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Effects of COVID-19 Pandemic on Changes in Nutritional Status and Physical Activities of School-Age Children: A Scoping Review

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ABSTRACT

This study's objective is to review the consequence of the COVID-19 epidemic on physical activities, sedentary lifestyles, screen time, and changes in the nutritional status of school-age children. The outcomes of this study are intended to be applicable to obesity management in children. This study reviewed full-text articles and open-access publications on the sedentary lifestyle of children during the pandemic. and the data were analyzed using cohort, case-control, and cross-sectional designs. The results of reviewing 17 articles show that school-age children's physical activities and nutritional status have decreased, but their sedentary lifestyle and screen time have increased due to social restrictions during the COVID-19 pandemic. Children's decreased physical activities are caused by the absence of a comparable replacement mechanism as that before the pandemic. Meanwhile, the increasingly sedentary lifestyle highly influences children's physical and mental health. Screen time has also increased and is unavoidable during the pandemic because children's activities were limited and their learning systems are switched to online learning; as a result, their supporting sedentary lifestyle increases while physical activities decrease. These factors have changed the nutritional status of children during the pandemic. These results support the idea that the pandemic will impact the health of school-age children, especially their nutritional status. This review concludes that it is important to establish policies that prevent children's further health effects, such as obesity, caused by COVID-19.

Keywords: COVID-19, nutritional status, physical activities, school-age children, sedentary lifestyle

INTRODUCTION

Obesity has become a world health problem, and it is estimated that 39% of people are overweight and obese (Chooi *et al.* 2019). The prevalence of overweight in women is lower than in men; on the contrary, obesity prevalence in women is higher than in men (Chooi *et al.* 2019). The national data show that 10.3% of the prevalence of adult obesity is found in women, and 7.5% of the prevalence of adult obesity is found in men; these numbers are higher than those of the regional data (GNR 2022).

The Indonesian Baseline Health Research reports that the percentage of overweight school children (6–14 years old) has increased from 2007 to 2013 (Megawati *et al.* 2021). Obesity in children has become a major public health problem, particularly in low socioeconomic groups (Sahoo *et al.* 2015).

World Health Organization (WHO) has declared the COVID-19 outbreak a global pandemic in early 2020 (Cucinotta & Vanellli 2020). All authorities respond by stipulating several policies to reduce the transmission rate, such as social restriction, social distancing, temporary school closure, restrictions on public places, restrictions on mass gatherings or crowds, and the obligation to wear masks (Cucinotta & Vanellli 2020). In the end, these policies directly impact society, including school-age children (Arum & Susilaningsih 2020).

A study has reported that school-age children perform a lack of physical activities during the COVID-19 pandemic (Moore *et al.* 2020). Approximately 70% of school-age children decreased their physical activities due to social restrictions during the pandemic (Zheng *et al.* 2020). This fact is against school-age children's natural characteristics, such as playing, moving, interacting in groups (Chusna & Utami 2020), and more actively exploring many things (Rachmawati *et al.* 2021). Another study has reported that the Body Mass Index (BMI) of

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children aged 2–19 years and obesity prevalence have increased by 16.1% during the COVID-19 pandemic (Lange *et al.* 2021). Children's limited mobility during the pandemic could lead to a lack of physical activities, a sedentary lifestyle, and changes in the nutritional status (Zheng *et al.* 2020).

Exploring the effects of the COVID-19 pandemic on school-age children's physical activities, sedentary lifestyle levels, screen time, and changes in nutritional status are pivotal and relevant to current conditions. This review aims to review the latest research results on decreased physical activities, sedentary lifestyle levels, screen time, and changes in nutritional status of school-age children during the pandemic. The results of this study are expected to bring important information to create a strategic solution and combat the effects of COVID-19 on the obesity in school-age children.

METHODS

This scoping review was carried out by involving articles, full-texts, and open access articles on the sedentary lifestyle of children published in 2020–2021. This study employed cohort, case-control, and cross-sectional designs. This study excluded investigation on non-child subjects, review studies, and studies without the cohort, case-control, and cross-sectional designs. The keywords were sedentary, sedentary lifestyle, sedentary behavior, sedentary behavior AND pandemic, COVID-19, COVID AND obesity, obese AND children, child, and school age. The search process was carried out using the Boolean technique on four journal databases: PubMed, ProQuest, ResearchGate, and Sciencedirect. The PRISMA flow diagram was used to ensure the best process of the article selection.

A total of 2,119 articles were identified through a database search. Most of the articles are published by ProQuest for 1,404 articles, followed by Science Direct, Research Gate, and Pubmed. Furthermore, all articles were examined in more detail based on the relevant titles and topics. Therefore, 2,075 articles were excluded. In the next stage,the abstracts of 44 selected articles were examined by considering the inclusion and exclusion criteria; this examination resulted in 28 articles. The next step was examining the full texts of the 28 remained articles. This examination resulted in seven articles for review. The seven articles consisted of six cohort studies and one cross-sectional study. The whole process of the article selection is presented in Figure 1.

RESULTS AND DISCUSSION

Seven selected articles were reviewed and presented descriptively. The impacts of the COVID-19 pandemic on children are grouped into physical activities, sedentary activities, screen time, and nutritional status

Physical activities of children during the COVID-19 pandemic

The effects of COVID-19 on children's physical activities are reported by five of the seven articles reviewed. These five articles mention that children's physical activities have significantly decreased during the pandemic; all p values are <0.01 with a negative association direction (Table 1).

A cohort study in Czech children in 2021 has found children's activities more severely

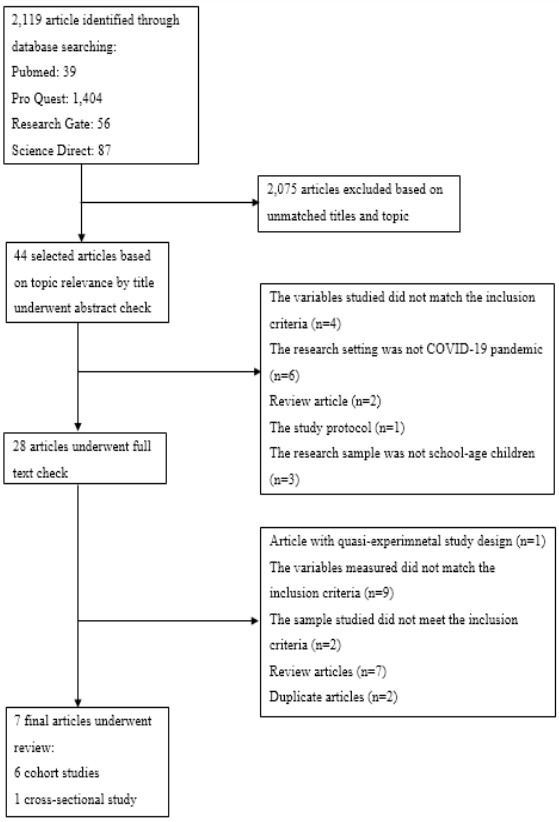

Figure 1. The PRISMA flow article selection diagram

decrease during the pandemic than before (Stverakova *et al.* 2021). The study reported that the children experienced a decline not only in total physical activities but also in spare time, before–school-activities, sports class activities, and rest activities (Stverakova *et al.* 2021). Another study in the Netherlands compared data from two cohorts and report non-converging results (Ten Velde *et al.* 2021). One of the cohort results mentioned that children's total physical activities ($p<0.01$) decrease. However, this result disagrees with another cohort study (Ten Velde *et al.* 2021). Children's decreased physical activities have also been recorded by a previous study which reveals a p-value of 0.002 (Alonso-Martinez *et al.* 2021). This result was supported by another study although it was not significant (Cachon-Zagalaz *et al.* 2021).

Children's physical activities decrease because they do not have alternative substitute activities during the pandemic (Stverakova *et al.* 2021). Children's organized indoor and outdoor activities decline; organized physical activities in distance learning encounter various challenges so that decreased physical activities of children cannot be optimally prevented (Vilchez *et al.* 2021; Gobbi *et al.* 2020). Another study also reported that returning children's physical activity levels to the same level as before the pandemic was probably difficult due to lack of parental support, amount of sleep time, lower energy, and lower time (Moore *et al.* 2020).

This review notes that several selected studies analyse age and gender with mixed results. A recent study states that neither age nor gender was significantly associated with decreased physical activities during the pandemic (Stverakova *et al.* 2021). Another study by Ten Velde *et al. (*2021) agrees that children's age was not associated with decreased physical activities, but data on gender show that girls' physical activities decrease more significantly than boys'. The next cohort study reported that physical activities decrease along with the increasing age; moreover, the study has found that girls' leisure time greatly increases (Dunton *et al.* 2020). A weaker cross-sectional study by Cachon-Zagalaz *et al.* (2021) reported that children's daily activities increased as they got older.

A longitudinal study has found that girls' physical activities have decreased; the older the girls, the greater the decline (Treuth *et al.* 2009). During the pandemic, another study cites children could not fulfil their basic physical activities due to social restrictions (Moore *et al.* 2020). Moore *et al.* (2020) explain that genders showed differences in physical activities; boys are physically more active than girls. The data on age denote that older children experienced a bigger impact of changes in their activity patterns than younger children do (Moore *et al.* 2020).

Sedentary activities of children during the COVID-19 pandemic

The sedentary lifestyle was reviewed from three selected articles (Table 1). An increased sedentary lifestyle was reported by Ten Velde *et al.* (2021) from two cohort results. Moreover, they report that the children's physical activities have lightly, moderately, and vigorously increased during the pandemic ($p<0.01$). The same result was reported by Alonso-Martinez *et al.* (2021) with a p-value of 0.006. Whereas a study has found two types of significant sedentary lifestyles in children: playing computer or video games by boys and talking on the phone or texting by girls (Dunton *et al.* 2020).

Keeping children from experiencing a sedentary lifestyle during the pandemic was proven to protect children's mental well-being (Gilbert *et al.* 2021). Children were the age group who are affected the most by the pandemic (Runacres *et al.* 2021). Runacres *et al.* (2021) stated that the increased sedentary lifestyle negatively impacts children's mental health, depression, anxiety, and quality of life. These problems are influenced by several factors, such as socioeconomic (the main factor), education levels of parents, overweight or obese parents, and parents' high anxiety about COVID-19 (Runacres *et al.* 2021). Runacres *et al.* (2021) have found that gender was not related to an increasingly sedentary lifestyle; however, girls were consistently reported to be more sedentary than boys.

Screen time of children during the COVID-19 pandemic

This review has found two articles reporting changes in screen time of children during the COVID-19 pandemic (Table 1). Ten Velde *et al.* (2021) report several results of screen time. They investigated two cohorts and have found that screen time for school purposes has significantly increased on weekdays and weekends (Ten Velde *et al.* 2021).

Table 1. Extraction results of articles on the impact of the COVID-19 pandemic on physical activity, sedentary lifestyle, screen time, and changes in nutritional status in school-age children

Title (Author; Year)	Country (Participant)	Type of study	Variable	Result	Association		
					Significancy	Type	Direction
Physical activity							
The impact of COVID-19 on physical activity of Czech children (Stverakova *et al.* 2021)	Czech Republic (Children aged 8–12 years (n=98) during lockdown and (n=206) pre-COVID)	Cohort	Pre COVID vs during COVID	The mean PAQ-C (physical activity) total score	Significant (p<0.001)	Decreased	(-)
				Spare time (activities during leisure time)	Significant (p=0.001)	Decreased	(-)
				Activities before school	Significant (p=0.003)	Decreased	(-)
				Activities during sports learning	Significant (p<0.001)	Decreased	(-)
				Activity at Rest	Significant (p<0.001)	Decreased	(-)
			Pre COVID vs during COVID by gender	The PAQ-C scores between gender	No data mentioned	n/a	n/a
			Pre COVID vs during COVID by age	The PAQ-C scores between age	Not significant (p=0.217)	n/a	n/a
Physical activity behaviour and screen time in Dutch children during the COVID-19 pandemic: Pre-, during- and post-school closures (Ten Velde *et al*. 2021)	Netherland (Cohort A=children aged 4–18 years participating in children obesity and lifestyle during COVID-19 (COLC) (n=102) Cohort B=children ages 7–12 years from clinicatrial.gov study: NCT03440580 (n=131)	Cohort	Before COVID vs during COVID based on subjective measurement	The total time of physical activity - Cohort A	Significant (p<0.01)	Decreased	(-)
				- Cohort B	Not significant	n/a	n/a
				School activities - Cohort A	Significant (p<0.01)	Decreased	(-)
				- Cohort B	Not significant	n/a	n/a
				Sport activities - Cohort A	Significant (p<0.01)	Decreased	(-)
				- Cohort B	Significant (p<0.01)	n/a	n/a
				Leisure activities - Cohort A	Significant (p<0.01)	n/a	n/a
				- Cohort B	Not significant	n/a	n/a
			Before COVID vs during COVID by age	Total physical activity	Not significant	n/a	n/a
			Before COVID vs during COVID by gender	Light physical activity between boys and girls	Significant (p<0.02)	Decreased (girls>boys)	(-)

Continue from Table 1

Title (Author; Year)	Country (Participant)	Type of study	Variable	Result	Association		
					Significancy	Type	Direction
Early effects of the COVID-19 pandemic on physical activity and sedentary behaviour in children living in the US (Dunton *et al.* 2020)	USA (211 children aged 5–13 years through an online survey reported by parents)	Cohort	Physical activity by age	Total time of physical activity	Significant (p=0.001; β=-0.234)	Decreased (older>younger)	(-)
				School time	Significant (p<0.001; β=0.422)	Increased (older>younger)	(+)
				Sitting time	Significant (p=0.004; β=0.206)	Increased (older>younger)	(+)
				Sitting time to relax	Significant (p<0.001; β=0.337)	Increased (older>younger)	(+)
				Sitting time to relax	Significant (p=0.001; β=0.235)	Increased (girls>boys)	(+)
			Physical activity by gender	At home/garage	Significant (p=0.003)	Increased	(+)
			Physical activity by location	Sidewalk/street house	Significant (p=0.038)	Increased	(+)
				The park	Significant (p=0.040)	Decreased	(-)
Physical activity, sedentary behaviour, sleep, and sleep-regulation in Spanish pre-schoolers during the COVID-19 lockdown (Alonso-Martinez *et al.* 2021)	Spain (Children aged 4 to 6 years from 3 (three) different schools (n=268). The data comes from the initial assessment (September-December 2019) and the second evaluation in March-April 2020)	Cohort	Children experience during lockdown	Physical activity	Significant (p=0.002)	Decreased	(-)
				Strenuous physical activity (MVPA)	Significant (p<0.001)	Decreased	(-)
				Sleep efficiency	Significant (p=0.047)	Decreased	(-)
				Internalizing behaviour	Significant (p=0.003)	Increased	(+)
				Externalizing behaviour	Significant (p<0.001)	Increased	(+)
Physical activity and daily routine among children aged 0–12 during the COVID-19 pandemic in Spain (Cachon-Zagalaz *et al*. 2021)	Spain (Children aged 0–12 years (n=837), 50.2% boys (n=420) and 49.8% girls (n=417)	Cross-sectional	Physical activity during COVID-19	Sleep time	Significant (p=0.033)	Increased (girls>boys)	(+)
				There was a significant difference between the type of family in children's daily screen time, sleep time in a day, and daily activities			
				Daily activities	Significant (p=0.025)	Increased (girls>boys)	(+)
			Physical activity during COVID-19 by age	Daily physical activity practices	Significant (p=0.03)	Increased (older>younger)	(+)
				Daily activity	Significant (p=0.002)	Increased (older>younger)	(+)

Continue from Table 1

Title (Author; Year)	Country (Participant)	Type of study	Variable	Result	Association		
					Significancy	Type	Direction
			Physical activity during COVID-19 by family type	The highest sleep time per day was recorded in children living with several families	Significant (p=0.025)	n/a	n/a
				The highest daily activity was recorded in children with divorced parents	Significant (p=0.010)	n/a	n/a
			Physical activity during COVID-19 by children's level of active	The more active children, the daily physical activity will increase	Significant (p=0.000)	Increased	(+)
Sedentary lifestyle							
Physical activity behaviour and screen time in Dutch children during the COVID-19 pandemic: pre-, during-and post-school closures (Ten Velde *et al.* 2021)	Netherland (Cohort A= children aged 4–18 years participating in Children Obesity & Lifestyle during COVID-19 (COLC) (n=102); Cohort B=children ages 7–12 years from clinicatrial.gov study: NCT03440580 (n=131)	Cohort	Before COVID vs during COVID based on objective measurement	Sedentary time	Significant (p<0.01)	Increased	(+)
				Light physical activity	Significant (p<0.01)	Decreased	(-)
				Moderate to vigorous physical activity	Significant (p<0.01)	Decreased	(-)
Early effects of the COVID-19 pandemic on physical activity and sedentary behaviour in children living in the US (Dunton *et al.* 2020)	USA (211 children aged 5–13 years through an online survey reported by parents)	Cohort	Type of sedentary lifestyle by gender	Playing computer or video games	Significant (0.006)	Increased (boys>girls)	(+)
				Talking on phone/texting	Significant (0.008)	Increased (girls>boys)	(+)
Physical activity, sedentary behaviour, sleep, and sleep-regulation in Spanish pre-schoolers during the COVID-19 lockdown (Alonso-Martinez *et al.* 2021)	Spain (Children aged 4 to 6 years from 3 (three) different schools (n=268). The data comes from the initial assessment (September–December 2019) and the second evaluation in March–April 2020)	Cohort	Children experience during lockdown	Sedentary time	Significant (p=0.006)	Increased	(+)

Continue from Table 1

Title (Author; Year)	Country (Participant)	Type of study	Variable	Result	Association		
					Significancy	Type	Direction
Screen time							
Physical activity behaviour and screen time in Dutch children during the COVID-19 pandemic: pre-, during-and post-school closures (Ten Velde *et al.* 2021)	Netherland (Cohort A= children aged 4–18 years participating in Children Obesity and Lifestyle during COVID-19 (COLC) (n=102); Cohort B= children ages 7–12 years from clinicatrial.gov study: NCT03440580 (n=131)	Cohort	Before COVID vs during COVID	Screen time related to school			
				- Cohort A	Significant (p=0.04)	Increased	(+)
				- Cohort B	No data	n/a	n/a
				Weekday screen time			
				- Cohort A	Not significant	n/a	n/a
				- Cohort B	Significant (p<0.01)	Increased	(+)
Physicalactivity and Daily Routine among Children Aged 0–12 during the COVID-19 Pandemic in Spain (Cachon-Zagalaz *et al.* 2021)	Spain (Children aged 0–12 years (n=837), 50.2% boys (n=420) and 49.8% girls (n=417))	Cross-sectional	Screen time during COVID-19	Screen time	Significant (p=0.013)	Increased (boys>girls)	(+)
			Screen time during COVID-19 by age	Daily screen time	Significant (p=0.000)	Increased (older>younger)	(+)
			Screen time during COVID-19 by family type	The highest screen time was in children with single parents compared to other children	Significant (p=0.043)	n/a	n/a
			Screen time during COVID-19 by children's level of active	The more active children, the screen time will decrease	Significant (p=0.018)	Decreased	(-)
Nutritional status							
Paediatric BMI changes during COVID-19 pandemic: An electronic health record-based retrospective cohort study (Brooks *et al.* 2021)	United State of America (Children aged 6–17 years (n=191,846) with details taken from the results of the WCC U.S Electronic Health Record (EHR) data from Optum 2017–2019 (n=144,714) and 2020 data (n=47,132)	Cohort	BMI changes (ΔBMI) vs age group	Children aged 6–9 years	Significant (p=0.002)	Increased	Potentially (+)
				Children aged 10–13 years	Significant (p=0.003)	Increased	Potentially (+)
				Children aged 14–17 years	Not significant	n/a	n/a
Projecting the impact of the coronavirus disease (continue)	United State of America (Children who come from various (continue)	Cohort	BMI and Childhood Obesity Prevalence	BMI in girls in the group of children with COVID-19 compared to the control.	Significant (p<0.05)	Increased	(+)

Continue from Table 1

Title (Author; Year)	Country (Participant)	Type of study	Variable	Result	Association		
					Significancy	Type	Direction
(continue) 2019 pandemic on childhood obesity in the United States: a microsimulation model (An 2020)	(continue) economic backgrounds, races, regions (n=15.631), were taken from data from the Early Childhood Longitudinal Study, Kindergaten Class of 2010–2011 (ECLS-KC:2011))			The prevalence of obesity in the group of girls with COVID-19 compared to the control group	Significant ($p<0.05$)	Increased	(+)

Another cross-sectional study by Cachon-Zagalaz *et al.* (2021) noted several results. They reported that screen time significantly increases in boys and girls. However, boys experienced a higher increase in screen time than girls do. An identical condition has also been found in older children compared to younger ones (Cachon-Zagalaz *et al.* 2021). Children with a single parent have more screen time than other children do although the difference was not significant ($p=0.043$). Meanwhile, active children have shown less screen time than physically not active children with a p-value of 0.018 (Cachon-Zagalaz *et al.* 2021).

According to Musa *et al.* (2021), screen use was necessary during the COVID-19 pandemic. Parents are strongly advised to have vigilance of screen-time sedentary behaviour as a precursor of NCDs (Musa *et al.* 2022). Another study deploys that increasing screen time in children during the pandemic is unavoidable, but screen time not for school purposes or learning activities should be limited (Olive *et al.* 2021). Olive *et al.* (2021) mentioned that an increase in screen time can usually be accompanied by sleep disturbances, mental health problems, and physical activity issue that strongly urge all families to significantly deal with this issue (Olive *et al.* 2021).

Nutritional status of children during the COVID-19 pandemic

Two studies reported a significant increase in children's BMI as presented in Table 1. Brooks *et al.* (2021) report that children aged 6–9 years and 10–13 years significantly increased their BMI; this condition did not occur among children aged 14–17 years. An (2020) reports that girls have experienced an increase in BMI during the COVID-19 pandemic. Both studies also reported that obesity prevalence has inclined in girls and boys.

Lange *et al.* (2021) have found increase in children's BMI values. The BMI of children aged 2-19 years has doubled during the COVID-19 pandemic (Lange *et al.* 2021). Children who were initially overweight or obese before the pandemic experienced a higher average BMI increase than children with a normal weight do (Lange *et al.* 2021). The increased BMI is triggered by an online or hybrid environment which reduces children's opportunities to do physical activities or obtain healthy food as provided at school (Lange *et al.* 2021).

Another study has revealed a change in the Z-score of children during the pandemic (Weaver *et al.* 2021). Weaver *et al.* (2021) also state that girls have a higher increment of the z-score than boys do. They argue that this change was caused by children's difficulty to access scheduled regular activities, compulsory physical activities, and physical education at school (Weaver *et al.* 2021). Children also experienced food insecurity since they cannot access healthy food usually provided by the school as well as experience changes in sleeping time; both were factors triggering overweight and obesity (Weaver *et al.* 2021).

CONCLUSION

This review has generally shown the advanced risk of overweight and obesity in childhood during the pandemic. The results of the review strengthen other studies that underline

a potentially grown prevalence of overweight and obesity. Therefore, the results of this review could serve as a consideration to determine a better preventive strategy for dealing with the prevalence of overweight and obesity in children. Some strategies include adding or activating children's daily physical activities at home and at school. The unavoidable increase in screen time due to the pandemic must be immediately addressed to increase children's physical activities outside school hours at home. All parties must respond to changes in the nutritional status of children by suppressing the causative factors, such as low physical activities, increased sedentary lifestyle, and screen time, during the pandemic.

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DECLARATION OF INTERESTS

The authors state that there is no conflict of interest in the implementation of this research from start to finish.

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Students' Nutrition Knowledge and Teachers' Perceptions of Integrating Nutrition Messages into Junior High School Curriculum

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ABSTRACT

This study aimed to measure nutritional knowledge and observe teachers' perceptions of delivering nutrition messages through an e-module within the junior high school curriculum. This study was conducted at SMPN 35 Medan and employed the quasi-experimental approach, and a one-group pretest-posttest design was used. This study's population was students in grades 7 and 8. The minimum sample size was 102 students after adding 10% of the total sample size. Teachers' perceptions were taken from four subject teachers. Data were collected using a questionnaire survey and an interview. A focus group discussion was conducted with the teachers to gather information about their perceptions of using an e-module to deliver nutrition messages at school. The data were analyzed using the Wilcoxon test. The results showed that the student's average total knowledge score before receiving the nutrition education intervention was 22.66. It increased to 26.48 after students received the intervention. Teachers used the e-module to deliver content learning about nutritional messages in schools and employed the e-module to deliver the relevant subject matters of nutrition messages at school. The teachers realized the importance of delivering nutrition messages to the students. The e-module could broaden the teachers' horizons as they came to realize that nutrition messages could be delivered through various subjects. They initially believed that nutrition messages could only be taught in the subject of natural sciences. However, they discovered that nutrition messages could also be delivered in other subjects, such as mathematics, crafts, and physical education.

Keywords: integration, junior high school curriculum, nutrition messages

INTRODUCTION

Adolescence is the second period of rapid growth in the human life cycle; low nutritional quality in this stage will cause stunting and potentially hamper optimal physical growth and cognitive development. Currently, Indonesian youth bear three nutritional burdens: malnutrition, excess body weight, and micronutrient deficiencies, which still show quite high levels (UNICEF 2020). The national short stature prevalence for adolescents aged 13–15 years was 35.1% (13.8% indicating very short and 21.3% indicating short). Meanwhile, underweight (body mass index for age) and wasting showed 6.7% and 1.4% of prevalence, respectively (Ministry of Health Republic of Indonesia (MoH RI) 2018). The 2018 Basic Health Research (Riskesdas) reported that the anemia prevalence in adolescents was 32%, meaning that 3–4 adolescents out of 10 suffer from anemia. However, overnutrition still becomes a problem among Indonesian adolescents because the overweight prevalence is still relatively high at 8.3%, and 2.5% of adolescents are obese (MoH RI 2018). Nearly 15% of adolescents are overweight or obese. The trend occurs more frequently in girls than boys. Many adolescents and parents are unaware that their current eating habits will impact their future health status.

The very rapid development of technology has changed adolescents' diets and physical activities (UNICEF 2021). Most adolescents spend their free time in a lack of physical activities. Instead of doing physical activities, they spend their time on the Internet while eating processed food, cakes, fried foods, and crackers. The easier access to food provided by various online food applications has contributed to the severe decline in adolescents' physical activities.

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Such conditions indirectly raise nutritional problems in adolescents (Juniartha & Darmayanti 2020).

Physical activities and healthy eating behavior could significantly prevent obesity (Hastoety *et al.* 2017). The conditions of being overweight and obese during childhood and adolescence could be overcome by improving one's food environment, increasing healthy food consumption, avoiding unhealthy food consumption, and increasing physical activities (UNICEF 2020). Improving nutrition could significantly impact youth. Adolescent girls have a strategic role in improving the nutritional status of their future children to prevent malnutrition.

A school is a place for students to learn and presents a great opportunity to allow them to shape and change their behavior as desired. Moreover, some efforts are systematically made at school to shape their behavior. It is known that there is a close relationship between knowledge and behavior (Haryana *et al.* 2019; Lathifa & Mahmudiono 2020). Teachers play a big role in providing knowledge and a source of information for adolescents at school. Teachers can influence students' mindsets, increase their knowledge, improve their attitudes, and encourage changes in their behavior. Currently, nutrition materials are rarely delivered in schools. These limited materials are only delivered in a select few subjects in junior high schools (Nurjhani *et al.* 2012). If teachers have insufficient knowledge about nutrition, nutrition information cannot be delivered to students. Research on students' nutritional concept mastery revealed that, on average, students did not reach 50% of all concepts taught in the junior high school curriculum (Nurjhani *et al.* 2012). The lack of nutritional information accessible to students from their junior high school curriculum causes these students to perform poor nutritional behavior. Strategies to integrate nutrition messages into the subject taught by teachers may pave the way to implementing nutrition education for junior high school students. Thus, the need for nutrition education guidelines, especially for adolescents, now arises.

A study found that properly packaged modules with interesting pictures could become one of the most effective learning media to increase knowledge for both teachers and students (Aries *et al.* 2018). Nutritional information availability is very important to improve students' nutritional behavior (Haryana *et al.* 2019; Wardhani *et al.* 2021). If students are given access to nutrition information at school, they will be more likely to apply it. Teachers can provide nutrition messages for students. Most students will heed the information they deliver because they trust the teachers; therefore, integrating nutrition messages into school subjects will increase the possibility for students to apply the nutrition messages. During the COVID-19 pandemic, students did online learning from home; this condition forced them to spend a lot of time on sedentary activities, meaning their physical activities decreased (Firmansyah *et al.* 2021). Students need information about correct nutritional behavior to avoid nutritional and health problems.

This study aimed to measure nutritional knowledge and observe teachers' perceptions of delivering nutrition messages through an e-module according to the junior high school curriculum.

METHODS

Design, location, and time

This study employed a quasi-experimental design with one pre-test and post-test group. This study provided nutrition education for research subjects by implementing nutrition messages at schools. Afterward, changes in knowledge were measured before and after the treatment. This study was conducted at SMPN 35 Medan (a public junior high school) from September to November 2020. The research site was selected purposively because this school was strategically located. The research site was located between offices, schools, shopping centers, and several campuses which probably influenced students' nutritional behavior.

The Research Ethics Committee of the Faculty of Public Health, Universitas Sumatera Utara approved the research protocols (No. 552/KEP/USU/2020).

Sampling

The population of this study was 820 students from 22 classes of grades 7 and 8 at SMPN 35 Medan. The sample was calculated using the Lemeshow formula with a proportional consideration of 0.5. The calculation obtained a

sample size of 93 people plus a 10% correction. The sample class was selected using the random sampling technique. For grade 7, classes 7.3 and 7.8 were selected; for grade 8, class 8.1 was selected. The sample is carried out by total sampling from the selected class which amounts to 102 respondents. Teachers' perceptions were observed by four subject teachers. Data were collected through a questionnaire survey and interview.

Data collection

This study employed a pre-post intervention research design by delivering nutrition messages using an e-module at school to junior high school students. Nutrition knowledge was measured to investigate any changes before and after the intervention. The nutrition messages at school were delivered via online and offline methods. The intervention was conducted twice a week for two weeks in each class. The duration of each meeting was 30–45 minutes. The intervention time was determined based on an agreement with the teachers and the school.

The e-module to apply nutrition messages at school is part of this study. The e-module was designed by the teachers for teaching the subjects by considering nutrition messages. This e-module was created by incorporating nutrition messages into the topic of several selected subjects. Previous research revealed four selected subjects taught in grades 7 and 8: natural science, physical education, mathematics, and crafts. The nutritional messages inserted into the subject topics included messages, benefits, suggested messages equipped with examples, and practice questions.

The nutritional messages that were integrated into these subject topics included message content, benefits, suggestions, some examples, and exercises. The e-module served as a guide for teachers to integrate nutritional messages into the subject topics taught in the class. The 16 nutrition messages included: 1) consuming a variety of foods; 2) consuming fibrous food, such as vegetables and fruits; 3) having breakfast every morning; 4) increasing knowledge about the relationship between nutrition and reproductive health; 5) eating iron-rich food; 6) eating calcium-rich food; 7)consuming various carbohydrate-rich foods; 8) limiting sugar, salt, and fat consumption; 9) limiting fast food consumption; 10) reading the label when buying packaged food; 11) drinking eight glasses of clean water a day; 12) consuming safe foods for health; 13) doing physical activities and monitoring body weight regularly; 14) not smoking and drinking alcohol; 15) using smartphones wisely, and 16) consuming iodized salt.

This e-module was a guide for teachers to successfully insert nutrition messages into the subjects they taught. The teaching methods they used for this study were lectures and discussions. Data on students' nutritional knowledge were obtained by distributing a questionnaire on Google Forms. The case-based e-module was made using Google Sites and Google Forms.

Data analysis

The nutrition knowledge questionnaire consisted of 36 questions. Each correct answer for a question scored 1, and each incorrect answer scored 0 (Khomsan 2021). The data on the nutrition knowledge variable were processed by adding up the scores. Nutrition knowledge data were collected using the survey method. If the collected data were normally distributed, it would be analyzed using the Wilcoxon test. Focus group discussions were conducted to explore teachers' perceptions of using e-modules to implement nutrition messages at schools. Some questions were asked about the teachers' perceptions of the nutrition messages, as well as the benefits and difficulties of delivering messages and suggestions. The data on teachers' perceptions of using the e-module were analyzed qualitatively.

RESULTS AND DISCUSSION

Characteristics of junior high school students

The research samples were dominated by female students. The students were from small-sized families (33.7%), moderate-sized families (51.5%), and large-sized families (13.8%). They were 13, 14, and 15 years old (20.7%, 28.7%, and 49.6%, respectively). Moreover, most sample students had normal nutritional status (74%). Only 18.8% of the students had poor nutritional status, and 5.9% of them were obese. In addition, this study found that 72.2% of the students came from non-poor families (Table 1).

Students' nutrition knowledge

The results show that the student's average knowledge score before receiving the nutrition

Table 1. Subjects' socio-demographic characteristics

Characteristics	n	%
Sex		
Male	58	57.4
Female	43	42.6
Household size		
Small	34	33.7
Medium	52	51.5
Large	15	14.8
Age (year)		
13	21	20.7
14	29	28.7
15	51	49.6
Body mass index		
Underweight	19	18.8
Normal	74	74.3
Obese	7	6.9
Socioeconomic status		
Poor families	28	27.8
Non-poor families	73	72.2

education intervention was 22.66. However, their average score increased to 26.48 after receiving the intervention (Table 2). To summarize, the students' average knowledge score increased by 3.82 points, from 22.66 to 26.48. The statistical results showed a significant difference between the knowledge scores before and after the intervention ($p<0.05$).

Yurni and Sinaga (2017) investigated nutrition education's effect on elementary school students' balanced nutrition knowledge. They found that after receiving a nutrition education intervention, the student's knowledge of balanced nutrition increased from 44.2% to 65.4% and was categorized as good. Another study examined 216 students in Istanbul and involved three types of interventions for mathematics subjects, such as video-mediated, peer-directed, and visual aids. The results of the study showed that the students' nutritional knowledge increased after the intervention in their mathematics class using all learning methods (Aydin *et al.* 2022). All the intervention methods resulted in significant increases in post-test scores ($p<0.05$).

Table 2. Changes in the proportion of sample students by nutrition knowledge level before and after the delivery of nutrition messages

	Mean±SD	*p*
Before intervention	22.66±3.86	0.05*
After intervention	26.48±4.09	
Score difference	3.82	

SD: Standar Deviation

Table 3 presents the average nutritional knowledge percentage before and after the intervention. The nutrition knowledge questionnaire comprised 36 questions about 16 nutritional messages. Each message, examined with a different number of questions, was used. The knowledge percentage increased to 14.8 points after the nutrition education was implemented by the teachers.

Students' average nutritional knowledge percentage before education was 61.3 However, their average percentage increased to 14.8 after the e-module with nutrition messages was applied. Nutrition education for students could improve their nutritional knowledge and practices (Ekayanti *et al.* 2014; Haryana *et al.* 2019; Follong *et al.* 2022).

Table 3 shows that the message with the lowest number of correct answers was message 12, "consuming safe foods for health." Initially, the students did not know how to choose safe foods with an average percentage of 22.3 point, but after the intervention, most of them understood how to choose and consume safe food with an increased percentage of 44.5 points. Warlenda and Desnovianti (2018) also found a low level of knowledge about safe food selection (38.2%). Applying a modified monopoly game could improve elementary school student's knowledge and attitudes toward food safety (Enjelina *et al.* 2020). Inadequate knowledge is one of the factors that contribute to selecting unsafe snacks (Warlenda & Desnovianti 2018; Enjelina *et al.* 2020).

The message with the second-fewest correct answers was message 16, "consuming iodized salt." This study found that the students did not know the benefits of iodized salt (average percentage of 36.1 points). After the intervention, the iodized salt knowledge percentage increased to 78.7 points. Long-term iodine deficiency will decrease someone's intelligence. A previous study proved that health education on iodized salt affected students' knowledge at Campursalam Public Elementary School in Parakan District, Temanggung Regency (Ariyoso 2016).

Table 3. Average nutritional knowledge percentage of each message before and after intervention

Nutrition message	Pre-test	Post-test
	Mean±SD	Mean±SD
Eat a variety of foods	43.6±0.50	60.4±0.49
Consume fibrous foods such as vegetables and fruit	64.4±0.48	77.7±0.42
Have breakfast every day	74.8±0.44	86.6±0.34
Increase knowledge about the relationship between nutrition and reproductive health	72±0.46	78.8±0.42
Eat iron-rich foods	61.4±0.51	66.7±0.47
Eat calcium-rich foods	67.3±0.47	71.3±0.46
Get used to consuming a variety of carbohydrate-rich foods	59.4±0.49	71.3±0.46
Limit sugar, salt, and fat consumption	58.9±0.49	63.4±0.48
Limit fast food consumption	80.2±0.40	90.1±0.30
Read the label every time you buy packaged food	67.3±0.47	80.2±0.40
Drink eight glasses of clean water per day	77.2±0.42	81.7±0.39
Eat foods that are safe for the health	22.3±0.36	66.8±0.50
Do physical activity and monitor your body weight regularly	83.7±0.37	88.6±0.32
Do not smoke or drink alcohol	60.4±0.49	65.8±0.48
Use your smartphone wisely	52.5±0.50	89.6±0.31
Consume iodized salt	36.1±0.48	78.7±0.50
Average of all items	61.3±0.45	76.1±0.42

SD: Standar Deviation

Teachers' perceptions of delivering nutrition e-module at school

The e-module for delivering nutrition messages at school was integrated into four junior high school subjects: natural sciences, physical education, mathematics, and crafts. Teachers played an important role in integrating 16 nutritional messages into these subjects by considering the materials taught. For example, basic competence 4.2 of the craft subject stated one of the subject objectives was "to process, serve, and package vegetable foodstuffs into health foods and beverages in the local area". To achieve this competence, four nutrition messages were incorporated, namely message 2 "consuming fibrous foods, such as vegetables and fruits", message 10 "read labels anytime buying a packaged food", message 11 "drinking eight glasses of clean water every day", and message 12 "consuming safe food for health." Each message consisted of message content, examples, and exercises. The following is one instance of a nutrition message getting incorporated into the craft subject, which inserted the second nutrition message about consuming fibrous foods, such as vegetables and fruits.

Figure 1 and Figure 2 show a cover, a lesson plan containing a message, basic competencies expected to be acquired after learning, the meaning of the message, materials, and learning activities involved. The teachers were given detailed lesson guides, examples, activities, and exercises aided by video media and flyers, connected directly from the sources, and equipped with a questionnaire to measure the students' nutritional knowledge.

After receiving socialization on using the e-module to deliver nutrition messages in schools, many teachers realized the importance of these messages for students; in other words, this socialization broadened their horizons to understand that nutrition messages could be inserted into various subjects. They used to think that the topic of nutrition could only be taught in natural sciences. They realized that nutrition materials can also be inserted into other subjects, such as mathematics, crafts, and physical education. A study on junior high school mastery of nutrition concepts by Nurjhani *et al.* (2012) reported that some nutrition materials taught in natural sciences could be useful in everyday life

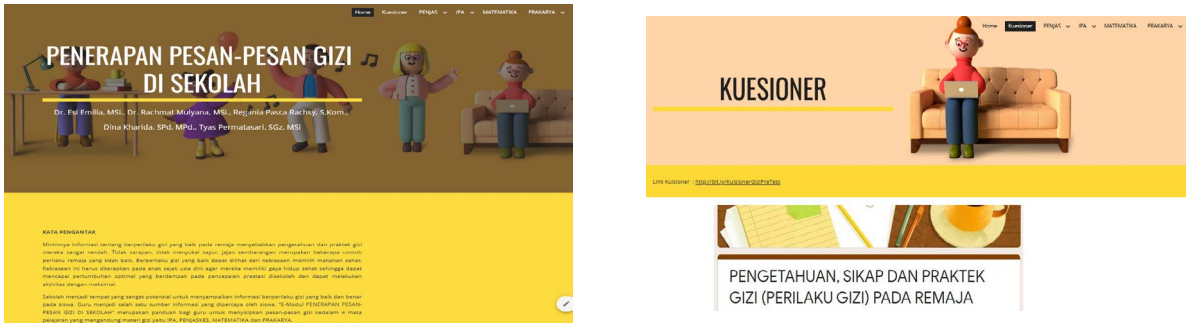

Figure 1. Cover and questionnaire e-module delivery of nutrition messages in school

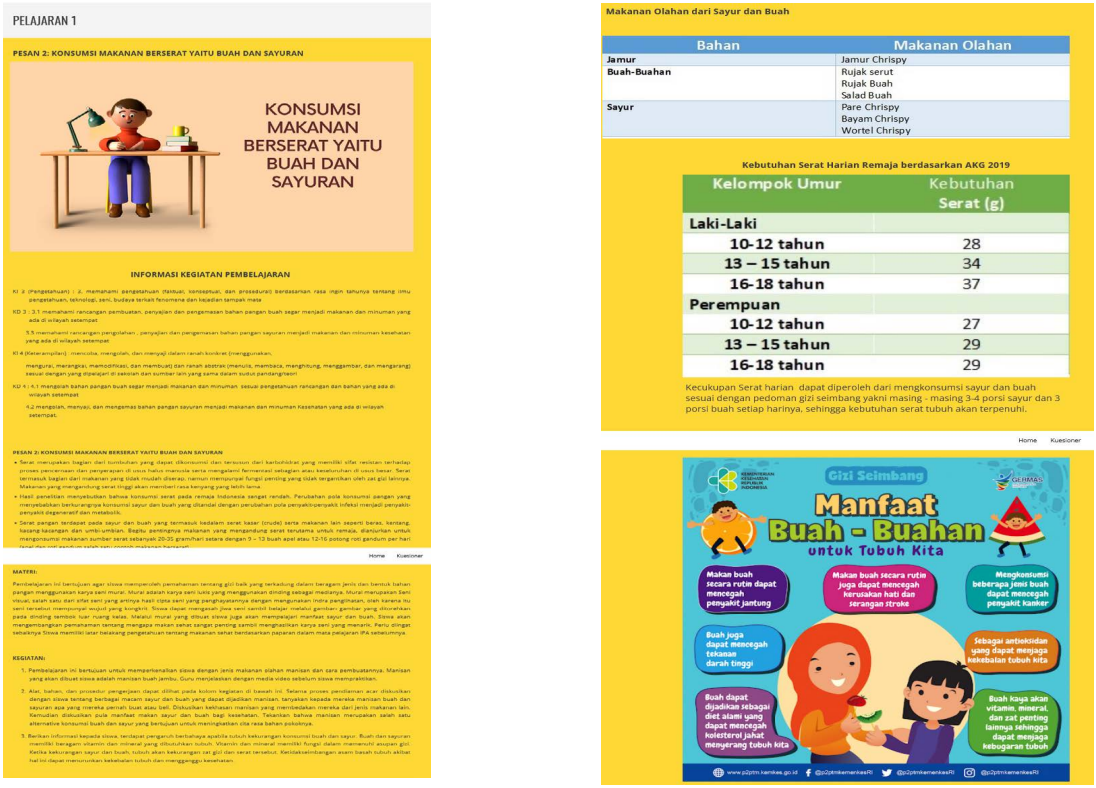

Figure 2. A material example in the e-module

(Nurjhani *et al.* 2012). For example, balanced foods are arranged in a food pyramid, strategies to read labels on food packaging, and animals' digestive enzymes.

A Focus Group Discussion (FGD) was conducted with teachers to bring to light their perceptions of using the e-module to deliver nutrition messages at school, its benefits, and its implementation in the classroom. According to the FGD, the e-module was easily understood, had a simple presentation, and was in line with the learning materials. The essence of the delivered messages was well-illustrated in the learning activities, and the instructions for using the guidebook and the learning process were clear.

One of the results of the FGD with the teachers showed that some students had difficulties in implementing the message of having breakfast every morning. The teachers recognized that many students did not have breakfast at home for various reasons. Even many teachers did not have time for breakfast. Students who miss breakfast do not have enough energy intake, causing them to be non-productive, have difficulty concentrating, and become lethargic (Larega 2015).

The teachers suggested planting fruit trees within the school area. It is known that schools and other public areas are usually decorated with ornamental plants. Additionally, planting fruit trees in the school area is expected to produce delicious fruits for students and teachers; thus, their vitamin, mineral, and dietary fiber needs would be fulfilled.

The teachers realized the importance of instilling good nutritional behavior from an early age because it greatly impacts the students' growth and determines their achievement of optimal health in adulthood. Besides that, the teachers realized the need for delivering nutrition messages during lessons at school. The nutrition interventions at school should involve parents and teachers because they can affect children's eating behavior (Haryana *et al.* 2019).

The e-module could motivate teachers to innovate in learning while delivering nutrition messages, broaden their horizons, and provide greater examples than guidebooks. Teachers' creativity in teaching nutrition materials in the classroom gives the teachers and students an idea of the importance of correct nutritional behavior. Teachers play a very important role in providing nutrition information for students. From an early age, teachers occupy the best position to influence them (Aries *et al.* 2018)

This e-module received a lot of positive responses from the teachers. The teachers proposed that nutrition messages should be inserted into other subjects besides the four selected ones, such as English and Indonesian Language subjects. In addition, some teachers even suggested reestablishing the home economics education subject that previously was a part of the education curriculum applied in Indonesia. Slater *et al.* (2014) conducted a study to explore the perception of applying home economics subjects. The subjects taught the students about knowledge and skills in nutritious food choice and preparation. They discovered that nutrition had significant potential to reduce the risk of obesity and chronic diseases. The results also showed that education can be an important means of transferring basic knowledge and skills to adolescents (Slater *et al.* 2014). They also deemed this subject very useful in instilling students' morals and raising their awareness of the importance of good and correct nutritional behavior from an early age.

The current study has several weaknesses. Since it was carried out at the beginning of the COVID-19 pandemic, learning was carried out online and offline. Teachers and students, as research respondents, were not all present at the research schedule, making it difficult to obtain optimal data.

CONCLUSION

The teachers applied a nutrition e-module at schools when teaching subjects relevant to the nutrition messages. The results of different Wilcoxon tests on knowledge data before and after the intervention showed a significant difference, and there were increased knowledge scores from 22.66 to 26.48.

The teachers realized the importance of delivering nutrition messages to the students. The e-module could broaden the teachers' insight, and they believed that nutrition messages could be inserted into several learning materials. Initially, the teachers believed that nutrition messages could only be delivered in the subject of natural sciences.

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DECLARATION OF INTERESTS

The authors declare that there is no conflict of interest with other person or institution.

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Consumer Fruit Preferences: The Role of Nutrition Knowledge in Fruit Purchase and Consumption

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ABSTRACT

This study aims at ascertaining consumer fruit preferences and role of nutrition knowledge in consumers' attitudes and practice as it concerns fruit consumption. An online questionnaire was used for this cross-sectional survey carried out in South Africa. The questionnaire link was circulated in the nine provinces for 4weeks; information gathered include sociodemographic data, respondents' nutrition knowledge, and consumer fruit preferences alongside their fruit consumption patterns. Based on their responses, Nutrition Knowledge Scores (NKS) were calculated. Pearson correlation test was used to check for any relationship between the NKS, some sociodemographic factors and fruit preferences/consumption (significance was accepted at $p<0.05$). Three provinces; Gauteng, North West and KwaZulu-Natal accounted for over 70% of the 517 responses received. Almost half of the surveyed population had high NKS (45.5%) while 27.3% scored moderately and another 27.3% low. The most preferred fruits were oranges, bananas, and mangoes; others such as plums and berries were also preferred but not as consumed as the others due to their seasonal nature. The results show a positive relationship ($p<0.001$) between nutrition knowledge and fruit consumption frequency and healthy dietary patterns, but only significant but weak correlation between respondents' nutrition knowledge and priority factors that affect their dietary product choices and purchases. Nutrition education is vital in enhancing awareness that will in turn yield positive results in fruit consumption and health outcomes.

Keywords: consumers preferences, consumption pattern, fruit choices, nutrition knowledge, plant-based diet

INTRODUCTION

Dietary choices are driven by many factors such as economic power, nutritional benefits, sensory qualities, nutrition awareness and holistic health outcomes of food purchases (Chivenge *et al.* 2015). Due to the importance of healthy diets in the maintenance of health and prevention of diseases, current researches examine the complex relationships between diet and disease, consumer knowledge and dietary patterns, economic status and purchasing behavior relating to various foods, including organic, genetically modified, and conventional (Muchiri *et al.* 2016). Globalizations and industrialization have brought about a lot of changes (both positive and negative) in lifestyle, food choices and dietary patterns (Frison *et al.* 2005; Kucich & Wicht 2016). Some positive changes brought about by industrialization include technological advancements in healthcare, communications and use of sophisticated software for information and dietary monitoring; the negative changes include increase in air and water pollution thereby reducing food safety/quality, sedentary lifestyle and consumption of junk foods etc. The upsurge in cases of non-communicable and infectious diseases is also a growing cause for concern. Medical professionals are now employing dietary management in addition to synthesized drugs used in the treatment and management of diet-related diseases (Onyenweaku *et al.* 2019). This is due to the fact that over the years, the role of proper nutrition and adequate diet has been established. Research has shown that plant-based diets comprising of mostly fresh fruits and

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vegetables, are healthier than over-processed animal-sourced foods (Kucich & Wicht 2016).

Knowledge/awareness significantly influences people's choices, lifestyle and inadvertently their health outcomes; hence it is imperative that people have correct information with regards to food and health (Wardle *et al.* 2000; Nyawo *et al.* 2020). According to Kucich and Wicht (2016), a daily consumption of more than 7 portions of fruit and vegetables significantly reduces the risk of death from any disease, "yet many South Africans living below the poverty line have a very low or even zero intake of fruit and vegetables". Nutrition education on the importance of consuming healthy but affordable diet needs to be achieved by promoting indigenous alternatives that are of higher nutritional quality or equal to that of "exotic" fruits.

Some past researches observed that knowledge of healthy foods (or higher educational status generally) remarkably influences dietary habits and health status (Barreiro-Hurle *et al.* 2010; Webbink *et al.* 2010), while some others establish that such influences may vary based on individual personalities (i.e. cross-sectional heterogeneity). Conversely, the studies all assert that nutrition knowledge influences dietary patterns in the same way irrespective of their financial levels (Shimokawa 2013). This assumption may be controversial based on recent discoveries that consumers may respond differently in different economic situations (Shimokawa 2010; 2013).

Statistics also show the positive relationship between consumption of plant foods and household earnings as seen in the fact that lower socioeconomic groups have more limited choice of nutrient-dense fruits - apples, bananas and oranges being the preferred choice (Jansen & Stoltz 2008; Kumar *et al.* 2021). "A nutrient dense diversified diet may cost 69% more on average, so where households are reliant on grants and pensions, meeting this extra cost becomes prohibitive" (Temple *et al.* 2011). Most times, people select foods (including fruits) due to on certain reason(s). Various factors influence people's food choices/preferences, and they include: wholesomeness and nutritional value, cost, and currently the processing techniques (natural/organic, Genetically Modified-GM), as well as cultural values and possible environmental impact (Wunderlich & Gatto 2016). For instance, many published studies report that consumers' understanding of GM foods is poor. Many consumers are therefore very cautious with regards to GM foods, one study reported that "over 70% believe that GM-food production is unsafe for all living things" (Turker *et al.* 2013).

In order to comprehend variations in food product choices/preferences, various forces, both external (e.g. characteristics of the food products) and internal (e.g. past experience) that struggle for consumers' attention, must be taken into consideration (Lindberg *et al.* 2018). Nevertheless, the degree to which these forces ultimately affect consumers' purchasing choices varies with individual personalities, analyzing them will certainly increase understanding of consumers' purchase decision processes with regard to food and, thus, facilitating proper planning for food industry stakeholders (Garber *et al.* 2003; Lindberg *et al.* 2018). Consequently, there is the need to ascertain the extent to which presently nutrition knowledge influences consumers' consumption of fruits, their fruit preferences and ultimately - purchases. This will enable stakeholders increase nutrition education (where necessary), encourage proper food labelling and enforce policies that promote production/consumption of plant foods (fruits and vegetables) in order to improve health and increase life expectancy.

METHODS

Design, location, and time

The research design of this study is an online cross sectional survey. The nine (9) South African provinces were covered by this online survey namely Gauteng, North West, Northern Cape, Free State, Eastern cape, Western cape, KwaZulu-Natal, Limpopo and Mpumalanga. The choice of South Africa for this study was as a result of the 2 main researchers being resident in this country for data collection and the rich diversity of fruits present in the country. South Africa is also comprised of people from different races, nationals and continents; this helps in gathering views from people of different cultures and backgrounds. The survey took about six weeks – May to June, 2021. The ethical clearance for this study was obtained from the School of Tourism and Hospitality Research and Ethics Committee, University of Johannesburg with the code - 20STH04.

Sampling

The study population consisted of 517 respondents who participated in the online cross-sectional survey, from the nine South African provinces mentioned above. Summarily, the number of responses from the different provinces were: Gauteng (222), KwaZulu-Natal (56), North West (110), Free State (23), Eastern Cape (26), Western Cape (26), Northern Cape (12), Limpopo (17) and Mpumalanga (25). The survey was distributed across diverse to people of different socio-economic class and culture. A target sample size of 384 was calculated using the Leslie Kish formula, as shown below:

$$n=Z\times Z.p(1-p)/e\times e \text{ (Kish 2017)}$$

Where:n=estimated sample size.
Z=standard normal deviation usually set at 1.96 for 95% confidence.
p=prevalence of any disease under study put at 50% where prevalence is not ascertained.
1–p=0.5
e=degree of accuracy desired, set at 0.05
Substituting the above values, n=384

We hereby report findings on the first 517 replies to the online survey on 'Consumer fruit preferences: the influence of nutrition knowledge on fruit purchase and consumption patterns'.

Data collection

Random sampling (within the study population–South Africa), alongside the snowball sampling method, was used to recruit the study participants bringing the total sample size to 517 participants. The questionnaire link was circulated online because it was easier to gather data this way during this period due to the continued restrictions in movements and social distancing as a result of the third coronavirus wave in South Africa.

Questionnaire design and administration. In order to get data from respondents, a well-structured questionnaire was designed and used in this survey. The survey instrument was designed from a review of previous literature and content-validated by nutrition experts, then pre-tested on 20 persons. The reliability coefficient (Cronbach Alpha) of the questionnaire was 0.75. The questionnaire was structured to gather data on socio-demographics, nutrition knowledge, fruit preferences/consumption and factors that influence consumers' choices and purchase of fruits. The Microsoft word document of the questionnaire was prepared and then converted into the online survey format using Google forms which ensured anonymity of the participants. The questionnaire was circulated electronically using the online survey link which was distributed to participants via social media and electronic means (WhatsApp and emails). The dietary-related knowledge, attitudes, perceptions and practices of the participants were also covered. A review of literature from research articles and journals was employed in designing the questionnaire. Participation in the study was voluntary.

Informed consent and data privacy. Before completing the questionnaire, respondents were asked to carefully read and understand the summary of the research. The informed consent process assured survey participants that all information given were to be strictly used for research purposes. Participants' responses were recorded anonymously and kept confidential according to Google's privacy policy "(https://policies.google.com/privacy?hl=en)". Names and/or contact information were not required of participants. Furthermore, participants were allowed to stop participating in the study and leave the questionnaire page at any point before submission, and that way their responses would not be saved. Just the "submit" button was used for saving responses when tapped on. Participants voluntarily agreed to take part in this anonymous study by completing the survey.

Data analysis

The Statistical Package for Social Sciences software (SPSS, version 25.0) was used to analyse the data in this research. Descriptive statistics such as frequencies, percentages and charts, were used to define the proportion of responses for each question and the total distribution in the total score of each questionnaire. Among the questions asked, the ones pertaining to nutritional knowledge were scored and the total score of all the knowledge-related questions was 15 marks. For example, a correct response of "Yes" was scored 2 marks, "No" zero mark and "Not certain" 1 mark. Using percentiles, the scores were classified as low (2–9), average (10–12) and high (13–15). Data was recoded to get percentage scores. Significance was accepted at $p<0.05$ and Pearson's Chi square test/logistic regression were also used to check for association between variables. Phi values were also used to ascertain

the strength of association viz: <0.5=Weak association, >0.07=Strong association (Kirk 2008).

RESULTS AND DISCUSSION

Socio-demographics characteristics of the surveyed population

Table 1 presents the socio-demographic characteristics of the surveyed population (517 people). The provinces were represented thus: Gauteng (43%), North West (21%), KwaZulu-Natal (11%), Western Cape (5%), Eastern Cape (5%) and the other four provinces accounted for the remaining 15%. Females constituted 38.3% of this population and among them, 40.6% were aged between 18–29 years old while about 50% were aged between 30–49 years. Most of them had a tertiary education level (68.1%) and just few had secondary education level (23.2%) or less (8.7%). A higher percentage of them reported to be single (52.4%) while 33.3% were married. About 40% were living in a household of 1–2 persons, the others in either 3–5 person households (48.5%) or above (12.4%). They generally had a public (16.6%) or private job (19.7%), and others were self-employed (32.7%); 22.2% were unemployed. Some of them reported a low monthly income of below R5,000 i.e. 271USD (29.6%), others earned between R5,000–R20,000 (40%) i.e 271–1,086USD while about 30.3% earned above R20,000 i.e. 1,209USD per month.

Participants' nutrition knowledge scores and fruit consumption pattern

On the whole, the participants showed a good knowledge of the importance of fruit consumption in promoting health and preventing diseases (Table 2a). A good number of the participants (84.7%) agreed that fruits are important for maintain good health; although 11.4% asserted that some fruits are not good for consumption giving reasons such as 'apples are too sweet', 'lemons are too sour' and 'bananas are too starchy'. Up to 67.7% of the respondents gave the correct response that fruits contain micronutrients and antioxidants that are useful to the body, 20.3% were not sure. About 73% of the respondents had a Nutrition Knowledge Score (NKS) which was above average. With regards to their fruit consumption pattern (seen on Table 2b), the respondents mostly consumed fruits 3–6 times a week (36.6%) and some others – less than

Table 1. Socio-demographics characteristics of the sample population

Variable	Sub-variable	Frequency	%
Province	Gauteng	222	42.9
	KwaZulu-Natal	56	10.8
	North West	110	21.3
	Western Cape	26	5.0
	Eastern Cape	26	5.0
	Limpopo	17	3.3
	Mpumalanga	25	4.8
	Free State	23	4.4
	Northern Cape	12	2.3
	Total	517	100.0
Sex	Female	198	38.3
	Male	291	56.3
	Prefer not to say	28	5.4
	Total	517	100.0
Age group	18–29 years	210	40.6
	30–39 years	156	30.2
	40–49 years	100	19.3
	50–59 years	39	7.5
	60 years & above	12	2.3
	Total	517	100.0
Marital status	Single	271	52.4
	Married	172	33.3
	Divorced	48	9.3
	Widowed	26	5.0
	Total	517	100.0
Education	No formal education	17	3.3
	Primary school	28	5.4
	Secondary (High) School	120	23.2
	Tertiary institution	352	68.1
	Total	517	100.0
Monthly income	R0–R4,999	153	29.6
	R5,000–R9,999	101	19.5
	R10,000–R19,999	106	20.5
	R20,000–R29,999	73	14.1
	Above R30,000	84	16.2
	Total	517	100.0
Household size	Live alone	98	19.0
	2	104	20.1
	3–6	251	48.5
	≥6	64	12.4
	Total	517	100.0
Employment sector	Public	86	16.6
	Private	102	19.7
	Informal	45	8.7
	Unemployed	115	22.2
	Self employed	109	32.7
	Total	517	100.0

Table 2a. Respondents' nutrition knowledge scores

Questions	Answers	% responses (n=517)
Are fruits important in maintaining good health?	No	7.0%
	Yes	84.7%
	Not sure	18.3%
Do you think some fruits are not good for consumption?	No	11.4%
	Yes	88.6%
If no (to above question), mention the fruits with reason	Apples–too sweet	5.5%
	Lemons–too sour	4.5%
	Bananas–too starchy	2.4%
Fruits contain micronutrients and antioxidants that are useful to the body.	True	67.7%
	False	12.0%
	Do not know	20.3%
What special potentials do you think consuming fruits may have?	Protects the body	72.3%
	Detoxifies the system	75.4%
	Boosts the body's immunity	79.4%
	Assists in weight loss	67.4%
	Improves digestion	72.6%
	No idea	28.6%
Nutritional knowledge scores	High (13–15)	45.5%
	Average (10–12)	27.3%
	Low (0–9)	27.3%

3 times a week (36.4%). It is worthy of note that 7.2% of the respondents said they do not consume fruits at all, while only 19.9% consumed fruits on a daily basis. Supermarkets (75.2%) and local markets (72.2%) were the most popular sources of fruits while 'personal garden' was the least (39.9%). The most commonly consumed fruits reported were citrus–oranges, grapes and lemons (78.3%) > bananas (76.3%) > mangoes (70.1%) > pawpaw (68.3%). The least consumed fruits were plums (40%) followed by pineapples (58%). The most common way of consuming fruits was reported to be as whole fruits (79.2%) followed by as salads (65.5%) then as juices (64.8%). A good proportion (45.5%) of the surveyed population had high NKS while 27.3% had average scores.

Relationship between nutrition knowledge and fruit consumption patterns/frequency

Table 3a shows the results of the Regression analyses carried out on respondents' nutrition knowledge scores and fruit consumption patterns. As seen in the Table, the logistic regression model was statistically significant, chi (2)=45.613, $p<0.001$, the model correctly explains 16.6% (Nagelkerke R2) of the variation in nutritional knowledge amongst respondents. Wald test shows that respondents' nutritional knowledge significantly affects their fruit consumption. In addition, the ordinal regression model was statistically significant, chi (2)=33.609, $p<0.001$, the model correctly explains 6.9% (Nagelkerke R2) of the variation in nutritional knowledge amongst respondents. Wald test shows that respondents' nutrition knowledge significantly affects their frequency of fruit consumption, the higher the nutritional knowledge, the higher their frequency of fruit consumption. The ordinal regression model was statistically significant, chi (2)=4.077, $p<0.043$, with poor goodness of fit, the model correctly explains only 1.0% (Nagelkerke R2) of the variation in nutritional knowledge amongst respondents. Wald test shows that nutrition knowledge significantly affected the frequency of fruit consumption for COVID-19 prevention by the respondents. Similarly, in checking for association between factors that consumers consider priority when

Table 2b. Respondents' fruit consumption patterns

Questions	Answers	% responses (n=517)
How often do you eat fruits?	I do not consume	7.2%
	Less than 3 times a week	36.4%
	3–6 times a week	36.6%
	More than 6 times a week	19.9%
Where do you obtain the fruits you consume?	From nearby farmers	42.9%
	Supermarkets/shops	75.2%
	Personal gardens	39.9%
	Local market	72.2%
Most popular way of consuming fruits: as -	As smoothies	55.4%
	As salads	65.5%
	As juices	64.8%
	As whole fruits	79.2%
	As dried fruits	45.0%
Top 5 most frequently consumed fruits	Citrus–oranges, lemons, grapes	78.3%
	Bananas	76.3%
	Mangoes	70.1%
	Pawpaw	68.3%
	Apples & English pear	68.2%

purchasing food products, the result showed a positive, significant but weak correlation between respondents' nutritional knowledge and the priority factors (Table 3b).

The study population consisted more of young people who were well-educated. Most of those who earned lower monthly incomes were students who were either self-employed or working part-time jobs while studying. Almost half of the study population had high NKS with majority asserting that fruits were important in maintaining good health and preventing disease; this is similar to the report of Shimokawa (2013). A small but significant part of the surveyed population asserted that some fruits were not healthy for consumption, giving reasons such as: apples being too sweet, lemons being too sour and bananas being too starchy. To some extent, this could apply but particularly when giving dietary recommendations to people living with certain conditions such as diabetes (Muchiri *et al.* 2016), stomach ulcers or even obesity (obese individuals are advised to limit their intake of carbs/starchy foods); but generally speaking, fruits are healthy and beneficial especially when consumed in adequate amounts (WHO 2003). People with gastrointestinal reflux problems or certain ulcers, are usually advised to reduce intake of very acidic fruits such as oranges, sour apples and lemons; these could sometimes be diluted in water and taken on a non-empty stomach. This helps to prevent the negative side effects that may have occurred in those special cases if such fruits are not consumed cautiously. A good percentage of the respondents consumed fruits on a daily basis and some others 3–6 times a week. This is a commendable practice despite the fact that this particular study was not focused on the quantity, but on the frequency of fruit consumption (i.e. choices/consumption patterns). Chivenge *et al.* (2015) made a contrary observation where respondents were not consuming fruits (especially the indigenous ones) frequently. This could be due to differences in cultural dietary patterns, economic status of participants, or even dietary ignorance. Similar to results reported by Obayelu *et al.* (2019), the most popularly consumed fruits seem to be oranges (and lemons), bananas, mangoes and paw paw. This may be partially due to their availability in these regions and affordability, unlike certain 'exotic' fruits which are expensive and not easily available everywhere-like blue berries, rasp berries and plums (Kucich & Wicht

Table 3a. Relationship between nutrition knowledge and fruit consumption patterns/frequency

Variable	Logistic regression test	Test value	*p*
Fruit consumption	Wald	219.509	0.001
(Correctly classified cases-88.6% eat fruit)	Score	50.68	0.001
	Chi-Square	45.613	0.001
	-2 Log likelihood	321.502	0.001
	Nagelkerke r square	0.166	
	PLUM-ordinal regression		
	Wald (FOFC=1)	28.608	0.001
	FOFC=2	18.487	0.001
	FOFC=3	109.162	0.001
Frequency of fruit consumption[b]	Nutrition Knowledge	33.486	0.001
	Chi-Square	33.609	0.001
	-2 Log likelihood	57.408	0.001
	Nagelkerke r square	0.069	
	PLUM-ordinal regression		
	Wald (NFFC=1)	0.872	0.35
	NFFC=2	0.009	0.924
Fruit consumption for COVID-19 prevention[c]	Nutrition knowledge	4.076	0.043
	Chi-Square	4.077	0.043
	-2 Log likelihood	31.235	0.043
	Nagelkerke r square	0.01	

a: The logistic regression model was statistically significant, chi (2)=45.613; p<0.001

b: The ordinal regression model was statistically significant, chi (2)=33.609; p<0.001

c: The ordinal regression model was statistically significant, chi (2)=4.077; p<0.043 with poor goodness of fit

NFFC: Nutrition knowledge vs Fruit Frequency Consumption; FOFC: Frequency of Fruit Consumption; PLUM: Polytomous Universal Model

Table 3b. Relationship between nutrition knowledge & priority factors in product purchase

Variable	Test	Priority
Nutritional knowledge	Pearson correlation	0.124**
	Sig. (2-tailed)	0.005
	N	517

Result shows positive, significant but weak correlation between respondents' nutritional knowledge & their priority

2016). Consumption of these 'exotic' fruits whenever they are in season, is however highly encouraged as they have been found to be rich in antioxidants that prevent cancers and many other diseases (Kucich & Wicht 2016).

On the other hand, the prices of food products also go a long way to affect consumer choices; these exotic types of fruits (apart from being unavailable sometimes) are usually costly because they are sometimes imported and difficult to store for long periods. It therefore becomes necessary to promote consumption of healthy indigenous fruits/vegetables especially where finances are a limitation for some people (Temple *et al.* 2011). Most of the indigenous fruits are free of preservatives used on the imported ones, and so may be a healthier/fresher choice for consumers. Another factor that influences consumer choice of fruits is the taste and texture (Layade & Adeoye 2014); less sweet, sour and hard fruits (such as lime, guava and walnuts) are sometimes not as appealing as others.

It is imperative to note here that meeting the WHO (2003) '5-a-day' recommendation is important in maximising the health benefits of fruits/vegetables to prevent disease. The World Health Organization (WHO) '5-a-day' guidelines were developed following the recommendation that consumption of 400 g of fruits/vegetables per day can reduce the risks of chronic diseases", viz: cardiovascular disorders, certain cancers and obesity (WHO 2003; 2020). The guidelines recommend the daily consumption of a minimum of 5 portions of various fruits and vegetables. Consumption of fruits/vegetables may also help in weight reduction when combined with reduced fat intake, this "may reduce the risk of Type 2 diabetes and impaired cognitive function" (Bazzano *et al.* 2008; WHO 2020). In a large survey conducted across the United States, it was reported that majority of the participants (61%) consumed less than the WHO recommended 5 portions of fruits/vegetables per day (Erinosho *et al.* 2012). While some previous research may have reported no association between nutrition knowledge and fruit consumption patterns (Variyam 2008; Barreiro-Hurle *et al.* 2010),– which may be due to differences in methodology and statistical analyses (Shimokowa 2013), the results of this study show that the higher the nutrition knowledge, the higher their frequency of fruit consumption. This agrees with the report of some other studies where knowledge had positives outcomes on dietary intake and health (Ahmad *et al.* 2022; Lin & Yen 2008; Brinkley & Golub 2011) and it goes to show that nutrition awareness promotes healthy food choices. This study also showed that respondents with higher nutrition knowledge scores consumed certain fruits to prevent COVID-19 infection (more than those with low NKS). This implies that they understand the function of micronutrients present in fruits, as immune system boosters (Kumar *et al.* 2021). Consequently, knowledge can be said to be a major determinant of consumer food choices and consumption patterns.

Limitations of the study

This study was limited to an online survey due the COVID-19 precautionary measures such as social distancing which did not allow research assistants to go to certain peri-urban settlements to include respondents from those places. As a result, this study only covers a particular socio-economic class of people who are educated and have access to android phones and the internet. The study was focused on the current nutrition/ health situation of the young population during the second wave of the COVID-19 pandemic (in the first half of 2021). The validity of answers is also a general problem of online surveys which may be difficult to ascertain.

CONCLUSION

This study reports that oranges, apples, bananas and mangoes are some of the most popularly consumed fruits. Various factors are determinants of consumer's dietary choices and food product prices, palatability and dietary knowledge are some main factors. The results in this paper suggest that nutrition knowledge affects the frequency of fruit consumption and people's ability to use diet as medicine - which is seen in the case of consumption of certain fruits as preventive diet for COVID-19. Fruits contains micronutrients and antioxidants which boost the immune system and fight diseases. Adequate consumption of fresh fruits (and vegetables too) should be encouraged. Many participants had a high nutrition knowledge score and it is recommended that people apply dietary knowledge in making food product choices. Nutrition labels are also quite helpful currently as they will enable consumers make informed choices, especially with the advances in technology which has birthed GMOs. Consequently, nutrition education via various means such as seminars, health talks, courses and social media, should be promoted by stakeholders in order to increase people's nutrition awareness and understanding of the role of diet in maintenance of good health and prevention of disease. Fresh crop production should also be supported by government in order to increase availability of fresh fruits and vegetables all-year round.

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DECLARATION OF INTERESTS

The author declares no conflict of interests.

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Alternative Dietary Fiber Sources from Kenaf (*Hibiscus cannabinus* L.) Seeds and Their by-Products

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ABSTRACT

This study evaluates the macronutrients and Dietary Fiber (DF) of kenaf seeds and their secondary by-products to promote food sustainability and support the zero-waste concept. The first part concentrates on macronutrients and potential DF sources of kenaf seeds and their by-products, i.e., kenaf seed meals and dregs. Following this, the DF from the most probable source was fractionated to quantify its composition. The results showed that the macronutrients of kenaf seeds are comparable to other commercial oilseeds such as soybean, almond, and hemp seeds. Additionally, the secondary by-products could be reused as DF sources. It was found that the kenaf seed by-products had 20.63–35.08% DF contents which were comparable to soybean by-products. Moreover, the fractionation of DF from kenaf seed dregs showed that the DF comprised 1.86%, 1.01%, 6.33%, and 66.33% (dry basis) of acid-soluble pectin, calcium-bound pectin, alkali-soluble hemicellulose, and cellulose, respectively. The soluble (pectins and hemicelluloses) and insoluble (cellulose) fractions are related to the modulation of gut microbiota which have similar potential to conventional prebiotics and an excellent role in bodyweight management, respectively. These findings provide useful information for researchers and industries to venture into alternative DF sources from kenaf seeds as a value-add ingredient for functional food applications.

Keywords: by-products valorization, dietary fiber fractions, food sustainability, oilseeds, potential prebiotics

INTRODUCTION

Obesity and type 2 diabetes are epidemics that are causing global concern. Extrinsic factors, such as sedentary lifestyle and excessive caloric intake, are primary contributors to their emergence (Sharma *et al.* 2018). According to a recent study, more attention should be paid to the adequacy of fiber intake in diet-based weight loss programs aimed at improving body composition and metabolic health (Tremblay *et al.* 2020). Dietary Fiber (DF) is a crucial food component that is resistant to digestive enzymes in the small intestine and can be fermented partially or completely in the large intestine (Fuller *et al.* 2016). It has a unique role as a component of prebiotics, which is helpful for the growth of intestinal microflora (Kusharto 2006). DF exists in insoluble and soluble forms with varying physiological and physicochemical properties (Gupta & Premavalli 2011).

Over the last two decades, the research has thoroughly documented the health benefits of DF (Li & Komarek 2017). Besides diabetes and cardiovascular diseases, adequate DF consumption lowers the risk of gastrointestinal disorders and improves immune function (Hussain *et al.* 2020). There are three major trends in the development of food products using diverse DF sources: (1) utilization of the whole fiber-rich raw materials in conventional food production; (2) fortification of isolated or purified fiber in unconventional food; (3) utilization of food by-product as a source of DF and other bioactive compounds (Li & Komarek 2017).

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Studies on the fermentability of DF in the colon and its interactions as prebiotics with colonic bacteria were limited due to the misunderstanding of the initial definition of DF, which referred to the non-digestible food component in the upper Gastrointestinal (GI) tract (Li & Komarek 2017). Researches have correlated the health properties of DF to various functionalities of the upper GI tract (Mackie *et al.* 2016). Specifically, the increase of viscosity caused by soluble DF can alter gastric emptying, provide satiety sensations and result in the nutrient release and sensing in the duodenum. The interactions between insoluble DF and colonic microbiota, on the other hand, have been investigated using current DNA sequencing technologies (Simpson & Campbell 2015). It is proposed that DF fermentation releases varying amounts of Short-Chain Fatty Acids (SCFAs), which play a crucial role in the metabolic activity and diversity of the microbial community. This impacts gut health, the immune system, and the body's resistance to certain chronic diseases (Simpson & Campbell 2015).

The various health benefits of DF have fueled the interest of many researchers and food manufacturers to incorporate DF in developing novel food products (Dhingra *et al.* 2012). However, because DF contains a complex mixture of undigested polysaccharides, the exact mechanism by which DF components may exert their effect has not been well understood (Brownlee 2014). Thus, the fractionation of DF into its constituent is necessary to isolate and quantify the essential components, eliminate undesirable compounds and to better understand the function of DF. However, only limited research has been done in this area.

Kenaf (*Hibiscus cannabinus* L.) seed is one of the most commonly discarded kenaf plant by-products (Chan *et al.* 2013). However, due to their richness in essential nutrients, extensive studies of kenaf seed oil, protein concentrate, and kenaf seed-based food products (i.e. noodles, tofu, milk) have been conducted in recent years (Ibadullah *et al.* 2021; Karim *et al.* 2020; Mariod *et al.* 2017; Monti 2013; Zawawi *et al.* 2014). Defatted kenaf seed meals and kenaf seed dregs are the secondary by-products of kenaf seed oil and milk extractions. These by-products can serve as a potential source of bioactive compounds and subsequently reduce the amount of food processing waste which is beneficial for the environment. However, to date, no work has been reported on the composition of kenaf seed by-products as an alternative, low-cost DF source. Therefore, this study aimed to evaluate the nutritional contents of the whole, dehulled kenaf seeds and kenaf seed by-products (meals and dregs). Following this, the DF from the most potential source was fractionated to quantify its composition.

METHODS

Design, location, and time

The study consisted of two parts. The first part evaluated the nutritional composition and the DF contents of the whole, dehulled and by-products (meals and dregs) of kenaf seeds. Secondly, the DF from the most potential source was fractionated to quantify its composition. This project was carried out at the Laboratory of Functional Carbohydrate and Protein, Faculty of Food Science and Technology, Universiti Putra Malaysia, from November 2020–August 2021.

Materials and tools

Kenaf seeds variety V36 and defatted kenaf seeds resulting from cold-press kenaf seed oil were provided by the National Kenaf and Tobacco Board (LKTN) in Kangar, Perlis, Malaysia. All chemicals used in this study were of analytical grade.

Procedure

Sample preparation. The whole seed impurities, including immature seeds, dust, chaffs, and stones, were eliminated. The clean, whole seeds were rinsed three times under running tap water, oven-dried at 40°C for 5 h, and then kept in plastic bags at room temperature (25±2°C) until use.

Kenaf seed dregs were the residue left after the extraction of kenaf seed milk (Karim *et al.* 2020). Briefly, cleaned kenaf whole seeds were washed three times under running tap water, soaked at 60°C for 1 h, blended for 3 min (seed: water=1:8), and filtered. The remaining solids (kenaf seed dregs) were oven-dried at 40°C for 40 h, ground and sieved (<500µm/35 mesh).

Dietary Fiber (DF) analysis. The total, soluble and insoluble DF (TDF, SDF, and IDF) of samples were determined using the total DF assay kits (K-TDFR-100A) from Megazyme

(Bray, Ireland). The procedure was carried out according to AOAC Method 991.43, "Total, Soluble, and Insoluble Dietary Fiber in Foods" (First Action 1991) and AACC Method 32-07.01, "Determination of Soluble, Insoluble, and Total DF in Foods and Food Products" (Final Approval 10-16-91). Specifically, 1 g of dried materials (in duplicate) were sequentially digested with heat-stable α-amylase, protease, and amyloglucosidase. The IDF was filtered, and the residue was rinsed with warm distilled water. For SDF determination, a solution containing filtrate and water washings was precipitated with 4 volumes of 95% ethanol. The precipitate was filtered and oven-dried at 103°C overnight. For the final calculation of SDF and IDF values, both SDF and IDF residues were corrected for protein, ash and blank. For TDF determination, after ethanol precipitation of the SDF, the precipitate was filtered, dried and weighed. The TDF value was corrected for protein and ash content.

Sequential fractionation of DF. The sequential fractionation method (Alba *et al.* 2018) was used to isolate and quantify DF fractions (Figure 1).

Physicochemical analysis. The moisture, ash, fat, protein and DF contents were determined using the AOAC procedures of 925.09, 923.03, 920.85, 920.87, and 991.43, respectively. The procedure proposed by Parrot and Thrall was used to determine the direct and bulk densities of samples (Parrot & Thrall 1978). By placing the powdered samples in a calibrated 10-ml cylinder, the direct density (in g/ml) was determined. Before emptying the cylinder, the samples settled at the bottom and were weighed. Bulk density (in g/ml) was calculated by loading 2 g of sample into a graduated syringe. The samples were packed in the syringe with sufficient pressure. Following that, the sample volume in the syringe was measured.

Calculations on powder cohesiveness (HR) and powder compressibility (CI) were performed using the equations below (Jinapong *et al.* 2008):

$$HR = DD/BD \quad (1)$$

$$CI(\%) = \left(\frac{DD - BD}{DD}\right) X100 \quad (2)$$

Where HR=Hausner Ratio, CI= Carr Index, DD=Direct Density, and BD=Bulk Density.

Data analysis

The physicochemical tests were conducted in triplicate. Minitab statistical software version 17.0 (Minitab Inc, State College) performed a one-way ANOVA on raw data. Research Part I consisted of one factor (kenaf seeds) and three levels (whole seeds, dehulled seeds, seed hulls), whereas Part II consisted of one factor (DF fractions) and four levels (ASP, CBP, HEM,

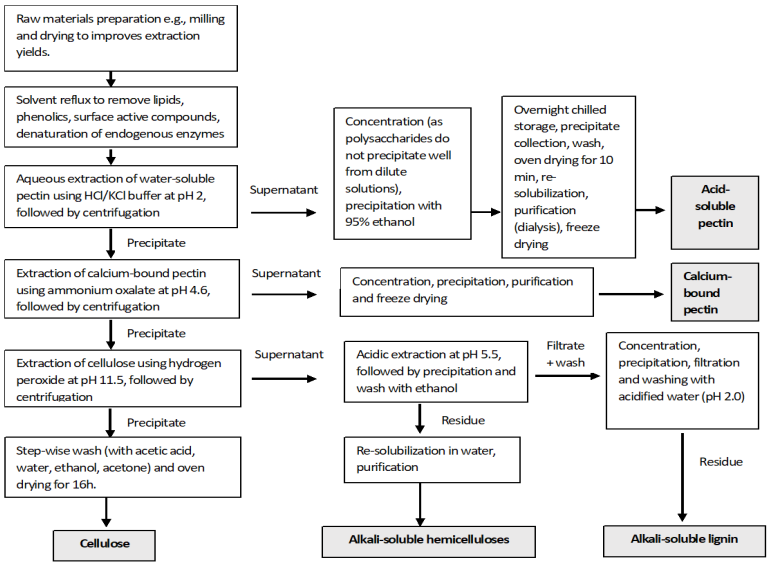

Figure 1. Sequential fractionation method (adopted from Alba *et al.* 2018)

CEL). Tukey's multiple comparison test at a 95% confidence level ($p<0.05$) was used to determine the significant difference, and the results were reported as means and Standard Deviation (SD).

RESULTS AND DISCUSSION

Composition of whole and dehulled kenaf seeds

The structure of kenaf seeds comprised of the seed and hull (Figure 2) with a ratio of 1.6:1. The composition of whole and dehulled kenaf seeds are presented in Table 1. Whole kenaf seeds contained 39.05% protein, 27.15% fat and 20.63% DF. After the dehulling process, the protein and fat contents were found to be accumulated in the seeds.

In terms of DF, the whole kenaf seeds had the highest value (20.63%) compared with the seed and hull, with the majority of insoluble fiber constituents. This value represented the total fiber content of the seed and its hull. However, the dehulled kenaf seed exhibited the highest soluble fiber content (11.80%), whereas its hulls contained a higher insoluble fiber fraction (13.16%). The concentration of cellulosic and non-cellulosic polysaccharides differs significantly between cotyledon (dehulled seed) fibers and hulls. Soluble DF, such as soluble hemicelluloses, pectins, and gums, are common components of cotyledon fibers, whereas the hulls are primarily composed of insoluble fiber, i.e., cellulose, hemicelluloses and lignin (Shen *et al.* 2020).

Kenaf seeds can be considered as one of the potential sources of functional food ingredients from non-conventional oilseeds due to their considerable amount of protein, fat and DF contents. Figure 3 displays the composition of kenaf seeds and several commercial oilseeds, i.e., soybean, almond and hemp seeds. The moisture content of kenaf seeds (7.34%) was lower than soybean (8.54%) but higher than almond (5.25%) and hemp seeds (5.90%). Moisture content is one of the most fundamental and essential analyses that can be performed on a food product to indicate its storage stability and also as one of the quality factors (Nielsen 2017). Interestingly, kenaf seeds showed the highest ash content (6.92%) among other oilseeds (3.11–4.87%). The ash content in foods represents their mineral content. As certain foods are rich in particular minerals, ash content can be significant from nutritional, toxicological, and food quality perspectives (Nielsen 2017).

In terms of protein content, kenaf seeds showed a higher value (39.05%) than other

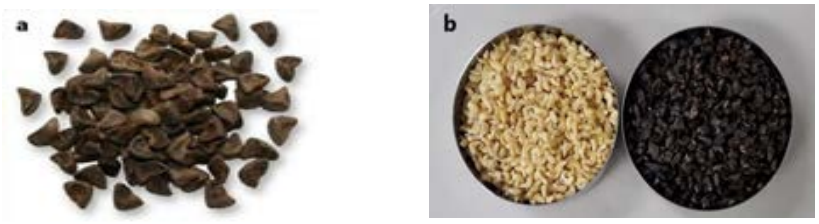

Figure 2. (a) Whole kenaf seeds (Mariod *et al.* 2017); (b) dehulled seeds (white) and seed hulls (black)

Table 1. Composition of whole and dehulled kenaf seeds

Parameters	Whole kenaf seeds	Dehulled kenaf seeds	
		Seeds	Hull
Moisture content (% db)	7.34±0.21[a]	4.03±0.12[b]	7.24±0.26[a]
Ash content (% db)	6.92±0.02[a]	5.43±0.07[b]	2.41±0.02[c]
Crude protein content (% db)	39.05±0.50[b]	42.12±0.87[a]	11.05±0.30[c]
Crude fat content (% db)	27.15±0.04[b]	30.70±0.12[a]	1.77±0.05[c]
DF content (% db)	20.63±0.92[a]	13.52±0.66[b]	16.65±0.71[ab]
Soluble (% db)	2.77±0.14[b]	11.80±0.49[a]	3.49±0.15[b]
Insoluble (% db)	17.86±0.78[a]	1.72±0.07[c]	13.16±0.65[b]

The data are expressed as mean±standard deviation

Different letters in the same row denoted statistically significant differences ($p\leq0.05$)

DB:Dry Basis

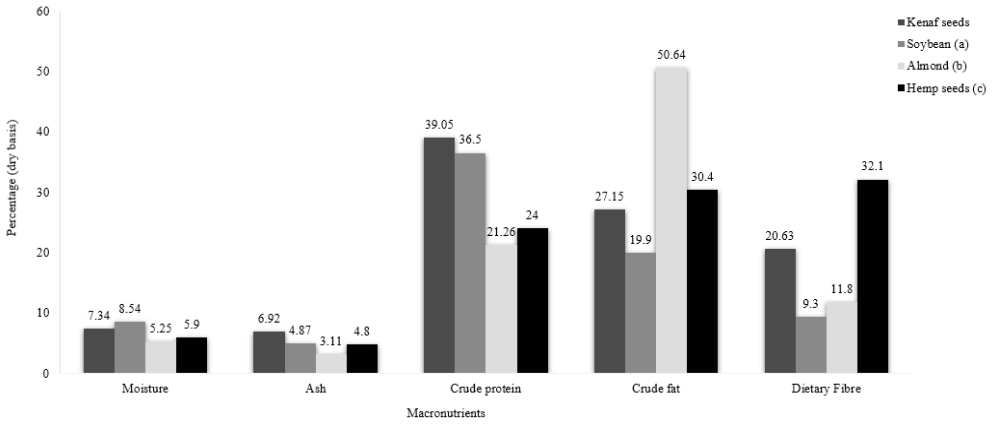

Figure 3. Macronutrients contents of kenaf seeds and several commercial oilseeds a (Colletti *et al*. 2020); b (Yada *et al.* 2013); c (Leonard *et al.* 2020).

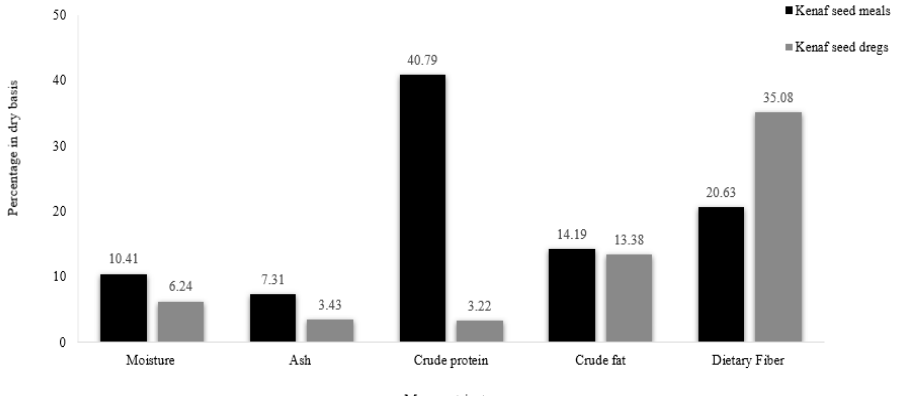

Figure 4. Compositions of kenaf seed by-products

commercial oilseeds. Ibadullah *et al.* (2021) extracted the protein concentrate from defatted kenaf seeds and found that it was high in essential and non-essential amino acids with several functionalities. They proposed that kenaf seed protein concentrate can be incorporated as an ingredient in tofu, butter, mayonnaise, and a meat extender. Nowadays, plant proteins are regarded as biologically active components rather than essential nutrients (Oomah *et al.* 2011). Hence, kenaf seeds may be a potential source of inexpensive plant protein to tackle severe problems in developing countries, such as protein deficiency.

Furthermore, the fat content of kenaf seeds (27.15%) was lower than almond (50.64%) and hemp seeds (30.40%) but higher than that of soybean (19.90%). The bioactive compounds such as tocopherols, tocotrienols, phytosterols, and phenolics in kenaf seed oil provide significant health benefits, i.e., antioxidant activity, anti-hypercholesterolemic activity, anti-cancer, anti-inflammatory, anti-ulcer, and anti-thrombotic activity) (Chew & Nyam 2019). The DF of kenaf seeds (20.63%) were higher than soybean (9.30%) and almond (7.9-12.24%) but lower than hemp seeds (32.10%). These findings emphasized that kenaf seeds are potential ingredients for producing high-protein and high-fiber food products. A recent study has shown that pasta enriched with 30–40% of hemp flour showed acceptable sensory properties by consumers (Teterycz *et al.* 2021). In another study, Martínez *et al.* (2021) substituted wheat flour with a variety of oilseed meals, including poppy, flax, chia, and sesame, to enhance the

nutritional content of commercial cookies. Based on consumer tests, they discovered that sesame and flax cookies were equally well-received as commercial wheat cookies in all evaluated parameters. Several works have indicated that ingredients derived from plants, such as oilseed protein or fiber, can be substituted into healthier meat-based processed foods (Nevara *et al.* 2022), such as burgers enriched with chia and poppy seed meals (Souza *et al.* 2015).

The most notable attributes of oilseeds are the fat and protein contents; however, less focus is on the DF of oilseeds. The abundance of commercial seed oils and plant-based milk available in the market, such as soybean oil, almond oil, sunflower oil, soybean milk, almond milk, etc. Interestingly, more work is needed to valorise the by-products generated after the oil and milky extracts are removed from the seeds. In light of their DF content, these by-products are the potential ingredients for enriching food products such as bakery and pasta (Nevara *et al.* 2022). Incorporating DF into the formulations could enhance the nutritional values of the final food products (Alba *et al.* 2018). Providing consumers with a variety of high-fiber meals will eventually assist in resolving the deficiency problems prevalent in developing countries.

Composition of kenaf seed by-products

With an increasing world population and rising demand for food, it is critical for sensible and resource-saving use of raw materials, which include the use of underutilized oilseed by-products. Figure 4 presents the proximate composition of kenaf seed meals and dregs. Generally, protein and DF are desirable compounds after the oil and milk components are extracted from the seeds.

In terms of protein content, the kenaf seed meals (40.79%) had significantly ($p<0.05$) higher values than kenaf seed dregs (3.22%) (Figure 4). The increasing trend is similar to that of soybean by-products, where the protein content of soybean meals (33.04–56.27%) is greater than that of soybean okara (28.52%) (Redondo-Cuenca *et al.* 2008; Rosset *et al.* 2014).

In contrast, the DF value of kenaf seed meals (20.63%) was considerably ($p<0.05$) lower than that of kenaf seed dregs (35.08%). This finding is comparable to soybean by-products, whereby the soybean meals contain lower DF content ranging from 17–20.70%, compared with okara (50–55.48%) (Grieshop *et al.* 2003; Redondo-Cuenca *et al.* 2008; Li *et al.* 2012). Furthermore, Li *et al.* (2012) suggested that okara was a good source of DF because DF made up about 50% of its composition. In addition, Redondo-Cuenca *et al.* (2008) found that the beneficial properties of soybean seeds fiber are attributed to its okara due to their similar monomers composition comprising of glucose, galactose, arabinose, xylose and uronic acids.

Based on these results, kenaf seed dregs could be a potential source of DF compared to kenaf seed meals. The low protein content of the dregs can serve as a suitable raw material for isolating the soluble and insoluble DF fractions, as described in the following section.

Fractionation and physical characteristics of DF fractions

In this study, kenaf seed dregs were used as the raw material for the DF source. Since DF refers to the complex mixture of undigested polysaccharides, fractionation was conducted to quantify the DF compositions. Following the sequential fractionation protocol by Alba *et al.* (2018), four DF fractions were isolated from defatted kenaf seed dregs, i.e., acid-soluble and calcium-bound pectins, alkali-soluble hemicellulose, and cellulose (Figure 5) with the yield of 1.86%, 1.01%, 6.33%, and 66.33%, respectively.

The effectiveness of DF in promoting health benefits is determined by the source

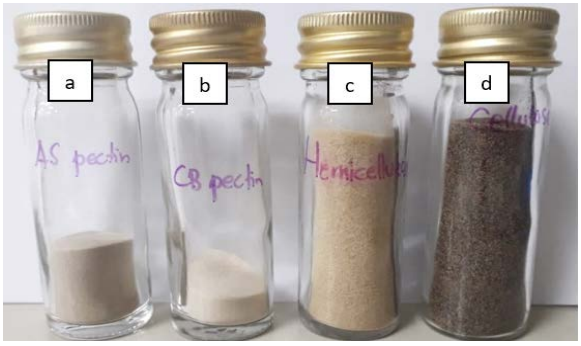

Figure 5. DF fractions from kenaf seed dregs (a) acid-soluble pectin; (b) calcium-bound pectin; (c) alkali-soluble hemicellulose; (d) cellulose

and composition of the DF (Alba *et al.* 2018). Fractionating the DF into its constituents is essential for isolating and quantifying fractions and eliminating undesirable compounds. Moreover, the properties of DF fractions could explain their technological and physiological functions in food products and their potential for other industrial applications, such as pharmaceutical sectors.

Several health-beneficial properties of soluble DF fractions, such as pectin and hemicellulose, are related to the modulation of gut microbiota. Blanco-Pérez *et al.* (2021) emphasized the potential of pectins for allergy treatment. Likewise, oligosaccharides derived from hemicelluloses play a role in alleviating autoimmune diseases, urinary tract infections, diabetes, Antimicrobial Resistance (AMR), and cardiovascular diseases. Thus, these DF fractions have similar potential to conventional prebiotics and can be supplemented into functional foods (Jana *et al.* 2021). On the other hand, cellulose, as the insoluble DF fraction, has an excellent role in bodyweight management due to its water-holding capacity, where the swelled cellulose can improve satiety (Phirom-on & Apiraksakorn 2021).

Furthermore, a comprehensive understanding of DF characteristics is required for its incorporation into food. The interactions between DF and other ingredients can significantly influence the acceptability and microstructure of the final product (Alba *et al.* 2018).

The physical properties of kenaf seed fiber fractions are presented in Table 2. The direct and bulk densities are critical factors that affect powder functionality by providing information on the order and packing of powder particles (Niknam *et al.* 2020). The direct density of both Acid Soluble-Pectin (ASP) and Calcium-Bound Pectin (CBP) were higher than Alkali-Soluble Hemicellulose (ASH) and lower than Cellulose (CEL). The same trend is shown in the bulk density values. The flow properties of these fiber fractions are calculated based on the ratio of bulk and direct densities.

In terms of powder cohesiveness, ASH demonstrated the highest value (8.71), CEL showed the lowest (1.32), whereas the ASP and CBP were in the middle (3.64–4.01). According to Jinapong *et al.* (2008), the Hausner ratio (HR) can be categorized into three, i.e., high (>1.4), intermediate (1.2–1.4), and low (<1.2). It was observed that the ASH and CEL showed the highest and lowest fiber cohesiveness, respectively. Cohesiveness is the internal bond strength of a food structure determined by the structure's deformation resistance (Noorlaila *et al.* 2017). The cohesiveness of the powder could be helpful in the development of food formulation.

The trend for powder compressibility was the same as the powder cohesiveness property. The highest to the lowest Carr Index (CI) were ASH, CBP, ASP, and CEL, with values of 88.93, 75.02, 72.52, and 22.66, respectively. The powder compressibility can be divided into several categories based on very poor CI values (>45), poor (35–45), fair (20–35), good (15–20), and very good (<15%). All the soluble fractions (ASH, CBP, ASP) and insoluble fiber (CEL) had very poor and fair compressibility, respectively. A higher HR value of soluble fractions than insoluble fiber indicates that soluble fractions are very cohesive powders but have poor flowability compared to insoluble fiber. Overall, the soluble fractions of DF demonstrated lower flowability

Table 2. Physical properties of kenaf seed fiber fractions

Parameters	Kenaf seed fiber fractions			
	ASP	CBP	ASH	CEL
Bulk density (g/ml)	0.23±0.01^{b}	0.21±0.01^{b}	0.07±0.00^{c}	0.57±0.02^{a}
Direct density (g/ml)	0.45±0.01^{b}	0.42±0.00^{c}	0.30±0.00^{d}	0.72±0.00^{a}
Powder cohesiveness (HR)	3.64±0.18^{b}	4.01±0.14^{b}	8.71±0.01^{a}	1.32±0.05^{c}
Powder compressibility (CI) (%)	72.52±1.33^{b}	75.02±0.87^{b}	88.93±0.72^{a}	22.66±1.01^{c}

The data are expressed as mean±standard deviation

Different letters in the same row denote statistically significant differences ($p \leq 0.05$)

ASP: Acid-Soluble Pectin; CBP: Calcium-Bound Pectin; ASH: Alkali-Soluble Hemicellulose

CEL: Cellulose; HR: Hausner ratio; CI: Carr Index

and compressibility than the insoluble fractions. Powder flowability and compressibility are essential properties in selecting a suitable processing methods, packaging, storing, and shipping method of the powder; hence it is necessary to examine these data for future application of the samples (Niknam *et al.* 2020).

CONCLUSION

The role of kenaf seed and its by-products as potential DF sources was analysed. The kenaf seed dregs showed higher (35.08%) DF content than kenaf seed meals (20.63%) which is comparable to soybean by-products. Four different fiber fractions were identified and isolated from kenaf seed dregs, which were acid-soluble pectin (1.86%), calcium-bound pectin (1.01%), alkali-soluble hemicellulose (6.33%), and cellulose (66.33%). Results for physical properties determination demonstrated that all the soluble DF fractions had a high Hausner Ratio (HR) and Carr Index (CI), implying that they are very cohesive powders but have poor flowability compared to the insoluble fiber fraction. This study provides fundamental data on kenaf seeds as Dietary Fiber (DF) sources. However, further investigations on the techno-functional and chemical properties of kenaf seed fiber fractions are required to elicit their functions in food products and provide clues about their physiological potential for industrial use.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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Identifying the Characteristics of Pregnant Women with Inflammation/Infection in Indonesia

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ABSTRACT

Infection in pregnant women is common and one of the highest causes of death in Indonesia. Reducing infection conditions through early infection prevention needs to be done, one of which is by knowing the characteristics that contribute to the incidence of infection in pregnant women in Indonesia. This study used the Classification and Regression Tree (CART) method to determine the pregnant women with infections and not infections characteristics and classify them. The results of the CART analysis found that seven variables contributed to separating infected and not-infected status in pregnant women, they are nutritional status based on Body Mass Index (BMI), history of anemia, pregnancy distance, Chronic Energy Deficiency (CED) status, ages, socioeconomic and gestational age. Characteristics of the highest incidence of infection, namely 79%, occurred in the group of pregnant women with overweight – obese (BMI>25.0), anemia and pregnancy distance <3 years. The classification analysis of the CART method in this study resulted in the accuracy of identification performance which was still not good, with an accuracy value of 52.78%. It is necessary analysis with other classification methods such as the Chi-square Automatic Interaction Detection (CHAID) in the future.

Keywords: anemia, body mass index, CART, infection, pregnant women

INTRODUCTION

Infection is the entry of viral, bacterial, parasitic, or fungal microorganisms into the body. According to Sinaga and Hasanah (2019), pregnant women are most vulnerable to infection. Based on the Indonesia Health Profile 2020, the number of deaths of pregnant women in 2020 has increased from the previous year, from 4,221 to 4,627 deaths, and one of the highest causes of death is infection. Inflammation /Infection ranks the fourth highest cause of death in pregnant women after bleeding, hypertension, and circulatory system disorders (MoH RI 2021).

The laboratory analysis measured level of C-Reactive Protein (CRP) in serum using Enzyme-Linked Immunosorbent Assays (ELISA). This method was an analysis that can be used as an early marker of infection or inflammation. C-reactive protein is an acute phase protein that increases rapidly in the first 6 to 8 hours after infection and reaches a peak after 48 hours (WHO 2014). Dewi *et al.* (2013) have used this CRP analysis to determine the inflammation/infections status in dyslipidemia patients. However, detection of infection with CRP analisys is still relatively expensive, and not all of hospitals or regional laboratories in Indonesia able to do this analisys, especially for remote areas. However, cases of inflammation/ infection in pregnant women in Indonesia must be minimized, so that cases of death or disability in pregnant women and babies born can be suppressed. One effort that can be done to reduce infection cases in pregnant women in Indonesia is to find out what factors are at risk as a cause of inflammation/infection in pregnant women.

Several factors can increase the risk of infection in pregnant women. The increasing infection risk factors are: socioeconomic status (Mohamed *et al.* 2017; Oechsle *et al.* 2020); child spacing of fewer than two years or pregnancy distance of fewer than three years (Mohamed *et al.* 2017); anemia (Sulistyawati & Khanifah 2015; Mohamed *et al.* 2017); nutritional based on Body Mass Index or BMI (Dewi *et al.* 2013; Fakhriadi

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et al. 2018); Chronic Energy Deficiency or CED (Fitrianingtyas *et al.* 2018); age when the woman was pregnant (Fitriyah *et al.* 2019); gestational age and number of children (Ginting *et al.* 2019) and young marital age and low education (Surapathi *et al.* 2021) .

Sinaga and Hasanah (2019) stated that most pregnant women are unaware of their infection condition and do not know until the baby with a disability birth. This condition will not only reduce the quality of Indonesian Human Resources (HR) but will also seriously endanger the health and safety of the mother and fetus. Therefore, characteristics contribute to infection incidence need to know of reducing and preventing infections in pregnant women in the future.

One of analyzes to identify characteristics able to use is a classification analysis. This classification analysis had widely applied in everyday life and was used to diagnose a disease in the health field (Suwardika 2017). Analysis of data patterns with this supervised learning approach will produce grouped outputs, so the new data classification from the separator function between one label and another can be searched by studying the available data classes

According to Setiawaty *et al.* (2021), one method for classification without assumptions of statistics is the Classification and Regression Tree (CART) method. This method can see the relationship between the response variable and one or more explanatory variables (Hartati *et al.* 2012). This binary recursive partitioning method will divide the parent node into two child nodes, and then from each child node, it will be divided into two new child nodes. This repeated process until all nodes cannot divide again. Furthermore Nazar (2018) stated advantages of the CART method are: the ability to use both categorical and numerical data types, is not affected by outliers, collinearities, and heteroscedasticity from explanatory variables, and produces easy-to-understand decision trees. Suwardika (2017) used this CART method to classify hepatitis data with a high accuracy value of 83.2%.

In this study, we used the CART method to identify characteristics to determine pregnant women with infection and not infection and classify them. Our hope with knowing the characteristic pregnant women with infection condition will be to use for early detection of pregnant women with infections, and further avoid the causes of infection to reduce infection rates in pregnant women in the future

METHODS

Design, location, and time

The design of this research was secondary data analysis from Riskesdas 2013 data. Riskesdas was a national-scale survey with a cross-sectional and non-interventional design. The research location for Riskesdas 2013 was in 33 provinces in Indonesia, meanwhile the data analysis of this research was conducted in Bogor on February-July 2022.

Sampling

The data used in the research is especially the pregnant women in four age groups: early teens (12–16 years), late teens (17–25 years), early adulthood (26–35 years), and late adulthood (36–45 years). The inclusion criteria for this study are individual data had been complete data for all variables used (Table 1). Exclusion criteria if an individual's data is not a link between the Public Health block data and the Biomedical Block Data in 2013, and Biochemical Biological Materials (BBT) analysis data in 2016 from Biomedical Block samples. The available data includes 360 data on pregnant women respondents from all provinces in Indonesia, both urban and rural. The variables used in the study can be seen and presented in Table 1.

Data collection

The secondary data used in this research consisted of three sets of Riskesdas 2013 data, namely: the Community Health Data RISKESDAS 2013, the Biomedical Data RISKESDAS 2013 and laboratory analysis data from Biochemical Biological Materials (BBT) in 2016. All secondary data RISKESDAS 2013 were obtained from the National Institute of Health Research and Development (NIHRD), Ministry of Health of Republic Indonesia (MoH RI).

Data analysis

The CART method was developed by Leo Breiman, Jerome H. Freidman, Richard A. Olshen, and Charles J. Stone. The CART method is one nonparametric method used to see the relationship between variable response with

Table 1. Research Variables

Notation	Variables	Description	Source
Y	Infection status	0= Inflammation/Infection (if serum CRP>5 mg/l) 1= Not inflammation/Infection/normal (if serum CRP<5 mg/l)	WHO (2014); Mahapatra *et al.* (2021)
X1	Age	1= Early teens (12–16 years old) 2= Late teens (17–25 years old) 3= Early adulthood (26–35 years old) 4= Late adulthood (36–45 years old)	MoH RI (2019)
X2	Nutritional status based on BMI	1= Very thin (BMI is <17.0) 2= Thin (BMI is 17.0-<18.5) 3= Normal (BMI is 18.5–25.0) 4= Fat (Overweight) (BMI is >25.0–27.0) 5= Obese (BMI is >27.0)	MoH RI (2014)
X3	Gestational age	1st trimester (0–13 weeks) 2nd trimester (14–26 weeks) 3rd trimester (27–40 weeks)	Ginting *et al.* (2019)
X4	Pregnancydistance	1= <3 years 2= ≥3 years	Mohamed *et al.* (2017)
X5	Number of children	1= ≤3 children 2= >3 children	Ginting *et al.* (2019)
X6	CED status	0= Not CED (Upper arm circumference >=23.5 cm) 1= CED (Upper arm circumference <23.5 cm)	Fitrianingtyas *et al.* (2018)
X7	Anemia History	0= Normal (not anemia) (Hb≥11 g/dl) 1= Snemia (Hb<11 g/dl)	Sulistyawati and Khanifah (2015)
X8	Socio-economic status	1= Poor 2= Middle 3= Upper	Mohamed *et al*. (2017); Oechsle *et al*. (2020)

CRP: C-Reactive Protein; CED: Chronic Energy Deficiency; BMI: Body Mass Index

one or more explanatory variables (Hartati *et al.* 2012). this method consists of two analyses, namely classification tree and regression tree. When variable the response is categorical data, a classification tree will be generated, but if the response variable is a continuous variable then it will generated regression tree (Breiman *et al.* 1993). Therefore, on research This will produce a classification tree because the response variables used are of type categorical. CART generally works by partitioning or sorting the parent node into two child nodes left and right. Then from each node the child will be the new parent node which will be partitioned again later into two new child nodes. This process takes place continuously until the vertices can no longer be sorted. Therefore, Lewis (2000) mentions that CART is a binary analysis method recursive partitioning. The term "binary" means that each node will be split into two child nodes. The term "recursive" refers to a binary partitioning process done repeatedly. The term "partitioning" describes that dataset divided into sections or partitioned. The process of forming a CART tree This is in line with the

CART method algorithm developed by Breiman *et al.* (1993). The stages in the formation of a CART classification tree includes four things, namely: 1) Sorter Selection: At this stage, the separator of each node will be determined resulted in a decrease in the highest level of heterogeneity. To measure The degree of heterogeneity of a particular node in the classification tree is known with the term impurity measure or improvement. Impurity is a level the variety, randomness or dirtiness of a node. As for those who were chosen to be the best sorter is the one with the highest impurity reduction value. Score High impurity indicates that the node is not yet homogeneous, while a node that has a low impurity value indicates a node it is homogeneous. There are several types of impurity functions, one of which will used is the Gini index. The Gini index is a function of impurities The calculation process is quite simple. As for the equation of the Gini index, that is $i(t)=1-\sum_{j=1}^{j} p^2\ (j \mid t)$, where, $p(j \mid t)=\frac{N_j(t)}{N(t)}$, $i(t)$=Gini index Heterogeneity Function, $p(j \mid t)$=Probability of observing category j at node t, $N_j(t)$=Number of categories j at node t, $N(t)$=Number of observations at node t. The heterogeneity reduction of the s selector at the t-th node can be determined based on the goodness of split criteria with the equation: $\Delta i(s,t)=i(t)=P_L\ i(t_L)-P_R\ i(t_R)$, where $c\Delta i(s,t)$=Derivation of impurity class to the t-th node, I(t)=Heterogeneity function, P_L = Left node observation probability, $i(t_L)$=Impurity value of the left t-node, P_R=Right-node observation probability, $i(t_R)$= Right t-node impurity value. The separator with the highest goodness of split value is the separator the best because it can reduce the highest heterogeneity; 2) Terminal Node Determination: A node t will become a terminal node if at node t it is there was no significant decrease in heterogeneity in the sorting, with In other words, the vertices are homogeneous or because of the minimum limit of cases that are occur. According to Breiman *et al.* (1993), generally the minimum number of cases in a terminal node is 5 cases and if it is met then growth tree will be stopped; 3) Class Marking: According to (Breiman *et al.* 1993), assigning class labels to terminal nodes based on the rule of greatest number, namely: p(j0|t)=jmax p(j|t), where j0=class label for terminal node p(j|t)=probability of observation in the jth category of node t; 4) Classification Tree Pruning: After the classification tree is formed, the next step is pruning trees to prevent the formation of large trees. A large classification tree will result in a high complexity value (Breiman *et al.* 1993). Therefore, it is necessary to make pruning efforts to obtain a feasible tree size based on cost complexity. Here's the equation: $R\alpha(T)=R(Tk) + |\hat{T}k|$, where is $R\alpha$ (T)=A measure of the complexity of sub-tree T_k at complexity α, R(T*k*)=Size of misclassification in sub tree T_k, A=complexity cost parameter, $|\hat{T}k|$=number of tree terminal nodes T_k. Cost complexity can determine the sub-tree T_k that minimizes R(T) for each value of α. The results of pruning are several trees T_k classification and with cross-validation a classification tree can be determined optimal, namely the T_{k0} subtree which has the smallest error value, namely: $R^{Cv}(T_{ku})=\min_k R^{cv}(T_k)$.

Stages of data analysis procedure

To complete the research, the stages of the data analysis procedure are as follows: 1) Pre-processing data is in the form of labeling data according to the expected variable categories in Table 1; 2) Data exploration using descriptive statistics to find out the percentage of infection and not infection for each categories of independent variables; 3) Divide the data into 80% training data and 20% test data; 4) Classify the status of infection and not infection using the CART method; 5) Interpretation of results, and 6) Assessing the performance of the classification results of the CART method.

RESULTS AND DISCUSSION

Data exploration

Exploration of C-Reactive Protein (CRP) levels data found 188 from 360 pregnant women have inflammation/infections condition and 172 pregnant women without inflammation/ infections (Figure 1). The pregnant women with inflammation/infection status are slightly higher than pregnant women without inflammation/ infections are 52% vs. 48%. This data includes balanced data because the difference in the percentage of data obtained is not too different. According to Sun *et al.* in Achmad *et al.* (2022), the data with binary classes is unbalanced if the comparison of minor and mayor are 1:100, 1:1,000, or more. Percentage of inflammation/ infection and not inflammation/infection status for all explanatory variables is show in Table 2.

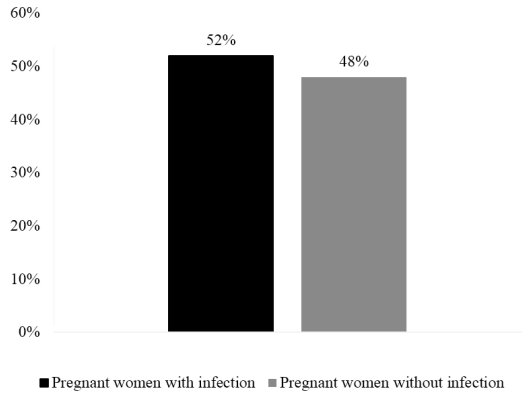

Figure 1. Percentage of inflammation/infection and not inflammation/infection status in pregnant women

Table 2 shows that infection status during pregnancy has different percentages each group. Inflammation/Infection status during pregnancy for each age group, gestational age, the number of children, nutritional status based on BMI, CED status, and history of anemia are different. Shown that age, gestational age, number of children, nutritional status based on BMI, CED status, and history of anemia affect the inflammation/ infection status of pregnant women, and this followed the research of Fitriyah *et al.* (2019); Mohamed *et al.* (2017); Fakhriadi *et al.* (2018); Fitrianingtyas *et al.* (2018); Sulistyawati and Khanifah (2015), as well as socioeconomic status (Mohamed *et al.* 2017)

Based on the age variable (Table 2), the pregnant women who experience inflammation/ infection dominated by the early adult age group (26–35 years), followed by late adolescence and late adulthood. While in the early adolescent group, there were no infected pregnant women, this is likely because the number of women in the early adolescent age group who became pregnant was only one respondent. The age group of early adolescents is still very young, namely 12–17 years (MoH RI 2019), so they are still too young to get pregnant and generally do not have a family. So the number of respondents in this early adolescent group is minimal in this study

Table 2. Shows inflammation/infection status on nutritional status dominated by the obese group or BMI>27 kg, while gestational age dominated in the 3rd trimester of pregnancy. Child spacing of fewer than two years or pregnancy distance of fewer than three years (<3 years) is

Table 2. Percentage of inflammation/infections and not inflammation/infections itatus based on groups of explanatory variables

Explanatory Variables	Number of cases (%)	
	Inflammation/ Infections	Not inflammation/ Infections
Age		
Early teens	0.00	100.00
Late teens	51.33	48.67
Early adulthood	55.15	48.85
Late adulthood	45.10	54.09
Nutritional status based on BMI		
Very thin–thin	42.86	31.82
Normal	42.22	41.03
Overweight	58.97	57.78
Obese	68.18	57.14
Gestational age		
Ist trimester	43.66	45.03
2nd trimester	53.62	46.38
3rd trimester	54.97	56.34
Pregnancy distance		
<3 years	59,26	40.74
>=3 years	50.98	49.02
Number of children		
<=3 Children	52.07	47.93
>3 children	52.45	47.55
CED Status		
Normal (Not CED)	57.71	66.67
CED	33.33	42.29
Anemia history		
Normal (Not anemia)	55.46	44.54
Anemia	45.56	53.44
Socio-economic status		
Poor	55.56	44.44
Middle	48.96	51.04
Upper	57.14	42.86

BMI: Body Mass Index; CED: Chronic Energy Deficiency

also the group with the highest inflammation/ infection cases than the other groups, the same for women with more than three children (Table 2). This condition follows the opinion of Dewi *et al.* (2013); Fakhriadi *et al.* (2018); Fitriyah *et al.* (2019); and Ginting *et al.* (2019).

Table 2 also shows that the percentage of healthy pregnant women (without CED and anemia status) have a higher inflammation/infection than pregnant women with CED and anemia. It is the same with the upper socioeconomic. In upper socioeconomic, cases inflammation /infection cases are more than among pregnant women with lower socioeconomic status. This situation is different from research by Fitrianingtyas *et al.* (2018); Sulistyawati and Khanifah (2015); and Mohamed *et al.* (2017). They found the incidence of inflammation/infection more in CED conditions, anemia, and low economic status. The percentage analysis in Table 2 is only between the same variables and does not consider the interaction between variables, so the results are not yet a decision. So the research continued with CART analysis.

CART analysis

CART analysis of 8 explanatory variables resulted in 21 nodes arranged by seven explanatory variables. The process of pruning the maximum classification tree after the classification tree is formed is carried out to obtain the optimal tree. The trimming process is based on the Complexity Parameter (CP). The CP with the smallest relative error value was chosen to trim the maximum classification tree. Based on Figure 2, the smallest relative error value is obtained when c=CP is 0.01. Furthermore, the tree is pruned with a value of CP=0.01.

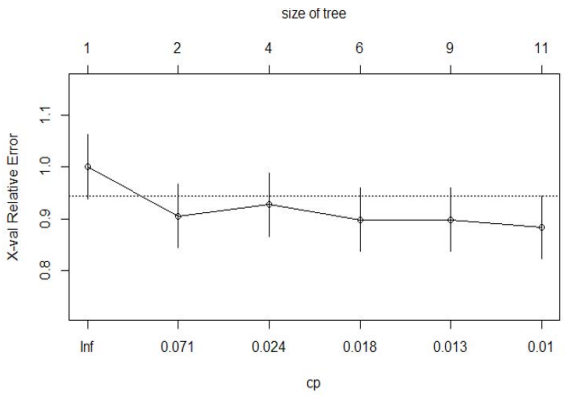

Figure 2. Complexity parameter CART plot

CART analysis after pruning still produced 21 nodes arranged by seven explanatory variables, namely nutritional status based on BMI, history of anemia, pregnancy distance, CED status, ages, socioeconomic and gestational age. The tree of CART analysis results can be seen in Figure 3.

The results of the CART analysis resulted in 11 terminal nodes which were the last nodes of the tree. Terminal nodes showed the classification results of the variables related to the incidence of inflammation/infection. Of the 11 terminal nodes shown dark color area (for pregnant women in the not infected) and the light color area (for pregnant women in the inflammation/infection), there are 5 terminal nodes in the inflammation/ infections category and 6 terminal nodes, not inflammation/infections (Figure 3).

Figure 3 shows that the highest characteristic of infection status in pregnant women is 79% (terminal node 2), followed by terminal node 1, which is 75%, and terminal 7 node at 65%. Interpretation of all of Figure 3 can to reading in Table 3.

Based on the CART method to classify inflammation /infection and not inflammation/ infection status for pregnant women (Figure 3 & Table 3), the highest incidence of inflammation/ infection is 79%. The highest incident occurred in terminal node 2, in the group of pregnant women with BMI>25 kg/m^2 (overweight-obese), who had a history of anemia and with a pregnancy distance <3 years. The result is in line with the research of Fakhriadi *et al.* (2018), which states that a person with a BMI>25 kg/m^2 is more susceptible to infection. The immune system with obese nutritional status (BMI>25 kg/m^2) tends to be poor, so the body does not have an adequate resistance system to fight inflammation/infection.

This study is also in line with Sulistyawati and Khanifah (2015) research, which states that pregnant women with a history of anemia are more susceptible to inflammation /infection because anemia affects the immune system and wound healing process, thereby increasing the infection risks. Our study is also in line with the research of Mohamed *et al.* (2017), which states that the condition of the uterus that has not entirely healed due to postnatal wounds with a pregnancy distance <3 years are more susceptible to inflammation/infection. In addition, women of

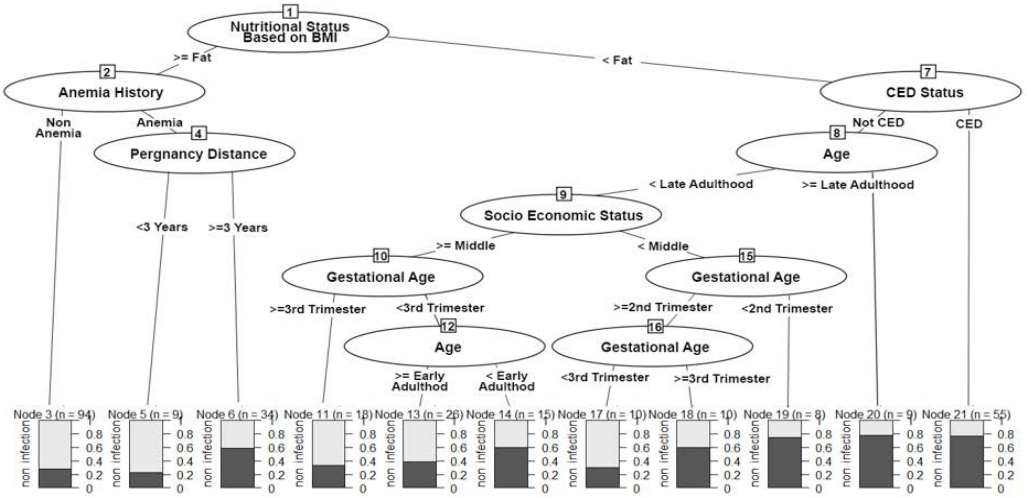

Figure 3. CART analysis classification result tree

Table 3. Classification of inflammation/ infection and not inflammation/infection according to CART analysis

Terminal code	Characteristics	Status	
		Infection	Non-infection
1	Pregnant women with BMI ≥25 kg/m^2 (overweight–obese) with an anemia condition	75%	25%
2	Pregnant women with BMI ≥25 kg/m^2 (overweight–obese) and with anemia condition and pregnancy distance <3 years	79%	21%
3	Pregnant women with BMI ≥25 kg/m^2 (overweight–obese) and with anemia condition and pregnancy distance ≥3 years	40%	60%
4	Pregnant womon with BMI <25 kg/m2 (very thin–normal), not CED status, age <36 years, upper-middle socioeconomic status, and gestational age 27–40 weeks.	62%	36%
5	Pregnant women with BMI <25 kg/m^2 (very thin–normal), not CED status, age 26–35 years, middle to upper socioeconomic status, and gestational age <27 weeks	60%	40%
6	Pregnant women with BMI <25 kg/m^2 (very thin–normal), not CED status, age <26 years, upper-middle socioeconomic status, and gestational age <27 weeks	40%	60%
7	Pregnant women with BMI <25 kg/m^2 (very thin–normal), not CED status, age <36 years, lower socioeconomic status, and gestational age 14–26 weeks	65%	35%
8	Pregnant women with BMI <25 kg/m^2 (very thin–normal), not CED status, age <36 years, lower socioeconomic status, and gestational age 27–40 weeks	40%	60%
9	Pregnant women with BMI <25 kg/m^2 (very thin–normal), not CED status, age <36 years, lower socioeconomic status, and gestational age 1–13 weeks	22%	78%
10	Pregnant women with BMI <25 kg/m^2 (very thin–normal), status not CED, age 36–45 years	21%	79%
11	Pregnant women with BMI <25 kg/m^2 (very thin–normal), status CED	21%	79%

BMI: Body Mass Index; CED: Chronic Energy Deficiency

childbearing age who do not practice birth control and experience pregnancy at a close distance can increase the risk of lack of nutrients the body needs. For example, there is a lack of folic acid intake, which functions to form red blood cells. If the information on folic acid is not enough, it will result in reduced red blood cell production and will increase the occurrence of anemia. This anemia condition can also increase the risk of inflammation/infection in the body. This is in line with the study of Liyew *et al.* (2021). They found that anemia, in this case, iron deficiency anemia was an independent factor associated with inflammation/infection among surgical patients studied.

An analytical accuracy test was carried out to assess the accuracy of the classification results. The results of accurate test results of the CART method are presented in Table 4. The accuracy value of the classification results of the CART method for this study is 52.78%, with the sensitivity value or the proportion of positive infections that were classified correctly was 51.35%, and proportion correctly classified of not infections was 54.29%. Difference types of data cause different the results, which means the CART method unsuitable for this data, even though Suwardika (2017) found high accuracy value of 83.2% for groups of hepatitis data. Other classification methods like the Chi-square Automatic Interaction Detection (CHAID) can be used to improve the performance the results. The method can be applied to this data so that the results of identifying characteristics that contribute to the incidence of inflammation/ infection in pregnant women in Indonesia are more accurate.

Table 4. The accuracy of CART classification using test data

Observation	Prediction		Accuracy (%)
	Non-infection	Infection	
Non-infection	19	16	51.35
Infection	18	19	54.29
Accuracy			52.78

CONCLUSION

Seven variables that play a role in separating infection and non-infection in pregnant women based on the results of CART analysis are nutritional status based on Body Mass Index (BMI), history of anemia, pregnancy distance, Chronic Energy Deficiency (CED) status, age, socioeconomic and gestational age. Meanwhile, the highest incidence of inflammation /infection, which is 79%, occurred in the group of pregnant women with overweight-obese (BMI>25.0), anemia, and a pregnancy distance <3 years. CART classification analysis performed poorly in classifying pregnant women with inflammation/ infection, with an accuracy value of 52.78%

This study showed that identification performance accuracy is still not good, with an accuracy value of 52.78%. It is necessary to carry out a classification analysis with other methods, such as the Chi-square Automatic Interaction Detection (CHAID) method so that the results of identifying characteristics that contribute to the incidence of inflammation /infection in pregnant women in Indonesia are more accurate with higher sensitivity.

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DECLARATION OF INTERESTS

All the authors have no conflict of interests.

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Food Consumption in Relation to Hyperglycemia in Middle-Aged Adults (45–59 years): A Cross-Sectional National Data Analysis

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ABSTRACT

The study aimed to investigate the association between food consumption with hyperglycemia among middle-aged adults in Indonesia. This cross-sectional study utilized secondary data from the 2018 Indonesia Basic Health Survey (IBHS). A total of 8,477 subjects met the inclusion criteria and included in this study. Fasting Blood Glucose (FBG) was analyzed in the laboratory using an enzymatic analysis. The fasting blood glucose was categorized as hyperglycemia (≥126 mg/dl) and normal (<126 mg/dl). A food frequency questionnaire was used to assess the food intake. Multiple logistic regression was used to analyze the association of food consumption and hyperglycemia. Our results found that the prevalence of hyperglycemia in this population was 43%. The mean FBG was 104.68±31.99 mg/dL for male and 110.75±43.92 mg/dl for female subjects. Frequent consumption of sweet desserts (OR=1.265; CI=1.132, 1.413), Sugar-Sweetened Beverages (SSB) (OR=1.433; 95% CI:1.263−1.626), salty foods (OR=1.189; 95% CI=1.079−1.311), fried foods (OR=1.172; 95% CI=1.033−1.331), and instant foods (OR=1.186; 95 % CI=1.088−1.293) were significantly associated with increased odds of hyperglycemia. There was a significant association between food consumption and hyperglycemia among middle-aged adults in Indonesia.

Keywords: diet, food consumption, hyperglycemia, fasting blood glucose, Indonesia

INTRODUCTION

Non-communicable diseases are the leading cause of public health problems in developed and developing countries (Naghavi M 2017). Diabetes, one of the non-communicable diseases, is the main cause of death in the world (Zheng *et al.* 2018). Diabetes or hyperglycemia is characterized by an increase in blood sugar levels. Previous studies found that prevalence of hyperglycemia and the components of metabolic syndrome increased rapidly with age in women and men (Wu *et al.* 2017; Jiang *et al.* 2018). Indonesia is count as fourth globally after India, China, and America, in the number of people with diabetes (Naghavi M 2017). The prevalence of diabetes in Indonesia was around 6% (Mihardja *et al.* 2014) and based on the 2018 Indonesia Basic Health Survey (IBHS), higher prevalence of around 10% was found among middle-aged adults (MoH RI 2018).

Diabetes is caused by many factors including lifestyle (Sudargo *et al.* 2018). Sedentary lifestyle has been associated with the increasing risk for diabetes (Permatasari & Syauqy 2022). Previous study also found that diet was strongly associated with increased prevalence of diabetes (Lambrinou *et al.* 2019). Consumption of western foods or unhealthy foods is correlated with an increased prevalence of hyperglycemia and metabolic syndrome (Syauqy *et al.* 2018). Western foods or unhealthy foods are often high in simple carbohydrate, saturated fat, and sodium. In addition to increased consumption of this unhealthy food, there is also an increasing trend of inadequate consumption of vegetables and fruits which can also contribute to increase in diabetes prevalence (Syauqy *et al.* 2018; Schwingshackl *et al.* 2017).

Studies have found significant association between food consumption and metabolic syndrome among middle-aged adults in Taiwan (Syauqy *et al.* 2018). Middle-aged adults with high fruits and vegetables consumptions and lower unhealthy foods consumptions had better quality of life (Lo *et al.* 2016). However, Indonesian people tend to have high consumption of western foods and low fruits and vegetables (MoH RI

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2018). However, to the best of our knowledge, study investigated the association of unhealthy foods, fruits, and vegetables intakes with diabetes among middle-aged adults in Indonesia is limited, especially using a national database that can represents the Indonesian population. Therefore, this study aimed to investigate the association between food consumption with hyperglycemia among middle-aged adults in Indonesia utilizing the 2018 Indonesia Basic Health Survey (IBHS).

METHODS

Design, location, and time

This cross-sectional study was done using data from the 2018 Indonesia Basic Health Survey (IBHS). The IBHS used a two-stage stratified cluster sampling method survey population includes all Indonesian households, representing 26 Provinces and utilizing a sample framework from the national socio-economic survey in March 2018 (MoH RI 2018). This study had received ethical approval from the Health Research Ethics Commission, Medical Faculty, Universitas 'Aisyiyah Yogyakarta No. 1415/KEP-UNISA/VI/2021.

Sampling

The target sample included 300,000 households from 30,000 census blocks of the national socio-economic survey framework (MoH RI 2018). The total population data of the IBHS were 713,783 people aged ≥15 years (MoH RI 2018). The inclusion criteria in this study were individuals aged 45−59 years, had complete data of foods consumption, and had complete data on fasting blood glucose (n=8,481). While, subjects were excluded due to extreme values or missing data (n=4). Finally, a total of 8,477 subjects met the inclusion criteria and included in this study.

Data collection

The independent variables in this study were foods consumption; while, the dependent variable was blood glucose level grouped into hyperglycemia and normal. Fasting blood glucose were measured with fingertip capillary blood tests (Accu-Chek Performa, Roche Diagnostics GmbH, Mannheim, Germany). All participants were instructed to fast overnight (8−10 hours) before blood sampling. The fasting blood glucose was categorized as hyperglycemia (≥126 mg/dl) and normal (<126 mg/dl) (Kahn 2003; MoH RI 2018). A validated Food Frequency Questionnaire (FFQ) was used to assess the daily food consumption. The FFQ was validated by the IBHS prior the study (MoH RI 2018). The FFQ includes carbonated drinks, energy drinks, sweet desserts, SSB, salty foods, fried foods, grilled foods, processed foods, seasonings, instant foods, fruits, and vegetables (MoH RI 2018). Consumption of unhealthy foods (carbonated drinks, energy drinks, sweet desserts, SSB, salty foods, fried foods, grilled foods, processed foods, seasonings, instant foods) was categorized as frequent (≥ 1-time per day or 1−6 times per week) and infrequent (≤3 times per month or never). Fruits and vegetable consumption was categorized into adequate (≥5 servings per day) and inadequate (<5 servings per day) (MoH RI 2018). Sociodemographic data (age, gender, education, and place of residence) and lifestyle (smoking status, alcohol intake, and physical activity) were obtained using a structured questionnaire. Smoking was categorized into yes and no. Consumption of alcoholic beverages was categorized into yes and no (Atamni *et al.* 2016). Gender was categorized as male and female. Education level was categorized as high (completed 12-year compulsory education or bachelor/diploma/higher education graduates) and low (not completed 12-year compulsory education). Residency was categorized as urban and rural. Physical activity was categorized as low (doing heavy physical activity for <150 minutes/week) and high (doing heavy physical activity for ≥150 minutes/week (MoH RI 2018)

Data analysis

Univariate analysis was presented using mean±standard deviation for numerical data and frequency (percentage) for categorical data. In addition, bivariate analysis was performed using independent samples t-test for continuous variables and the Chi-square test for categorical variables. Whereas, multivariate analysis using multiple logistic regression was used to analyze the association of food consumption and hyperglycemia. Odds Ratio (OR) with 95% confidence intervals was used. We used unadjusted (model 1) and adjusted (model 2). Model 2 was adjusted for demographic data (age, gender, residency) and lifestyle (smoking status, alcohol consumption, and physical activity).

Adjustment for demographic data and lifestyle were done due to their potential association with hyperglycemia. All analyses were performed using the SPSS program 25 version with a p-value <0.05 considered statistically significant.

RESULTS AND DISCUSSION

Table 1 shows the characteristics of the subjects, the majority of the subjects with hyperglycemia were older (52.05±4.29), female (63.7), not smoking (69.8), and had low physical activity (53.3). Our results also found that the prevalence of hyperglycemia in the population was 43%. The mean FBG was 104.68±31.99 mg/dl for male and 110.75±43.92 mg/dl for female subjects. The prevalence of hyperglycemia was higher in females (44.6%) than males (40.6%).

The association of food consumption and hyperglycemia are described in Table 2. Among subjects with hyperglycemia, 20.2%, 15.5%, 28.3%, 14.1%, 10.3%, and 48.3% frequently consumed sweet desserts, SSB, salty foods, fried foods, seasonings, and instant foods, respectively. Moreover, among subjects with hyperglycemia, 73.2% consumed inadequate amount of fruits.

The odds ratios (95% confidence intervals) for food consumption across hyperglycemia are presented in Table 3. Frequent consumption of sweet desserts (OR=1.168; CI=1.035, 1.315), SSB (OR=1.306; CI=1.137, 1.600), salty foods (OR=1.159; CI=1.049, 1.281), fried foods (OR=1.153; CI=1.014, 1.312), seasoning (OR=1.119; CI=1.007, 1.356), and instant foods (OR=1.116; CI=1.020, 1.221) were significantly associated with increased crude odds (model 1) of hyperglycemia (R2=2%). After adjusting for age, gender, education levels, residency, smoking status, alcohol consumption, and physical activity (model 2), frequent consumption of seasonings was not significantly associated with hyperglycemia (R2=9%, it increased after adjusting for confounders).

Table 1. Characteristics of the subjects

Variables	Hyperglycemia		*p*
	Yes (n=3,648)	No (n=4,829)	
Age (mean±SD)	52.05±4.29	41.27±4.24	<0.001*
Gender (n%)			<0.001**
Male	1,323 (36.3)	1,935 (40.1)	
Female	2,325 (63.7)	2,894 (59.9)	
Education levels (n%)			0.310**
High	1,239 (34.0)	1,691 (35.0)	
Low	2,409 (66.0)	3,138 (65.0)	
Residency (n%)			0.188**
Rural	1,837 (50.4)	2,502 (51.8)	
Urban	1,811 (49.6)	2,325 (48.2)	
Smoking status (n%)			<0.001**
No	2,546 (69.8)	3,195 (66.2)	
Yes	1,102 (30.2)	1,634 (33.8)	
Alcohol consumption (n%)			0.465**
No	3,604 (98.8)	4,779 (99.0)	
Yes	44 (1.2)	50 (1.0)	
Physical activity (n%)			0.019**
High	1,684 (46.2)	2,355 (48.8)	
Low	1,964 (53.8)	2,474 (51.2)	
Fasting blood glucose (mean±SD)	130.84±52.65	91.47±5.43	<0.001*

*Comparison between continuous variables and hyperglycemia were performed using independent samples t-test

**Comparison between food consumption and hyperglycemia were performed using Chi-square test

SD: Standard Deviation

Table 2. Food consumption and hyperglycemia*

Variables	Hyperglycemia		OR (95% CI)	*p***
	Yes (n=3,648)	No (n=4,829)		
Carbonated drinks (n%)				
Infrequent	3,396 (93.0)	4,448 (92.2)	0.877	0.123
Frequent	254 (7.0)	379 (7.8)	(0.966, 1.343)	
Energy drinks (n%)				
Infrequent	3,463 (94.9)	4,566 (94.6)	0.944	0.300
Frequent	187 (5.1)	261 (5.4)	(0.873, 1.284)	
Sweet desserts (n%)				
Infrequent	2,912 (79.8)	4,021 (82.3)	1.265	<0.001
Frequent	736 (20.2)	808 (17.7)	(1.132, 1.413)	
Sugar-sweetened beverages (n%)				
Infrequent	3,086 (84.5)	4,281 (88.7)	1.433	<0.001
Frequent	564 (15.5)	546 (11.3)	(1.263, 1.626)	
Salty foods (n%)				
Infrequent	2,618 (71.7)	3,625 (75.1)	1.189	<0.001
Frequent	1,032 (28.3)	1,202 (24.9)	(1.079, 1.311)	
Fried foods (n%)				
Infrequent	3,137 (85.9)	4,236 (87.8)	1.172	0.015
Frequent	513 (14.1)	591 (12.2)	(1.033, 1.331)	
Grilled foods (n%)				
Infrequent	2,594 (71.1)	3,398 (70.4)	1.033	0.515
Frequent	1,056 (28.9)	1,429 (29.6)	(0.940, 1.135)	
Processed foods (n%)				
Infrequent	2,936 (80.4)	3,804 (78.8)	0.905	0.069
Frequent	714 (19.6)	1,023 (21.2)	(0.813, 1.007)	
Seasonings (n%)				
Infrequent	3,274 (89.7)	4,402 (91.2)	1.190	0.020
Frequent	376 (10.3)	425 (8.8)	(1.028, 1.377)	
Instant foods (n%)				
Infrequent	1,889 (51.7)	2,702 (56.0)	1.186	<0.001
Frequent	1,761 (48.3)	2,125 (44.0)	(1.088, 1.293)	
Fruits (n%)				
Adequate	976 (26.8)	1,374 (28.5)	1.090	0.042
Inadequate	2,674 (73.2)	3,453 (71.5)	(0.990, 1.200)	
Vegetable (n%)				
Adequate	637 (17.5)	841 (17.4)	1.002	0.495
Inadequate	3,013 (82.5)	3,986 (82.6)	(0.895, 1.123)	

*Frequent (≥ 1-time per day or 1−6 times per week) and infrequent (≤3 times per month or never); Adequate (≥5 servings per day) and inadequate (<5 servings per day)

**Comparison between food consumption and hyperglycemia were performed using Chi-square test

We found that frequent consumption of sweet desserts and SSB were significantly associated with risk of hyperglycemia. Our result was in line with another cross-sectional study where subjects with metabolic disorders also had higher intake of desserts and beverage than those without metabolic disorders (Permatasari & Syauqy 2022). Sweet desserts and SSB contained carbohydrates or simple sugars with a high Glycemic Index (GI) value, leading

Table 3. Odds ratios (95% confidence intervals) for food consumption across hyperglycemia

Variables	Model 1**			Model 2***		
	OR	95% CI	*p*	OR	95% CI	*p**
Carbonated drinks			0.122			0.419
Infrequent	1			1		
Frequent	1.066	0.889, 1.279		1.071	0.907, 1.266	
Energy drinks			0.565			0.772
Infrequent	1			1		
Frequent	0.961	0.778, 1.187		0.971	0.798, 1.182	
Sweet desserts			<0.001	1		<0.001
Infrequent	1					
Frequent	1.168	1.035, 1.315		1.135	1.005, 1.281	
Sugar-sweetened beverages			<0.001			<0.001
Infrequent	1			1		
Frequent	1.306	1.137, 1.600		1.284	1.116, 1.477	
Salty foods			<0.001			<0.001
Infrequent	1			1		
Frequent	1.159	1.049, 1.281		1.140	1.031, 1.260	
Fried foods			0.014			0.042
Infrequent	1			1		
Frequent	1.153	1.014, 1.312		1.137	1.000, 1.294	
Grilled foods			0.504			0.735
Infrequent	1			1		
Frequent	0.980	0.888, 1.082		0.964	0.872, 1.065	
Processed foods			0.410			0.495
Infrequent	1			1		
Frequent	1.048	0.937, 1.173		1.079	0.969, 1.202	
Seasonings			0.040			0.167
Infrequent	1			1		
Frequent	1.119	1.007, 1.356		1.156	0.998, 1.340	
Instant foods			0.016			0.052
Infrequent	1			1		
Frequent	1.116	1.020, 1.221		1.127	1.032, 1.229	
Fruits			0.080			0.008
Adequate	1			1		
Inadequate	1.038	0.937, 1.149		1.086	0.985, 1.197	
Vegetable			0.969			0.098
Adequate	1			1		
Inadequate	0.953	0.846, 1.074		1.001	1.893, 1.123	0.883

*Differences between food consumption and hyperglycemia were analyzed using multiple logistic regression

**Model 1 was unadjusted.

***Model 2 was adjusted for age, gender, education level, residency, smoking status, alcohol consumption, physical activity.

to accelerated increase in blood sugar levels (Medina-Remón *et al.* 2018). In addition, study also found that consuming sweetened sugary beverages decreases the endothelial cells' micro and macro cellular function (Loader *et al.* 2017). These metabolic abnormalities are due to the increased in oxidative stress and decreased in NO's (nitric oxide) bioavailability, which plays an important role in glucose metabolism. The decreased in NO bioavailability is also related

to risk of developing type 2 diabetes (Loader *et al.* 2017). Added sugar intake is involved in the production of reactive oxygen species (ROS). This increases the expression of cytokines and cell adhesion molecules (Prasad & Dhar 2014).

Participants who frequently consumed salty foods were also associated with increased risk of hyperglycemia. This result is in line with a previous study (Nur *et al.* 2016). High consumption of salty foods is correlated with an increased risk factor for DM (Nur *et al.* 2016). High intake of sodium increases the risk of hyperglycemia through the PPAR δ/adiponectin/ SGLT2 mechanism in regulating sodium and glucose homeostasis (Zhao *et al.* 2016).

We also found frequent consumption of fried foods was significantly associated with risk of hyperglycemia. Fried foods are high in saturated fat and cholesterol. A high-fat diet significantly contributes to obesity and non-insulin-dependent diabetes mellitus (Naja *et al.* 2013). Previous study found a positive relationship between high intake of saturated fat and cholesterol and increased hyperglycemia and type 2 diabetes in humans and rats (Cahill *et al.* 2014). Saturated fat in the cell membrane will decrease the viscosity of the lipid bilayer of a cell membrane and lead to a decrease in the insulin receptors (Min *et al.* 2018).

Frequent consumption of instant foods also had a significant relationship with the incidence of hyperglycemia as indicated by an increase in FBG in this study. Our results are consistent with other studies that high intake of instant foods were linked to a higher risk of developing diabetes due to the high carbohydrate and fat (Huh *et al.* 2017). An animal trial of monosodium glutamate found a significant increase in glucose levels as evidenced by an increase in HOMA-IR value in rats. It is due to the changes in insulin binding or insulin post receptors in the target tissues (Helal *et al.* 2019). Monosodium glutamate may trigger the degradation of neuronal membranes, allowing calcium ions to enter cells because of its permeability of sodium ions, calcium ions, and water. Then, it might damage the pancreatic gland and hyperglycemia (Jusuf *et al.* 2020).

In this study, individuals with inadequate consumption of fruits and vegetables had a 1.086 and 1.001 times risk for hyperglycemia than those with adequate consumption of vegetables and fruits, but these associations were not statistically significant. In contrast, other study found that higher intakes of fruits and vegetables can reduce hyperglycemia (Samaan 2017). Fiber might delay the digestion and absorption of carbohydrates and increase satiety effect. In individuals with insulin resistance, fiber can increase peripheral insulin sensitivity through short-chain fatty acids produced by fiber fermentation in the gut (Samaan 2017) . In addition, a diet high in fruits and vegetables is associated with high intake of magnesium and iron (Zhang *et al.* 2015). Magnesium is an important cofactor for several enzymes in glucose metabolism, which further plays a role in the development of diabetes (Verma & Garg 2017). Diabetes is a chronic disease. People with diabetes might change their diet, and eat more healthy food; however, it cannot change immediately the condition of the disease.

Result from bivariate analysis was in line with a previous study conducted in Indonesia (Permatasari & Syauqy 2022). Among subjects with metabolic disorders, 8.8%, 6.3%, and 21.2% frequently consumed soft drink, energy drinks, and processed meat. Moreover, among subjects with metabolic disorders, 91.9% and 88.4% consumed inadequate fruits and vegetables, respectively.

To the best of our knowledge, this study is the first study analyzing the association of food consumption with hyperglycemia among middle-aged in Indonesia. Our study used a large sample that reflected the Indonesian population. However, despite its strength this study also has several limitations. Firstly, dietary data were taken using a frequency of intake which contain no information related to the nutrients. Further research with a priori or a posteriori method is highly recommended. By using a priori or a posteriori method, researchers may derive the dietary patterns consisting of complex foods with many nutrients that represent the diet intake among population of interest. Moreover, the R2 of logistic regression analyses in this study was relatively low; suggesting other factors outside the model can explain the incidence of hyperglycemia in middle-aged adults. Finally, the cross-sectional design restricts the results in maintaining the causality between the variables. Additional longitudinal study is needed to explore the mechanism between variables to established causality.

CONCLUSION

There was a significant association between food consumption and hyperglycemia status among middle-aged adults in Indonesia. Frequent consumption of sweet desserts, SSB, salty foods, fried foods, and instant foods are all increased the odds (chance) for hyperglycemia. Further research with a priori or a posteriori dietary pattern approach is highly recommended. Additional longitudinal study is needed to explore the mechanism between variables.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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Health Literacy: How is it Related to Body Mass Index of Patients with Diabetes Mellitus?

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ABSTRACT

This study aimed to assess the level of health literacy and determines the association between health literacy and Body Mass Index (BMI) among T2DM patients in Hospital Universiti Sains Malaysia (HUSM). A cross-sectional study was conducted among 96 patients with T2DM. Health literacy was measured using the Malay version of the European Health Literacy Survey Questionnaire 16 (HLS–EU–Q16). Information about sociodemographic, weight, height, and body mass index were obtained. The majority of the participants had sufficient health literacy (60.4%), whereas the mean BMI of patients was 28.59 kg/m^2. A significant association was found between BMI with health literacy levels. The median BMI value of the sufficient health literacy group was significantly higher, 28.38 (6.02) than the problematic health literacy group, 25.38 (7.52) using Kruskal Wallis test. This indicates that health literacy may be a predictor of BMI. Or maybe, the other way around is true, increased BMI may result in increased awareness on health. Still, other stronger determinants besides health literacy such as income and dietary intake which were not included in this study might influence the BMI of T2DM patients.

Keywords: body mass index, diabetes, health, health literacy

INTRODUCTION

The prevalence of diabetes has risen significantly throughout the years. Around 462 million people were diagnosed with T2DM in 2017, representing 6.28% of the global population or a prevalence rate of 6,059 cases per 100,000 and this figure is expected to rise to 7,079 individuals per 100,00 by 2030 (Khan *et al.* 2020). T2DM affects around one in every eleven adults worldwide, with Asia serving as the epicentre of the global T2DM epidemic (Zheng *et al.* 2018). Similarly, Malaysia's overall diabetes prevalence has increased from 11.2% in 2011, 13.4% in 2015, to 18.3% in 2019 (Institute for Public Health 2020). T2DM patients are exposed to the possibility of several complications owing to multifaceted and interrelated processes such as hyperglycemia, insulin resistance, inflammation, and atherogenesis (Schlienger 2013).

In order to halt the disease progression, health literacy is required in patients with T2DM to practice multiple tasks. Multiple tasks of patients with T2DM, namely monitoring their blood glucose level, adherence to medication or diabetic diet, and appointment with a doctor, require good health literacy. Health literacy is related to literacy and requires the knowledge, motivation, and ability of individuals to access, comprehend, and apply health information in order to make judgments and decisions about healthcare, disease prevention, and health promotion to sustain or improve the quality of life throughout life (Sørensen *et al.* 2012). High health literacy is linked with greater diabetes related knowledge, self-efficacy and self-care behaviours (Bailey *et al.* 2014). Thus, health literacy is crucial to be assessed in patients with T2DM, so that improvement can be made in the lacking aspect for recovery from diabetic-related health outcomes of patients.

Overweight and obesity have been recognized as a global concern worldwide for the past years. Besides, T2DM was four times more prevalent in obese patients constituting approximately one-half of cases compared to people with normal Body Mass Index (BMI) (Abbasi *et al.* 2017). In addition, overweight and obesity are prevalent among patients with metabolic diseases such as T2DM. Higher BMI

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may contribute to poor glycaemic control and risk of cardiovascular disease. Besides, high BMI is also related to a poorer health-related quality of life (Wong *et al.* 2013).

Poor health literacy is generally linked with poor health behaviours and health outcomes. Based on a systematic review, recent evidence suggests that low health literacy is one of the contributors of obesity and, more importantly, maybe a significant factor in obese people's inability to lose weight (Michou *et al.* 2018). There is limited study on the association between health literacy and BMI among T2DM patients. Physical inactivity and unhealthy dietary behaviour are examples of factors that can contribute to high BMI and excessive weight gain and further deteriorate health outcomes. Based on a Danish population-based study, 30.7% of the participants are physically inactive. The study found that diabetes patients with low health literacy are more likely to be physically inactive (Friis *et al.* 2016). A framework illustrating association between health literacy with BMI (intermediate outcomes) through physical activity and nutrition/diet (self-care behaviours) has been postulated. Low numeracy skills, which is one of the components of health literacy assessed using the Rapid Estimate of Adult Literacy in Medicine (REALM) is also associated with high BMI (Huizinga *et al.* 2008). Meanwhile, another study found no association between health literacy and BMI among T2DM African American population (Al Sayah *et al.* 2015). Even though there is a mixed review on the association of health literacy with BMI among T2DM patients, it is beneficial to consider the level of health literacy of patients when developing interventions, in order to improve patient's health outcome. Therefore, the objectives of this study are to assess the level of health literacy, assess the mean BMI, and determine the relationship between health literacy and body mass index among T2DM participants in Hospital Universiti Sains Malaysia (HUSM).

METHODS

Design, location, and time

This study implemented a cross-sectional study design and was conducted at selected clinics and wards in Hospital USM by using purposive selection. This location was chosen because it is the place that T2DM patients get treatment for their disease. The data collection was conducted from October 2021 to January 2022. The study population was patients with T2DM who were admitted to wards (Medical Wards and Orthopaedic Wards) and attended outpatient clinics in HUSM. Patients diagnosed with T2DM for the past one year, had been on diabetes mellitus treatment (oral anti-diabetic agents or insulin or both) at least for the past four weeks, aged 18 years old and above, and able to speak and understand the Malay language were recruited in the study. The exclusion criteria of the study are participants who were diagnosed with Type 1 Diabetes Mellitus or Gestational Diabetes Mellitus, wheelchair bound patients, bed-ridden or patients in the Intensive Care Unit (ICU), having severe mental health issue and is currently under follow-up of the psychiatric and undergoing dialysis. We have only included T2DM patients in this study to obtain precise results regarding health literacy among this specific group of patients.

Sampling

One proportion formula had been used for calculating the sample size, and the proportion value will represent the proportion of limited health literacy 65.3% among T2DM patients in Perak, Malaysia (Abdullah *et al.* 2019). With a 95% confidence level and drop-out rate of 10%, the total number of recruited T2DM patients were 96. The sampling method that was used in this research is convenience sampling. Subjects who met the inclusion criteria were included in this study.

Data collection

Potential subjects at each medical ward and clinic were approached to participate in the study. Potential participants were screened thoroughly for only selecting those meeting the inclusion criteria. The patients who matched the inclusion and agreed to participate in the study were explained the purpose and benefits of the study. Informed consent was given by the patients prior to the start of interview. Data was collected via the interviewer-administered method. The researcher filled in the socio-demography characteristics and health literacy part according to patients' answers, while anthropometry data (weight and height) were retrieved from medical records of patients as these data were taken almost daily in

the inpatient setting or taken during each follow-up in the outpatient setting. The interview session was conducted approximately for 10 minutes.

The questionnaire had three sections namely socio-demography, anthropometry, and health literacy. As for the socio-demography section, data such as age, gender, ethnicity, marital status, educational level, employment status, household income and type of diabetes treatment (diet therapy, Oral Anti-Diabetic (OAD), and insulin) were collected through the section. Data about anthropometry measurements, including weight (kg) and height (cm) were obtained from medical records. Then, body weight and height were used to calculate the Body Mass Index (BMI). The classification of BMI followed WHO International BMI cut-off points and is as follows: BMI<18.5 kg/m^2 (underweight), between 18.5–24.9 kg/m^2 (normal), ≥25 kg/m^2 (overweight) and ≥30 kg/m^2 (obese) (WHO Expert Consultation 2004). For older adults aged 60 years and above, a different cut-off point was used: Nutrition Screening Initiative (NSI) criteria developed in 1991 in the United States and has been validated in American older adults (Posner *et al.* 1993). The BMI for elderly is as follows: BMI<24 kg/m^2 (underweight) between 25 to 26 kg/m^2 (normal), ≥27 kg/m^2 (overweight) and ≥30 kg/m^2 (obesity).

The Malay version of The European Health Literacy Survey Questionnaire 16 (HLS–EU–Q16) was used to assess health literacy (Duong *et al.* 2017). The HLS-EU-Q16 Malay version consists of 16 items and has three sub-domains: health care, disease prevention, and health promotion. Response for selected items from this questionnaire were analysed. The HLS-EU-Q16 Malay version's internal consistency is strong, with Cronbach's alpha ranging from 0.775 for the disease prevention domain, to 0.779 and 0.795 for the health care domain and health prevention domain, respectively (Baharum *et al.* 2020). The HLS-EU-Q16 measures each item by using 4 points Likert scale scoring from 1 (very difficult); 2 (fairly difficult); 3 (fairly easy) and 4 (very easy). For the scoring purpose, scores 1 and 2 were categorized as 0, while scores 3 and 4 were given value of 1. Thus, scores range from a minimum score of 0 to a maximum score of, 16 created from summation of all the 16 questions. The level of health literacy was classified into three categories, namely "inadequate" when the health literacy score was between 0–8, "problematic" and "sufficient" when the health literacy scores were between 9–12 and 13–16, respectively. The scoring had been done based on the guidelines from previous study by Mekhail *et al.* 2022.

The process of data collection was conducted when ethical approval from the Human Research Ethics Committee USM (USM/JEPeM/21060451) and permission from the Director of Hospital USM were obtained.

Data analysis

Data analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS), version 26.0. Descriptive statistics were used to summarize the socio-demographic characteristics of subjects and the response given for some selected items in The European Health Literacy Survey Questionnaire 16 (HLS–EU–Q16). The data was presented using number (n) and percentage (%) for categorical data. Mean (SD) or Median (IQR) represented numerical/continuous data based on their normality distribution. The association between health literacy (categorical variable) and BMI (numerical variable) was tested using Kruskal Wallis Test, as the data were not normally distributed. Mann-Whitney Test was used to check which pairs of health literacy levels are significant with BMI value. The significance level was set at 0.05 and 95% confidence interval.

RESULTS AND DISCUSSION

Socio-demographic and clinical characteristics

The socio-demographic and clinical characteristics of T2DM patients in Hospital USM were shown in Table 1. The mean age of patients was 60.0 years old (SD=9.65). The majority of the patients were female, 77 (89.2%) and were predominantly Malay (n = 92, 95.8%). Majority of patients (n=50, 52.1%) were unemployed (housewife) and has less than RM2000 household income (n=56, 58.3%) or around 424 USD. Regarding the type of diabetes treatment, 42 (43.8%) of patients were using only OAD, while 26 (27.1%) and 28 (29.2%) were using an insulin regime and both OAD and insulin, respectively.

Health literacy level

Table 2 demonstrated the distribution of particpants` health literacy score based on

Table 1. The socio-demographic and clinical characteristics of T2DM patients (n=96)

Variables	Mean±SD	Frequency (n)	%
Age of patients (years)	60.01±9.65		
Gender			
Male			
Female		19	19.80
Ethnicity		77	80.20
Malay		92	95.8
Chinese		3	3.1
Punjabi		1	1.0
Marital status			
Single		3	3.1
Married		92	95.8
Widow		1	1.0
Educational level			
Illiterate		4	4.2
Primary		20	20.8
Secondary		49	51.0
Tertiary		23	24.0
Employment status			
Government sector		12	12.5
Private sector		4	4.2
Self-employed		6	6.3
Retired		24	25.0
Unemployed		50	52.1
Household income			
<MYR 2,000		56	58.3
MYR 2,000–3,899		20	20.8
MYR 3,900–6,619		13	13.5
>MYR 6,620		7	7.3
Type of diabetes treatment			
OAD		42	43.8
Insulin regime		26	27.1
Both OAD & insulin		28	29.2

OAD: Oral Anti-Diabetic Agent; MYR: Malaysian Ringgit
SD: Standar Deviation

Table 2. Distribution of health literacy scores according to each item in the HLS-EU-Q16

Question	Very difficult n (%)	Fairly difficult n (%)	Faily easy n (%)	Very easy n (%)
Q1	23 (24.0)	14 (14.6)	11 (11.5)	48 (50.0)
Q2	2 (2.1)	3 (3.1)	8 (8.3)	83 (86.5)
Q3	1 (1.0)	6 (6.3)	19 (19.8)	70 (72.9)
Q4	0 (0.0)	1 (1.0)	18 (18.8)	77 (80.2)
Q5	3 (3.1)	7 (7.3)	14 (14.6)	72 (75.0)
Q6	1 (1.0)	17 (17.7)	29 (30.2)	49 (51.0)
Q7	0 (0.0)	7 (7.3)	13 (13.5)	76 (79.2)
Q8	30 (31.3)	14 (14.6)	16 (16.7)	36 (37.5)
Q9	1 (1.0)	7 (7.3)	13 (13.5)	75 (78.1)
Q10	1 (1.0)	1 (1.0)	14 (14.6)	80 (83.3)
Q11	22 (22.9)	24 (25.0)	24 (25.0)	26 (27.1)
Q12	19 (19.8)	22 (24.0)	23 (22.9)	32 (33.3)
Q13	25 (26.0)	22 (22.9)	11 (11.5)	38 (39.6)
Q14	5 (5.2)	6 (6.3)	11 (11.5)	74 (77.1)
Q15	15 (15.6)	9 (9.4)	13 (13.5)	59 (61.5)
Q16	0 (0.0)	4 (4.2)	18 (18.8)	74 (77.1)

each item in the questionnaire. Meanwhile, Table 3 reported the specific score of each item according to the domains. In the domain of health care, almost 38.5% of the participants reported that they had difficulties finding information about the illness that concerns them. In addition, almost 47.9% of the patients had lack of ability to determine the accuracy of the health-related information in the social media. Another 49.0% of the patients reported that they had difficulties

Table 3. Summary of the HLS-EU-Q16 scores according to each domain

Questions	Very difficuly to fairly difficult n (%)	Fairly to very easy n (%)
Health Care		
Q1	37(38.5)	59 (61.5)
Q2	5 (5.2)	91 (94.8)
Q3	7 (7.3)	89 (92.7)
Q4	1 (1.0)	95 (99.0)
Q5	10 (10.4)	86 (89.6)
Q6	18 (18.8)	78 (81.3)
Q7	7 (7.3)	89 (92.7)
Diseases prevention		
Q8	44 (45.8)	52 (54.2)
Q9	8 (8.3)	88 (91.7)
Q10	2 (2.1)	94 (97.9)
Q11	46 (47.9)	50 (52.1)
Q12	42 (43.8)	54(56.3)
Helath promotion		
Q13	47 (49.0)	49 (51.0)
Q14	11 (11.5)	85 (88.5)
Q15	24 (25.0)	72(75.0)
Q16	4 (4.2)	92 (95.8)

to find activities to improve their mental well-being.

The mean total health literacy score is 12.7(3.0). Analysis according to domain demonstrated higher mean value for the domain of health care,6.1(1.1). The majority of the participants (n=58, 60.4%) had sufficient (13–16) health literacy (Table 4).

Majority of the participants (86.5%) find it very easy to "get professional help when they are ill," whereas 83.3% of the participants felt it very easy to "understand why they need health screenings". This indicates that the participants may have fewer problems in obtaining and comprehending health information, which contributed to a higher health literacy level among the participants. Moreover, they routinely and willingly come to the hospital for follow-up appointments with their doctor or dietitian,

Table 4. The scores of healthy literacy according to domains and health literacy level among T2DM patients

Variables	Mean±SD	Frequency (n)	%
Health literacy domains			
Health care	6.1±1.1		
Disease prevention	3.5±1.3		
Health promotion	3.1±1.1		
Health literacy level			
Inadequate (0–8)		10	10.4
Problematic (9–12)		28	29.2
Sufficient (13–16)		58	60.4

SD: Standar Deviation

indicating the rate of appointment compliance is high. Compliance with doctor's appointments is indeed helping the participants to access and understand health information, as delayed care and not having seen a doctor in the previous year are the behaviours that are likely to be observed in low health literacy individuals (Levy & Janke 2016). Furthermore, frequently taking blood sugar tests and blood pressure at the hospital may facilitate the participants' understanding of the importance of health screening. On the other hand, information search on the ways to manage mental health problems and performing tasks that improves mental health is very challenging. It is understandable that the participants felt mental health information is difficult to obtain as negative stereotypes commonly accompany mental health. T2DM patients with mental health comorbidities such as depression, anxiety, or schizophrenia had a 24% higher risk of 4-year mortality, because these comorbidities affected quality of life and ability to perform self-care activities (Guerrero Fernández de Alba *et al.* 2020). Thus, mental health literacy may need significant consideration when managing T2DM patients.

This study revealed that 60.4% of the participants had sufficient health literacy. The health literacy level in this study is inconsistent with the results reported in Yi and Ismail (2020), which stated the overall prevalence of low health literacy among patients visiting a government health clinic was 83.1%, respectively. The discrepancies in the health literacy level among T2DM patients across several studies are due to the

multiple measuring tools that report psychometric features in different ways, making it difficult to compare final results (Abdullah *et al.* 2019).

Nutritional status of participants

Based on Table 5, the mean weight of participants was 70.68 kg (SD=16.14), whereas the mean height was 157.08 cm (SD=7.63). Furthermore, the mean BMI of patients was 28.59 kg/m^2 (SD=6.17), which was within the overweight category.

Association between health literacy with education level and body mass index

Table 6 revealed the relationship between health literacy with education level and BMI among 96 T2DM patients in Hospital USM. Subjects with secondary and tertiary education had sufficient health literacy level as compared to those who are illiterate (51.7%) and with primary education (37.9%).

Kruskal-Wallis test (non-parametric test) revealed a statistically significant difference in the median BMI of participants with three health literacy levels (p=0.01). After post-hoc test were conducted by doing comparison analysis with separate pairs using the Mann Whitney test and Bonferroni's correction, it was found that the significant different BMI value was contributed by the comparison between problematic and sufficient health literacy groups (p=0.009, <0.05). The median BMI value of the sufficient health literacy group (median=28.38, IQR=6.02) was significantly higher than the problematic health literacy group (median=25.38, IQR=7.52).

The current study found that health literacy is significantly associated with level of education. Participants who are illiterate and with primary education had very low level of sufficient health literacy score as compared to those with secondary and tertiary education (p<0.05) (not reported in table). Level of education is indeed one of the factors that influence health literacy. Study by Ueno *et al*. (2019) found that there is an association between educational level and health literacy among T2DM patients. Participants with greater education level will engage in health-seeking behaviour and have greater access to health-related websites and resources, resulting in improved health literacy (Bayati *et al.* 2018).

This study demonstrated that health literacy is associated with BMI among T2DM patients in Hospital USM and further post-hoc analysis revealed significant association between the problematic and sufficient health literacy groups. It was assumed that the median BMI of problematic health literacy groups would be higher than the sufficient groups. This is because individuals with low health literacy will have difficulties maintaining a healthy weight as they lack the necessary skills to obtain, comprehend, appraise and utilize the health information appropriately (James *et al.* 2015). However, our results showed otherwise. This study is consistent with Mashi *et al.* (2019) study, which also reported that the BMI value of the adequate health literacy group among T2DM patients was slightly higher than the marginal and inadequate health literacy group. Previous studies regarding the association between health literacy and BMI showed mixed results. Enomoto *et al.* (2020) revealed no significant association between level of health literacy and BMI. A systematic review by Michou *et al.* (2018) confirmed the association between health literacy and BMI. However, those studies suggested that the lower the health literacy level, the higher the BMI, which is contrary to our study, which found high BMI in the high health literacy level group. Therefore, it was believed that higher BMI among the sufficient health literacy group might be due to other stronger factors such as poor knowledge on carbohydrate counting, lack of physical activity, or poor socioeconomic status that have more impact on the BMI of T2DM patients. Low health numeracy skills related to weight management, such as monitoring calorie intake, interpreting food labels, and tracking daily steps, may also contribute to higher BMI in the adequate health literacy group because patients with limited numeracy abilities may be unable to successfully interpret or use typical

Table 5. Nutritional status of T2DM patients in Hospital USM

Variables	Mean±SD	Minimum	Maximum
Weight (kg)	70.68±16.14	39.00	131.00
Height (cm)	157.08±7.63	141.00	195.00
BMI (kg/m^2)	28.59±6.17	19.48	58.22

BMI: Body Mass Index; SD: Standard Deviation

Table 6. Relationship between health literacy with education level and BMI among T2DM patients

Variables	Indequate	Probelmatic	Sufficient	Kruskal-Wallis H (df)	*p**
Health literacy level n (%)					
Illiterate	2 (20.0)	2 (7.1)	0 (0.0)		
Primary	6 (60.0)	8 (28.6)	6 (10.3)		
Secondary	2 (20.0)	17 (60.7)	30 (51.7)		
Tertiary	0 (0.0)	1 (3.6)	22 (37.9)		
Health literacy level n (%)					
BMI	10	28	58	9.14 (2)	0.01
Median (IQR)	28.73 (6.11)	25.38 (7.52)	28.38 (6.02)		

*Tested using Kruskal Wallis Test; *Post hoc with Bonferroni's correction

Inadequate vs. Problematic; p-value=0.183

Inadequate vs. Sufficient; p-value=3.00

Problematic vs. Sufficient; p-value=0.009

weight management counselling (Huizinga *et al.* 2008). T2DM patients with a higher BMI did not meet HbA1c targets, ate sweeter foods, had less physical activity, and were more likely to skip breakfast (Al-Mountashiri *et al.* 2017).

The findings of this study demonstrated that the BMI of the patients were in the overweight category with mean BMI of 28.59kg/m^2. Maintaining BMI within the optimal range is essential for diabetic patients well being as abnormal increase in BMI leads to changes in blood glucose, blood pressure, and serum lipid profile Hu e*t al.*2021). Gray *et al.* (2015) mentioned that weight control is critical for preventing diabetes mellitus-related complications because a high BMI increases risk of complications. Hence, weight-loss management, including dietary, exercise, and behavioural interventions, is essential in the long term and may result in better diabetic outcomes.

Most health outcomes are unlikely to be influenced directly by health literacy; rather, health outcomes are likely to be influenced by various mediating mechanisms, called health actions (Wallace 2010). This revealed that health literacy does not solely influence health outcomes. That study also suggests that motivational processes will ultimately influence an individual to perform health actions, as an individual may already have some knowledge about physical activity and health screening. Still, the knowledge is only a force to form intentions about health actions. However, motivation alone is not the only predictor of adopting a health action. Self-efficacy and social support can mediate the association between health literacy and BMI (Squiers *et al.* 2012). For example, an individual may understand that excessive energy intake may cause high BMI but may not have the social support or self-efficacy to control their food intake. Social support is important to make changes, as people with diabetes who have received positive support from their relatives and friends are more likely to adhere to self-care behaviours (healthy dietary patterns and exercise) (Mohebi *et al.* 2018).

The current study determines the relationship between health literacy and BMI among T2DM patients in Hospital USM. The association of health literacy and BMI will provide insights into ways to improve the health outcomes of T2DM patients. Health literacy is a study area that is gaining attention at the moment. Therefore, this study will also contribute to Malaysia's health literacy data. In this regard, this study will help healthcare professionals better understand the overall health literacy scenario. The fact that there are still 39.6% of the participants with low health literacy cannot be overlooked. Hence, this finding could help policymakers create better educational programmes and help healthcare providers pay greater attention to their communication style with patients to improve health literacy.

This study was performed in a single hospital in Malaysia, thus the findings of this study are not generalizable to all T2DM population in Malaysia. Moreover, the data was collected in an area where Malay is the majority ethnicity, so the majority of the participants were Malay, which cannot be generalised to Malaysian population settings. As a result, future studies should use a better sampling approach that can balance participants of varying ethnicities. Besides, we recruited study participants using the purposive sampling technique without randomization. As a result, the study's generalizability and reliability are limited. Since the health literacy level and BMI were assessed cross-sectionally, the causal associations could not be discovered.

CONCLUSION

It can be concluded that the majority (60.4%) of patients with T2DM in Hospital USM have sufficient health literacy. The most probable reason for this finding is that more than half of our study participants have good educational backgrounds, with 51.0% and 24.0% of the participants at secondary and tertiary levels, respectively. Besides, it was found that most of the participants were within the overweight category. Other than that, we found a statistically significant relationship in the median BMI of participants according to the three health literacy level (p=0.01). The significant difference BMI value was contributed by the comparison between problematic and sufficient health literacy groups. The median BMI value of the sufficient health literacy group was significantly higher than the problematic health literacy group. This revealed that the interaction between health literacy and BMI is more multifaceted than just direct one way effect, which may be influenced by dietary behavior, physical activity, numeracy skills, motivation, and social support. Nevertheless, this study is able to contribute to the knowledge of the relationship between health literacy with BMI among T2DM patients in Hospital USM.

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DECLARATION OF INTERESTS

The authors have no conflict of interest.

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