely HP. The study examines the impact of Patient-Centered Care on Hospital Performance, specifically focusing on the role of Hospital Collaboration.

This idea is substantiated by prior studies conducted by Al-Nawafleh *et al.* (2021), Saeed *et al.* (2020), Rajabzadeh *et al.* (2020), and Ozmen *et al.* (2019). The research conducted by Al-Nawafleh *et al.* (2021) aimed to examine the correlation between Patient-Centered Care and hospital performance, with a focus on the mediating role of hospital collaboration. The findings of the study indicate that Patient-Centered Care has a statistically significant and positive impact on the level of collaboration inside hospitals. Furthermore, this increased collaboration is found to have a statistically significant and beneficial influence on hospital performance. A separate investigation conducted by Saeed *et al.* (2020) explored the influence of Patient-Centered Care on the performance of hospitals, with interdepartmental collaboration serving

Table 2. Path Coefficient and Hypothesis Testing Results (SEM-PLS Output)

Relationship	**Path Coefficient (β)**	**t-Statistic**	**p-Value**	**Significance**
PCC → Hospital Collaboration	0.412	4.728	0.000	Yes
Hospital Collaboration → Hospital Performance	0.475	6.231	0.000	Yes
PCC → Hospital Performance	0.216	3.395	0.001	Yes
Indirect Effect (PCC → HC → HP)	0.196	3.812	0.000	Yes

R^2 Hospital Collaboration = 0.453
R^2 Hospital Performance = 0.524
SRMR = 0.062 (Model fit is acceptable)

as a mediating factor. The results of the study revealed that participative and collaborative communication (Patient-Centered Care) exerted a favorable and statistically significant impact on the level of collaboration across different departments within the hospital. Furthermore, this enhanced interdepartmental collaboration was found to have a positive and statistically significant influence on the overall performance of the hospital. In contrast, a study conducted by Rajabzadeh *et al*. (2020) examined the effects of patient-centered care on hospital performance, with a focus on the role of intra-organizational collaboration as a mediating factor. The findings of the study indicate that the presence of a positive and statistically significant relationship exists between Patient-Centered Care and intra-organizational collaboration.

Furthermore, it was observed that this collaboration has a positive and statistically significant impact on hospital performance. Finally, a study conducted by Ozmen *et al*. (2019) examined the correlation between patient-centered care, collaborative efforts inside hospitals, and overall hospital performance. The findings of the study indicate that Patient-Centered Care has a statistically significant and beneficial impact on hospital collaboration. Furthermore, it was observed that this collaboration, in turn, has a statistically significant and positive influence on hospital performance. The collective findings of these studies indicate that the implementation of Patient-Centered Care has favorable outcomes in terms of hospital performance, with the underlying mechanism being the facilitation of collaborative efforts inside the healthcare institution. This underscores the need to foster collaboration within healthcare institutions as a strategy for enhancing patient-centered care and hospital performance. Collaboration across interdisciplinary teams enhances patient-centered care by facilitating shared decision-making and care coordination (Heip *et al*., 2022).

The performance of hospitals is a critical aspect of the healthcare system, as it directly impacts the quality of care provided to patients, the efficiency of resource utilization, and the overall effectiveness of the healthcare sector. In this research paper, we will examine the key indicators and theories that underpin hospital performance, with a particular emphasis on the global landscape and the unique challenges and opportunities faced by the Indonesian healthcare sector (Afifi, 2023). The analysis of hospital performance has been a subject of extensive research, with numerous studies exploring various dimensions of this multifaceted concept (Jonny, 2016). A recent study of Taiwanese medical institutions shows that applying the COSO internalcontrol framework can enhance organizational effectiveness in hospitals. Their results indicate that risk assessment and control operations are most strongly associated with improved performance, whereas information & communication and monitoring display weaker links (Lee *et al*., 2021).

Health systems are increasingly implementing policy-driven programs to incentivize performance in healthcare organizations and networks using contracts, targets, scorecards, rankings, rewards, and sanctions (Li & Jenna M Evans, 2022). This aligns with the broader literature on organizational structure and performance, which suggests that formalized rules, procedures, and governance mechanisms can contribute to improved performance in the healthcare sector (Shukri & Ramli, 2015). In the global context, researchers have characterized the performance of the healthcare sector into two primary criteria: internal measures, such as cost or financial status, and external measures, such as quality performance (Anuar *et al*., 2018). This multidimensional approach to performance evaluation is essential, as it captures both the operational efficiency and the patient-centric aspects of hospital performance.

The literature also emphasizes the role of lean healthcare practices in improving operational performance (Anuar *et al*., 2018). Lean management, which aims to eliminate unnecessary activities and optimize processes, has been increasingly adopted in the healthcare sector. However, researchers have noted that the sociotechnical aspects of healthcare organizations are often overlooked in these interventions, and future research should explore the relationship between lean healthcare, sociotechnical factors, and

operational performance (Anuar *et al*., 2018). In the context of Indonesia, the healthcare industry has undergone a significant transformation since the country's independence in 1957, with the public and private sectors playing an increasingly important role (Tajudin & Habidin, 2020). The implementation of lean healthcare practices in public hospitals has been explored, and studies have demonstrated their potential to improve patient performance (Tajudin & Habidin, 2020). Overall, the existing literature highlights the multifaceted nature of hospital performance, encompassing both internal and external measures, as well as the importance of organizational structure, internal control systems, and lean healthcare practices. As the healthcare sector continues to evolve, further research is needed to explore the unique challenges and opportunities faced by different countries, including Indonesia, to develop comprehensive and effective strategies for improving hospital performance (Munaa & Ummah, 2022).

Out of 306 participants, 63% were female. 37% of respondents were 45–54 years old, and 31% were 24–34. In a hospital or healthcare setting, "respondent by gender" refers to those who are actively participating in survey answers or healthcare-related research. Due to gender differences in healthcare experiences and results, this information may help explain them. For instance, a hospital's patient satisfaction survey may ask patients to declare their gender. This study seeks to inform the hospital about gender-related differences in patient satisfaction and healthcare experiences. Similarly, researchers may collect gender data on study participants while testing a treatment or medicine. This data is then analyzed to determine gender differences in treatment outcomes. Another interesting finding is that 73% of research participants work for type C hospitals, and 49% have less than three years of professional experience. Long-serving Members of Provincial Parliament (MPP) may have extensive healthcare collaboration expertise. Participants can provide valuable insights regarding collaborative processes, challenges, and effective ways to improve hospital cooperation, both within and outside.

Additionally, 68% of responders had NERS education. The offered information pertains to the educational credentials of healthcare workers conducting surveys or research. This information may help healthcare workers with different educational backgrounds. Hospital workers' education and training depend on their employment and obligations. Medical professionals like doctors and nurses have more education and training than administrative or support staff. Data on hospital staff education may help identify differences in experiences and perspectives among people in different roles and with different degrees. Data on respondents' educational attainment in a hospital setting may reveal healthcare professionals' traits and experiences, helping improve healthcare delivery and outcomes.

Note that 98% of respondents' hospitals have BPJS facilities. Hospital collaboration involves public and private hospitals, clinics, and other healthcare professionals working together. Hospital partnership in BPJS involves multiple healthcare providers providing medical care to beneficiaries. Hospitals that work with BPJS aim to provide prompt and appropriate medical care to eligible patients. Patient-centered treatment for BPJS beneficiaries includes respect, cultural awareness, and alignment with the patient's medical history and personal circumstances. Open innovation may also involve asking patients and healthcare providers for feedback to improve care, operations, and system issues. Understanding that most BPJS users are hospital employees is key. As Satoto *et al*. (2025) emphasize in their study of cardiac care coordination, 'Effective care coordination advances patient-centered care by guaranteeing that all aspects of a patient's medical journey are interconnected and tailored to address their specific requirements, assembling a varied team that collaborates to develop personalized treatment plans resulting in improved personalized patient care and ultimately better health outcomes.' This highlights the operationalization of PCC through collaboration as an essential mediator for achieving desired performance outcomes.

The implementation of Patient-Centered Care has been found to have a positive impact on Hospital Performance, particularly in the context of hospitals in Indonesia. This

relationship is further influenced by the presence of Hospital Collaboration, which acts as a moderating factor. The healthcare strategy is one that places emphasis on prioritizing the needs, values, and preferences of patients. This strategy places significant emphasis on the significance of comprehending the distinct circumstances of each patient and customizing treatment approaches to cater to their specific requirements. Research has demonstrated that the implementation of patient-centered care has yielded favorable effects on multiple dimensions of healthcare, encompassing patient happiness, health outcomes, and healthcare utilization. Patient-centered care (PCC) has been shown to improve hospital performance by enhancing patient satisfaction, reducing readmission rates, and fostering effective collaboration among healthcare teams. Moreover, hospital collaborations amplify these effects by facilitating resource sharing and coordinated care delivery

Similarly, Tjiptabudi & Antonio (2025) highlight in their study on diabetes care that Diabetes Treatment Satisfaction, conceptualized as a higher-order construct involving Patient Empowerment, has a strong positive impact on Hospital Reputation. This relationship is mediated by both Patient Empowerment and Patient Well-being, underscoring the critical role of empowering patients in enhancing healthcare outcomes and institutional reputation. This is achieved through fostering collaboration among healthcare providers to optimize hospital performance. In fact, Tremblay *et al*. (2017) found that "Interdisciplinary teamwork significantly improves patient-reported experience in cancer care, through better coordination and communication across care teams. This evidence underscores how multidisciplinary collaboration acts as a key mediator of Patient-Centered Care outcomes, enhancing dimensions such as care coordination, communication, continuity, and prompt access to services.

By placing emphasis on the requirements and preferences of patients, hospitals have the potential to enhance patient happiness and foster trust, ultimately resulting in heightened levels of loyalty and an increase in referrals. Moreover, the use of patient-centered care has the potential to provide enhanced health outcomes, encompassing ameliorated clinical outcomes and diminished instances of hospital readmissions. The establishment of efficient partnerships between hospitals and other healthcare institutions can provide positive outcomes in terms of care coordination and the provision of suitable services and support to patients. Patient-centered care facilitates stronger patient-provider relationships, which lead to increased patient satisfaction and trust. Collaborative networks among hospitals enhance the sharing of resources and knowledge, improving care coordination and reducing costs, while also positively impacting clinical outcomes and reducing readmissions. This phenomenon has the potential to result in improved health outcomes and decreased healthcare expenditures. By placing patient-centered care as a top priority and fostering successful teamwork, hospitals in Indonesia have the potential to enhance their overall performance and deliver improved healthcare services to their patients.

It is recommended that the hospital engage in collaborative efforts with other hospitals within Indonesia and on a worldwide scale to exchange best practices and foster mutual learning. This approach has the potential to facilitate the identification of novel solutions aimed at enhancing patient-centered care and fostering a culture of ongoing improvement. As Reeves *et al*. (2017) emphasize, interprofessional collaboration enhances coordination and clinical outcomes by fostering shared goals and communication among healthcare teams, which is crucial for patient-centered care and hospitals. Hospitals must engage in collaborative efforts not only within their sector but also across industries. An example of cross-industry implementation resulting from collaborative efforts within the healthcare sector involves the integration of technology into healthcare practices. Hospitals have the potential to engage in collaborative partnerships with technology businesses in order to foster the development of novel solutions aimed at enhancing patient care, optimizing operational efficiency, and mitigating financial burdens. One potential approach involves establishing collaborations between hospitals and software

businesses to facilitate the development of electronic health records (EHR) systems, which enable seamless exchange of patient data across healthcare practitioners. The implementation of this approach has the potential to enhance the overall quality of healthcare delivery and mitigate the occurrence of medical errors.

Data were collected for the study at a single moment in time using a cross-sectional design. This makes it harder to conclude that hospital performance and customer centricity are causally related. To gain a deeper understanding of the causal linkages, longitudinal research would be required. In the healthcare industry, the notion of customer centricity can be intricate and multidimensional. It's possible that certain aspects of customer centricity were missed in this study or that the measurements employed did not fully represent the construct. Not all potential contextual factors, such as alterations in regulations, changes in the economy, and developments in technology, that potentially affect hospital performance were taken into consideration in this study. These outside variables may have an effect on the connection between hospital performance and customer centricity. Low survey and interview response rates may have contributed to non-response bias. Those who did not participate may have had very different experiences and viewpoints from those who did.

As a gauge of hospital performance, patient outcomes should receive more specific attention in future research. A more comprehensive perspective would come from looking into how patient happiness, recovery rates, and overall health outcomes are affected by customer centricity. Future research could benefit from examining how cutting-edge methods and technology can improve customer centricity. Best practices could be informed by knowledge of how telemedicine, patient portals, and digital health tools support a patient-centered culture. It would be advantageous to look into practical methods for establishing and maintaining a patient-centered care culture in hospitals. Examining leadership positions, employee training initiatives, and organizational policies that promote customer-centric activities are a few examples of how to do this. Future studies might examine how customer centricity affects hospital performance financially. Cost-benefit studies would be part of this to ascertain whether hospitals can profit financially from investing in customer-centric operations. Working with academics from other fields, like business, sociology, and psychology, could open our eyes to new ideas and improve our comprehension of patient-centered care. Interdisciplinary research has the potential to provide creative and all-encompassing solutions.

Conclusion

Patient-Centered Care (PCC) is a holistic approach that places the needs, values, and preferences of patients at the core of healthcare services. By strengthening communication, involving patients, and fostering collaboration among medical teams, PCC has been proven to improve patient satisfaction, trust, and clinical outcomes. Empirical findings from a SEM-PLS analysis of 306 hospital respondents in Indonesia show that PCC has a significant direct impact on hospital performance, and this impact is further enhanced through the mediating role of hospital collaboration. The relatively high R^2 values and acceptable model fit indicate that the model is reliable. Overall, the implementation of PCC is not merely a service strategy but a cultural transformation that requires managerial commitment, cross-sector coordination, and technological support. To sustainably improve hospital performance, strengthening collaborative culture and investing in patient-centered digital innovation are strongly recommended.

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Walking Towards Wellness: Exploring Community Views on Urban Walkability for a Healthier Lifestyle in Semarang

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Abstract

Promoting active mobility, such as walking, is a key measure in creating a healthier urban environment. In support of Semarang City's Urban Mobility Plan, which prioritises low-carbon strategies, the local government has undertaken extensive development of pedestrian infrastructure since 2017. This study investigates public willingness to utilise pedestrian pathways, a critical component in ensuring the effectiveness of such interventions. Data were collected through a survey involving 254 respondents across 24 major roads in Semarang. Findings indicate that walking is predominantly undertaken for shopping and health-related activities, typically covering distances between 200 and 800 metres on weekends. Destinations most frequented include shops, markets, stalls, and shopping centres. The results highlight the importance of integrating user-centred design into pedestrian infrastructure and emphasize the function of pedestrian paths as a social interaction space for both physical exercise and building community cohesion, thereby maintaining the mental health of residents.

Introduction

Today's urban environments continue to experience a decline in liveability due to air pollution from high carbon emissions. Several Sustainable Development Goals (SDGs), especially those pertaining to environmental sustainability, sustainable cities and communities, are greatly aided by the incorporation of pedestrian routes into urban planning. Enhancing pedestrian pathways to improve urban walkability considerably aids urban adaptation to global threats such as climate change. Walkability denotes the suitability of urban areas for pedestrian activity, incorporating design, connection, and accessibility elements that render walking an appealing means of transportation. Enhancing pedestrian paths will have a positive impact on urban air quality.

Walkability has an impact on reducing greenhouse gas emissions (GHG). Urban areas that prioritize walking and cycling can reduce dependence on private vehicle usage and reduce air emissions, especially from the transportation sector. Improving urban walkability, according to research, is crucial to Net Zero Emissions, especially in densely populated cities. Creating liveable and resilient cities is the embodiment of the UK Sustainable Development Goals (Brand *et al*., 2021; Dovey & Pafka, 2019; Huang & Khalil, 2023). Walking as part of non-motorized transportation can reduce CO2 emissions so that the city's air is cleaner. The transportation sector is the largest contributor to GHGs, and real mitigation measures are needed. The government's steps with low-carbon policies, including increasing the mobility of non-motor vehicles, are considered the most appropriate

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step (Karaşan *et al.*, 2024). The city of Semarang has implemented strategic steps to mitigate the impact of GHG due to transportation by building pedestrian paths. The city can achieve sustainability and environmentally sound development by expanding and enhancing pedestrian paths (Azizah *et al.*, 2025).

The construction of urban pedestrian paths is also associated with the reduction of Urban Heat Island (UHI), as it often involves green paths along its corridors. By providing an inclusive area that is safe for pedestrians, equipped with canopies, shading, and greening, pedestrian corridors can reduce heat stress and increase safety and comfort for their users (Necira *et al.*, 2024; Siqi *et al.*, 2023; Vartholomaios, 2023). Survey data from Singapore indicates that thermal comfort levels affect a user's ability to walk for extended periods. Those who said they felt at ease said they would be willing to travel farther if the weather was comparable (Subramanian *et al.*, 2024). Pedestrian paths that are integrated with green open spaces can reduce urban heat and improve urban air quality. The green paths on pedestrian paths provides comfort to pedestrians in summer and reduce the impact of harmful pollutants (Song *et al.*, 2023). Comprehensive urban planning is needed to create a microclimate that improves comfort and public health, without ruling out the fulfilment of pedestrian accessibility and natural surroundings (Badach *et al.*, 2022).

Semarang is one of the major cities located in the coastal area. The coastal areas experience unique problems, challenges, and opportunities that are different from other areas (Susilawati *et al.*, 2023). The deficiency of public open space in Semarang City is a significant concern for the municipal authorities. The emphasis on creating public places for the community is a developmental objective. One of the government's initiatives in this instance is the development of pedestrian pathways, which have been extensively constructed lately. The primary function of pedestrian pathways in today's urban development is evolving into public open spaces, which are also becoming essential for preserving citizens' physical and emotional well-being. Because of this, the fundamental layout of pedestrian pathways at least offers locals of all ages and physical abilities a safe main pedestrian route. Other functions must not interfere with this primary line. Furthermore, there is an area for complementary facilities such as sitting benches, hydrants, drainage systems, rubbish bins, statues or attractive installations, and green lanes (Joga *et al.*, 2022).

One revitalisation tactic to improve sustainability and liveability in cities and other urban areas is to encourage pedestrianisation. It enhances urban mobility and contributes to decreasing the negative effects of the trip on the environment (Soares & Tosato, 2024). Pedestrianization is a term used to describe regions where people primarily walk. It is especially appropriate for high-density, central locations along major retail corridors. Delivery traffic may be feasible during particular daily hours, and in certain instances, it is implemented with the sole supply of public transportation services. The goals of pedestrianization programs are to attract more people into the downtown on foot, foster a greater respect for the pedestrianized region, and increase public understanding of the city environment. To achieve these goals effectively, it is essential to engage the community actively in planning and implementation processes.

A key component of sustainable development is public involvement, which guarantees that the opinions of many stakeholders are heard and taken into account during the decision-making process. In order to effectively solve complex environmental and societal difficulties, it is imperative that sustainable development topics be incorporated into both traditional and interdisciplinary research. This involves public participation (Ermakov & Ermakov, 2020). Achieving sustainable development goals requires incorporating environmental adaptation into routine sector operations. Analysing pedestrian behaviour is crucial for enhancing public health, safety, and urban planning to create pedestrian-friendly areas and increase society's standard of living, generally in urban settings. Sustainable cities will become more significant from an environmental perspective if pedestrian safety is given top priority in urban development. Encouraging walking and other non-motorized forms of transportation in a safe pedestrian

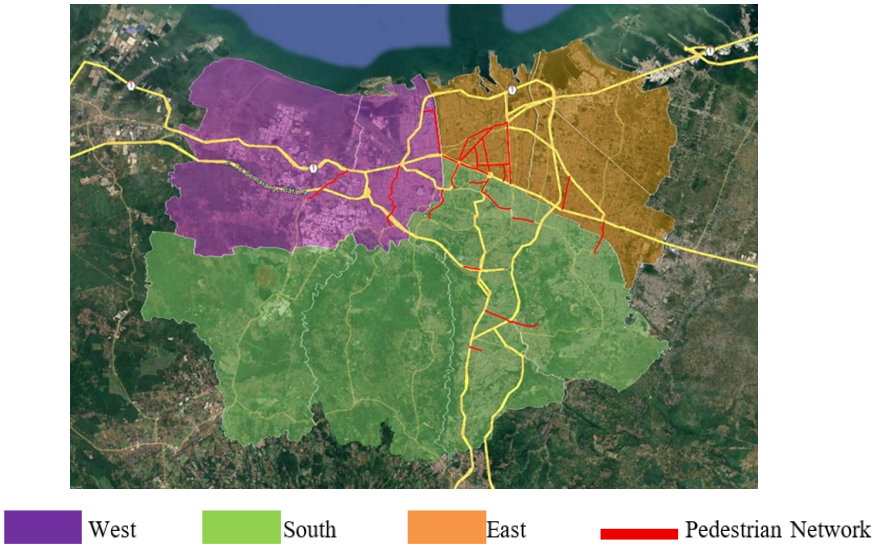

Figure 1. Survey Location (Primary Data, 2025)

environment lowers emissions and pollution from driving (Varsha *et al*., 2023).

Methods

This research was carried out in two stages; the first was analysing secondary data obtained from the Semarang City Public Works Department in 2023. The second stage was a survey with multi-purpose sampling with planned respondents of 254 people, with pedestrian path locations spread across 24 locations throughout Semarang city. The survey involved 254 respondents who use pedestrian paths in Semarang City, spread across 24 locations, and was carried out using the go-along interview method. The survey location is divided into three areas. The west, east, and south areas of Semarang City are shown on Figure 1.

The go-along interview method is often used in qualitative research techniques, especially in the social sciences related to public perception of infrastructure. The go-along interview results in an in-depth understanding. The involvement of interview participants to gain a direct in-depth experience about the surrounding environment that will be the focus of the study. The go-along interview method offers the advantage of direct interaction of participants with the environment. This method is to find out and measure how much impact local infrastructure has on people's social connectivity. This method makes it possible to describe the public view of the development carried out, as well as analyse the needs of the community that have been met and which parts need improvement (Berg *et al*., 2023; Reed & Ellis, 2018). Participants are invested in the go-along method's participation element, which gives them a sense of ownership in expressing their opinions about infrastructure (Muro *et al*., 2020).

The following is a formulation of questions developed into three categories to reveal the public's perception of pedestrian paths: a) What is your purpose for walking? (for shopping / work / using public transport / go for a walk / walking home / walk to parking area / doing sport / walk to public facility); b) What is your motivation while walking? (for enjoy the fresh air / using public transport / to be healthier / limited parking space); c) How far you walk? (less than 200 meters /200 – 800 meters / more than 800 meters). From the 254 data collected, a data analysis method was carried out using SPSS software to conduct a chi-square test, which is highly beneficial for testing the relationship between demographic categories and frequency of pedestrian use. In studies involving community participation, this analysis method is imperative (Sofiyah *et al*., 2025).

Result And Discussion

In Semarang, pedestrian walkway development started in 2017 and has continued

TABLE 1. Respondent Data and Chi-Square Analysis Result

		Age Range			
< 20 years		**21 - 50 years**	**> 50 years**		**Total**
Gender	Female	11	68	14	93
	Male	21	111	29	161
Total		32	179	43	254

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	.520[a]	2	0,771
Likelihood Ratio	0,525	2	0,769
Linear-by-Linear Association	0,061	1	0,805
N of Valid Cases	254		

Source: Primary Data, 2025

until 2023, when it will have covered 20% of all municipal roads (Semarang Public Works Service, 2023). The massive construction of pedestrian paths certainly requires public perception of the built pedestrian paths as a measure of community participation to support the reduction of urban GHG. The goals of pedestrianization programmes are multifaceted and aim primarily to draw a greater number of people into the city centre on foot, thereby reducing dependence on private vehicles and contributing to the overall vibrancy and economic vitality of urban areas. In addition to encouraging foot traffic, these initiatives seek to foster a heightened respect and appreciation for the pedestrianized zones, promoting a sense of community ownership and enhancing the aesthetic and environmental quality of the urban landscape.

The development of pedestrian walkways in Semarang has generated different public acceptance at several levels (Semarang City Regional Planning and Development Agency (BAPPEDA), 2023). As a measure of development success, it is necessary to study the public perception that arises. The application of impact analysis to pedestrians is beneficial for ongoing community projects in communities affected worldwide by the construction of historic highways and the divestment of human-scale infrastructure (Sevtsuk *et al*., 2024). Data collection regarding public perceptions involved 254 pedestrian respondents in Semarang City on 24 roads. The collected respondent data is grouped by age and gender categories, as seen in Table 1.

From the results of the chi-square analysis, an insignificant relationship was obtained between the age range of pedestrians and gender, with a p value 0,771 > 0,10. It means that gender differences do not have a significant effect on the willingness to walk in various age categories. Respondents' purpose for walking on pedestrian facilities in the city of Semarang (Figure 2) consist of walking to work, walking to shops/stalls/shopping centres/markets for shopping, just for a walk, walking to the bus stop to use public transportation, walking to public facilities (schools, parks, hospitals, mosques, etc.), walking to homes, walking to parking lots, and for exercising. As many as 34% of the 254 respondents walked to shops/stalls/shopping centres/markets to shop. Pedestrian paths centred in Semarang City CBDs allow residents and tourists to reduce the number of motor vehicle trips, thereby reducing emissions from the transportation sector. Pedestrian paths can enable users to engage in physical activity and exercise as part of a healthy lifestyle.

The next largest pedestrian purpose is to go to public facilities such as city parks by 18% and take public transportation by 13%. The accessibility of public amenities is greatly impacted by the layout and interconnectivity

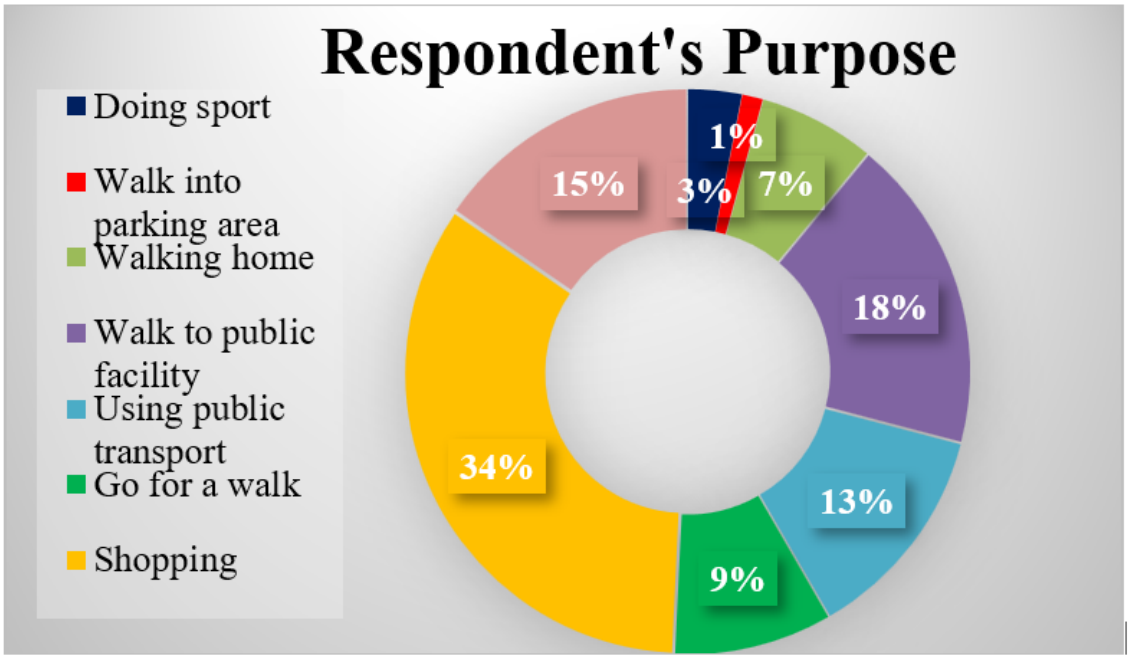

FIGURE 2. Respondents' Purpose for Walking (Primary Data, 2025)

of pedestrian walkways. According to research, places with a high land use density and a variety of public, commercial, and service facilities benefit from providing enough pedestrian routes, which in turn promotes greater use of sustainable transportation (Juanita *et al.*, 2023). How readily people may move across urban areas depends on a number of important elements, including the quality of pedestrian infrastructure and the spatial distribution of destinations (Alamoush & Kertesz, 2022).

Most of the respondents' motivations (seen in Figure 3) for walking using pedestrian facilities in Semarang City are to be healthier (43%), while the others are to enjoy the atmosphere (26%), to be able to use public transportation (20%), and limited parking space (11%). As many as 20% of respondents answered regarding the purpose and motivation for using pedestrian paths because they access public transportation. Pedestrian paths must have good connectivity to public transportation facilities such as bus stops or commuter train stations. It is, of course, in the context of

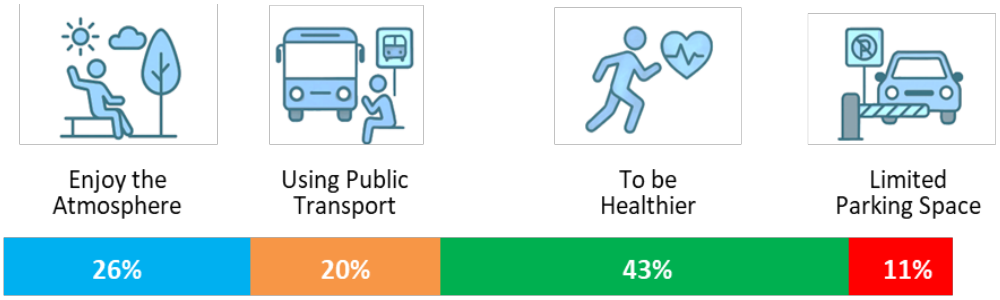

FIGURE 3. Respondents' Motivations for Walking (Primary Data, 2025)

realizing Low Carbon Mobility by encouraging urban communities to switch from using private vehicles to mass public transportation.

The level of awareness of urban communities regarding the importance of a healthy lifestyle is also something that cannot be ignored in designing public facilities. Occupying the largest portion, 43% of respondents stated the reasons for using pedestrian paths to live a healthier life by walking. Walking can improve the body's metabolic system and non-communicable illnesses, including heart disease, hypertension, diabetes, and obesity (Li *et al*., 2022; Prihanti *et al*., 2022). By getting used to walking, people get physical activity, which increases personal immunity and improves air quality by reducing carbon emissions. Additionally, creating pedestrian routes to encourage walkability can have a major positive impact on public health. An urban environment that creates walkability will encourage city dwellers to engage in physical activities and lead to a healthy lifestyle. Obesity rates can be lowered, and cities can save on costs for treatment. Good urban planning will create walkability and active commuting (Kim *et al*., 2020). Among the elderly, physical fitness and psychological well-being have a significant relationship to their quality of life. One of the most relevant indicators in maintaining fitness is walking for 6 minutes and steps for 2 minutes (Lufthiani *et al*., 2022; Prastyawan *et al*., 2024). Meanwhile, in adolescents, physical activities such as walking can improve physical fitness and lung capacity, especially in the context of a healthy lifestyle (Irawan *et al*., 2019). These activities are very possible to be done on pedestrian paths as public open spaces.

The survey results stated that 26% of respondents had the motivation to walk to 'enjoy the atmosphere'. In the routine of a complex urban society, public open spaces are needed to improve the feasibility and comfort of city living. A well-designed pedestrian path is one of the elements to meet the needs of public open space. Wide pedestrian walkways, usually equipped with plazas, provide interaction space for city dwellers. In addition to facilitating movement, these spaces can form social engagement and improve mental health, thus contributing to a liveable urban environment. The integration of pedestrian infrastructure into urban planning can not only increase mobility but also increase social cohesion, making cities more inclusive and more liveable. Pedestrian areas are increasingly in demand for social gatherings, trade, and entertainment. Therefore, understanding the elements that contribute to attracting pedestrians and creating a pleasant feeling while doing so is very important (Sun *et al*., 2023).

Pedestrian paths can not only contribute directly to the improvement of urban public open space, but also benefit from improving the mental health of citizens. The integration of pedestrian paths into urban planning encourages social interaction and community cohesion that are essential for mental well-being. A decent public open space will provide opportunities for socialization and community involvement, which can reduce feelings of loneliness and isolation (Uniaty, 2017). The design of the corridor that combines green space and seating areas can invite residents to spend time outdoors (Braubach *et al*., 2017). To support this concept, the quality of the pedestrian path that focuses on greenery and visual diversity will increase the attractiveness for residents, as well as provide a sense of belonging and togetherness (Villanueva *et al*., 2015).

Numerous standards for streetscape design have gained popularity and success in urban planning research. These guidelines evaluate how effectively streetscape design accomplishes walkability objectives by examining pedestrian satisfaction levels and operating volume after implementation (Chriqui *et al*., 2016; Giles-Corti *et al*., 2008; Hansen, 2014). The majority of these studies point to the benefits of design standards for improving pedestrian comfort, as measured by higher levels of running volume and pedestrian satisfaction. Therefore, it is still burdensome to create aesthetically pleasing streetscapes using design rules (Lee & Park, 2023). Beyond just providing access, pedestrian walkways in metropolitan areas also enhance the general liveability and appeal of cities. The city becomes beautiful and provides an attraction to locals and tourists alike with integrated pedestrian path planning. Especially in locations that

depend on tourism activities, pedestrian paths can give a positive impression that supports increased local income (Mahayani *et al*., 2023). The increase in walkability is influenced by the visual appearance (streetscape) and the character of the environment or local wisdom lifted from the pedestrian path. Research says that adding green lanes and landscaping arrangements to a corridor will increase the number of pedestrians (Wang & Van Ameijde, 2023). Pedestrian paths as part of usable public space that support the walking activities of city residents will increase the liveability dimension of the city (Baobeid *et al*., 2021).

The fulfilment of urban green spaces has a great impact on walkability (Figure 4). The study stated that aspects of environmental quality, including the quality of greening, affect walking behaviour (Kim *et al*., 2020). Some additional details, commonly called street furniture, consisting of benches, aesthetic elements such as decorative lights, and tree canopies, enhance the perception of a positive experience in pedestrians, as well as add value to the landscape (Kumalasari *et al*., 2022; Wu *et al*., 2024). Areas with high pedestrian indexes often show increased citizen engagement in the community, resulting in an increased need for open space that positively affects the mental health of urban residents and social connectivity (Hellberg *et al*., 2021).

In the United States, walkability is confirmed to be influenced by both aesthetics and traffic safety. The results of the testing indicated that the towns may increase neighbourhood walkability by extending their walkways and installing buffers between them (Bokharaei & Nasar, 2023). The desire to walk can increase along with improving sidewalk facilities, either by widening pedestrian paths or adding green open space. The survey results show that the distance travelled by most respondents in Semarang City, 61% of the 254 respondents, was 200-800 meters. 26% respondents walk less than 200 meters, while 13% of respondents walked on pedestrian facilities in Semarang City for more than 800 meters (Figure 5).

In Semarang City, the ideal distance travelled by pedestrians is 200m - 800m. It is in line with research in Bangkok, underlining the "accepted distance" for walking is 400m – 500m in the CBD area (Janpathompong *et al*., 2022). If the facility is within a walkable radius and is equipped with safe and supportive infrastructure, residents will prefer walking

FIGURE 4. Wide Pedestrian Lane and Greening at Pemuda Street (Author Collection, 2025)

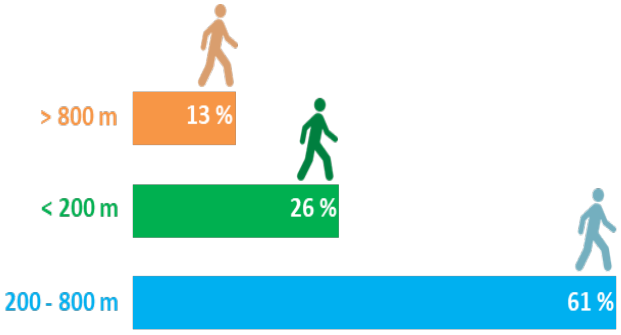

FIGURE 5. The Distance Travelled by Respondent (Primary Data, 2025)

more than using motor vehicles. Especially if the pedestrian path is supported by greening, sky, and flowers, the willingness to walk can increase by 60 – 70 meters (Basu & Sevtsuk, 2022). Semarang City is located in a coastal area. So it tends to have hot temperatures. The local government anticipates this by carrying out greening along pedestrian paths. Shaded pedestrian paths escalate the comfort of pedestrians, thereby attracting people to walk on the path. Therefore, attention needs to be paid to improving the walkability environment from an advanced perspective, environmental multifunctional appeal, and park green open spaces (Koster & Rouwendal, 2012). 13% of respondents who walked on pedestrian facilities in Semarang City for more than 800 meters to do sports activities.

Conclusions

The survey results suggest that public awareness of the need for a healthy lifestyle and active mobility by walking is quite high. Therefore, it is necessary to enhance pedestrian paths that can accommodate the community's needs. Most respondents answered that the walking distance was 200-800 meters. Pedestrian paths that are good in terms of function and integration and have high aesthetics by combining the concepts of landscaping and greening will improve the ability and willingness to walk and support the concept of urban low-carbon mobility. Shady and visually appealing pedestrian paths, proper lighting, and visually engaging urban design not only improve comfort but also increase the attractiveness of walking as a daily mode of transport. Pedestrian paths integrated with green infrastructure make a positive contribution to environmental quality and public health, both physically and mentally. Thus, the development of pedestrian paths is not only carried out in terms of the physical development aspect of the route, but also prioritizes aspects of social function and public health, by paying attention to local wisdom, public perception, and being inclusive for all levels of citizens.

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