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Risk Factors of Chronic Kidney Disease in Indonesian Patients with Diabetes Mellitus

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ABSTRACT

Chronic Kidney Disease (CKD) is a public health problem with increasing prevalence and incidence. About 1 in 3 adults with Diabetes Mellitus (DM) has CKD. This study aims to determine the risk factors for Chronic Kidney Disease in Diabetes Mellitus (CKD-DM) patients in Indonesia. A cross-sectional study was conducted with secondary data, Indonesia Basic Health Research 2018. Data analysis was carried out univariate, bivariate, and multivariate. Also, spatial analysis was carried out to map the prevalence of cases. Among 14.932 samples, the prevalence of CKD-DM in Indonesia was 1.8%. Multivariate analysis results found that gender (aPR=3.24; 95%CI 3.182-3.306), every day smoker (aPR: 2.47; 95%CI 2.415 – 2.535), someday smoker (aPR=1.93; 95%CI 1.875 – 1.987), hypertension (aPR=1.56; 95%CI 1.540 – 1.591), pre elderly (aPR=1.13 95%CI 1.098 – 1.158), elderly (aPR=0.81; 95%CI 0.790 – 0.834), exercise (aPR =1.07; 95%CI 1.055 – 1.090), and obesity (aPR=0.90; 95%CI 0.891 – 0.924) have a significant relationship with the incidence of CKD-DM in Indonesia. This study found that gender is the dominant variable in the incidence of CKD-DM in Indonesia. It is desired that healthcare providers and program makers should recognize gender differences in the progression of CKD and conduct screening program for risk factors of CKD-DM.

INTRODUCTION

Kidney disease is a systemic disease divided into acute kidney injury and chronic kidney disease.¹ Chronic Kidney Disease (CKD) is a health problem that exists in society with increasing prevalence and incidence. CKD is an abnormality in kidney structure or function that lasts for more than three months and has an impact on health. Most people are not aware that they are suffering from CKD until it is severe and requires hemodialysis or a kidney transplant to survive.² CKD mainly occurs in people with diabetes mellitus. It is known that around 1 in 3 adults with diabetes mellitus, either type 1 or 2, have CKD.³

CKD in patients with diabetes mellitus is caused by various factors, which can be categorized as modifiable and non-modifiable. Modifiable factors include age, gender, and the onset of diabetes mellitus. Aging is the most common risk factor, even in adults without diabetes, kidney function declines by approximately 1 mL/min per year after the age of 40.⁴ Regarding gender, men are more susceptible to CKD associated with diabetes mellitus than women.⁵ Sex hormones may influence the risk of chronic kidney failure in adults with diabetes mellitus. Women with Type 1 diabetes may experience decreased estradiol levels and increased testosterone levels, while men with Type 1 diabetes may have either increased or decreased free testosterone levels along with elevated estradiol levels.⁴ Other potential mechanisms related to gender that contribute to chronic kidney disease include differences in renal hemodynamics, diet, kidney and glomerulus size, and sex-specific genetic polymorphisms.⁵

Additionally, it is known that the earliest structural changes in CKD associated with diabetes mellitus appear 1.5 to 5 years after the onset of Type 1 diabetes. Early onset of Type 2 diabetes is associated with more comorbidities and risk factors that contribute to a more rapid progression of CKD and other complications.⁶ Non-modifiable risk factors for CKD include glycemic control, hypertension, lipid abnormalities, chronic inflammation, metabolic syndrome, smoking habits, physical activity/exercise, and Advanced Glycation End-products (AGEs).⁴ A study revealed that increased albuminuria is a major risk factor for developing

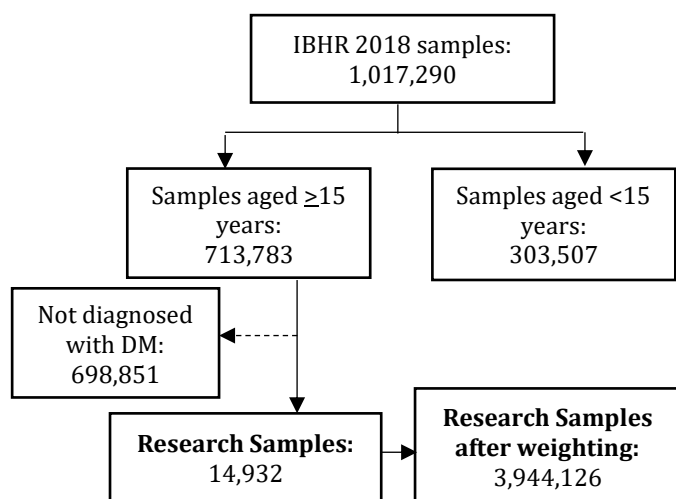
kidney disease in individuals with diabetes mellitus. Additionally, hyperglycemia, a common condition in people with diabetes, is also a risk factor that can worsen kidney function and lead to increased AGEs.⁷

Globally, CKD in type 1 Diabetes Mellitus patients (DM patients) was responsible for 12.9 thousand incidences, 5.02 million patients, and 8.20 thousand deaths. In addition, CKD in type 2 DM patients was responsible for 2.5 million new cases, 129.56 million patients, and 405.99 thousand deaths. It is known that type 2 diabetes mellitus is the second highest cause of CKD which is associated with death. In type 2 DM patients, the prevalence of CKD varies in countries around the world, 38.8% in China, 35.52% in Ethiopia, 34.4% in India, 11.4% in Saudi Arabia, 2.2% in the United States⁸, 12.8% in Vietnam, 10.0% in Thailand, 12.2% in Brunei and Malaysia, 11.1% in Cambodia, Laos, Myanmar, Philippines, and East Timor.⁹ In Indonesia, the prevalence of CKD generally increased from 2.0% in 2013 to 3.8% in 2018.¹⁰ Based on the 10th Report of The Indonesian Renal Registry in 2017, the percentage of CKD in DM patients was 21.¹¹

Based on data from the Social Health Insurance Administration Body, CKD is one of the 10 catastrophic diseases with the extensive budget absorption in the National Health Insurance program.¹² Identifying high-risk groups can reduce the impact of CKD on both individuals and society.¹³ One of the groups of individuals at risk of CKD is DM patients. This study aims to determine the risk factors for CKD in DM patients (Types 1 and 2) in Indonesia.

MATERIAL AND METHOD

This study used a cross-sectional study design from Indonesia Basic Health Research (IBHR) 2018, obtained from the Ministry of Health of the Republic of Indonesia. The study was conducted in October-December 2023. Respondents aged ≥ 15 years who suffered from diabetes mellitus in IBHR 2018 became the study population. The sample used for analysis was 14,932 respondents from IBHR 2018 with criteria ≥ 15 years and diagnosed with diabetes mellitus. However, weighting was carried out in data analysis to obtain a sample that was close to the population. SPSS Statistics version 25 was used for the weighting, resulting in a weighted sample of 3,944,126 (Figure 1).



Source: Indonesia Basic Health Research, 2018

Figure 1. Sampling Flow

The instrument for this study is the IBHR 2018 questionnaire. The data collection process is carried out through an application and permission to use the data submitted to the Ministry of Health of the Republic of Indonesia. The status of CKD was seen from the presence of the diagnosis of CKD by a doctor. Independent variables in this study are age, gender, hypertension, smoking, exercise, and obesity. Age is categorized into teenager and adult, pre-elderly, and elderly. Smoking was categorized into the everyday smoker, someday smoker, and never smoking. Meanwhile, other variables were categorized into Yes/No.

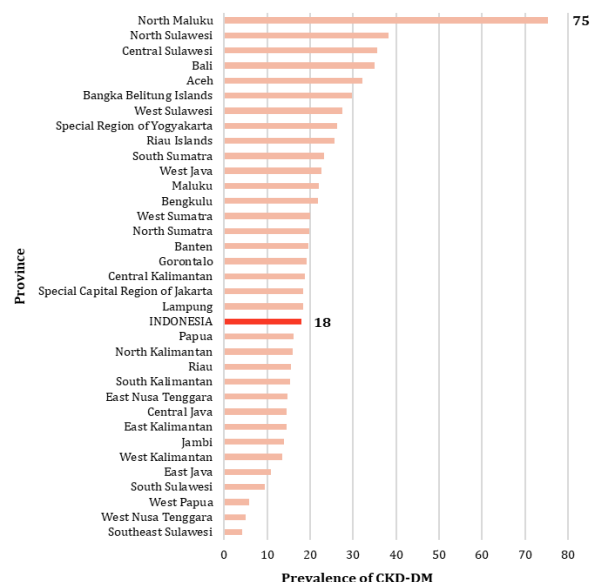
Data analysis was carried out using the Cox regression model to determine the factors related to Chronic Kidney Disease-Diabetes Mellitus (CKD-DM) incidence. The Cox regression model was chosen to obtain a risk value. The Cox regression model needs a time variable and this study uses a cross-sectional study design, so in the multivariate analysis, a time variable is created which contains the value "1" as a null value. The first step was to carry out bivariate analysis (chi-square) to select candidate independent variables that would be included in the model. Associations between independent variables and CKD were analyzed separately. In the second step, all independent variables were entered into the model because they all had p -value <0.25 . The adjusted prevalence ratio in the multivariate analysis was assessed at 0.05 with a 95% Confidence Interval

(CI 95%). All statistical analyses used SPSS software version 25.

Spatial analysis was also carried out by mapping high-risk areas based on the prevalence ratio of CKD-DM cases in each province in Indonesia using QGIS software (ver. 3.28.4). The protocol of this study was approved by The UPN Veteran Jakarta Research Ethics Committee (419/XI/2023/KEP). All personal information was kept confidential and not reported in this paper.

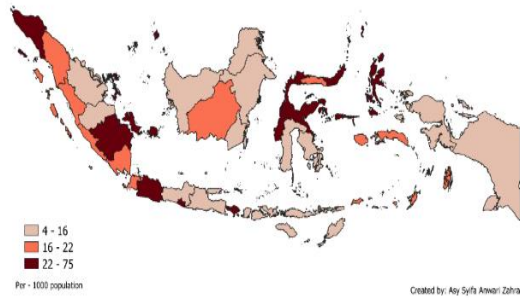
RESULTS

The prevalence of CKD-DM in Indonesia is 18 cases per 1000 population (Figure 2). Then, a distribution map of CKD-DM prevalence was created based on provinces in Indonesia. Based on the map, it was found that the lighter the map color, the lower the CKD-DM prevalence, and vice versa, the darker the map color, the higher the CKD-DM prevalence. From calculating data, it was found that the average prevalence of CKD-DM in Indonesia was 21 cases per 1000 population. The province with the lowest prevalence of CKD-DM is Southeast Sulawesi, which has 4 cases per 1000 population. Meanwhile, the province with the highest prevalence of CKD-DM is North Maluku, with 75 cases per 1000 population (Figure 3).



Source: Indonesia Basic Health Research, 2018

Figure 2. Prevalence of CKD-DM in Indonesia Based on Province



Source: Indonesia Basic Health Research, 2018

Figure 3. Distribution of CKD-DM in Indonesia by Province

Compared with the prevalence of CKD-DM in Indonesia nationwide, 14 provinces have a lower prevalence, 2 provinces have the same prevalence, and 18 provinces have a higher prevalence than the national prevalence. Provinces with prevalence higher than the national prevalence are Gorontalo, Central Kalimantan, Banten, West Sumatra, North Sumatra, Bengkulu, Maluku, West Java, South Sumatra, Special Region of Yogyakarta, Riau Islands, West Sulawesi, Bangka Belitung Islands,

Aceh, Bali, Central Sulawesi, North Sulawesi, and North Maluku.

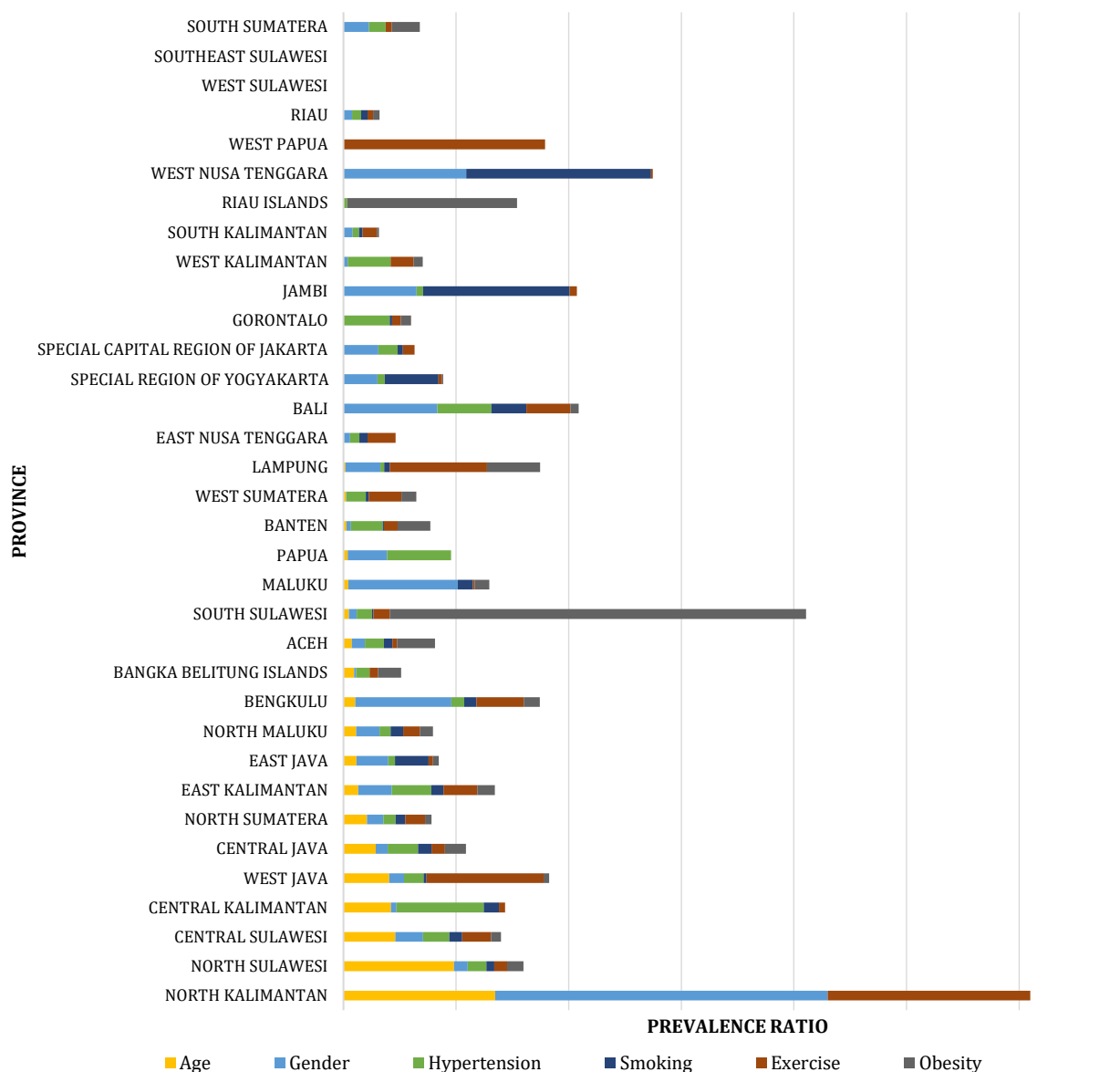
Diabetes patients who are the unit of analysis are dominated by the pre-elderly age category (50.7%). Female respondents were the most respondents with a total of 59.5%. Based on hypertension status, it was found that 54.6% of DM patients were not hypertensive. 69.7% of respondents who were DM patients never smoked, 51.9% of them did not exercise, and 66.4% of them were not obese (Table 1).

Subsequently, the Prevalence Ratio (PR) was calculated from the distribution of CKD-DM risk factors based on provinces in Indonesia to see the risk level. Based on age, gender, and exercise variables, the province with the highest risk for CKD-DM is North Kalimantan. Meanwhile, Central Kalimantan Province is at the highest risk based on the hypertension variable, West Nusa Tenggara Province is at the highest risk based on the smoking variable, and South Sulawesi Province is at the highest risk based on the obesity variable (Figure 4).

Table 1. Distribution and Frequencies of CKD-DM Risk Factors in Indonesia

Variables	n = 14,932	n (weighted) = 3,944,126	%
Age			
Elderly	5,290	1,404,660	35.6
Pre-elderly	7,632	1,999,331	50.7
Teenagers & adults	2,010	540,135	13.7
Gender			
Male	5,805	1,599,304	40.5
Female	9,127	2,344,822	59.5
Hypertension			
Yes	5,103	1,336,216	33.9
No	8,089	2,152,606	54.6
Missing system	1,740	455,304	11.5
Smoking			
Every day smoker	2,937	822,869	20.9
Someday smoker	1,280	373,965	9.5
Never smoked	10,715	2,747,292	69.7
Exercise			
No	7,870	2,046,152	51.9
Yes	7,062	1,897,974	48.1
Obesity			
Yes	4,223	1,137,010	28.8
No	10,044	2,618,789	66.4
Missing system	665	188,327	4.8

Source: Indonesia Basic Health Research, 2018



Source: Indonesia Basic Health Research, 2018

Figure 4. Risk Levels Based on Province

In the first stage (before multivariate analysis), all variables were significantly associated with CKD-DM. After multivariate analysis, the results of the study showed that gender was the variable that had the most influence on the incidence of CKD-DM, where male DM patients were 3.24 times more likely to experience CKD-DM than those of female gender. DM patients who smoke every day have a 2.47 times greater risk, and DM patients who do not smoke every day have a 1.93 times greater risk of experiencing CKD-DM than those who never smoke.

DM patients who have hypertension are 1.56 times more likely to experience CKD than those who do not have hypertension. Then, it was found that pre-elderly DM patients had a 1.13 times risk of experiencing CKD-DM compared to teenagers and adults. Meanwhile, the elderly category is a protective factor in the occurrence of CKD-DM. DM patients who do not exercise are 1.07 times more likely to experience CKD than those who exercise. The obesity variable was found to be a protective variable in the occurrence of CKD-DM with an adjusted PR of 0.90 (95% CI: 0.891 – 0.924).

Table 2. Risk Factors of CKD-DM in Indonesia

Variables	Chronic Kidney Disease				Total		Adjusted PR (95% CI)	p-value
	Yes		No					
	n	%	n	%	n	%		
Age								
Elderly	31,152	2.2	1,373,508	97.8	1,404,660	100	0.81 (0.790 – 0.834)	0.00
Pre-elderly	32,089	1.6	1,967,242	98.4	1,999,331	100	1.13 (1.098 – 1.158)	0.00
Teenagers & adults	7,407	1.4	532,728	98.6	540,135	100	Ref	
Gender								
Male	35,795	2.2	1,563,487	97.8	1,599,282	100	3.24 (3.182 – 3.306)	0.00
Female	34,851	1.5	2,309,995	98.2	2,344,846	100	Ref	
Hypertension								
Yes	32,372	2.4	1,303,865	97.6	1,336,237	100	1.56 (1.540 – 1.591)	0.00
No	33,513	1.6	2,119,097	98.4	2,152,610	100	Ref	
Smoking								
Every day smoker	11,597	1.4	811,273	98.6	822,870	100	2.47 (2.415 – 2.535)	0.00
Someday smoker	7,129	1.9	366,827	98.1	373,956	100	1.93 (1.875 – 1.987)	0.00
Never smoked	51,920	1.9	2,695,383	98.1	2,747,303	100	Ref	
Exercise								
No	37,191	1.8	2,008,990	98.2	2,046,181	100	1.07 (1.055 – 1.090)	0.00
Yes	33,454	1.8	1,864,491	98.2	1,897,945	100	Ref	
Obesity								
Yes	18,882	1.7	1,118,163	98.3	1,137,045	100	0.90 (0.891 – 0.924)	0.00
No	44,916	1.7	2,573,835	98.3	2,618,751	100	Ref	

Source: Indonesia Basic Health Research, 2018

DISCUSSION

The prevalence of CKD-DM in Indonesia is 1.8%. IBHR 2018 conducted interviews with residents aged ≥ 15 years regarding chronic kidney failure status. Based on the IBHR 2018 National Results Report, it was found that the prevalence of chronic kidney failure in the population aged ≥ 15 years in Indonesia based on a doctor's diagnosis was 3.8%.¹⁰ This shows that the prevalence rate of CKD-DM is almost half the prevalence rate of chronic kidney failure in the population aged ≥ 15 years in Indonesia. This research also created a distribution map of the incidence of chronic kidney failure in Indonesia by province. Based on the mapping results, it was found that the province with the highest prevalence rate was North Maluku Province at 7.5% and the province with the lowest prevalence rate was Southeast Sulawesi Province at 0.4%. It is known that according to the IBHR 2018 results, North Maluku Province is also the province with the second highest prevalence rate of chronic kidney failure in residents aged >15 years, namely 5.6%.¹⁰ Looking at the Provincial Report related to IBHR 2018, it was found that the prevalence of diabetes mellitus in North Maluku Province was higher, namely 1.00%,¹⁴ when compared to the

prevalence rate of diabetes mellitus in Southeast Sulawesi Province, which was 0.87%.¹⁵ It is possible that the higher the prevalence rate of diabetes mellitus, the greater the possibility of suffering from chronic kidney failure, considering that diabetes mellitus is one of the factors associated with the incidence of chronic kidney failure.³ From the results of the data analysis, there are 17 other provinces apart from North Maluku with CKD-DM prevalence rates above the national average or $>1.8\%$. This should be a concern because more than half of the provinces that were currently participating in the IBHR 2018 had high prevalence rates of CKD-DM.

The final results of the multivariate analysis indicate that gender is the dominant variable in the incidence of CKD-DM in Indonesia. Oshima *et al.* (2023) also showed that men are at a 1.34 (95% CI: 1.02 – 1.075) times risk and are more likely to experience CKD-DM compared to women.¹⁶ The difference in risk levels between men and women is likely due to the role of sex hormones. It is estimated that some of the kidney failure development in men is due to the adverse effects of testosterone, which can affect the Glomerular Filtration Rate (GFR). Conversely, previous studies have also shown

the important role of estrogen as a protective factor in women experiencing CKD-DM.¹⁷ Therefore, the development of CKD-DM to become End-Stage Renal Disease (ESRD), a late-stage kidney disease, is faster in women. This is because women in the postmenopausal period no longer have the protection of estrogen hormones. This research shows that individuals with diabetes mellitus who smoke, whether everyday smokers or someday smokers, are at risk of experiencing chronic kidney failure. This is in line with research conducted by Nazzal, et al, (2022), where DM patients who smoke are 2.3 (95% CI: 1.3 – 4.2) times more likely to experience CKD-DM compared to non-smokers.¹⁸ Smoking can accelerate the development of CKD-DM, especially since, according to the CDC, the percentage of smokers among DM patients was still relatively high in 2018, at 21.8%. The exact mechanism by which smoking habits mediate the development of CKD-DM is not yet clearly understood. However, it is estimated that the main triggers are sustained sympathetic activity, oxidative stress, and hyperlipidemia. These factors are closely related because diabetes mellitus is a multisystemic metabolic disease.¹⁹

Hypertension is also found to be a risk factor in the occurrence of CKD-DM. A case-control study conducted in Indonesia, specifically at a hospital in Surabaya by Sutadji, et al (2023), showed a similar result, where diabetic patients with hypertension are at a 3.80 times greater risk (95% CI: 1.875 – 7.706) of experiencing CKD-DM compared to those without hypertension.²⁰ Hypertension in CKD-DM is multifactorial, but mostly mediated by increased vasoconstriction and increased extracellular volume, which will then increase kidney performance and ultimately cause kidney damage due to overwork.²¹ This study found that the pre-elderly category is more at risk of experiencing CKD-DM compared to teenagers and adults, while the elderly category becomes a protective factor. However, statistically, the Adjusted PR value generated from the study is not significant because it approaches the null value. A cohort study on the risk factors and burden of CKD-DM conducted by Xie, et al (2023) showed a similar thing, where an increased risk of CKD-DM occurrence was found with increasing age, even after controlling for

period and cohort effects. Especially in the age group of 55-59 years, diabetic patients aged 55-59 years have an 8.21 times greater risk of experiencing CKD-DM.²² Humans are biological creatures that can experience aging, including a progressive decline in kidney function and structure. A source states that changes in kidney function during normal aging are the most dramatic changes compared to any other organ system. In addition, the mechanism behind age becoming a risk factor for CKD-DM may also be due to hormonal changes associated with aging. Such as estrogen hormone in women which functions as a protective factor decreases as women age because they begin to experience menopause.²³ Therefore, the implementation of CKD-DM screening and intervention measures according to its risk factors, namely in the elderly population (pre-elderly and elderly), needs to be done.

Not exercising also poses a greater risk of experiencing CKD than those who exercise. However, statistically, the Adjusted PR value generated from this study is not significant because it approaches the null value. Wang *et al.* (2023) showed that those who did not engage in physical activity are at a 1.78 (95% CI: 0.42 – 3.14) times risk more likely to experience CKD-DM compared to those who engaged in physical activity. The potential mechanism that may occur is that exercise or physical activity increases mitochondrial β -oxidation, thereby slowing the progression of kidney disease.²⁴

Individuals with diabetes mellitus often experience progressive kidney failure. Therefore, the beneficial effects of physical activity on the prevention and early detection of kidney disease in this population may have a large clinical importance. This study found that obesity is a protective factor for CKD-DM with an Adjusted PR value of 0.90. However, the Adjusted PR is not statistically significant because it approaches the null value. Another study conducted by Xia et.al, (2022) showed a different result, where obese diabetic mellitus patients have a 1.60 times greater risk (95% CI: 0.93 – 2.76) of experiencing CKD-DM compared to those who are not obese.²⁵ There are various studies related to obesity and CKD-DM with varying results. Some show that BMI is not related to CKD-DM. Others show that obesity or high BMI is a risk factor for CKD-DM, while some

other studies suggest that a high BMI is a protective factor against CKD-DM. Potential reasons for the differing research results may include different study participants. A negative correlation between BMI and CKD-DM, where a higher BMI leads to a lower risk of CKD-DM, is widely observed in Asia. Therefore, the potential factor influencing the Adjusted PR value of this study is due to the research being conducted in Indonesia one of the Asian countries.²⁶

The limitation of this study relates to the secondary data sources used, in which there is a potential for loss or incompleteness of data. Additionally, the scope of variables available in secondary data sources may only partially capture some relevant factors influencing the phenomenon under investigation. Future research should consider employing primary data collection methods to address these limitations comprehensively.

CONCLUSION AND RECOMMENDATION

The prevalence of CKD-DM in Indonesia is 18 per 1,000 population. Risk factors for CKD-DM in Indonesia include pre-elderly age, gender, hypertension, smoking, and lack of exercise. Gender is the dominant factor of CKD-DM in Indonesia. The differential hormonal environment between gender plays a significant role in the pathophysiology of CKD. Higher testosterone levels in men may lead to increased kidney damage and a faster decline in kidney function. Understanding the gender-related differences in CKD is crucial for tailoring prevention strategies and treatment plans. It is desired that healthcare providers and program makers should recognize gender differences in the progression of CKD and conduct screening program for risk factors of CKD-DM such as blood tests (e.g., eGFR) and urine tests (e.g., urine albumin-to-creatinine ratio).

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AUTHOR CONTRIBUTIONS

ASAZ Sand CS contributed to the conceptualization of the research; ASAZ collected and analyzed the data; ASAZ wrote the script; The manuscript and data analysis were evaluated by CS. The manuscript's published version has been approved by all authors, who have also reviewed and approved it. The authors read and approved the final manuscript. ASAZ = Asy Syifa Anwari Zahra; CS = Chandrayani Simanjourang.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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Effect of *Citrus sinensis* and *Musa textilia* Consumption on Lactic Acid Levels and Muscle Tension in Fish Auction Workers

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ABSTRACT

Potassium deficiency is known to induce muscle fatigue, necessitating the inclusion of potassium-rich foods, such as orange (*Citrus sinensis*) and banana (*Musa textilia*) in diet. Previous studies have shown that consuming 150 g and 300 g of banana is effective in preventing muscle fatigue, with orange containing 237.4 mg of potassium per 300 ml. Therefore, this study aims to examine the relationship between lactic acid concentration and muscle tension reduction in fish auction workers after the administration of orange and banana. The study procedures were carried out with a quasi-experimental pre-test and post-test group design, and the samples were divided into 4 groups. Group 1 received both orange and banana, 2 was given only orange, 3 received only banana, while 4 was not given any intervention. Supplemental observations were then conducted over 3 consecutive days, followed by data analysis using Two-Way Analysis of Variance (ANOVA) and Multivariate Analysis of Variance (MANOVA) to compare lactic acid levels (independent variable) with muscle tension and strength (dependent variables). The results showed that banana significantly affected lactic acid levels but did not influence muscle tension. The combination of orange and banana produced varying levels of lactic acid and muscle tension, indicating the ineffectiveness of only banana. The intake of both fruits was also reported to influence lactic acid levels but did not affect muscle strength, suggesting the ineffectiveness of orange. These results indicated that while orange and banana could reduce lactic acid levels, the fruits did not significantly affect muscle strength or tension.

INTRODUCTION

Transportation workers are an essential demographic that demands special consideration due to the numerous hazards associated with their job procedures. These workers typically rely on physical strength to carry heavy loads, which often exceed the recommended weight limits. The issue is particularly evident among fish auction workers in Indonesia, who play an essential role in fishing sector by transporting fish from the port to auction sites.¹⁻³ Several studies have shown that sustained physical activity without sufficient rest causes an imbalance, leading to the accumulation of lactic acid faster than the body can eliminate the compound. This buildup exacerbates fatigue rapidly and decreases workplace performance.

The recognized health risks associated with physically demanding activities are extensive. Previous studies reported a significant association between extended periods of physical exertion, incorrect lifting methods, and back discomfort and muscular fatigue. For instance, data from the United States indicate that a significant percentage of low back pain is associated with occupation lifting, with 80% of cases ascribed to this factor.³ In addition, studies conducted in Sweden emphasized that incorrect lifting methods significantly contributed to musculoskeletal problems, specifically among those engaged in manual labor.⁴ This indicates that it is essential to use efficient measures to regulate lactic acid levels and muscle tension, specifically in physically demanding professions, such as fish auction employment.

One of the primary challenges faced by fish auction workers is the effective management of lactic acid buildup and the consequent muscle fatigue caused by the strenuous physical requirements of their profession. Engaging in repetitive lifting of loads that are frequently above the recommended weight thresholds not only leads to immediate exhaustion but also exacerbates chronic musculoskeletal problems. Endogenous lactic acid buildup, resulting from an imbalance between the body's capacity to eliminate the compound and its generation, causes persistent muscle fatigue and exhaustion. This issue is worsened in settings, such as Fish Auction Place/*Tempat Pelelangan Ikan (TPI)* in Juwana, where workers often bear substantial

burdens weighing up to 210 kg for prolonged durations.²

A promising solution to this issue lies in dietary therapies that can effectively decrease lactic acid levels and improve muscle strength. Vitamin-dense foods, such as orange (*Citrus sinensis*) and banana (*Musa textilia*) have been recognized as efficacious in addressing fatigue due to their abundant potassium content and other advantageous nutrients. Given their abundant availability in Indonesia, these fruits are readily suitable for inclusion into the diet of fish auction workers. The ingestion of the fruits can alleviate the consequences of lactic acid buildup and decrease muscular tension, thereby enhancing general physical performance and decreasing the likelihood of work-related accidents.^{5,6}

The health benefits of *Citrus sinensis*, commonly known as sweet orange, have been extensively investigated, specifically focusing on its contribution to muscle recovery and mitigation of oxidative stress. Previous studies have shown that its addition to the diet can enhance metabolic parameters, such as glucose and lactate levels, which are essential for controlling the accumulation of lactic acid.⁷ Moreover, the orange's antioxidant characteristics help enhance general health by reducing muscle tension and facilitating more effective recovery from physical exhaustion.⁸ These qualities make the fruit a promising dietary supplement for reducing muscle tension and regulating lactic acid levels in physically strenuous occupations.

According to previous studies, *Musa textilia*, a variety of banana, is rich in potassium and other essential elements that promote muscular performance and recuperation. Potassium has been reported to play an important role in maintaining ion concentration in cell membranes, which is crucial for controlling muscle contraction and relaxation. Due to its carbohydrate content, banana has been reported to be associated with the replenishment of glycogen stores and the provision of a rapid source of energy.⁹ Despite the scarcity of studies on the impact of banana on lactic acid and muscle tension in fish auction workers, the recognized nutritional advantages indicate that it may greatly enhance physical performance and facilitate recuperation.

Orange and banana have shown great potential in lowering muscle tension and lactic acid levels, but there need to be more studies on their use among fish auction workers. Although existing literature has emphasized these fruits' overall advantages in muscle recovery and fatigue reduction, they have yet to investigate their impact in real-life, high-pressure settings, such as fish auction.^{7,8} In addition, the majority of studies are carried out either on animals or in controlled environments, which may not comprehensively show the difficulties encountered by manual workers in the fishing sector.⁵

Another significant gap in the existing literature is the absence of a thorough investigation that integrates nutritional therapies with ergonomic evaluations. The majority of studies have either concentrated on the nutritional components of orange and banana or ergonomic hazards without considering these concerns to establish a comprehensive strategy for controlling muscle tension and lactic acid build up.⁶ Therefore, this study aims to examine the correlation between the intake of orange and banana berries and decreased in lactic acid levels and muscle fatigue in fish auction workers. The results are expected to address the existing gap in the literature by presenting empirical data on the efficacy of these fruits in a high-pressure, real-life setting. The present study is innovative in emphasising a particular occupational cohort frequently disregarded in ergonomic and nutritional investigations. This helps to enhance the overall comprehension of how dietary interventions improve the health and performance of workers. The present study evaluated lactic acid and muscle tension levels in transport workers at Fish Auction Place (TPI) in Juwana, Pati Regency, both before and after administering orange and banana. The results are anticipated to offer valuable knowledge on effective nutritional interventions that may be applied to improve the health of workers in physically strenuous occupations, thereby decreasing the occurrence of work-related injuries and enhancing overall productivity.

MATERIAL AND METHOD

The sample population consisted of 100 transport workers at Juwana TPI in Pati

Regency, selected through total sampling. The samples were then divided into 4 groups using a randomization system. Group 1 received both orange and banana, 2 received only orange, 3 received only banana, and 4 was not given any intervention. The inclusion criteria for participants were normal Body Mass Index (BMI), male, and aged 20-60 years, while the exclusion criteria were a history of diseases affecting lactic acid levels, such as hypoperfusion, hypoxemia, chronic kidney failure, liver failure, diabetes mellitus, cancer, malaria, and cholera.

Data collection was carried out by filling out observation questionnaires that covered personal data, work history, disease history, group division, and BMI measurement. Lactic acid levels were then measured before the participants began their work, and intervention was administered according to the assigned groups. In addition, lactic acid levels, muscle tension, and muscle strength were measured 2 hours after intervention. Ethical clearance for this study was obtained from the Faculty of Public Health, with approval number 245/EA/KEPK-FKM/2021.

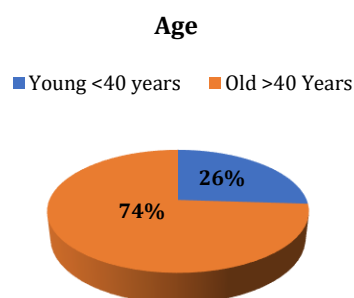
This quasi-experimental study employed a Pre-Test-Post-Test Group Design, and observations were conducted over 3 consecutive days for each group. Data collected over these days were averaged for analysis to account for daily variations and ensure reliable results.

Data analysis was performed using several statistical tests. First, a normality test was conducted to determine if the data were normally distributed. The homogeneity of variance was tested using Levene's test. When the data were normally distributed, Two-Way Analysis of Variance (ANOVA) was used to identify significant differences between groups, followed by post-hoc analysis for pairwise comparisons when needed. Meanwhile, when the data were not normally distributed, the Kruskal-Wallis test was applied. Multivariate Analysis of Variance (MANOVA) test was used to examine the relationships between the independent variable (lactic acid) and the dependent variables (muscle strength and muscle tension) post-intervention.

RESULTS

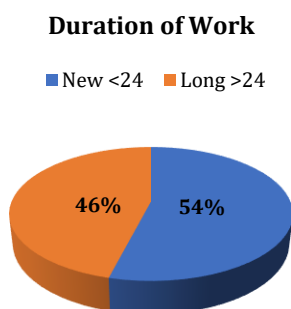
The characteristics of respondents based on age are shown in Figure 1. The results indicated that 74 out of 100 respondents were over 40 years old, while the remaining 26 were < 40 years. Based on duration of work, Figure 2 shows that 54 out of 100 had been working for more than 24 months, while 46 respondents had been working for less than 24 months.

Lactic acid inhibited enzymes in energy-producing pathways and interfered with the excitation-contraction process, leading to the depletion of muscle energy reserves.¹⁰ Muscle fatigue was assessed using muscle tension measurements with an electromyograph, while muscle strength was examined with a leg dynamometer. The accumulation of lactic acid, which played a significant role in muscle fatigue, was also measured. The frequency distribution of lactic acid levels, muscle tension, and muscle strength among respondents is presented in Table 1.



Source: Primary Data, 2021

Figure 1. Frequency Respondent Characteristics by Age



Source: Primary Data, 2021

Figure 2. Frequency Respondent Characteristics by Duration of Work

The results indicated that 60 respondents experienced muscle tension, and 60 had abnormal lactic acid levels. This high level of muscle tension and lactic acid accumulation suggested that many workers were experiencing significant physical strain (Table 1).

Lactic acid was often produced as a by-product during the process of anaerobic glycolysis. Approximately 80% of the lactate produced in anaerobic glycolysis was transported from muscle into the bloodstream. This process occurred when muscle required a quick supply, but oxygen was limited, as evident in individuals exercising at a high intensity. Under conditions of low oxygen supply, reoxidation of Nicotinamide Adenosine Dinucleotide Hydrogen (NADH) formed from Nicotinamide Adenosine Dinucleotide (NAD⁺) during glycolysis is disrupted. Consequently, NADH is reoxidized through an anaerobic pathway by reducing pyruvate to lactate, where 2 hydrogen atoms are added to form lactate.¹¹

The average lactic acid level in the first measurement was 2.568 mmol/L with a standard deviation of 0.699 mmol/L. In the second measurement, an average of 2.004 mmol/L was obtained with a standard deviation of 0.449 mmol/L. The results revealed that there was an average decrease in lactic acid content of 0.564 mmol/L with a standard deviation of 0.250 mmol/L after giving interventions in the form of orange and banana. In addition, the results of the statistical test obtained a P-value of 0.001, hence, it could be concluded that there was a significant difference between the measured lactic acid levels before and after the administration of orange and banana in this group (Table 2).

Table 1. Frequency Distribution of Muscle Tension, Muscle Strength, and Lactic Acid Levels

Variable	n = 100	%
Muscle Tension		
Relaxed (<3 μ V)	40	40
Tense (>3 μ V)	60	60
Muscle Strength		
Strong	55	55
Very Powerful	45	45
Lactic Acid		
Normal (<2 mmol/L)	40	40
Abnormal (>2 mmol/L)	60	60

Source: Primary Data, 2021

Table 2. Average Distribution of Lactic Acid Levels Before and After Giving Orange and Banana

Measurement Time	Group 1			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	2.568±0.699	2.4 (1.6-4.8)	0.140	0.001
After	2.004±0.449	2 (1.2-3.2)	0.090	

Source: Primary Data, 2021

In group 2, treatment was given in the form of banana to 25 respondents. The results of the analysis of the average lactic acid level before intervention was 1.972 mmol/L with a standard deviation of 0.403 mmol/L. In the second measurement, an average of 1.940 mmol/L was obtained with a standard deviation of 0.563 mmol/L. In addition, there was an average difference in lactic acid content of 0.032 mmol/L before and after intervention. The results of the statistical test obtained a p-value of 0.841, hence, it could be concluded that there was no significant difference between the measured lactic acid levels before and after the administration of orange (Table 3).

In Table 4, the average lactic acid level in the first measurement was 2.204 mmol/L with a standard deviation of 0.733 mmol/L. In the second measurement, there was an average decrease to 1.660 mmol/L with a standard deviation of 0.095 mmol/L. In addition, there was an average decrease in lactic acid content of 0.544 mmol/L with a standard deviation of 0.052 mmol/L after banana supplementation. In this group, the p-value (0.001) was < 0.05, indicating that there was a significant difference between the measured lactic acid levels before and after the administration of banana.

Table 3. Average Distribution of Lactic Acid Levels Before and After Orange Feeding

Measurement Time	Group 2			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	1.972±0.403	2.0(1.1-3.0)	0.081	0.841
After	1.940±0.563	1.9(1.2-3.3)	0.112	

Source: Primary Data, 2021

Table 4. Average Distribution of Lactic Acid Levels Before and After Banana Feeding

Measurement Time	Group 3			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	2.204±0.733	2.0(1.3-4.4)	0.147	0.001
After	1.660±0.473	1.6(1.0-2.6)	0.095	

Source: Primary Data, 2021

Muscle tension increased on average after the intervention of orange and banana in 25 respondents in group 1. The average of the first measurement was 4.268 mV with a standard deviation of 3.015 mV. In the second measurement, an average of 4.280 mV was obtained with a standard deviation of 2.509 mV. The results of the statistical test obtained a p-value of 0.985 (>0.05), indicating that there was no significant difference between muscle tension before and after the administration of orange and banana (Table 5).

Group 2, with intervention in the form of giving orange, had an average muscle tension before the intervention of 8.548 mV with a standard deviation of 10.995 mV. In the second measurement, an average of 6.648 mV was obtained with a standard deviation of 9.057 mV. In addition, there was an average reduction in muscle tone of 1.9 mV before and after intervention. The results of the statistical test obtained a P-value of 0.985, indicating that there was no significant difference in muscle tension before and after the administration of orange (Table 6).

Based on Table 7, there was an average decrease in muscle tension of 1.02 mV after intervention in the form of banana. The average muscle tension at the first measurement was 6.640 mV, with a standard deviation of 5.322 mV. In the second measurement, an average of 5.620 mV was obtained with a standard deviation of 5.376 mV. The results of the statistical test obtained a p-value of 0.404, indicating that there was no significant difference between muscle tension before and after intervention in this group.

Group 1, with intervention in the form of giving orange and banana to 25 respondents, had an average muscle strength of 162.85 before intervention, with a standard deviation of 64.02. In the second measurement, an average of 159.46 was obtained with a standard deviation of 60.32. There was also an average decrease in muscle strength of 3.39 before and after intervention. The results of the statistical test obtained a p-value of 0.679, indicating that there was no significant difference in muscle strength before and after the administration of orange and banana (Table 8).

Table 5. Average Distribution of Muscle Tension Before and After Giving Orange and Banana

Measurement Time	Group 1			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	4.268±3.015	3.0(0.7-10)	0.603	0.985
After	4.280±2.509	3.0(1.0-10)	0.502	

Source: Primary Data, 2021

Table 6. Average Distribution of Muscle Tension Before and After Orange Feeding

Measurement Time	Group 2			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	8.548±10.995	5.0(0.7-50)	2.198	0.985
After	6.648±9.057	4.0(0.7-45)	1.811	

Source: Primary Data, 2021

Table 7. Average Distribution of Muscle Tension Before and After Banana Feeding

Measurement Time	Group 3			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	6.640±5.322	5.0(2.0-20)	1.065	0.404
After	5.620±5.376	4.0(1-20)	1.075	

Source: Primary Data, 2021

The average muscle strength at the first measurement was 151.1, with a standard deviation of 72.05. In the second measurement, there was an average increase of 172.26 with a standard deviation of 72.76. There was also an increase in average muscle strength of 21.16 with a standard deviation of 0.71 after the administration of citrus fruit supplementation. In this group, with a p-value of 0.073, it can be concluded that there is no significant difference in muscle strength before and after the administration of intervention (Table 9).

In Table 10, the average muscle strength of group 3 at the first measurement was 157.9, with a standard deviation of 50.522. In the second measurement, an average of 186.6 was obtained with a standard deviation of 55.289. In addition, there was an increase in average muscle strength of 28.7, with a standard deviation of 4.767 after the administration of banana. The results of the statistical test obtained a p-value of 0.001, indicating that there was a significant difference between muscle strength before and after the administration of banana in this group.

A multivariate analysis was conducted to test the effect of the administration of orange and banana, orange only, and banana only on the respondents' lactic acid levels, muscle tone, and muscle strength.

Table 8. Average Distribution of Muscle Strength Before and After Giving Orange and Banana

Measure-ment Time	Group 1			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	162.85±64.02	165(25-335)	12.804	0.679
After	159.46±60.32	155(34-317.5)	12.064	

Source: Primary Data, 2021

Table 9. Average Distribution of Muscle Strength Before and After Orange Feeding

Measure-ment Time	Group 2			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	151.1±72.05	150(25-265)	14.41	0.073
After	172.26±72.76	170(30-300)	14.55	

Source: Primary Data, 2021

Table 10. Average Distribution of Muscle Strength Before and After Banana Feeding

Measure-ment Time	Group 3			
	Mean± SD	Median (Min-Max)	SE	p-value
Before	157.9±50.522	155(40-275)	10.104	0.001
After	186.6±55.289	200(55-280)	11.058	

Source: Primary Data, 2021

The analysis results showed that there was a decrease in lactic acid levels in groups 1 and 3, while in group 2, there was an increase. Group 1, with the supplementation of orange and banana, experienced the highest decrease in lactic acid of -0.629 (95% CI: -1.060 to -0.198), with a p-value of 0.005. The next highest lactic acid reduction score was in group 3 with the administration of banana with a reduction score of -0.536 (95% CI: -0.973 to -0.009), and the decrease was significant with a p-value of 0.017. Group 2 with citrus fruit administration experienced an increase in lactic acid with a score of 0.025 (95% CI: -0.411 to 0.461) and had a significance value of 0.911. This indicated that there was no significant increase in lactic acid (Table 11).

Table 11 revealed that group 2, with treatment in the form of citrus fruit supplementation, experienced the highest decrease in muscle tension compared to other groups. This decrease score is -5.307 (95% CI: -9.796 to -0.818) and significant with a p-value of 0.021. The next highest muscle tone reduction score was in group 3 with the administration of intervention in the form of banana with a reduction score of -4.747 (95% CI: -9.249 to -0.246), and the decrease was significant with a p-value of 0.039. In group 1, with the administration of orange and banana, there was a decrease with a score of -3.874 (95% CI: -8.312

to 0.564) and a significance value of 0.085. This indicated that there was no significant decrease in muscle tone in the group.

Based on the analysis results, muscle strength of respondents had increased when compared to the control group. The highest muscle strength increase score was in group 3 with banana administration intervention. In this group, there was an increase of 50.068 (95% CI: 20.112 to 80.023) with a p-value of 0.001, indicating that there was a significant increment. In addition, group 2, with the treatment of citrus fruit supplementation, experienced an increase in muscle strength of 43.162 (95% CI: 13.289 to 73.034) and a significant increase in muscle strength with a p-value of 0.005. Group 1, with intervention in the form of orange and banana, experienced an increase with a score of 15.643 (95% CI: -13.892 to 45.178) and had a significance value of 0.296, indicating there was no significant increase in muscle strength (Table 11).

DISCUSSION

This study investigated the impact of orange and banana consumption on lactic acid serum levels and muscle strain in transport workers. The results revealed a statistically significant decrease in lactic acid levels following intervention, as evidenced by a p-value of 0.001. This suggested that ingesting of these fruits

successfully reduced lactic acid in the body. However, the intervention had no substantial effect on muscular tension, as indicated by a P-value of 0.403. This indicated that although lactic acid levels declined, there was no evidence of a significant decrease in muscle tension.

Muscle fatigue is a complex physiological phenomenon characterized by a temporary decline in muscle ability to generate force or power during physical activity. This reduction in performance can arise from both central and peripheral mechanisms, making it a multifaceted issue in exercise physiology and rehabilitation. Muscle fatigue can vary significantly depending on the type of exercise performed, the duration of the activity, and individual factors, such as fitness level and muscle fiber composition.¹²

Disruptions in the body's energy metabolism system had been reported to have the potential to cause muscle fatigue. The accumulation of lactic acid in muscle interferes with cellular mechanisms, inhibiting aerobic and anaerobic enzymes and as reducing endurance capacity. In addition, the formation of Creatine Phosphate (CP) is inhibited, affecting the coordination of muscle movements. This process also inhibits the enzyme phosphofructokinase, leading to decreased release of Ca⁺⁺ ions in troponin C, which disrupts muscle fiber contraction. ATP activity in these fibers can be quickly inhibited because ATP is highly sensitive to acid.

Table 11. Effect of Intervention on Lactic Acid Levels, Muscle Tension, and Muscle Strength

Parameter	B	SE	Sig	LB for B	UB for B
Lactic Acid, R square = 0.162					
Intercept	-0.513	0.370	0.169	-1.248	0.222
Group 1	-0.629	0.217	0.005	-1.060	-0.198
Group 2	0.025	0.220	0.911	-0.411	0.461
Group 3	-0.536	0.220	0.017	-0.973	-0.009
Group 4	0 ^a	.	.	.	.
Muscle Tention, R square = 0.114					
Intercept	-0.472	3.811	0.902	-8.040	7.095
Group 1	-3.874	2.235	0.086	-8.312	0.564
Group 2	-5.307	2.260	0.021	-9.796	-0.818
Group 3	-4.747	2.267	0.039	-9.249	-0.246
Group 4	0 ^a	.	.	.	.
Muscle Strenght, R square = 0.134					
Intercept	-34.175	25.361	0.181	-84.536	16.186
Group 1	15.643	14.873	0.296	-13.892	45.178
Group 2	43.162	15.043	0.005	13.289	73.034
Group 3	50.068	15.085	0.001	20.112	80.023
Group 4	0 ^a	.	.	.	.

Source: Primary Data, 2021

The analysis of lactic acid and muscle tension after administering orange and banana yielded different results. Muscle tension is also affected by various physiological and pathological conditions. For example, increased muscle tension can be a response to stress or anxiety, leading to muscle tightness and discomfort.¹³ However, these results differ from the results obtained in this study that lactic acid levels decreased after the administration of orange, but this did not lead to a reduction in muscle tension, as indicated by a P-value of 0.117. Orange contains various nutrients, including potassium, crucial for fluid balance, nerve impulses, and muscle contractions. Both potassium and sodium play important roles in preventing muscle fatigue by maintaining the depolarization of sarcolemmal and tubular membranes, which are essential for contraction. Disruptions in these membranes can affect Ca^{++} ion regulation in cells, crucial for muscle contraction by facilitating the binding of myosin to actin.¹⁴

Despite the potassium content in orange being capable of balancing bodily fluids and preventing muscle tension, banana proved to be more effective. Banana contains tryptophan, an essential amino acid the body converts into serotonin, which helps relax and improve mood, reducing muscle tension. The study showed that while banana significantly affected lactic acid levels, the fruit did not significantly affect muscle tension. A previous study by Mitha found that banana smoothies did not significantly impact anaerobic muscle fatigue in football athletes. However, muscle tension leading to fatigue can occur when sudden or excessive movements exceed muscle strength, as reported by respondents in this study.¹⁵ Muscle tension leading to fatigue occurs when sudden or excessive waist movements exceed muscle strength involved. For example, respondents in this study reported the presence of sudden and excessive movements when changing positions.

The results are consistent with prior studies, which showed the efficacy of orange and banana in decreasing lactic acid levels. This supports the notion that the nutritional compositions of the plants can impact metabolic processes associated with muscular fatigue.^{7,9} Similarly, a previous study conducted on Sepak Takraw athletes reported that the administration of banana before exercise significantly prevented

muscle fatigue in the aerobic phase.¹⁶ Other studies focusing on the influence of banana on metabolism and glucose found no adverse effects on normal rats, although a significant reduction in body mass and improvement in metabolism, which affected lactic acid levels, was discovered.¹⁷

The absence of a substantial impact on muscle tension is inconsistent with a previous study, highlighting the essential role of potassium and other nutrients in promoting muscle relaxation and reducing tension.¹⁴ The disparity implies that although these fruits help to decrease lactic acid, their effect on muscular tension may be restricted, or other variables, such as the level of physical exertion, may have a more significant influence on regulatory muscle tension.

Dietary therapies incorporating orange and banana can alleviate muscle tiredness in physically demanding employment, as shown by the notable decrease in lactic acid levels. This holds special significance for workers in demanding settings, such as fish auction, maintaining physical stamina is key. The results also suggest that the reduction of muscle tension may need further measures beyond dietary interventions, potentially including physical activities or ergonomic modifications. The results emphasize the need to adopt a holistic strategy toward workers' health, which includes combining dietary and physical measures to improve performance and minimize the likelihood of injury.

The present study examined the synergistic impact of orange and banana consumption on lactic acid levels and muscular strength among individuals employed in the transportation industry. The results revealed a notable decrease in lactic acid levels, as evidenced by a P-value of 0.001, indicating that intervention successfully reduced lactic acid in the body. However, intervention failed to reinstate muscular strength, as shown by a P-value of 0.989. These data indicate that although ingesting these fruits is advantageous in decreasing lactic acid levels, it does not greatly affect muscle strength. Several studies have shown that muscle strength cannot be restored by giving orange and banana, but through specific exercises, such as Range of Motion (ROM) exercises. A previous study on stroke

patients by Chris suggested that muscle strength was restored by implementing ROM at least twice a day for 10 to 15 minutes.¹⁸

The decrease in lactic acid levels is consistent with previous studies that reveal the significance of potassium-rich foods, such as banana, in controlling lactic acid buildup and enhancing muscular recovery.¹⁹ However, the absence of significant enhancement in muscle strength revealed that dietary changes alone may be inadequate. Evidence suggests that targeted activities, such as ROM exercises, are more efficient in restoring muscle strength compared to dietary methods alone.¹⁸ This reveals the necessity of adopting a holistic strategy that integrates both dietary interventions and physical activity to tackle muscular weakness.

The results of this study emphasize the need to take into account several aspects when attending to muscle tension and strength in physically strenuous occupations. Although the decrease in lactic acid levels implies that nutritional treatments can influence the alleviation of muscle fatigue, the absence of effect on strength suggests that these interventions in isolation are inadequate. From a practical standpoint, this implies that those in physically strenuous occupations must not only depend on nutritional remedies but should also integrate specialized physical activities aimed at enhancing muscle strength. The adoption of this holistic strategy has the potential to result in improved general health results, including decreased weariness and increased physical performance.

Based on this study, p-value of lactic acid and muscle strength were 0.675 and 0.073, respectively, indicating the absence of effect after the administration of orange to transport workers. This is consistent with a previous investigation on giving orange juice and yellow watermelon juice before 400 m sprint, which does not affect lactic acid levels.²⁰ However, Evi expressed a different opinion that the administration of orange juice 30 minutes before exercise significantly prevented muscle fatigue in the anaerobic phase.²⁰ Orange contains various bioactive compounds, including flavonoids and ascorbic acid, which may enhance metabolism and reduce the

accumulation of lactic acid. Previous studies revealed that these compounds could increase antioxidant capacity in the body, helping to reduce oxidative stress and inflammation associated with lactic acid buildup.²¹ Moreover, consuming foods rich in antioxidants, such as orange, can expedite muscle recovery after intense exercise by enhancing the clearance of lactic acid from the bloodstream.²² A study by Fitrianto and Maarif found that active recovery could lower lactate levels in athletes, suggesting that a good recovery strategy could mitigate the negative effects of lactate accumulation.²³ Given that orange are a good source of hydration and nutrition, consuming the fruits after exercise may contribute to better recovery and a reduction in lactic acid levels, thereby supporting muscle strength.²⁴

Orange consumption can play an important role in regulating lactic acid levels and supporting muscle strength. By reducing the accumulation of lactic acid through antioxidant mechanisms and better recovery, orange can become an important part of the diet for physically active individuals. A previous study on giving orange and yellow watermelon juice before the 400 m sprint showed that it did reduce lactic acid levels.²⁰

The provision of orange intervention was selected due to the nutrients, such as carbohydrates and el citrulline contained in the fruits. Orange contains 54.9 g carbohydrates, which can rapidly provide energy. Generally, all types of carbohydrates consumed are converted into glucose in the body. By giving carbohydrates at a rate of 30-60 g/hour, it was expected to maintain glucose levels, thereby potentially reducing lactic acid levels in the body.

The consumption of banana after work decreased lactic acid levels and muscle strength in transport workers. Banana and its nutrients contribute to muscle recovery and the reduction of lactic acid levels. The consumption of fruits, such as banana, is generally associated with replenishing glycogen stores and providing essential nutrients that support muscle function and recovery.⁹ The presence of potassium is highly beneficial for muscle function, potentially reducing cramps and tension that may arise from heavy activity.⁹ In addition, the presence of

dietary fiber in banana can support overall digestive health, leading to better nutrient absorption and energy availability for muscle function.²⁵

The study conducted by Faturachman on the effectiveness of giving banana and vitamins B1, B6, and B12 against fatigue showed that the group treated with intervention before anaerobic running was effective in preventing muscle fatigue compared to others.¹⁹ Ryan also investigated the effect of giving banana juice and sports drinks on volleyball athletes, finding that banana juice significantly reduced lactic acid levels in the pre-test group compared to the post-test and sports drink groups. Banana provides a high amount of energy to the body and are easily digested due to their soft texture.²⁶ The carbohydrate content, in the form of crude fiber and pectin, also contributes to energy provision.

Banana is also rich in tryptophan, a type of essential amino acid that is converted into serotonin by the body to relax and improve mood. This leads to a sense of happiness and helps the performance of blood energy muscle. Banana is included in the type of fruits with an abundant source of potassium, providing about 23% to the body. Lio Ways also reported that the fruits and yellow watermelons were effective in preventing muscle fatigue in anaerobic running. Therefore, athletes are recommended to consume 200 g banana and 575 g watermelon to prevent muscle fatigue.²⁷

The results of this study indicate that while both orange and banana significantly reduce lactic acid levels, the fruits do not significantly affect muscle strength. Banana appears to be more effective in reducing muscle tension due to the serotonin-boosting properties. Therefore, while incorporating these fruits into the diet can help reduce lactic acid levels and potentially prevent fatigue, they are not sufficient to restore muscle strength without complementary physical exercises.

CONCLUSION AND RECOMMENDATION

In conclusion, this study revealed that the consuming orange and banana had distinct effects on lactic acid levels and muscle tension among transport workers. Banana is more effective in reducing muscle tension compared

to orange. Both fruits significantly reduced lactic acid levels, but neither had a significant impact on muscle strength. The potassium content in orange supports carbohydrate, glycogen, and glucose metabolism and acts as an antioxidant due to its vitamin C content. The results showed that banana is more effective in reducing muscle tension due to its serotonin-boosting properties.

Based on the results, transport workers can incorporate banana into their daily diet to reduce muscle tension and lactic acid levels, thereby enhancing physical performance and reducing fatigue. Orange can also be included in the diet for its beneficial effects on lactic acid levels and overall health, but additional strategies are needed to improve muscle strength; Regular physical exercises, such as ROM exercises, should also be implemented to restore and maintain muscle strength, ideally performed at least twice a day for 10-15 minutes. In addition, employers must educate workers on proper lifting techniques to prevent excessive muscle strain and reduce the risk of chronic muscle fatigue and injuries. Implementing regular breaks and ergonomic interventions can help manage and reduce physical workload, thereby improving workers' health and productivity. Future studies are advised to explore the combined effects of dietary interventions and structured physical exercise programs on muscle strength and fatigue in transport workers. Investigations into other potassium-rich foods and their comparative effectiveness on muscle health could provide more comprehensive dietary recommendations.

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AUTHOR CONTRIBUTIONS

The authors conceptualized and designed the study. BK and MZR drafted the manuscript, N conducted the data analysis, and SY and N provided additional analysis. The authors have read and approved the manuscript. The authors equally contributed to this study. BK = Bina Kurniawan; MZR = Mohammad Zen Rahfiludin; N = Nurjazuli; SY = Setyaningsih Yuliani.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Foodborne Outbreak Investigation in Elementary School Students in Bantul, Yogyakarta, 2023

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ABSTRACT

Bantul District Health Office received notification that 75 students in elementary school were sick with symptoms of nausea, vomiting, and dizziness after they consumed snacks from the school canteen. An epidemiological investigation was conducted to confirm the outbreak, identify additional cases, determine risk factors and causes, and recommend preventive measures. This investigation conducted active case finding followed by a retrospective cohort study. Individuals who experience one or more symptoms, such as nausea, vomiting, diarrhea, stomach pain, dizziness, fever, and malaise after consuming snacks were defined as cases. Data was collected through direct interviews with students, teachers, staff, and food sellers. Samples of food and vomit were collected and sent to the health laboratory. Data were analyzed using chi-square and multiple binomial regression. There were 150 cases. Most cases were found in the female group (53.22%), 9-year-old group (55.32%), and third-grade students (65%). Dizziness (66.67%), vomiting (56.67%), and nausea (46%) were the most common symptoms. The epidemic curve was a common source, with incubation periods ranging from one to 26 hours. Meatballs were associated with the increased risk of becoming a case in this outbreak (aRR = 1.49; 95% CI = 1.22-1.81). The causative agent was suspected to be *Salmonella* spp, but the laboratory analysis results were inconclusive due to contamination. Potential risk factors were large storage in the refrigerator, insufficient reheating, and cross-contamination. Improvements in food safety monitoring for schools and food handlers, along with appropriate sampling by healthcare facilities, are required to control outbreaks.

INTRODUCTION

Humans need nutrition to survive; nevertheless, certain foods can cause diseases and even death in people who have symptoms such as diarrhea, headache, vomiting, nausea, abdominal cramps, and more. Due to globalization and active food trade between countries, foodborne outbreaks have recently become increasingly severe.¹ Countries have different laws to regulate food safety and disease prevention, but foodborne illnesses are still rising. Regardless of economic circumstances, animal-based products are the leading cause of bacterial diseases such as *E. coli*, *Salmonella*, *Listeria monocytogenes*, *Campylobacter*, and *Staphylococcus aureus*.²

Every year, contaminated food causes 600 million instances of foodborne illness and 420,000 fatalities. Foodborne illness affects 7.69% (600 million) of the world's population (7.8 billion) each year, accounting for 7.50% (420,000) of all deaths (56 million) that year.³ A foodborne disease outbreak happens when two or more people become sick as a result of consuming food that has been epidemiologically proven to be a source of infection.⁴

According to the 2023 report of BPOM Indonesia, food poisoning in Indonesia affected 8,937 people, with 4,729 showing symptoms (52.91%). However, there were eighteen fatalities (a case fatality rate of 0.38%). The attack rate increased between 2019 and 2021 and then decreased in 2022 (45.29% in 2019, 46.62% in 2020, 69.40% in 2021, 50.64% in 2022).⁵ Food poisoning affects 54.6% more women than men. The age ranges were highly diverse, but most were dominated by school-age and adults.⁶ Snack food and celebrations are common situations for foodborne outbreaks. Based on location, food poisoning is most common in the household, followed by schools and factories.⁶ In 2022, food poisoning is the most common type of outbreak in the Yogyakarta Special Region province in 2022.⁷

On February 3, 2023, the Bantul District Health Office received notification from the Pleret Public Health Center that 75 students were sick with symptoms of nausea, vomiting, and dizziness at one of the elementary schools. It happened after students consumed snacks from the school canteen the day before. Because all of the children had gone home from school that

day, the epidemiological investigation continued the next day, on February 4, 2023. The investigation found that 150 students had complaints and a history of consuming nearly the same food.

Foodborne diseases represent a considerable yet preventable public health concern, and identifying the source of contamination is a crucial step in outbreak investigations to prevent foodborne illnesses.⁸ Accordingly, this investigation is needed to confirm an outbreak and define a working case definition. This assessment must be initiated and completed quickly to prevent further illnesses. It should include checking the validity of the information, obtaining reports of applicable laboratory tests that have been performed, identifying cases and obtaining information about them, and ensuring the collection of appropriate clinical specimens and food samples.⁴

MATERIAL AND METHOD

An active case finding followed by a retrospective cohort study was used in this investigation. The population at risk in this study includes all students, teachers, education staff, and other school people in elementary school, Bantul District. Case is defined as an individual who has one or more symptoms of food poisoning such as nausea, vomiting, diarrhea, stomachache, dizziness, fever, and weakness after consuming canteen snacks on February 2, 2023. The exposed group consisted of individuals who ate canteen snacks on February 2, 2023, and the unexposed group consisted of those who did not eat canteen snacks on February 2, 2023.

The epidemiological investigation begins with confirming the existence of an outbreak by visiting elementary schools and communicating with school principals. In addition, food and biological samples were collected and sent to the laboratory. Interviews were conducted with students, teachers, education staff, and food sellers in the school canteen using Google Forms. We collected various data, including individuals' age, gender, symptoms felt after consuming or not consuming canteen snacks, the time when they consumed canteen snacks, and when the symptoms developed. Food samples from the canteen, which included pizza, spaghetti, meatballs, fruit salad, orange ice, and tap water,

were collected by the investigation team on the first day of the investigation and immediately distributed for examination to the regional laboratory (Balai Laboratorium Kesehatan) in Yogyakarta on February 3, 2023. The following day, four samples of vomit from sick students were also collected by the investigation team and sent to the laboratory.

On February 6, 2023, an environmental investigation was conducted by interviewing food sellers using a questionnaire and conducting observations by visiting food production houses to watch over procedures in preparing food, such as cooking, storing, and serving.

The data was analyzed using the STATA 17 software.⁹ A descriptive analysis of the foodborne outbreak investigation was conducted by describing the data based on person (age, gender, signs and symptoms, time of onset, snacks consumed) and time variables. The attack rate was calculated for case distribution. The epidemic curve was used to examine time variables. The bivariate analysis estimated food-specific risk using a Risk Ratio (RR) with a 95% Confidence Interval (CI). The Chi-square test was also used to test the hypothesis of each food item. Food items with a p-value less than 0.25 will be included in multivariate analysis using multiple binomial regression to estimate adjusted RR.

RESULTS

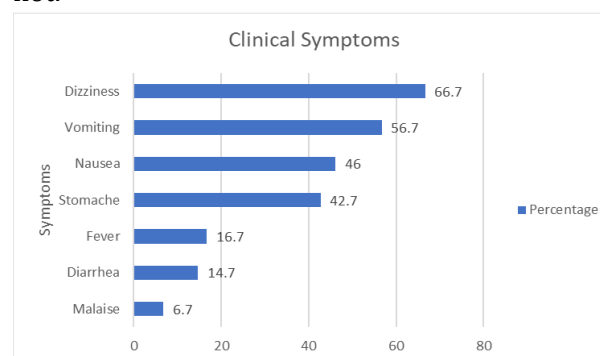
According to school administration data, there were 353 students, 27 teachers and education staff, and 3 food sellers as the population at risk on February 2, 2023. However, only 344 (89.8%) persons were successfully interviewed. Most cases were found in the female group (53.22%), 9-year-old group (55.32%), and third-grade students (65%). Detailed information on case distribution can be found on Table 1 below. Figure 1 shows that dizziness (66.67%), vomiting (56.67%), and nausea (46%) were the most common symptoms. No symptoms or danger signs were found in this outbreak investigation. Further details related with symptoms can be found on Figure 1.

Based on the epidemic curve in Figure 2, the type of outbreak transmission was a common source, where the same cause caused this type of transmission, and cases increased rapidly. Snack consumption began on February 2, 2023, at 09.00 am. An hour later, at 10.00 am, the first cases occurred, reaching a peak on February 3 2023 at 04.00 am, then gradually decreasing. The shortest incubation period is one hour, and the longest is 26 hours, with an average of 15 hours and 12 minutes and a median of 16 hours.

The following day, on February 3, 2023, at 1:00 pm, the investigation was done by visiting schools and interviewing all at-risk groups on February 4, 2023, at 9:00 am. Additionally, the Public Health Center treated individuals who were still symptomatic and educated students and their parents on the same day.

Table 2 shows food-specific RR figures. According to the table, meatballs, spaghetti, egg roll sausage, guava juice, and apollo chocolate had the highest RR. Meatballs had RR of 1.49, implying that it was 1.49 times more likely to cause food poisoning in elementary schools.

Table 3 shows the result of multivariable analysis using multiple binomial regression. Spaghetti, meatballs, egg roll sausages, and guava juice were found to have significant relevance in this analysis, as shown by the p-value of less than 0.001. Meatballs had the largest and most significant relative risk, with an adjusted RR of 1.49 and a CI of 1.22-1.81. This shows that, after adjusting for other variables, students who eat meatballs have a 1.49 times higher risk of becoming sick than those who do not.



Source: Primary Data, 2023

Figure 1. Clinical Symptoms of the Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Table 1. Case Distribution and Attack Rate by Person

Characteristic	Population at Risk	Number of Case	Attack Rate
Sex			
Male	173	59	34.10
Female	171	91	53.22
Age (Year)			
6	11	6	54.55
7	48	26	54.17
8	61	33	54.10
9	47	26	55.32
10	52	23	44.23
11	71	23	32.39
12	34	13	38.24
13	0	0	-
14	3	0	0.00
21-30	9	0	0.00
31-40	6	0	0.00
41-50	2	0	0.00
Class			
1	57	27	47.37
2	53	28	52.83
3	40	26	65.00
4	66	31	46.97
5	57	21	36.84
6	54	17	31.48
Others	17	0	0.00

Source: Primary Data, 2023

Table 2. Relative Risk for Food Items Related to Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Food Items	RR	p-value	CI 95%
Iced tea	0.88	0.39	0.65-1.19
Orange juice	0.92	0.83	0.38-2.17
Rice	0.91	0.77	0.49-1.69
Kentucky	1.08	0.81	0.60-1.91
tofu			
Pizza bread	1.29	0.54	0.62-2.66
Fruit salad	0.71	0.64	0.14-3.54
Bread	1.07	0.89	0.40-2.87
Rambak	0.00	0.18	0.00
crackers			
Spaghetti	1.36	0.11	0.97-1.88
Corndogs	0.53	0.38	0.09-2.92
Meatballs	1.49	<0.001	1.19-1.85
Egg roll	1.35	0.04	1.03-1.74
sausage			
Egg roll	0.76	0.40	0.37-1.54
meatballs			
Guava juice	1.34	0.09	0.99-1.81
Brown	0.71	0.64	0.14-3.54
sweet potato			
Avocado	1.30	0.28	0.84-2.00
juice			
Apollo	1.33	0.15	0.94-1.89
chocolate			
Tempura	0.71	0.51	0.22-2.21
Egg Noodles	0.71	0.64	0.14-3.54
Other	1.29	0.64	0.85-1.78

Source: Primary Data, 2023

Table 3. Multivariable Analysis of Food Items Related to Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Food Items	Adjusted RR	p-value	CI 95%
Spaghetti	1.34	<0.001	1.16-1.54
Meatballs	1.49	<0.001	1.22-1.81
Egg roll	1.39	<0.001	1.21-1.60
sausage			
Guava juice	1.46	<0.001	1.25-1.49
Apollo	1.20	0.109	0.95-1.51
chocolate			

Source: Primary Data, 2023

According to the laboratory findings, every food sample contained mold or yeast. We did not receive results that matched the laboratory results when we compared them to the differential diagnosis based on symptoms and food type; this could be because the food sent was not a sample consumed on February 2, 2023, the day food poisoning was suspected. There is also the risk of contamination from the samples sent due to the lack of appropriate containers for taking food samples from the start. Laboratory results for meatball, which has the greatest RR, show contamination with many organisms, including mold/yeast, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. Based on the symptoms, incubation period, type of food, and risk factors, the differential diagnosis refers to *Salmonella* sp as the cause of food poisoning. Detailed information on the differential diagnosis with an outbreak can be found in Table 4 below.

The results of the vomit samples showed the presence of mold/yeast, indicating that these samples were contaminated. This could be because the sample container did not meet sample storage criteria, because the parents of each student provided it. Also, the vomit sample has been more than 24 hours since the student last ate snacks from the school canteen; the presence of various bacteria, such as the *E. coli* pathogen and *Bacillus cereus*, may be due to a combination with other food consumed by students. Table 5 shows the laboratory results for each sample.

Additional interviews with food handlers found that no food handlers got sick while processing food on that day or in the prior few days. A visit to the food handler's house revealed

that huge amounts of meatballs were stored in the refrigerator. Regarding preparation, the purchased meatballs are boiled at home first, while the meatball soup is created in the school canteen using tap water. The seller noticed that the water was dirty at the time. A large amount of food stored in the refrigerator, incorrect reheating, and cross-contamination are all considerable risk factors.

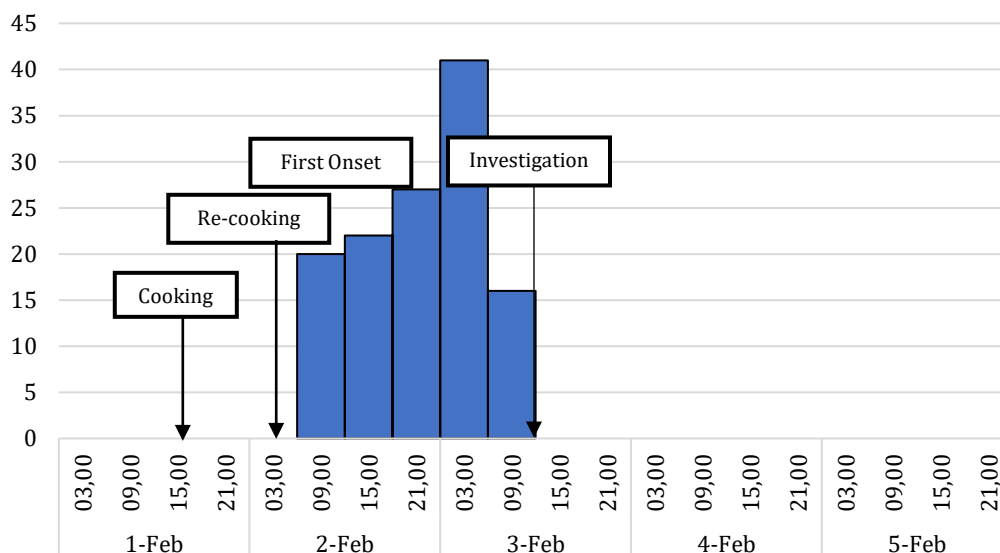
Further investigations were also conducted at the place where the meatballs were produced. Around the area, there are animal cages and some litter. Meatballs are formed with ground meat blended with all the seasonings, then boiled twice in a meatball production machine. After boiling, the meatballs are chilled using a fan before being wrapped in white plastic and placed in the refrigerator. According to conversations with meatball suppliers, there were no food handlers got sick while processing food on that day or in the prior few days.

DISCUSSION

According to the findings of epidemiological investigations, meatballs are the food that

causes food illness. Mold/yeast, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* were discovered in meatball samples during laboratory tests. This differs from the differential diagnosis, which suspects *Salmonella* bacteria as the cause of food-borne illness. The symptoms determine this, the type of food consumed, and the incubation period, which can last up to 26 hours. *Salmonella* species, which include *Salmonella typhimurium*, *Salmonella choleraesuis*, *Salmonella enteritidis*, and many more closely related species, can be one of the causes of food poisoning.¹⁰

Salmonellosis is the second most common gastrointestinal disorder in the EU caused by *Salmonella*-contaminated foods. Symptoms may include gastroenteritis, abdominal cramping, bloody diarrhea, fever, myalgia, headache, nausea, and vomiting.¹¹ The intensity of symptoms is determined by various factors, including serotype, bacterial cell count, age, and human susceptibility. Symptoms often occur between 12 to 72 hours, lasting 4 to 7 days. This is consistent with the 1–26 hour incubation period for foodborne outbreak in this case.



Source: Primary Data, 2023

Figure 2. Epidemic Curve of Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Table 4. Differential Diagnosis Related to Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Characteristic	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>	<i>Salmonella sp.</i>	Outbreak
Symptoms					
Nausea	+	+	-	+	+
Vomiting	+	+	-	+	+
Dizziness	-	-	+	-	+
Stomache	+	+	+	+	+
Fever	-	-	±	±	±
Diarrhea	±	±	±	±	±
Malaise	-	-	-	±	±
Incubation Period	2-4 hours	30 minutes-8 hours	12-48 hours	12-36 hours	1-26 hours
Risk Factors	Storing cooked food at room temperature, storing cooked food in a big container in the refrigerator, and preparing meals several hours before serving	Storing cooked food at room temperature, storing cooked food in a big container in the refrigerator, touching cooked food at room temperature, and preparing meals several hours before serving	Infected people handling food, insufficient cold storage, inadequate cooking, cleaning and hygiene, ingesting raw or undercooked meat	Storing prepared food at room temperature, storing large quantities of food in the refrigerator, reheating, contamination cross-contamination,	Meatballs are stored in large quantities in refrigerators and reheated before consumption, and cross-contamination with tap water is possible.
Food Characteristic	Cooked rice	Ham, meat and poultry products, high protein foods	Half-cooked meat, cheese, water	Meat and poultry and processed products	Meatballs

Source: Primary Data, 2023

Table 5. Laboratory Results of Foodborne Outbreak in Elementary School, Bantul, Yogyakarta

Type of Sample	Results	
Food Samples	Pizza	Mold/yeast, <i>Klebsiella pneumoniae</i> , <i>Staphylococcus capitis</i>
	Meatballs	Mold/yeast, <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i>
	Spaghetti	Mold/yeast, <i>Citrobacter freundii</i> , <i>Klebsiella ozaenae</i> , <i>Pseudomonas aeruginosa</i>
	Fruit Salad	Mold/yeast, <i>Citrobacter freundii</i>
	Orange Ice	Mold/yeast, <i>Staphylococcus capitis</i> , <i>Pseudomonas aeruginosa</i>
Water Sample	Tap Water	Mold/yeast, <i>E. coli non pathogen</i> , <i>proteus mirabilis</i> , <i>Bacillus thuringensis</i>
Vomit Samples	An. A	<i>Staphylococcus capitis</i>
	An. L	Mold/yeast, <i>E. coli pathogen</i> , <i>Staphylococcus capitis</i>
	An. Z	Mold/yeast, <i>Klesiella ozaenae</i>
	An. H	Mold/yeast, <i>Bacillus cereus</i>

Source: Primary Data, 2023

Healthy people can recover without the need for special care, but occasionally, germs can enter the circulation or lymphatic system, leading to a systemic infection and a more severe disease or even death.¹⁰ Children under 5, elderly, and immunocompromised adults are more susceptible to salmonellosis. Salmonellosis is a self-limiting illness that ceases within a week, but deaths have been recorded mainly in vulnerable population groups such as the very young, elderly, and immunocompromised people.¹² In this outbreak, no severe cases were found.

A significant cause of *Salmonella* infection in humans is consuming foods derived from animals, particularly poultry. Raw and undercooked poultry, beef and pig, meat products, and many other foods are thought to be the most common *Salmonella* carriers involved in infection.¹³ As the meatballs were made with the handler's beef food, the meat may have been contaminated with the *Salmonella* pathogen.

A study conducted in Sidoarjo, Indonesia, discovered that bacterial contamination of meatballs can occur at any stage of the production process, from cattle slaughter to packaging. Proper food hygiene and sanitation are essential for preventing microbe and bacterial contamination in meatballs.¹⁴ Another study found a high prevalence of *Salmonella* in retail meat shops (46.3%), commercial broiler farms (19.2%), and hatcheries (10.3%). These findings show that *Salmonella* contaminates poultry meat at a high level during the production and retail processes.¹⁵

Furthermore, there is a significant risk of *Salmonella* infection not adequately heated before consumption.¹⁵ This is consistent with the findings of interviews with food handlers, who stated that the purchased meatballs were boiled first at home, and the meatball broth was made in the school canteen with tap water. Its repeated heating may contribute to this outbreak.

Another study found that storing meatballs at room temperature rapidly increased the number of microbes. This is because room temperature (25-30°C) is ideal for bacteria to grow and reproduce rapidly.¹⁶ One way to slow bacteria growth is to keep them at temperatures that are

not ideal for microbes, such as 4°C, which can extend the shelf life of meatballs.¹⁷ Therefore, storing meatballs properly is essential to stop bacterial growth and prevent outbreaks.

Salmonella spp. food poisoning is typically sporadic, with no obvious connection to previous cases. In many cases, the mode of transmission is also unknown.¹³ According to another study, *Salmonella* has been identified in various areas within farms and slaughterhouses, and long-term livestock contamination appears to be a prevalent issue.¹⁸ The primary transmission mode is through the consumption of organisms in food (milk, poultry, meat, eggs) derived from infected animals. Infected food workers, cross-contamination due to inadequate hygiene, and infected animals' or humans' excrement can contaminate food.¹⁹ To prevent cross-contamination, raw meat should be stored in separate bags from foods ready to eat. The storage of meat is an essential and critical process. Raw meat and poultry should be stored in sealed bags at the bottom of the fridge as soon as possible.²⁰

The findings raised concerns about food safety in schools. It is essential to improve food safety measures in schools.²¹ To prevent future outbreaks, several measures should be implemented or improved. First, food handlers should receive formal education and training on food safety principles to enhance their knowledge, attitude, and practices. This is in line with research findings indicating the need for formal education and training programs aimed at positively influencing food handlers' knowledge and attitudes for them to improve their food-handling practices.²² Second, schools should strictly manage the foods provided to students and staff, including selection, storage, and cooking processes. Additionally, public health efforts should raise awareness about food poisoning.²¹

Our epidemiological investigations had several limitations. First, the meatball samples were collected on February 3, 2023, rather than the first day of the suspected outbreak, February 2, 2023. Therefore, the results did not reflect the food samples considered the outbreak's source. Second, the vomit samples were collected more than 24 hours after the first symptoms, suggesting contamination could have occurred

from meals other than school canteen food consumed by students. Third, there is a risk of contamination of the samples sent due to the lack of appropriate containers for collecting food samples from the start.

CONCLUSION AND RECOMMENDATION

A foodborne outbreak occurred in an elementary school, with the most cases found in the female group, the 9-year-old group, and third-grade students. Meatballs are the source of outbreak transmission, and *Salmonella* is the causal agent. The laboratory results do not show supporting results; this could be because the food samples sent were not food samples at the time of the outbreak, and there was the possibility of contamination in the food samples examined. This could be due to the lack of standard containers at the start of sampling.

It is important to raise awareness among school residents, including students, teachers, education staff, and food handlers, to adopt a clean and healthy lifestyle and prepare healthcare facilities to take and store food samples to avoid contamination.

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AUTHOR CONTRIBUTIONS

Conceptualization: SII, MJ. Data curation: SII, MJ. Formal analysis: SII, MJ, BSW. Methodology: SII, MJ, BSW. Writing –original draft: SII. Writing –review & editing: BSW, SA. SSI = Soraya Isfandiary Iskandar; MJ = Miftakhul Janah; BSW = Bayu Satria Wiratama; SA = Samsu Aryanto.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Nurse Managers' Experiences in Managing Inpatient Wards During a Crisis: Lessons from the COVID-19 Pandemic

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ABSTRACT

The COVID-19 pandemic has provided valuable lessons for all parties, including nursing services in hospitals. To date, literature has been lacking on the role of nurse managers in managing inpatient wards for COVID-19 patients, especially in Indonesia. This study aims to explore the experiences of, and the challenges encountered by nurse managers in managing inpatient wards during the crisis. This is a qualitative study with a phenomenology design. The study used a purposive sampling technique involving four nurse managers from several hospitals in South Sulawesi Province, Indonesia. Data were obtained through semi-structured interviews and were analyzed using thematic analysis. This study yielded three themes and nine sub-themes. Nurse managers experienced panic and fear but carried out inpatient management immediately. There was also a solid commitment to protect the fellow nurses from infection. Valuable lessons include the availability of human resources, strong commitment from all lines, management support, and teamwork. Meanwhile, nurse managers encountered challenges such as the lack of personal protective equipment, frequently changing service procedures and the psychological needs of nurses. Nurse managers obtained numerous lessons from the COVID-19 pandemic related to their capabilities in managing inpatient wards. The findings suggest the adaptability of nurse managers to similar challenging crisis encounters in the future by analysing the effects of frequent workflow changes on care quality and staff adaptation, examining the long-term psychological impact of pandemic work on nurses developing strategies to enhance organizational support for nurses including coping mechanisms and well-being related trainings and services, and to build dynamics of effective teamwork during crisis.

INTRODUCTION

The Coronavirus Disease-2019 (COVID-19) pandemic has left valuable lessons for Indonesia across various sectors. The pandemic began in late December 2019 with the discovery of symptoms and pneumonia-like images in a group of patients in Wuhan, China, which was later identified to be associated with a seafood wholesale market cluster in the area.^{1,2} Since being declared a global pandemic by the World Health Organization (WHO), the transmission of the COVID-19 virus has continued to spread and has had a significant multisectoral impact,³ including in the healthcare sector.

Regarding the impact of the disease on the human population, data from the Indonesian Ministry of Health indicates significant effects. Globally, the confirmed COVID-19 cases reached 776,546,006, with 7,065,880 deaths. In South East Asia, the confirmed Covid-19 cases accounted for 61,317,985, with 808,827 deaths.⁴ In Indonesia itself, the confirmed cases of COVID-19 have reached 6,417,490, with 157,966 deaths, and as of 22 September 2024, there were still 23,503 COVID-19 patients being cared for at healthcare facilities.⁵ This data indicates that COVID-19 continues to infect humans, posing an ongoing challenge to the healthcare system.

In facing the COVID-19 pandemic, a coordinated global response has been implemented to prepare optimal healthcare systems for patients needing care at healthcare facilities, especially hospitals. For example, WHO has provided several technical guidelines, including the Rapid Hospital Readiness Checklist (RHRC), to guide and benchmark hospitals in managing COVID-19, particularly concerning hospital capacity.⁶ In these guidelines, WHO emphasizes that hospitals must prioritize leadership, coordination, human resources, patient management, staff mental health, and infection prevention and control.⁶ Proper planning and organization are indeed among the primary tasks of hospitals. For example, the recruitment method is a regular process determining the number and type of staff needed to provide standard care in a healthcare institution.⁷

In the Guidelines and Control of COVID-19 issued by the Indonesian Ministry of Health, nurses are healthcare workers directly involved in COVID-19 services and clinical management

in hospitals, alongside doctors and other healthcare workers, as needed.⁸ Clinical management involves performing optimal and quality clinical governance so that patients receive comprehensive, patient-centered care continuously according to their needs and based on patient safety. In clinical management, inpatient care management is also included. Nurse managers play a crucial role in managing the charge nurses who provide care for the patients they serve. As part of the executive team or top management in hospitals, nurse managers should represent and voice the realities faced by frontline nurses, regardless of how complex or resistant these realities might be.⁹

The COVID-19 pandemic has imposed significant impacts and burdens on the healthcare system, particularly on nurses, who are frequently cited as being on the frontlines of the pandemic response. The increasing number of COVID-19 cases has led to an overburdened healthcare system, especially in hospitals. This situation has resulted in healthcare facilities facing shortages of Personal Protective Equipment (PPE), Intensive Care Unit (ICU) beds, and trained nurses to manage the substantial influx of critically ill patients.¹⁰ The inadequate availability of trained nurses and the insufficiency of PPE have contributed to heightened levels of fatigue and stress among nursing staff.¹¹⁻¹⁴

The COVID-19 pandemic has presented unprecedented challenges and difficulties for nurses, both professionally, socially, and psychologically. This situation has posed unique challenges for hospital nurse managers, requiring them to adopt, adapt, and develop new leadership competencies to navigate the current pandemic challenges and future uncertainties. In unprecedented ways, nurse managers have responded to the healthcare crisis brought on by the COVID-19 pandemic through various approaches.¹⁴ For example, the sudden increase in critically ill COVID-19 patients in Italy required hospital nurse managers to make abrupt and seemingly compulsory changes to address the unprecedented nursing shortages.¹⁵ For example, after ICU beds were made available, nursing management provided ICU nursing staff by combining trained ICU nurses with newly graduated nurses.¹⁵

The adaptation processes of nursing management in handling COVID-19 patients in

other countries also merit special attention. During the prevention and control of the epidemic in several hospitals in China, for instance, nurse managers, through the nursing department as one of the hospital's central functional departments, played a crucial role by implementing contingency management strategies to ensure proper, orderly, safe, and efficient services.^{16,17} One form of this contingency management involved the adjustment of wards for COVID-19 patients, the establishment of specialized task forces within the Nursing Department to provide clinical guidelines and directions for COVID-19 care to frontline nurses, as well as cross-sector coordination and communication within the hospital.^{16,17}

The role of nurse managers during the COVID-19 pandemic has also been briefly discussed in several literatures, primarily in editorial columns and commentaries. In one editorial reflection, Goh et al. wrote about the experiences of nurse managers in Singapore during the pandemic, focusing on the additional tasks beyond routine duties, including attention to the emotional health of frontline nurses.¹⁸ Pertinent to the role of nurse managers, research by Havaei et al. found that besides workplace conditions, the availability of necessary resources (logistics) for patient care and organizational support (leadership/nurse managers) were significantly related to nurses' mental health.¹² Consistent with these findings, Daly et al. emphasized that nurses on the frontline of the COVID-19 pandemic require and deserve to work alongside strong leaders (managers) because leaders are involved in decision-making to ensure that nurses' interests are served.¹⁹ Thus, the nurse manager's role entails full responsibility for the needs of frontline nurses and patient care during the pandemic, as well as in nursing care planning and supervision of frontline nurses providing such care.

In Indonesia, literature concerning the role of nurse managers in inpatient management amid efforts to combat this epidemic still needs to be expanded. A study by Asmaningrum et al. (2020), although conducted only in two hospitals in a district in East Java,²⁰ has at least provided insight that nurse managers play a role in staffing arrangements, scheduling, and efforts

to supply PPE to reduce infection incidents among nurses. Therefore, research materials or references related to the role of nurse managers in COVID-19 response and service provision, or in facing pandemics in general in hospitals in Indonesia within a broader context, are still highly needed. Continuous research regarding the role of nurse managers in the context of the healthcare system in Indonesia is necessary so that the nursing profession can effectively respond to the increased quality of inpatient care for patients during the pandemic, particularly in terms of nursing services. This is because healthcare institutions that consistently integrate evidence-based nursing science and strategies yield better outcomes in patient care, one example being nurse staffing arrangements during the pandemic,²¹ which indeed constitutes one of the responsibilities of nurse managers.

The limited scientific literature on the role of nurse managers in managing inpatient facilities presents both challenges and opportunities in inpatient care, especially for infectious disease patients during the pandemic. This is particularly relevant to nursing management and hospital administration. The lack of empirical data may hinder a comprehensive understanding of healthcare provision, making it challenging to establish evidence-based protocols or benchmark standards. However, this situation also allows scholars in tertiary education institutions to engage in ongoing research that could significantly contribute to scholarly discussions on healthcare, especially in pandemic response efforts.

According to data from the Health Human Resources Development and Empowerment Agency/ *Badan Pengembangan dan Pemberdayaan SDM Kesehatan (BPPSDMK)* under the Indonesian Ministry of Health, out of the 105 hospitals in South Sulawesi Province, ten have been designated as COVID-19 referral centers. However, there needs to be more scientific research on managing inpatient facilities for COVID-19 patients, highlighting a critical gap in research. Therefore, the current study aims to fill this gap by conducting foundational research involving nurse managers from various hospitals in South Sulawesi Province. The primary objective of this research is to delve into the experiences of nurse managers in navigating the challenges of inpatient management during

the COVID-19 pandemic across several health-care facilities in South Sulawesi Province.

MATERIAL AND METHOD

This research adopts a qualitative approach to address the research questions, explicitly employing a phenomenological design. The phenomenological qualitative inquiry aims to reveal the meaningful experiences of individuals in their daily lives and within the world.²² The explored topic in this study revolves around the experiences of nurse managers in managing inpatient wards designated for COVID-19 patients across several hospitals in the South Sulawesi Province.

This study was conducted from October – December 2021. The population of this study was the nurse managers in hospitals within the South Sulawesi Province that offer inpatient care for COVID-19 patients. Using the purposive sampling method, the study selected a sample with the following criteria: 1) nurses occupying the position of the nurse manager in hospitals providing inpatient care for COVID-19 patients; 2) middle-level Nurse Managers (Head of Nursing Section) or Senior Nurse Managers (Head of Nursing Department); 3) nurse managers who were part of the hospital's internal team involved in COVID-19 management, such as Rapid Response Teams (RRT), Working Teams, Task Forces, or similar groups.

In this study, a sample size of four individuals was obtained. In qualitative research, there is no specific format for determining sample size. Whitehead asserts that the minimum sample size in qualitative research depends on the research design employed.²³ This study was conducted in the working area of South Sulawesi Province, with most activities conducted online. As a result of the impact of the COVID-19 pandemic on sample recruitment, many qualitative researchers had to conduct interviews exclusively online.²⁴

The research instrument utilized in this study was an interview guide developed by the research team. The supporting tools included recording devices and field notes. Data collection employed in-depth interviews, where research subjects were individually interviewed to gather extensive data focused on specific issues in

detail. Interview questions were posed using a semi-structured approach to stimulate open discussions and obtain deeper insights. This method allows flexibility in the sequence of questions, enabling researchers to adapt questions according to responses and the direction of the conversation.²³ While the interview protocol guided interviews, question development occurred spontaneously and naturally in response to the evolving interaction.

The data analysis employed in this study is Thematic Analysis. In thematic analysis, researchers identify all significant issues, concepts, and themes from the interview data. The outcome of this stage is a detailed data index, all labeled according to subgroup. Thematic Analysis enables researchers to revisit data until meaningful themes are derived repeatedly.²⁵ The process involved in Thematic Analysis includes data familiarization, coding, theme identification, theme review, naming and defining themes, continued with writing the analysis.²⁶ The results of theme identification and the findings within these themes are then written and used to compile the research report.

This study obtained ethical approval from the Faculty of Public Health, Hasanuddin University in Makassar, Indonesia, and the ethical approval number is 9960/UN4.14.1/TP.02.02/2021. Respondents were informed about the objectives and purposes of the study, and their verbal consent to participate was obtained. Research Permit was also obtained from The Government of South Sulawesi Province with research permit Number 22489/S.01/PTSP/2021.

RESULTS

This study was conducted in the South Sulawesi Province, involving governmental hospitals in four regencies. These hospitals provided COVID-19 patient care and adhered to guidelines issued by the World Health Organization (WHO), the Ministry of Health of the Republic of Indonesia, the Governor's Policy of South Sulawesi Province, and other government regulations. Nurse managers (Head of Nursing Section) from these hospitals were involved as participants/informants. The characteristics of the informants can be seen in the Table 1.

Following interviews with all research subjects (informants), the interview transcripts were subsequently transcribed and structured into an interview matrix to facilitate data management for the researcher. Subsequently, the transcribed data underwent reduction and categorization into distinct data clusters or thematic categories and subcategories. The themes/variables and corresponding sub-themes/sub-variables derived from this data reduction process are delineated in the Table 2. The table depicts three themes that emerged from the thematic analysis. Within these three themes, nine sub-themes were identified as findings of this research.

Table 1. Informants' Characteristics

Code	Age (Years)	Gender	Position
P1	48	M	Nurse Manager
P2	41	F	Nurse Manager
P3	42	F	Nurse Manager
P4	42	M	Nurse Manager

Source: Primary Data, 2021

Table 2. Themes and Subthemes Resulting from Thematic Analysis

Themes	Subthemes
Experiences of nurse managers during the initial phase of the pandemic	1. Nurse managers initially encountered feelings of panic and fear. 2. Nurse managers responded promptly to the situation. 3. Desire to protect for both patients and frontline nurses.
Insights gained by nurse managers on the supporting factors in inpatient care management during the pandemic	1. The hospital's strength lies in the availability of human resources. 2. Robust commitment across all organizational levels and management support are crucial. 3. Effective teamwork emerges as a pivotal facilitator in the success of intervention efforts.
Barriers and challenges in inpatient care management during the pandemic	1. Limited availability of personal protective equipment (PPE). 2. Frequent changing of health service workflows. 3. Psychological needs of nurses providing direct care for COVID-19 patients.

Source: Primary Data, 2021

Experiences of nurse managers during the initial phase of the pandemic

The pandemic has various impacts on all layers of society. Healthcare workers, including nurse managers, also feel panic and fear experienced by the general public. This is evident in the information obtained as follows:

"...Well, there was panic among colleagues in the ward, including us as managers. Our panic was firstly whether we were ready to provide services to COVID patients, from the availability of our human resources and especially our facilities and infrastructure. The second panic was the danger that colleagues in the ward felt at the beginning of getting infected....." (P1)

A similar expression was obtained from another participant:

"...Yes... initially, perhaps we felt confused about what to do. ...the preparation of personnel, also related to facilities, how to address the needs of colleagues in the ward regarding their PPE requirements. So, we were somewhat overwhelmed..." (P2)

Nurse managers pointed out that the experience was new and unprecedented, causing fear in dealing with it.

"...Fear and not knowing what to do. We only saw social media and television news that a hazardous virus was already entering Indonesia ...we did not know how to deal with it or protect ourselves..." (P3)

"...To be honest, of course, we are worried and scared because the most concerning thing is us getting infected... the transmission can occur among colleagues, so of course, there is worry. Secondly, we are also worried about the preparedness of human resources and the available facilities. Because this was a new issue, our preparations were still unclear..." (P2)

Despite the panic and fear experienced at the pandemic's beginning, nurse managers responded quickly. As intermediaries between the nursing staff and hospital management, nurse managers exhibited significant initiative in organizing treatment areas for patients suspected or confirmed to have COVID-19. The following informant statement evidences this proactive approach:

".... as part of the management team, we had to take responsibility and collaborate with the Emergency Department (ED) to prepare the necessary processes and regulations from the ED to inpatient

care. Consequently, we organized an emergency meeting with the director, involving the nursing section, the heads of inpatient care, the ED, the laboratory, radiology, and the medical and nursing committees..." (P3)

"...Initially, we designated specific rooms to be used as special isolation units for COVID-19. We identified two rooms specifically for confirmed and suspected cases..." (P2)

"...Organizing these rooms was the first major task I had to undertake. We needed to map out which areas were designated for COVID-19 patients and which for non-COVID patients..." (P1)

The onset of the pandemic provided a unique experience for nurse managers, who felt a strong need to protect their fellow nurses and healthcare workers in service areas. The primary goal of nurse managers in managing inpatient care at the beginning of the pandemic was to safeguard patients and their colleagues who provided direct care. This is evident from the following statements by informants:

"... That was my primary concern, ensuring that services continued while keeping my colleagues safe from COVID-19 exposure in those early days..." (P4)

Other informants also expressed similarly:

"...first, our objective was to ensure that COVID-19 patients received proper care while not neglecting general patients... to avoid transmission among staff and their families..." (P1)

"...our principle at that time was primarily driven by the need to ensure that our nurses at the hospital could work effectively (so we were) responsible for their health... We also considered the well-being of their families at home...and that patients would not feel neglected if there were no staff willing to enter to provide care..." (P3)

Other immediate efforts taken by nurse managers can be seen in the following statement:

"...additionally, we were accommodated in hotels and could not return home during the early stages of COVID-19...(to avoid transmission)..." (P1)

"The main objective was to address the perceived high risk of COVID-19 exposure among healthcare workers, as reported by several hospitals. Thus, we organized the inpatient care and prepared specific rooms to manage COVID-19 patients." (P2)

Insights gained by nurse managers on the supporting factors in inpatient care management during the pandemic

In carrying out their duties within the COVID-19 response team, nurse managers regard human resources as the cornerstone of the hospital's strength. Sufficient staffing levels facilitate nurse managers in organizing personnel and managing inpatient care. This is evident from the insights provided by the following informant:

"...our human resources were adequate. We had a full complement of nurses and doctors..." (P4)

"In emergencies, our human resources were sufficient; perhaps that was our strength." (P1).

".... in terms of human resources, our staffing was adequate for preparing the care of COVID-19 patients." (P2)

"...in terms of strength, we have staff willing to work sincerely..." (P3)

In addition to facilities and human resources, a strong commitment and management support are essential in combating COVID-19. This is evident from the information provided by the informant:

"... our strength perhaps from the beginning has been the work commitments of our leaders, subordinates around us, and some colleagues who want to work ..." (P4)

Similar statements were obtained from other participants:

"...there is a strong spirit among colleagues who are ready to work..." (P2); "...our strength is that colleagues in (services) are willing to cooperate..." (P1); "... Initially, a volunteer team was formed at the hospital. So, we saw that those who joined the volunteer team were people ready to leave their families..." (P3)

Besides the strong commitment from the healthcare professionals, the management support was evident from the statements below:

"...we had support from the task force and the district government... (for example) at the beginning they helped provide masks, gowns, and others by sewing garments..." (P4).

"...another support, I think, comes from the directors... the directors are very supportive... there

is also support from the health department... the regent and the local government are very supportive in handling COVID-19..." (P2)

This study also found that teamwork played a significant role in succeeding in the management of inpatient care for COVID-19 patients. Regarding this, several informants stated the following:

"...our next strength is that colleagues in (services) are willing to cooperate..." (P1)

"... working together... it would be impossible for us to do it well if we worked alone without the help of a team. So, we truly collaborated as a team..." (P3)

"...the key at the hospital was coordination with the task force team, and it was indeed intense, 24 hours every day from our colleagues..." (P4)

Barriers and challenges in inpatient care management during the pandemic

The main weakness and challenge felt by nurse managers was primarily the availability of Personal Protective Equipment (PPE). This is evident from the statements of several informants as follows:

"...the challenge in terms of PPE at that time was initially a severe shortage..." (P2)

"...if the hospital's weakness is not having enough PPE for staff to use in providing services..." (P3)

"... because our focus was very high, especially on PPEs, we could not not use the required PPEs. It was like committing suicide, well, PPE was something very needed at that time..." (P1)

"...at the beginning, yes, there was a shortage of PPEs..." (P4)

In addition to the limited availability of PPE, the frequent changing of service flow also became a challenge in inpatient management. This is supported by the statements of informants as follows:

"... even for several months, the guidelines would suddenly change. So, the difficulty was there in the guidelines. Although they were available, we were still learning, experimenting, not fully understanding or knowing what to do because it was all new..." (P4)

"...there was a flow that we corrected. We changed the flow because... previously it was rapid antibody, now it is a rapid antigen, so from that change, we also changed the flow..." (P2)

"...there were changes in the flow... several times " (P3)

"...the flow changes through our internal arrangements... (particularly) in the patient assessment because when we make a mistake in our assessment, our prevention methods would also be affected and be changed...." (P1)

Another challenge in inpatient management is the psychological needs and comfort of the nurses. Several statements from the informants support this, as shown in the following quotes:

"... at that time, they sometimes felt tired, but when given encouragement, (and) they had to be accompanied continuously, (so) they would persevere to complete their duty period..." (P3)

"...in terms of nursing management, well, the weakness since the pandemic began, from the psychological aspect, is that our colleagues who were not prepared... especially with... their knowledge, their fear of being exposed, so during... handover or shift change, they were not at their best (due to this fear of exposure). That is one of them..." (P2)

"...the weakness is the psychological aspect of our colleagues. Some colleagues even, because of that fear, wanted to take a break; most of them are still non-civil servant nurses..." (P4)

DISCUSSION

Data from all informants indicated that nurse managers experienced panic and fear at the start of the pandemic. This was very natural, given the highly contagious nature and characteristics of the COVID-19 virus and its effects on the human body. In responding to the COVID-19 outbreak, healthcare workers were on the front lines, exposing them to danger and putting them at risk of infection. The dangers included exposure to pathogens, long working hours, psychological pressure, fatigue, job burnout, stigma, and physical and psychological effects.⁶

Healthcare workers were at risk of infection when examining and treating patients with respiratory infections. If healthcare workers who were supposed to handle COVID-19 patients became infected, the healthcare system would be disrupted. When the healthcare system is overwhelmed, mortality rates, both direct and indirect consequences of the outbreak/pandemic, can dramatically increase, including deaths from conditions that could have been prevented and treated with vaccines.⁶ In line with this, a study showed that patients, health-

care workers, including nurses, families, and the community as a whole, have gone through several psychological stages since the beginning of the COVID-19 pandemic.²⁷ The first and most prominent reaction was panic, which arose due to the unfavorable clinical course of COVID-19, lack of information about the disease, difficulties in obtaining PPE, and uncertainty about the future.

Nurse managers are responsible for implementing inpatient management at every health service facility. The COVID-19 pandemic, which has resulted in high morbidity with high transmission rates, has increased the burden on nurses in providing care and increased workload due to COVID-19 patients needing treatment without family support systems, as seen with pre-pandemic patients. This burdens nursing staff more due to insufficient resources for personal patient care. The shortage of nurses with critical care expertise required managers to develop strategies to help existing nurses gain critical care skills quickly and effectively. Innovative care models included pairing medical-surgical or ward nurses with intensive care unit nurses to work as a team caring for some COVID-19 patients. While this did not meet the expected standards and was not ideal, it was the best alternative during the pandemic.¹⁴

Data from this study also showed that nurse managers at several hospitals in South Sulawesi Province had made maximum efforts in managing inpatient wards. This aligns with previous research that showed internal hospital arrangements in managing and rearranging their wards to provide care spaces for COVID-19 patients. For example, Wu et al. found that hospitals initially serving as general hospitals were converted into specialized COVID-19 care hospitals with sudden changes quickly.¹⁷ These changes included preparing COVID-19 wards as needed, forming technical teams for nursing services, coordinating with the hospital level to ensure the availability of necessary equipment and supplies, and preparing nursing staff and training plans related to health services during the pandemic.

Other results from this research show that nurse managers in several hospitals in South Sulawesi Province consider adequate human resources to be a critical factor in implementing

inpatient management. All informants in this study stated that the number of nursing staff was sufficient to be deployed in COVID-19 service areas. This is interesting because it shows different results compared to previous studies. Research by Firmansyah et al. indicated that the ratio of healthcare workers to patients in COVID-19 services was not ideal, with a ratio of only 2.1 compared to the ideal 5.5.²⁸ This discrepancy may stem from different researcher perspectives. Firmansyah et al. viewed the ratio of healthcare workers (nurses and patients) by comparing it with developed countries,²⁸ while the nurse managers in this study assessed it based on their experience of meeting nursing staff needs in their respective wards.

A strong commitment within a team has long been proven to be a crucial element in completing tasks. Specifically for nurses, in crisis like the COVID-19 pandemic, professional commitment is necessary. Duran et al. stated that in difficult situations such as the COVID-19 pandemic, the professional commitment of nurses to providing services can be influenced by several factors, including the desire to leave the job, family support, job satisfaction, career choice, perception of institutional barriers, and education.²⁹ This implies that nurses' professional commitment can decrease in the long term if the factors affecting professional commitment are not identified or addressed, and nurse managers and institutions need to take necessary actions. Such professional commitment needs serious attention from nurse managers, especially in crises, as nurses wanting to leave their jobs during the pandemic will affect overall service performance. Nurse managers have the opportunity to create a supportive work environment that promotes the health and well-being of nurses, which in turn increases organizational commitment.³⁰ According to Duran et al., nurse managers can employ several strategies, including reducing workload, developing strategies to reduce organizational barriers, particularly administrative ones, supporting career development, providing child-care services, and more.²⁹

As the leading force in patient care, nurses face significant risks and challenges on the front lines of service to COVID-19 patients. This makes nursing management a critical department or

unit for implementing infection prevention and control. Nurses and nursing managers cannot work alone; teamwork is essential in combating COVID-19. This is in line with research by Wang et al. which stated that nursing management works closely with other departments to provide sufficient supplies and support for nurses as frontline healthcare workers, contributing to the successful handling of patients.¹⁶ For example, after nurses have completed caring for infected patients, whether they have been discharged or have passed away, the room must still be disinfected, requiring assistance from the disinfection unit. This coordination and teamwork, including with the responsible medical officer, supporting units providing PPE and medications, and even security personnel in the hospital, is imperative.

A finding from this study indicates that the main obstacle in implementing inpatient management is the availability of PPE for nurses providing direct care. The shortage of PPE has been a major issue in almost all healthcare facilities. This is consistent with research by Akkus et al., which found that PPE's limited availability was a central issue in tackling COVID-19.²⁷ Ensuring the safety of nurses and other healthcare professionals on the front lines of COVID-19 services requires serious attention. The risk of infectious disease transmission to healthcare professionals has long been felt. Healthcare workers have faced diseases such as HIV/AIDS, SARS, swine flu, and Ebola. Despite the lack of information about the virus, the disease's pathophysiology, transmission routes, and issues with PPE supply chain failures, healthcare workers continue to put themselves at risk in uncertain situations.³¹

The shortage of PPE supplies is a global issue, affecting nearly every country. Dyer mentioned that healthcare workers had to pay for PPE at the start of the pandemic in Russia.³² There were differences in PPE needs and supply, with severe shortages across all lines.³³ Therefore, during a pandemic, it is crucial to ensure that all equipment is used carefully to prevent waste and to ensure a continuous supply of PPE, even if production is limited. Some considerations for PPE use amidst supply shortages include ensuring healthcare workers treating COVID-19 patients and those in direct contact have PPE, consisting of gloves, protective gowns, masks,

face shields, and protective glasses. The same respirator can be used while examining multiple patients.³³ If supply shortages occur, wearing one for multiple patients is recommended. For the general public, improper use of medical masks can increase demand and hinder the supply of healthcare professionals who need PPE the most.

Another challenge in inpatient management during the pandemic is the frequently changing service flows. Wu et al. explained that converting general hospitals into COVID-19 treatment hospitals, where there is a demand to maintain high standards of care for every patient, requires nursing management to plan various strategic contingency management goals.¹⁷ These included establishing specialized COVID-19 care units that were unavailable, forming technical support teams, and ensuring that hospitals had backup nurses ready to work. Similarly, other studies found that hospital arrangements due to the crisis caused by COVID-19 required rapid adaptation and frequently revised guidelines.³⁴ These revisions included changes or expansions of rooms and staff redeployments, carried out gradually (step by step). This requires energy, focus, and time allocation from nurse managers. With the increasing number of patients and decreasing availability of staff and other vital resources, changes or adjustments in the types of care rooms become a distinct challenge.

Nursing is physically and emotionally demanding, even during ordinary circumstances or outside of a pandemic. The COVID-19 pandemic has added extra demands to the already pressure-filled roles and environments that nurses face daily. The rapid spread of COVID-19 and its susceptibility among the general population, including the families of nurses, physical fatigue, and workload can cause psychological stress for nurses on the front lines working in care units. Various reasons and stress triggers, including staff shortages and unpredictable staff placements, lack of role clarity, increased role complexity, workload, time pressure, uncertainty in meeting job requirements, patient deaths and suffering, exposure to infection, and many other factors have placed nurses under challenging situations.³⁵ Wu et al. suggested that nursing management can conduct psychological interventions for frontline nurses and their

family members, such as forming psychological counselling groups through social media (easily and quickly accessible) and inviting psychiatrists from their hospitals to join these groups to raise mental health awareness and address the mental health concerns of frontline nurses and their families free of charge.¹⁷ This way, nurses can be served by mental health experts without worrying about costs. According to Wu et al., positive stories and inspirational or successful cases were also shared in the counselling groups to motivate everyone in the hospital.¹⁷ Morse and Warshawsky also found that providing emotional support was crucial for patients and fellow nurses during the pandemic.¹⁴ Nurse managers can also play a key role in addressing the anxiety and fear of nurses related to COVID-19 by supporting their mental, psychological, and emotional health through evidence-based measures, issuing organizational policies that support enhanced mental health services, and providing a safe and secure work environment.³⁰

CONCLUSION AND RECOMMENDATION

This study found that at the beginning of the COVID-19 pandemic, nurse managers experienced panic and fear similar to the general public. Despite the fear and panic, nurse managers immediately reorganized inpatient rooms. For nurse managers, besides ensuring patient quality and safety, the main goal in inpatient management was the strong desire to protect the direct-care nurses. Valuable lessons from the pandemic for nurse managers include the availability of human resources, strong commitment from all levels, management support, and teamwork. These were the main supports in managing inpatient care for COVID-19 patients. Meanwhile, the shortage of PPE, frequently changing service flows, and the psychological needs of nurses were obstacles for nurse managers in the management of inpatient wards.

This study recommends that nurse managers assess the hospital's readiness to face a pandemic. Nurse managers are encouraged to create references that pertain to preparedness for dealing with a pandemic. This should include insights into managing inpatient facilities during the pandemic and analysing the factors support-

ing or hindering inpatient management. These references will be valuable resources for health policy and administration related to hospital preparedness in future pandemic-related crises.

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AUTHOR CONTRIBUTIONS

ABT and AAI conceptualized the study; ABT designed the methodology and conducted the interview; ABT and AAI performed the analysis and wrote, reviewed, and edited the manuscript. ABT: Andi Baso Tombong; AAI: Ani Auli Ilmi.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Nitric Oxide Levels in Primary Hypertension Patients Receiving Wet Cupping Therapy

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ABSTRACT

Wet cupping has been shown in several studies to lower blood pressure in hypertensive patients. However, the mechanism of action remains unknown, limiting its use as a complementary non-pharmacological treatment. This study aims to examine the effect of wet cupping on systolic blood pressure, diastolic blood pressure, and nitric oxide levels in hypertensive patients. The study employed a quasi-experimental method with a pretest and post-test design, including a control group. The sample consisted of 40 individuals, they were diagnosed with primary grade I hypertension. The participants were divided into two groups (treatment and control). The intervention group received wet cupping therapy twice, at a 28-day interval, while continuing their antihypertensive medication. The control group only consumed antihypertensive medication. The study revealed a significant decrease in systolic and diastolic blood pressure but no significant increase in nitric oxide levels. After the intervention, the systolic blood pressure in the intervention group decreased by 17.69 mmHg ($p=0.010$), compared to a decrease of 5.87 mmHg ($p=0.108$) in the control group, with a difference of ($p=0.010$). The diastolic blood pressure in the treatment group decreased by 11.56 mmHg ($p=0.000$), compared to a decrease of 0.73 mmHg ($p=0.570$) in the control group, with a difference of ($p=0.001$). The nitric oxide levels in the intervention group increased by 2.5 $\mu\text{mol/L}$ ($p=0.530$), compared to a decrease of 0.47 $\mu\text{mol/L}$ ($p=0.116$), in the control group, with a difference of ($p=0.539$). It can be concluded that wet cupping therapy reduces systolic and diastolic blood pressure but does not significantly increase nitric oxide levels in the blood of hypertensive patients.

INTRODUCTION

Hypertension is a chronic disease that affected 1.28 billion individuals in 2019. Indonesia accounts for 51.3 million cases, with a prevalence in adults aged 30-79 years reaching 40%. This figure is 5% higher than the global prevalence of 30.5% and the prevalence in the Southeast Asian region, which is 3%.¹⁻³ This figure is a cause for significant concern in Indonesia, given that statistical evidence indicates a 144% increase over the past two decades. The potential for various complications and the threat of being the main cause of death represent a significant burden for sufferers, underscoring the need for alternative treatments that can help prevent the worsening of the condition.⁴ Conversely, Furthermore, the average hypertensive patient also experiences a decrease in productivity due to their illness, which has an impact on their socioeconomic life. Additionally, they require high nominal medical expenses.⁵

Impaired vasodilation, stemming from endothelial dysfunction, serves as an initial indicator of hypertension. The vascular endothelium produces nitric oxide from L-arginine through the NO synthase enzyme. This molecule inhibits platelet adhesion and aggregation, facilitating blood vessel relaxation. Disruption in bioavailability or excessive degradation leads to decreased endothelial homeostasis.^{6,7}

The management of hypertension by the WHO and the Ministry of Health emphasises pharmacological intervention and lifestyle improvement through non-pharmacological means. The combination of these approaches is expected to assist patients in enhancing their quality of life by successfully controlling blood pressure and preventing complications.⁴ Controlled blood pressure is the primary treatment target for hypertensive patients. This can be achieved through dietary adjustments, reduced salt intake, exercise, maintaining an ideal body weight, avoiding smoking, and reducing stress. Data indicates a success rate of up to 30% with these methods.⁸

Wet cupping therapy, adapted from Middle Eastern medicine and Traditional Chinese Medicine (TCM), has been abandoned by many countries due to the transition to modern medicine. However, this practice has regained

popularity after being observed among athletes and celebrities worldwide.⁹ In Indonesia, it is common among certain groups and has been increasingly adopted over the years as an alternative for hypertension. Although no research explicitly mentions the growth of cupping use, the 2020 health profile report states that the growth of traditional health providers, which includes cupping therapy, has increased by 130 health centres from all over Indonesia.¹⁰ Data from a cupping clinic in Makassar City yearly increase in visits particularly after the COVID-19 pandemic. Several hospitals have begun integrating cupping with modern medicine through traditional and herbal medicine departments. Patient decisions, apart from being influenced by specific religious beliefs, are also based on the findings of several studies that have uncovered numerous health benefits of cupping, particularly in pain management.^{11,12}

The initial belief of the relationship was based on an experiment that found cupping dilates topical capillaries and increases blood flow in the skin. Blood vessels in the cupping area dilate by releasing vasodilators such as adenosine, noradrenaline and histamine, leading to increased circulation.¹³ Another study revealed that increased levels of NO synthase, an enzyme that produces NO from l-argin, were higher around the acupoints of rat skin. In line with this evidence, it is also explained that endothelial dysfunction and decreased NO production can affect the development of atherosclerosis. Mice with eNOS deficiency showed more atherosclerotic lesions, whereas mice with eNOS excess showed reduced lesion formation.¹⁴

This evidence strengthens the reason why the blood pressure of hypertensive patients who receive cupping can be controlled and affects their quality of life.¹² However, given the many doubts about cupping therapy other than for familiar therapies such as pain management.¹⁵⁻¹⁷ These conditions encourage the need for more research to prove that cupping is feasible as a complementary hypertension that can be accounted for in non-pharmacological management. Further research is required to elucidate the relationship between cupping and the reduction of patient blood pressure through the enhancement of nitric oxide bioavailability in individuals who undergo wet cupping.

MATERIAL AND METHOD

This study employed a quasi-experimental design with a pre-and post-test with control group design. The treatment's influence was assessed by comparing pre- and post-test values. The study population comprised hypertensive patients who made outpatient visit from July to December 2020 at clinics and hospitals in Makassar City. The sample consisted of individuals aged 36-60 years, consuming anti-hypertensive medications, non-smokers, and not consuming alcohol or herbs with high nitrate content. Exclusions were made for patients with a history of kidney disease and/or diabetes mellitus, insomnia, anemia, a history of blood clotting disorders, undergoing nitrate therapy, or being pregnant. Forty respondents were initially involved based on the hypothesis test calculation for the mean of two independent populations. Subjects were consecutively selected, with 9 of them dropping out during the study, resulting in data analysis involving only 16 individuals in the treatment group and 15 in the control group.

Patients' nitric oxide levels were obtained by venous blood sampling. Sample collection and examination were performed by laboratory assistants from Prodia Laboratory in Makassar. The samples were stored at a temperature of (-200c) and the analysis of the examination results was done simultaneously at the end of the study, namely at the beginning of the fifth week. Subsequently, the data from the laboratory examinations were subjected to analysis to

ascertain the discrepancies in the augmentation of nitric oxide levels between the treatment and control groups, employing the Paired T-test. To ascertain the discrepancy in the mean values prior to and following the intervention, the independent T-test and Mann-Whitney U-test were employed. This research has been granted ethical clearance by the Ethics Commission Health Research Faculty of Community Health Diponegoro University (No. 266/EA/KEPK-FKM/2020).

RESULTS

The baseline characteristics of the respondents were statistically homogeneous, except for nitric oxide levels. There were no significant differences between the two groups of respondents in terms of age, BMI, systolic blood pressure, diastolic blood pressure, and quality of life, with a p-value greater than 0.05. However, in terms of nitric oxide levels, the two groups exhibited statistically different characteristics (p-value 0.017) (Table 1).

After the intervention in the treatment group, the mean serum nitric oxide levels increased from 26.01 $\mu\text{mol/L}$ to 28.51 $\mu\text{mol/L}$, showing an increase of 2.5 $\mu\text{mol/L}$ with a p-value of 0.530. In contrast, in the control group, the levels decreased from 38.86 $\mu\text{mol/L}$ to 33.39 $\mu\text{mol/L}$, indicating a decrease of 0.47 $\mu\text{mol/L}$ with a p-value of 0.116. The statistical test results for the difference in nitric oxide levels between the two groups were not significant, with a p-value= 0.539 (Table 2).

Tabel 1. Analysis of Responden Charateristics

Variable	Treatment		Control		p-value
	Mean $\pm$ SD	Median (Min-Max)	Mean $\pm$ SD	Median (Min-Max)	
Age	47.83 $\pm$ 7.36	49 (33-63)	48.35 $\pm$ 9.09	46 (35-64)	0.849 ^a
BMI	26.13 $\pm$ 4.74	25.37 (18.73-37.78)	24.64 $\pm$ 3.14	25.61 (18.73-29.97)	0.258 ^b
Systolic Blood Pressure	137.39 $\pm$ 10.47	140 (120-150)	131.35 $\pm$ 0.25	132.50 (110-148)	0.087 ^c
Diastolic Blood Pressure	84.06 $\pm$ 5.87	83 (70-90)	80.75 $\pm$ 7.30	80 (70-97)	0.136 ^d
Nitric Oxide Levels	25.97 $\pm$ 10.73	25.10 (9.62-55.38)	36.59 $\pm$ 4.92	33.72 (16.74-1.30)	0.017 ^e
Quality of Life	56.50 $\pm$ 15.94	53.59 (26.45- 86.19)	58.12 $\pm$ 3.53	68.50 (8.58 - 96.30)	0.803 ^f
Duration of Diagnosis	5.55 $\pm$ 3.59	5 (1-12)	5.65 $\pm$ 3.72	5 (1-12)	0.931 ^g

Source: Primary Data, 2020

p-value a,b,e,f,g: Independent t-test; p-value c,d: Mann-Whitney

Tabel 2. Analysis of Serum Nitric Oxide Levels After Intervention

Nitric Oxide Levels	Treatment Group	Control Group	p-value
Mean $\pm$ SD	2.5 $\pm$ 15.57	- 0.48 $\pm$ 17.38	0.539 ^a
Δ Before – After Intervention	0.530 ^b	0.116 ^c	

Source: Primary Data, 2020

 Δ difference, a: Mann whitney b: Paired t-test c: Wilcoxon

The mean systolic blood pressure of hypertensive patients in the treatment group before the intervention was 139.19 and decreased to 121.50 mmHg after cupping therapy, indicating a decrease of 17.69 mmHg with a p-value of 0.001. In contrast, the control group exhibited a decrease from 131.87 mmHg to 126.00 mmHg, representing a decrease of 5.87 mmHg with a p-value of 0.108. The statistical test results for the difference in systolic blood pressure between the two groups were significant, with a p-value=0.010 (Table 3).

After the intervention in the treatment group, the mean diastolic blood pressure decreased from 83.63 mmHg to 78.06 mmHg, indicating a decrease of 11.56 mmHg with a p-value of 0.00. In contrast, the control group showed a decrease from 80.33 mmHg to 79.60 mmHg, representing a decrease of 0.73 mmHg with a p-value of 0.570. The statistical test results for the difference in diastolic blood pressure between the two groups were significant, with a p-value=0.001 (Table 4).

Table 3. Difference in Systolic Blood Pressure of Patients After Intervention

Systolic Blood Pressure	Treatment Group	Control Group	p-value
Mean $\pm$ SD	17.69 $\pm$ 14.79	5.87 $\pm$ 12.944	0.010 ^a
Δ Before – After Intervention	0.010 ^b	0.108 ^c	

Source: Primary Data, 2020

 Δ difference, a: Mann whitney; b,c: Wilcoxon**Table 4. Difference in Diastolic Blood Pressure of Patients After Intervention**

Dyastolic Blood Pressure	Treatment Group	Control Group	p-value
Mean $\pm$ SD	11.56 $\pm$ 7.42	0.73 $\pm$ 8.79	0.001 ^a
Δ Before – After Intervention	0.001 ^b	0.570 ^c	

Source: Primary Data, 2020

 Δ difference, a: Independent t-test; b,c: Wilcoxon

DISCUSSION

A decrease in blood nitric oxide levels is one of the early indicators of hypertension. Evaluated nitric oxide levels in hypertensive patients were found to be 25.14 μ mol/L $\pm$ 16.74, while in normotensive individuals, the levels were 55.28 μ mol/L $\pm$ 25.73.50. Vasodilation impairment resulting from reduced nitric oxide levels due to endothelial dysfunction in hypertension can be alleviated by the body's natural response to inflammation from the wound caused by cupping.^{6,18} An increase in NO synthase levels, the enzyme that produces NO from L-arginine around the cupping wound site, occurs. Another theory suggests that topical capillary dilation in the cupping area leads to increased blood flow in the skin area. This process releases vasodilators such as adenosine, norepinephrine, and histamine, thereby increasing circulation.¹³

However, these statements are not consistent with the findings of this study. The nitric oxide levels of the cupping intervention respondents increased by 2.5 μ mol/L (p=0.530), but this increase was not statistically significant. This discrepancy may be influenced by the NOS3 gene polymorphism. Its effect on blood pressure varies among individuals depending on ethnic groups, fat intake, and the patient's diet.¹⁹ These factors are confounders that were not controlled in this study, in addition to the initial non-homogeneous nitric oxide level data of the respondents in both groups.

The selection of cupping as an intervention in the study was based on several previous research findings that indicated its effectiveness in reducing blood pressure.^{20,21} Specifically, Aleyidi (2019) stated that there was a decrease in systolic pressure by 2.8 mmHg in hypertensive patients who underwent cupping intervention after the second intervention within a 4-week range. Similar studies conducted by Syahrumdani et al. (2021) also found the same result, with patient systolic blood pressure significantly decreasing (p=0.01 and 0.03).²² Besides these results, they also found that the total cholesterol levels of the respondents decreased by 5.41, which is thought to be one of the reasons for the decrease in systolic and diastolic pressure. This reaction is likely due to the hematological system

mechanism that significantly affects the coagulation pathway control by increasing blood flow and organ oxygenation.²¹ Another theory states that the reduction in arterial blood volume due to cupping incisions, as well as capillary dilation due to the negative pressure of the cup, leads to increased local blood flow.^{12,22}

The data analysis of systolic and diastolic blood pressure yielded consistent results, showing a significant decrease in systolic blood pressure by 17.69 mmHg ($p=0.010$) among respondents who underwent wet cupping intervention twice a 28-day interval. This is in line with the results of the significant difference between the intervention and control groups ($p=0.001$). However, there was a noticeable difference in the systolic pressure decrease by 14.89 mmHg compared to the previous study by Aleyidi, where they found a decrease in systolic pressure of only 2.8 mmHg. This difference could be attributed to the quantity and duration of cupping applications by the respondents. The effectiveness of cupping has been previously studied in 2019, and both of these factors significantly influenced the cupping outcomes.²³ Considering these results, cupping is likely a non-pharmacological complementary treatment for hypertension, with the clinical consideration that a stable and continuous 12 mmHg decrease in blood pressure in hypertensive patients can prevent 1 death out of every 11 treated patients.

From these results, a significant increase in blood nitric oxide levels does not accompany the decrease in blood pressure among respondents undergoing wet cupping. However, these results should be addressed. The mechanism of this decrease is likely due to a positive response associated with the improvement in the quality of life of patients following cupping compared to before.^{12,24}

CONCLUSION AND RECOMMENDATION

Based on this study, we can conclude that wet cupping therapy significantly reduces blood pressure in hypertensive patients. However, it does not significantly impact increasing nitric oxide levels. Further research is recommended for more accurate results. Homogenizing the treatment and control groups, especially regarding nitric oxide levels, needs to improve controlling respondent bias.

AUTHOR CONTRIBUTIONS

Conceived and designed the experiments by DP; NY performed the experiments, analyzed the data and wrote the manuscript; NR interpreted the respondent's laboratory results; MY made corrections to the manuscript and perfected the writing results. The authors read and approved the final manuscript. DP = Dwi Pudjonarko; NY = Nurhayani; NR = Nurahmi; MY = Misriyani.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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