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- Gender, education, eating patterns, and nutritional status among high school students in the tourist area of Bukittinggi, Indonesia
- A qualitative study on the experiences of the prospective brides about nutritional preparation during the preconception period
- Association between maternal anemia and low birth weight among stunting children 12−23 months in Dili, Timor Leste

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World Nutrition Journal (abbreviated: W Nutr J) is an international, English language, peer-reviewed, and open access journal upholding recent evidence related to nutrition sciences. The journal accepts manuscripts in terms of original paper, case report, editorial, and letter to editor.

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World Nutrition Journal was founded in 2016 as the official journal of Indonesian Nutrition Association. It aims to publish high quality articles in the field of community, clinical, and critical care aspects of nutrition sciences

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EDITORIAL

The role of artificial intelligence in nutritional assessment in clinical practice

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Nutrition has become an integral part of clinical practice, influencing everything from immune function, disease prevention, and treatment. To achieve a good nutrition practice tailored to every patient requires a proper nutritional assessment, which may be challenging. Moreover, there is no one-size-fits-all approach to nutrition as each patient's needs are influenced by factors such as age, gender, genetics, lifestyle, and comorbid conditions. The challenges may be elevated in assessing elderly patients.[1]

The traditional methods of evaluating nutritional status typically involve a combination of clinical assessments, laboratory tests, and patient history, such as dietary recalls and food diaries. These can be time consuming, subjective, and may be inaccurate as misreport and misinterpretation prone to happen.[2]

Enters the artificial intelligence or AI. The acceleration of technologies has developed into making AI as tools to many aspects in life, including clinical practice. AI, particularly machine learning (ML) and deep learning algorithms, is poised to address many of the challenges associated with traditional nutritional assessments. One of the most significant advantages of AI is its ability to analyze and interpret large volumes of data quickly and accurately.

Through AI, it is possible for patients to track and assess their own nutritional health outside of clinical settings. Furthermore patients can use apps to weight loss programs by utilizing camera to capture digital images in dietary assessment to help counting the amount of calorie intakes.[3] For clinicians, AI from patient's apps and wearable devices can help to assess dietary patterns instead of relying on dietary recalls alone, tracking patient's blood sugar levels, and many more.[3,4]

However, as promising as its potential might be, AI nutritional diagnostic does not come without obstacles. Several concerns may include the quality and accuracy of the data being used to train AI algorithms which, if it's poor, can lead to false diagnosis. This can lead to potentially compromising patient care.

Additionally, the use of AI raises ethical questions about data privacy and security, as AI systems process sensitive health information. This issue may threaten patient's data confidentiality.[5] Nevertheless, while challenges remain, the potential benefits of AI in nutrition therapy are undeniable. As technology continues to evolve, AI will undoubtedly play an increasingly critical role in shaping the future of nutrition diagnostics and healthcare at large.

Conflict of interest

The authors declare that there is no conflict of interest related to the study.

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EDITORIAL

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REVIEW

A scoping review: Potential nutraceutical values of bioactive compounds and antioxidant activity in durian seed – An exotic tropical plant

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Abstract

Background: Durian is a tropical fruit with a unique flavour and intense aroma. All parts of durian are reported to have many health benefits, especially the seeds. The seeds are known to have higher antioxidant activity and phytochemical compound than the pulp. Durian seeds are food waste that has the potential to be reused in the food and health industry.
Objective: This article provides information on the presence of bioactive compounds, antioxidant activity, and the potential use of durian seeds as therapeutic agents.
Methods: The study used a *scoping* review with four databases: Google *Scholar*, PubMed, DOAJ, and *ScienceDirect. Scoping* is needed to complete the article, summarize scientific data, and as a future reference regarding the nutraceutical potential of durian seeds.
Results: A total of 6 articles were reviewed based on the screening results. The bioactive compounds found in these articles are phenolics, flavonoids, α-tocopherol, terpenoids, saponins, anthraquinones, and several flavonoid classes such as catechin, rutin, isoquercitrin, quercitrin. Total phenolic content (TPC) and antioxidant activity were highest in the Chanee durian seed cultivar compared to the Monthong type and various other cultivars from several countries.
Conclusion: Durian seeds as food waste seem to have potential as a nutraceutical. Known as food waste that is rarely utilized, based on several studies, durian seeds have several benefits, one of which is to overcome various diseases. Further research needs to be done to prove that durian seeds can be helpful in the food industry as well as in pharmaceutical and cosmetic applications.

Keywords: antioxidant activity, bioactive compounds, durian seed, nutritional value

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Introduction

Durian known as *"The King of Fruits"* in Southeast Asia, is a Bombaceae plant that thrives in Southeast

Asia, including Indonesia.[1] Durian is a tropical plant with a unique taste and intense aroma. It is delicious and has potential in the health and food industry.[2,3] All parts of the durian plant, such as the pulp, leaves, outer skin, inner skin, and seeds, are believed to have potential and have many health benefits.[1]

Durian is an annual plant with tree height reaching 25-50 m. Durian trees are brown.[18] In plant systematics (taxonomy), durian is classified as follows.[9]

Kingdom	: Plantae
Subkingdom	: Tracheobionta
Super Division	: Spermatophyta
Division	: Magnoliophyta
Class	: Magnoliopsida
Super Order	: Rosanae
Order	: Malvales
Family	: Bombacaceae
Subfamily	: Helicteroidee
Genus	: Durio
Species	: (Durio ziberthinus)

In addition to being a delicious fruit, various components of durian can also be utilized for various purposes.[18] The creamy white, yellowish, pink, or orange flesh of durian is the most commonly consumed part of the fruit. It is rich in vitamins, minerals, phytonutrients, water, protein, and dietary fiber.[19] Durian seeds are shaped like a chestnut and can be roasted or boiled for consumption. Durian seeds are a good source of nutrients and minerals such as calcium and zinc. Durian peels contain various phytochemical compounds, including phenolic acids, phenolic glycosides, flavonoids, coumarins, triterpenes, and simple sugars.[9] The antioxidant and anti-inflammatory activities of durian pulp, seed, and peel extracts have been investigated, with results showing that durian seed extracts have the most effective antioxidant activity.[2]

One part of durian waste that has yet to be widely utilized is the seed.[7] Seeds are inside the edible pulp and covered with thin, light brown skin, shaped like a chestnut, and can be roasted or boiled for consumption.[5] Durian seeds are essential to develop because only 30% of the consumable part of the durian fruit is edible. At the same time, the rest is the inedible part, including 20-25% of the durian fruit, which consists of seeds.[6] 100 g of durian seed flour contains 8.97 g protein, 0.52 g fat, 75.27 g carbohydrate, and 21.54 g fiber.[7] Research reports that flour made from durian seeds can be used as a substitute for wheat flour in making cakes and cookies.[7,8]

Durian seeds contain good nutrients, minerals, and various phytochemical compounds, including phenolic acids, phenolic glycosides, flavonoids, coumarins, triterpenoids, and simple sugars.[9]

Durian seeds' antioxidant and anti-inflammatory activities showed the most effective antioxidant activity among other parts.[2] Several studies reported that the highest amount of antioxidant activity and content of phytochemical compounds are found in the inedible parts, such as the seeds and skin of durian, compared to the pulp.[10] The nutritional content and bioactive compounds in durian seeds are reported to act as antioxidants, antidiabetics, anti-inflammatory, and anticancer.[11,12]

This literature review was conducted to gather scientific information related to bioactive compounds and antioxidant activity from studies that have been conducted related to durian seeds. This article will help provide a summary of which cultivars and compounds can be studied further to determine the properties of their bioactive components and provide information related to the potential utilization of durian seeds as a nutraceutical that can be applied in the food and pharmaceutical industries.

Methods

The research was conducted by tracing related scientific articles through *literature* studies with a *scoping review* method that refers to the Arskey and O'Malley framework.[13] The literature review search protocol uses the PRISMA *checklist* table to select studies determined and adjusted to the study objectives. The *checklist* begins with identification and screening based on duplication, title suitability, and abstract article type. The article search used a combination of keywords, namely "Durian seed," "*Durio zibethinus* seed," "*Durio zibethinus*,"

"Bioactive compounds," "Antioxidant activity," "Nutraceutical" and *Boolean operations* (AND, OR, and NOT) which were used to expand or minimize the search to facilitate the determination of articles that were following the study objectives. Article identification was made by searching data using several databases: Google Scholar, PubMed, DOAJ, and ScienceDirect and then followed by screening articles based on inclusion criteria, namely English articles, full text according to IMRAD, focused on nutraceuticals of durian seed and designed by analytic quantitative and randomized controlled trial (RCT), published from 2015-2024, indexed by Scopus, DOAJ, Sinta, and Google Scholar. Exclusion criteria in this article are incomplete articles (IMRAD), not reputable, published before 2015, and focused on topics other than durian seeds, such as skin, ripe, leaves, roots, and others. These criteria are different from the research objectives and can make the article lack novelty.

Results

Source of evidence

The results of the article search resulted in a total of 1027 related articles. As shown in Figure 1, the search was carried out using four databases: Google Scholar had 883 articles, ScienceDirect 106 articles, PubMed 17 articles, and DOAJ as many as 21 articles. The next stage, selecting search results from the four databases, was carried out by identifying and screening the article titles one by one while reading the abstract, ensuring that the article was not a review article and duplication so that 16 relevant articles were produced. The next stage, 16 relevant articles were selected based on the inclusion criteria. The final results of the selection found six articles with full criteria per the study objectives that lead to the bioactive content and antioxidant activity of durian seeds. Finally, these six articles will be used in this review study. Details of the justification for screening the articles can be seen through the PRISMA flow chart in **Figure 1**.

Characteristics and synthesis of selected articles

Figure 1. shows that six scientific articles meet the selection criteria and will be reviewed further in this article review. Based on the screening results of the six articles, they have a quantitative design research design with experimental methods that show the amounts of bioactive components and antioxidant activity of durian seeds with nutraceutical potential through various test methods. These articles come from countries like Thailand, the Philippines, and China. After identifying and screening many articles, the selected articles investigated the bioactive components and antioxidant activity of durian seeds, which are reported to have therapeutic effects on various diseases.

Based on the six filtered articles, (1) The study investigated the effect of the addition of durian seed extract on the content of bioactive components and antioxidant activity in cosmetic products using the DPPH method and quantitative phytochemical compounds, (2) This study investigated the effect of durian seed extract on the content of bioactive components and antioxidant activity in cosmetic products. (3) This study from Thailand investigated the total phenolic content and antioxidant activity of Monthong and Chanee durian seeds with various tests such as ABTS, NO, superoxide, hydroxyl radical, and metal ion. (4) This study examines the content of bioactive compounds from durian seed oil; (5) Research investigates the content of bioactive compounds in durian seeds and antioxidant activity; (6) The last article examines the content of bioactive components, namely total phenolics and polyphenols and antioxidant activity tests through FRAP, DPPH and ABTS methods.

This review found that durian seed extract contains bioactive compounds with antioxidant properties, such as phenolics, saponins, anthraquinones, terpenoids, and flavonoids, as well as several flavonoid derivatives, which could be potential nutraceuticals with benefits for treating diabetes and dyslipidemia. The summarized findings of the articles are shown in **Table 1**.

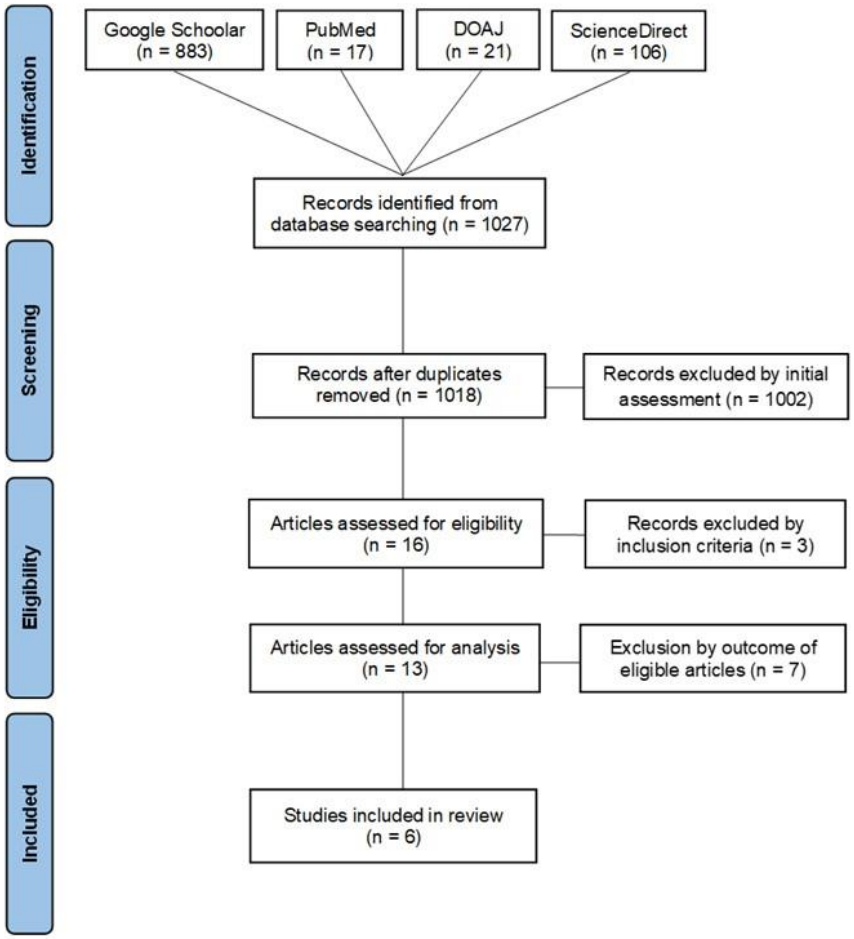

Figure 1. PRISMA flow chart

Table 1. Article summary

Source	Country	Study Assays	Result	
			Bioactive components	Antioxidant activity
Mungmai *et al.,* 2023.[14]	Thailand	Bioactive compounds: Total phenolics (Folin- Ciocalteu assay), flavonoids (Shinoda assay), tannins (ferric chloride assay), triterpenoids, steroids (The Liebermann- Burchard assay), alkaloids (The Mayer assay), and the carbohydrates (Molisch test) Antioxidant activity: - DPPH	- Durian seeds (S): Flavonoids, steroids and tannins - TPC of durian seeds: 0.33 ± 0.01 mg gallic acid/g - Tannins, triterpenoids, alkaloids and carbohydrates	DPPH: durian seed extract IC50: 0.08 ± 0.00 mg/ml) IC50: 80 ± 0.00 µg/mL
Juarah *et al.,* 2021.[10]	Malaysia	Bioactive compounds: Total phenolics (Folin- Ciocalteu assay), flavonoids (colorimetric assay) Antioxidant activity: FRAP, DPPH, ABTS	Total phenolic content of durian seed extract Sukang durian seeds (SS): 88.70 mg GAE/g Topoloh durian seeds (TS):143.60 mg GAE/g Total flavonoids from durian seed extract Sukang durian seeds: 193.50 mg GAE/g Topoloh durian seeds: 165.80 mg GAE/g	IC_{50} DPPH: - (SS): 27.87 ± 0.45 µg/ml - (TS): 20.37 ± 0.40 µg/ml IC_{50} ABTS: - (SS): 16.43 ± 1.40 µg/ml - (TS): 10.00 ± 0.60 µg/ml FRAP - (SS): 186.20 µg/ml - (TS): 297.90 µg/ml
Charoenphun and Klangbud, 2022.[2]	Thailand	Bioactive compounds: gallic acid-TPC standards Antioxidant activity: ABTS, NO, superoxide, hydroxyl radical, metal ion	Total phenolic content of durian seed extract: Monthong seed (MS): 4210.98 ± 15.40 mg GAE/g Chanee seed (CS): 4974.51 ± 60.85 mg GAE/g	ABTS: MS (13.85 ± 6.06 µg/mL); CS (6.83 ± 0.19 µg/ml) NO: MS (57.08 ± 16.31 µg/ml); CS (256.30 ± 135.40 µg/ml) Superoxide: MS (88.55 ± 7.97 µg/ml); CS (167.90 ± 14.95 µg/ml) Hydroxyl radical: MS (2.28 ± 0.22 µg/ml); CS (101.90 ± 3.50 µg/ml) Metal ion: MS (90.77 ± 30.08 µg/ml); CS (53.60 ± 2.70 µg/ml)
Desa *et al.,* 2016.[15]	Malaysia	Bioactive compounds: seed oil: Soxhlet extraction (SE)	- α-tocopherol: 9.093 ± 0.71 µg/L - TPC: 0.5 ± 0.09 mg GAE/g	-

Source	Country	Study Assays	Result	
			Bioactive components	Antioxidant activity
		Total phenolic (Folin- Ciocalteu assay) Flavonoids (Aluminum chloride Colorimetric test) α-tocopherol content (HPLC)	- TFC: 0.39 ± 0.32 mg QE/g dry plant	
Gabule *et al.,* 2018.[16]	Philippines	Bioactive compounds: alkaloids, phenols, anthraquinones, tannins, flavonoids, saponins, terpenoids Thin-layer test Chromatography (TLC) Antioxidant activity: - DPPH	- Durian seeds contain phenols, saponins, anthraquinones, flavonoids, and terpenoids.	- DPPH: durian seed extract (IC50 = 44.17 mg/L)
Chen *et al.,* 2016.[17]	China	Bioactive compounds: Total phenolic (Folin- Ciocalteu assay), polyphenol (UPLC analysis) Antioxidant activity: FRAP, DPPH, ABTS	- TPC: 7.26 ± 0.23 mg GAE/g - Rutin: 151.93 ± 0.13 µg/g - Isoquercitrin: 164.57 ± 0.5 µg/g - Quercitrin 160.45 ± 13.06 µg/g	- FRAP: 11.50 ± 1.19 µmol Trolox/g - DPPH: 39.77 ± 0.85 µmol Trolox/g - ABTS: 41.34 ± 0.85µmol Trolox/g

Note: DPPH(2,2-diphenyl-1-picrylhydrazyl,); TPC (Total Phenolic Content); TFC (Total Flavonoid Content); ABTS (2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid); FRAP (Ferric Reducing Antioxidant Power); NO (Nitrit oxidase); GAE (Gallac acid equivalent); QE (Quercetin equivalent); UPLC (Ultra-Performance Liquid Chromatography); HPLC (High-Performance Liquid Chromatography).

Discussion

Indonesia has eight candidates of exotic fruits with high annual productivity, such as mango, orange, snake fruit, papaya, durian, jackfruit, rambutan, and avocado.[20] The seeds of those fruits are reported to have many nutrients, bioactive compounds and offer great potential as primary sources of nutracueticals foods. In this literature review, 5 out of 6 articles discuss the content of bioactive compounds in durian seeds. The most bioactive components found in this study are total phenolics and flavonoids. Based on the results of the review, Chanee durian seeds have the highest total phenolic content compared to other types, such as Monthong, Topoloh, Sukang, and local Philippine durian, with consecutive totals can be seen in Table 1.[2] Meanwhile, the highest total flavonoids are found in Sukang durian seeds from Sabah Island compared to Topoloh and other types.[10]

Phenolics and flavonoids are a class of polyphenols found in durian seeds in this study. Phenolic and flavonoids are known as compounds that have potential for human health.[24] A study conducted on T2DM rats showed that phenolic compounds are antioxidant agents that can prevent and inhibit the formation of free radicals, thereby suppressing oxidative stress and helping to prevent the formation of free radicals, improving elevated blood glucose.[25] Therefore, the phenolic content in durian seeds is expected to improve human health by suppressing oxidative stress that triggers degenerative diseases.[26]

In addition, in this study durian seeds contained flavonoid class compounds, namely rutin, isoquercitrin, and quercitrin. The flavonoid has various properties such as lowering blood pressure, anti-hyperlipidemia, anti-hyperglycemia, antioxidant, antiviral, anticancer, anti-inflammatory, anti-microbial, neuroprotective, and cardioprotective effects.[28] Flavonoid classes plays a role in managing metabolic disorders by increasing adiponectin, reducing leptin and antioxidant activity, reducing insulin resistance, and increasing insulin levels.[29] A review article states that quercetin supplementation as one of sub-class of flavonoids plays a good role in patients with diabetes, rheumatoid arthritis, hepatitis, hypercholesterolemia, hypertension, and cardiovascular disease.[20] Other than quercetin, rutin is a natural flavonoid that found in durian seed have antioxidant and anti-inflammatory properties that help improve blood circulation, reduce inflammation, and strengthen blood vessels.[30] The antihyperglycemic mechanism of rutin plays a role in reducing carbohydrate absorption from the small intestine, inhibiting tissue gluconeogenesis, increasing tissue glucose absorption, stimulating insulin secretion from beta cells, and protecting the islets of Langerhans against degeneration.[31] In line with research in 2020, the administration of durian seed extract can reduce blood glucose levels in rats induced diabetes mellitus type 2.[32,37]

In addition to flavonoids and phenolics, durian seeds have also been shown to contain alkaloid and triterpenoid antioxidants.[16] Alkaloid compounds will regenerate cells by restoring partially damaged pancreatic cells, enabling them to function as antioxidants by combating free radicals and regenerating pancreatic cells through the mechanics of repair and protection of damaged pancreatic beta cells.[33] Triterpenoids found in durian seeds may contribute to lipid metabolism and adipocyte function alongside alkaloids. Triterpenoids can regulate the activity of specific genes responsible for lipid metabolism, including PPARγ and SREBP-1c. These genes play a crucial role in the development of fat cells and the production of lipids.[34] Furthermore, triterpenoids can stimulate AMP-activated protein kinase (AMPK), which acts as a cellular energy sensor and controls lipid metabolism. AMPK activation enhances lipolysis by promoting the breakdown of triglycerides into free fatty acids and glycerol.[35] In general, triterpenoids can influence the breakdown of fats by regulating the expression of genes involved in lipid metabolism, preventing the formation of fat cells, and activating AMPK.[34,36] These phytochemical substances are anticipated to enhance the state of degenerative diseases.[19]

In several in-vivo studies, the intervention of durian has many benefits, including antihyperglycemic and anti-hypercholesterolemia in rat models.[37,38] The intervention of durian seed extract ointment can accelerate wound healing in

rats with excision wounds, prolong epithelialization time, increase collagen deposition, and stimulate fibroblast cell proliferation.[11,39] Other in vitro studies report that the aqueous and ethanol extracts of durian seed coat have inhibitory effects on the growth of HSV-2 *(Herpes Simplex Virus Type 2)*. The durian seed extract has a better inhibition percentage than the aqueous extract.[12] These studies proved that durian seeds have been confirmed as a potential antioxidant food ingredient and restored its promising position in the region as an effective traditional medicine.[37,40]

Based on the results, durian seeds also have potent antioxidant activity. 4 out of 5 articles tested antioxidant activity shows that Topoloh durian seeds from Sabah Island have the highest antioxidant activity compared to Sukang, Monthong, and local durian species of the Philippines and Malaysia using the DPPH- radical test with an IC50 value of 20.37 ± 0.40 µg/ml.[10] Through the ABTS test, Chanee durian seeds have higher antioxidant activity than Monthong, Sukang, Topoloh, and other local durians with IC50 ABTS value of 6.83 ± 0.19 µg/mL. The IC50 value is defined as the concentration of antioxidant compounds needed to reduce free radical activity by 50%, whereas the more minor the IC50 value, is the higher the antioxidant activity.[22] A study also found that durian seed extract from Indonesia has high antioxidant activity through the DPPH test with an IC50 value of 23.10 µg/ml. [24]

All of the articles that discuss antioxidant activity and bioactive components in durian seeds of various cultivars reveal that in addition to total phenolics and flavonoids, through phytochemical screening, durian seeds also contain compounds such as α-tocopherol, carbohydrates, steroids, triterpenoids, tannins, alkaloids, saponins, terpenoids, anthraquinones, and flavonoids such as rutin, isoquercitrin, and quercitrin.[16,18] They have been found to contain medicinal properties, such as potential in anti-inflammatory and antidiabetic. This article can be used as reading material and further research to prove that durian seeds can be used as food waste that has nutraceutical potential.

The limitation of this scoping review: First, the article review only applies to articles written in English. Second, this study only identified four databases, and many articles needed to meet the standards. Third, the available sources related to durian seeds still need to be studied, especially the quantity of bioactive components in durian seeds. The strength of this study comes from reliable sources and filtering articles by selecting only the best articles that meet the inclusion and exclusion criteria to ensure that the articles found are relevant to the objectives of this study.

Conclusion

In conclusion, durian seeds of different species contain many bioactive components such as phenolics, tocopherols, terpenoids, saponins, anthraquinones, flavonoids, and many more and show high antioxidant activity through various test methods such as FRAP, DPPH, ABTS, NO, superoxide, hydroxyl radicals, and metal ions. Durian seeds have been reported to contain therapeutic properties for various diseases with anti-inflammatory, antioxidant, and antidiabetic roles. This scoping review has summarized various literature related to the content of bioactive components and antioxidant activity in durian seeds. Further research in the future on the efficacy of durian seeds in diabetes mellitus, dyslipidemia, hypertension, or metabolic syndrome. This article is expected to be a source of relevant and helpful literature for future research related to durian seeds.

Further research is needed so that durian seeds can be considered therapy to decrease insulin resistance and fasting blood glucose levels in patients with metabolic syndrome. Durian seeds can also be developed as supplements or processed products with high economic value.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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CASE STUDY

Effect of omega−3 fatty acid supplementation on reduce body weight and body fat mass in obesity: A case study with an evidence-based approach

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Abstract

Background: Obesity is a public health problem, especially in developing countries. Providing Omega−3 supplementation has benefits to reduce body weight and body fat mass.

Objective: This study aims to determine the effect of omega−3 supplementation on weight loss and body fat mass in obesity.

Methods: This study used a literature search using advanced queries in the databases PubMed, Scopus, ProQuest, Cochrane Library, and combined MeSH terms with Title/Abstract. The collected literature is discarded if there are duplicates, then literature that meets the eligibility criteria is filtered. We used the Oxford Center for Evidence-Based Medicine as a means of critical appraisal and determining the level of evidence of the selected literature.

Results: Four chosen study were selected. The first study involved 39 adults with obesity, there was a weight loss of 6.04 kg in the group given omega−3 supplementation of 6 g/day for 8 weeks compared to the placebo group 5.4 kg and there was a decreased in body fat mass in the intervention group. The second study did not show a significant result. The third study on 65 women showed a weight loss of 3.07 kg in the group given omega−3 consisting of 1.08 g EPA and 0.72 g DHA compared to 1.16 kg in the placebo group for 12 weeks. In the fourth study, a systematic review study, there was no conclusive result.

Conclusion: Omega−3 fatty acid supplementation could be beneficial in reducing weight in obese patients with dietary modification.

Keywords: obesity, omega−3 fatty acids, body weight, body composition, fat mass

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Case report

A 36 year old woman came to the nutrition clinic to lose weight. The patient said that her weight has increased since the Covid-19 pandemic. Weight gain of 20 kg in 3 years. She often eats fried food and also likes sweet cakes. The patient complained that her right leg often hurt, especially if she stood for too long. The patient has tried several diet methods obtained through social media or googling but none of them succeed. The patient works as an employee in a private company. The patient's activity is more often sitting in front of the computer. The patient said she rarely exercises. Her present body mass index is 28 kg/m^2. So far, the patient has never been to a clinical nutrition specialist for a weight loss program. There was no history of diabetes mellitus, hypertension, dyslipidemia, or heart disease. From laboratory examinations, the results were within normal limits. Body composition examination revealed a high fat mass.

Patient is advised to reduce calorie intake and increase physical activity. The patient had read in an online article that supplementation of omega-3 could help weight loss and body fat mass, then the patient asked a clinical nutrition specialist whether omega−3 had that role.

Introduction

Obesity is a global problem with prevalence increasing every year. According to the World Health Organization (WHO) data in 2014, there has been a two-fold increase in prevalence compared to the prevalence figure in 1980. More than 1 billion people worldwide are obese, including 650 million adults, 340 million teenagers, and 39 million children. This number keeps continuing to increase and WHO estimates that by 2025 there will be an additional 167 million people worldwide with obese. [1] According to Riskesdas data in 2018, the prevalence of obesity among adults aged over 18 years was 21.8%. This prevalence has increased compared to Riskesdas in 2013, namely 7%. DKI Jakarta ranks second among all provinces in Indonesia for obesity prevalence, which is 30%.[2]

Obesity is a condition where excess fat accumulates in the body, either generalized or localized in certain parts of the body, and occurs due to an imbalance between energy intake and output. Various etiologies cause obesity including food intake, physical activity, sedentary lifestyle, genetics, environment, neuroendocrine, drugs, other pathological factors, and socio-economics. [3] According to WHO, the definition of obesity is the accumulation of abnormal or excessive fat tissue that impacts health. Obesity can be assessed by body mass index (BMI). In Asia, obese if the BMI value is ≥ 25 kg/m^2.[1]

Adipose tissue plays a key role in the pathogenesis of obesity and associated complications. Three types of adipose tissue with different precursor cells, phenotypes, functions, and regulation have been, so far, identified: the energy-storing white adipose tissue (WAT), the energy-consuming brown adipose tissue (BAT), and the recently described/"brite" adipose tissue.[4] White adipose tissue is the main storage organ, accumulating the excess energy in the form of triglycerides, which can be mobilized under energy deprivation conditions. In addition, WAT acts as an important endocrine organ releasing a broad range of molecules called adipokines involved in the regulation of many physiological functions including body weight (leptin), vascular metabolism (PAI-1), glucose metabolism, and insulin sensitivity (adiponectin) and several inflammatory cytokines and chemokines (TNF-α, IL-1, IL-6, RBP-4 or MCP-1).[5,6] WAT is distributed around the body in different depots such as abdominal, subcutaneous, or gonadal regions with different adipokine secretion profiles. The presence of hypertrophy and hyperplasia of adipocytes causes increased secretion of pro-inflammatory cytokines. On the other hand, BAT is known to be specialized in adaptative thermogenesis being uncoupling protein 1 (UCP1) the main responsible. This thermogenic mechanism plays a key role in defending against hypothermia and obesity.[7] Omega-3 fatty acids fatty acids are polyunsaturated fatty acids with multiple double bonds. The three most crucial omega-3 fatty acids fatty acids are alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and

docosahexaenoic acid (DHA), which cannot be endogenously synthesized and must be obtained from dietary sources.[8] The possible mechanisms related to the effect of omega-3 fatty acids on body weight or body fat mass seem to be linked to metabolic changes related to obesity, including the modulation of lipid metabolism, regulation of adipokines (such as adiponectin and leptin), and decreased inflammation of adipose tissue.[9] Several studies omega-3 fatty acids at doses of more than 3 g/day can reduce appetite and increase thermogenesis, increasing plasma concentrations of adiponectin and leptin. In addition, administration of omega-3 fatty acids at a dose of 3 g/day can reduce body weight and body fat through postprandial satiety and changes in gene expression involving the regulation of fat oxidation in adipose tissue.[10]

Research demonstrating the effects of omega-3 fatty acids supplementation in reducing body weight and body fat mass in patients with obesity includes a study by Munro et al.[11]In this study, 39 obese individuals were divided into two groups, placebo, and intervention, with the intervention group receiving 6g/day of omega-3 fatty acids fatty acid capsules for eight weeks with diet modification. Patients receiving omega−3 fatty acids had significant weight loss (- 6.04 kg) compared to the placebo group (- 5.2 kg). A study by Noreen et.[12] with 44 individuals with obese was divided into two groups, placebo, and intervention, with the intervention group receiving omega-3 fatty acids fatty acid capsules 4 g/day containing 1.6 g EPA and 0.8 g DHA for 6 weeks. The omega-3 fatty acids group lost 0.5 kg of fat mass, while the control group gained 0.2 kg. This contrasts with a study by Defina et al.[13] there were no differences between group intervention and placebo in weight loss.

Based on previous research, it is not yet conclusive whether omega-3 fatty acids can reduce body weight and body fat mass in obese patients. This evidence based case report seeks to assess the impact of omega-3 fatty acids supplementation on weight loss and body fat mass in obese patients.

Clinical Question

"Can omega-3 fatty acids reduce body weight and body fat mass in patients with obesity?"
Participants [P]: Adult patients with obesity
Intervention [I]: omega-3 supplementation in conjunction with diet modification
Control [C]: diet modification
Outcome [O]: weight loss and body fat mass

Methods

Searching Strategy

A literature search was managed using an advanced search with a combination of MeSH Terms and Titles/Abstracts in four databases: PubMed, Cochrane Library, Scopus, and Proquest. Keywords included " *obesity", "obese", "omega 3", "omega-3 fatty acids', "placebo", "weight loss", "fat mass", body composition*". The Oxford Centre for Evidence-Based Medicine guidelines were utilized for critical literature assessment and determining the level of evidence**.**

Eligibility Criteria

Inclusion criteria: 1) adult with obesity aged > 18 years; 2) patients receiving omega−3 fatty acids supplementation; 3) research outcome focusing on weight loss and body fat mass; 4) study design being a controlled clinical trial or a systematic review/meta-analysis of randomized controlled trials; 5) articles published in English; 6) subject of study is human. Exclusion criteria: articles not available in full text.

Results

The selected articles met eligibility criteria through systematic reviews, meta-analyses, and controlled clinical trials. The literature search was independently conducted across four databases: PubMed, Cochrane Library, Scopus, and ProQuest. The literature search process is depicted in Figure 1. Keywords employed were "obesity", "obese", "omega 3", "omega-3 fatty acids fatty acids", "weight loss", "reduce weight", and "fat mass". Additionally, a review using Mendeley was performed subsequently to exclude duplicate

articles. The research will be critically assessed using the Oxford Centre of Evidence-based Medicine (CEBM) critical appraisal. The review assesses aspects of the validity, importance, and applicability of the research. As we can see in **table 1**, the research results of this study obtained 6 kinds of literature from Pubmed, 12 kinds of literature from the Cochrane Library, 8 kinds of literature from Scopus, and 138 kinds of literature from ProQuest. Duplication filtering was done using Mendeley. Furthermore, filtering was carried out based on method, title-abstract, PICO criteria, and full-text availability. The filtering results can be seen in **figure 1**.

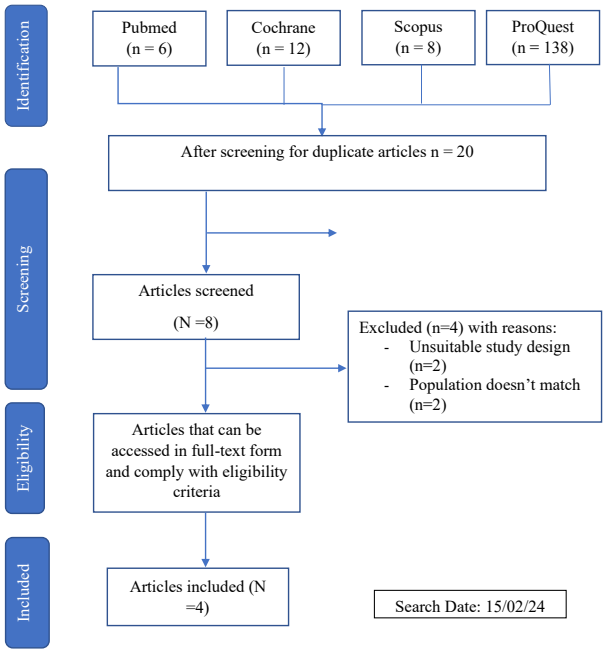

Figure1. Prisma's flow chart

Table 1. Literature searching strategies

Database	Search Strategy	Hits
Pubmed	((((((((((((obesity[Title/Abstract]) OR (obesity[MeSH Terms])) OR (obese[Title/Abstract])) OR (obese[MeSH Terms])) AND (omega 3[Title/Abstract])) OR (omega 3[MeSH Terms])) OR ("omega 3 pufa"[Title/Abstract])) OR (omega 3 pufa[MeSH Terms]))) AND ("weight loss"[Title/Abstract])) OR (weight loss[MeSH Terms])) AND ("body fat mass"[Title/Abstract])) OR (body fat mass[MeSH Terms])) OR ("body composition"[Title/Abstract])) OR (body composition[MeSH Terms])	6
Cochrane	ID Search Hits #1 (obesity):ti,ab,kw (Word variations have been searched) #2 (obese):ti,ab,kw (Word variations have been searched) #3 #1 OR #2 #4 ("omega 3 PUFA"):ti,ab,kw (Word variations have been searched) #5 ("omega 3 fatty acids"):ti,ab,kw (Word variations have been searched) #6 ("omega 3 polyunsaturated fatty acid"):ti,ab,kw #7 #4 OR #5 OR #6 #8 ("weight-loss"):ti,ab,kw (Word variations have been searched) #9 (reduce weight):ti,ab,kw (Word variations have been searched) #10 #8 OR #9 #11 ("body fat mass"):ti,ab,kw (Word variations have been searched) #12 ("body composition"):ti,ab,kw #13 #11 OR #12 #14 #3 AND #7 AND #10 AND 13	12
Scopus	TITLE-ABS-KEY (obesity) OR TITLE-ABS-KEY (obese) AND TITLE-ABS-KEY (omega 3) AND TITLE-ABS-KEY (weight AND loss) AND TITLE-ABS-KEY (Fat AND Mass)	8
ProQuest	obesity AND (omega 3) AND (loss weight) AND (fat mass)	138

Discussion

The results of the literature search obtained four studies that met the criteria. Delpino, et al[14]., conducted research with a systematic review design, with details of 20 RCT studies. The study aims to assess the benefits of omega-3 fatty acids supplementation in reducing body weight and fat mass in patients with obesity. The exclusion criteria that the authors applied were studies that were not RCTs, studies conducted by experimental animals, and studies that did not assess body weight or body fat mass as outcomes. The risk of bias was assessed based on the Cochrane risk assessment tool for RCT studies.

Table 2. Characteristic of the study

Researcher	Design	Population	Outcome	Result
Mendes F, et al.[14] (2021)	A systematic review of Randomized Controlled Trials consisting of 20 RCT	RCT: Patients with obesity taking omega−3 fatty acids supplementation	Weight loss and reduced body fat mass	From 20 RCT, 11 studies said there was no effect of supplementation omega-3 fatty acids on weight loss and body fat mass but another 9 studies said there was an effect of supplementation omega−3 on weight loss and body fat mass.
Munro, et al.[11] (2013)	*Randomized Double-Blinded Controlled Trial*.	Thirty-nine (n=39) subjects obesity with IMT 30-40 kg/m2, age 18-60 years, After randomization, divided into intervention and placebo groups. The intervention group received 6x1 g omega−3 supplementation in conjunction with diet modification and the placebo group received sunola oil. The intervention was carried out for 8 weeks	Weight loss and reduced body fat mass	After giving omega-3 for 4 weeks there was a significant reduction in body weight of 6.12 kg and a reduction in body fat mass of 4.36 kg in the intervention group ($p < 0.01$) and after continuing 4 weeks later there was a reduction in body weight of 5 .79 kg and fat mass of 4.46 kg ($p < 0.01$).
Defina, et al.[13] (2011)	*Randomized Double-Blinded Controlled Trial*	A total of 128 obese patients with a BMI of 26-40 kg/m2 aged 30-60 years, the intervention group received [3.0 g eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), ratio 5:1 (EPA:DHA)] with diet modification. The intervention was carried out for 24 weeks	Weight loss and reduced body fat mass	There was no significant in weight loss($P = 0.33$) and body fat mass ($p = 0.37$) between the intervention and placebo groups.
Ali S, et al.[15] (2018)	*Randomized Double-Blinded Controlled Trial*	A total of 65 overweight and obese patients with a BMI ≥25 kg/m^2 were given 6 omega−3 capsules per day containing 180 mg EPA and 120 mg DHA with diet modification. The intervention was carried out for 12 weeks	Weight loss	In the intervention group, there was a significant weight loss of 3.07 ± 3.4 kg, and in the placebo group 1.16 kg ± 2.7 kg with a p value = < 0.05

Table 3. Validity Criteria for Mendes F, et al[14]

Article	Study Design	Question	Find	Appraise	Inclusion	Total Up	Result	Applicability
Mendes F, et al.[14] (2021)	*Systematic Review*	+	+	+	+	+	A	+

A = Research involving 20 RCT studies providing omega−3 supplementation with a dose range of 2.8 g to 6 g with a duration of 3 weeks – 24 weeks showed inconsistent results. Nine studies state that providing omega−3 supplementation provides significant results in reducing body weight and body fat mass.

Table 4. Validity Criteria for Munro, et al.,[11] Defina, et al.,[13] and Ali S, et al[15]

Article	Study Design	Randomization	Similarity	Equally treated	Intention to treat analysis	Blinding	Result	Applicability
Munro, et al.[11] (2013)	*Randomized Controlled Trials*	+	+	+	+	Double-blind	B	+
Defina, et al.[13] (2011)	*Randomized Controlled Trials*	+	+	+	+	Double-blind	C	+
Ali S, et al.[15] (2018)	*Randomized Controlled Trials*	+	+	+	+	Double-blind	D	+

B After giving omega−3 for 4 weeks there was a significant reduction in body weight of 6.12 kg and a reduction in body fat mass of 4.36 kg in the intervention group ($p< 0.01$) and after continuing 4 weeks later there was a reduction in body weight of 5 .79 kg and fat mass of 4.46 kg ($p < 0.01$).
C = There was no significant in reduce of body weight ($p = 0.33$) and body fat mass ($p = 0.37$) between the intervention and placebo groups.
D = In the intervention group there was a significant weight loss of 3.07 ± 3.4 kg and in the placebo group 1.16 kg ± 2.7 kg with a p value = < 0.05

Nine RCTs examined the effects of omega−3 fatty acids supplementation on weight loss and body fat mass, having a total of 572 subjects randomized to get PUFA and placebo. In all nine RCT studies, the results were positive regarding the efficacy of omega-3 fatty acids for body weight loss and fat mass. However, 11 other RCT studies did not show any significant changes in reducing body weight and body fat mass when omega-3 fatty acids supplementation was given. The results of these systematic review studies have not obtained conclusive results on the role of omega-3 fatty acids supplementation in reducing body weight and body fat mass.[14]

Salman et al.,[16] conducted research with an RCT design on 40 adults with obesity having a body mass index of 27−35 kg/m2 in Turkey. In this study, calorie restriction was also carried out apart from being given omega-3 fatty acids supplementation. Subjects were divided into two groups; the intervention group received 1020 mg omega-3 fatty acids (580 mg eicosapentaenoic acid (EPA), 390 mg docosahexaenoic acid (DHA), 50 mg omega-3 fatty acids other PUFAs) for 12 weeks. The researcher assessed anthropometric and body composition data as well as cognitive function assessments which were assessed using the Montreal Cognitive Assessment (MoCA). Based on the results of this study, there was a decrease in body weight, body fat mass, and body mass index in the intervention group compared to the control group ($p\leq0.05$), but no significant results were obtained regarding cognitive function.

Omega-3 fatty acids a polyunsaturated fatty acids (PUFAs) which are generally found in fish oil as Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA). Fish oil supplementation containing omega−3 fatty acids can reduce body fat mass by increasing lipid oxygenation. In addition, PUFA supplementation can reduce the incidence of obesity by reducing an individual's appetite, increasing fat oxidation, and reducing fat deposition. The role of omega−3 fatty acids in an individual's appetite is by suppressing the appetite mediated by free fatty acid receptor 4 G protein-coupled receptor 120 (FFAR4 (GPR 120)). Omega-3 fatty acids are an

FFAR4 agonist that stimulates the secretion of cholecystokinin, a peptide hormone that is synthesized and released from the small intestine and plays a role in suppressing hunger. [10]

Several studies stated that giving omega-3 fatty acids supplementation has positive results in reducing body weight and body fat mass. According to a study conducted by Ali S et al.,[15] giving omega-3 fatty acids supplementation could reduce body weight in women with obesity. Omega-3 fatty acids also play a role in reducing insulin resistance, TNF-α and leptin, and increasing adiponectin. Other literature stated that supplementation with EPA 1600 mg and DHA 800 mg can reduce fat mass in healthy adults. In experimental animals, giving omega-3 fatty acids plays a role in reducing retroperitoneal and epididymal fat mass.

Research conducted by Munro et al.,[11] on 39 adults with obesity showed that giving 6x1 g omega-3 fatty acids supplementation (70 mg EPA and 270 mg DHA) for 8 weeks had a significant reduction in body weight and fat mass in the intervention group compared to the placebo group ($p< 0.01$). The mechanism by which omega-3 fatty acids are associated with reduced body weight and body fat mass is not fully understood. Evidence suggests that omega-3 fatty acids modulate fat metabolism by stimulating lipolysis and increasing hepatic fatty acid oxidation, inhibiting fatty acid synthesis and VLDL secretion. Based on research by Jump et al.,[17] DHA had a key role in hepatic lipid synthesis, having a major impact on fat metabolism. The duration and dose of omega-3 fatty acids supplementation can affect weight loss.

Omega-3 fatty acids PUFAs can partition dietary fuel away from storage and toward oxidation by suppressing lipogenic genes and activating genes that encode mitochondrial and peroxisomal fatty acid oxidation in both the liver and muscle. Omega-3 fatty acids have a cardioprotective role which can improve endothelial function by increasing nitric oxide production.[18] Furthermore, during exercise, fish oil has been shown to increase arterial dilation and blood flow to skeletal muscle. Increased blood flow can improve the distribution of fat which can be used as an energy source in skeletal muscles. EPA plays a role in β-oxidation, while DHA plays a role in catabolism and storage in tissues. [19] Gene expression of fatty acid synthase, hormone-sensitive lipase, lipoprotein lipase, and phosphoenolpyruvate carboxykinase in retroperitoneal fat can be decreased with DHA and EPA/DHA, not just by giving EPA.[20]

In another research by Defina et al.,[13] on 128 subjects with overweight and obesity, intervention in the form of 3.0 g eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA) with a ratio of 5:1 (EPA:DHA) for 24 weeks stated that there was no weight loss and significant fat mass. In this study, the intervention and placebo groups received lifestyle interventions and physical activity. The weight loss between the two groups was insignificant due to the lifestyle intervention.

The last research conducted by Ali S et al.,[15] on 45 patients with obesity given 180 mg EPA and 120 mg DHA for 12 weeks showed a significant body weight loss in the intervention group compared to the placebo group (3.07 ± 3.4 kg vs 1.16 ± 2.7 kg, $p = < 0, 05$). This study stated that the mechanism of omega−3 fatty acids for weight loss was still rarely found. Giving Omega-3 fatty acids along with dietary regulation and physical activity had more than 5% effect on weight loss.

The patient in the case is a 36 year old woman with grade 1 obesity. The patient's identity and diagnosis are similar to the identity and diagnosis of the research subjects discussed. Patients can be given omega-3 fatty acids supplementation for weight loss combined with dietary restriction and physical activity. Also, the patient can be advised to consume foods that are very high in omega-3 fatty acids, such as salmon, tuna, nuts, and flaxseed.

Conclusion

Reducing body weight and body fat mass in patients with obesity can be done by giving additional therapy which is omega-3 fatty acids supplementation. Based on a critical review that has been carried out in one systematic review and

three RCTs, omega-3 fatty acids supplementation can provide benefits on fat metabolism so that it can reduce fat mass and weight loss with diet modification in patients with obesity. Although omega-3 fatty acid supplementation is beneficial in reducing weight in obese patients alongside dietary modifications, further research is needed regarding its effective dosage.

Conflict of interest

The authors declare that they have no competing interests.

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CASE REPORT

Effect of magnesium supplementation on glycemic control in type 2 diabetes mellitus: evidence-based case report

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Abstract

Background: Diabetes mellitus is one of the most serious and common chronic diseases, leading to life-threatening, disabling and costly complications, and reducing life expectancy. Poor intracellular magnesium concentration may contribute to insulin resistance, whereas higher magnesium levels are associated with increased insulin sensitivity. This study aimed to investigate the effect of magnesium supplementation on glycemic control in patients with type 2 diabetes.

Objective: This study aimed to investigate the effect of magnesium supplementation on glycemic control in patients with type 2 diabetes.

Methods: A literature search was conducted using three major databases: PubMed, Cochrane Library, and EBSCOhost. MeSH terms, advanced search, and eligibility criteria were used for title and abstract screening after removing duplicates. Critical assessment tools and levels of evidence of the final articles are based on the Oxford Center for Evidence-Based Medicine.

Results: A meta-analysis and two RCTs met the PICO and eligibility criteria. One meta-analysis found that magnesium supplementation significantly reduced fasting blood glucose and HbA1c. One RCT reported that magnesium supplementation significantly improved HbA1c, insulin levels, and HOMA-IR. Another RCT found that there were no differences in HbA1C and continuous glucose monitoring.

Conclusion: Magnesium supplementation may have a beneficial effect on glycemic control in patients with type 2 diabetes. However, further research is needed to establish optimal dosage and the most effective form of magnesium supplementation.

Keywords: blood glucose, glycated hemoglobin, glycemic control, magnesium supplementation, type 2 diabetes mellitus

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Case scenario

Mr. IR, a 45-year-old male, visited the nutrition clinic complaining of fatigue, body aches, and poor sleep quality. He brought his laboratory results, which showed a fasting blood glucose level 160 mg/dL, a 2-hour post prandial blood glucose level of 220 mg/dL, and HbA1c of 7%. The patient had been diagnosed with type 2 diabetes and had been taking metformin 500 mg twice a day for the past four months. He wanted to modify his diet to improve glycemic control. The patient had heard that magnesium supplementation could help

improve blood glucose and HbA1c, so he asked the clinical nutrition specialist if it would be appropriate for him to take the supplement.

Introduction

Diabetes is a major global health issue and is recognized as one of the most important non-communicable diseases driven by unhealthy modern lifestyles.[1] The International Diabetes Federation (IDF) estimated that 536.6 million people worldwide were living with diabetes (diagnosed or undiagnosed) in 2021, and this number is expected to increase by 46%, reaching 783.2 million by 2045. According to the IDF, Indonesia ranks fifth among countries with the highest number of diabetes cases globally. The prevalence of diabetes in Indonesia was 10.6% in 2021 and increased to 11.7% in 2023.[2]

Diabetes mellitus can impact individuals in various ways, ranging from acute threats due to decompensated metabolism leading to severe hyperglycemic hyperosmolar coma, ketoacidosis, or severe hypoglycemia, to long-term serious complications affecting both large and small blood vessels as well as the nervous system. Additionally, it poses lifelong challenges to quality of life due to a wide range of psychosocial problems.[1] Studies have shown that individuals can remain in an asymptomatic phase of prediabetes and type 2 diabetes mellitus for 5-6 years before being diagnosed, during which microvascular and macrovascular complications may arise. Therefore, maintaining good glycemic control is fundamental in preventing diabetes-related complications.[2]. Self-monitored blood glucose, flash glucose monitoring, continuous glucose monitoring, and glycated hemoglobin (HbA1c) are the best information for assessing glycemic control.[3]

Type 2 diabetes is frequently associated with magnesium deficiency in both extracellular and intracellular compartments, which is related to hyperglycemia. An increased prevalence of magnesium deficiency has been observed in patients with type 2 diabetes, particularly in those with poor glycemic control, longer duration of the disease, and presence of microvascular and macrovascular complications.[4] Previous studies have shown that hypomagnesemia occurs in 9–48% of individuals with type 2 diabetes, and low serum magnesium levels have been implicated in the pathogenesis of type 2 diabetes and its cardiovascular complications.[5]

Magnesium ion plays a major role in carbohydrate metabolism and insulin function. Magnesium acts as a cofactor in glucose transport across cell membranes and in enzymes involved in carbohydrate oxidation and also plays a role in insulin release.[6] Magnesium improves insulin sensitivity by modulating tyrosine kinase activity of insulin receptors and promoting their autophosphorylation. Magnesium also inhibits calcium entry into adipocytes. Reduced intracellular magnesium levels lead to calcium accumulation in adipocytes, which subsequently increases inflammation, oxidative stress, and insulin resistance.[7] Several studies have reported that insulin resistance and/or hyperinsulinemia reduces renal tubular reabsorption of magnesium, increased magnesium excretion, and promotes its shift from extracellular to intracellular compartments. Additionally, inadequate magnesium intake is another major contributor to hypomagnesemia in diabetic patients.[8]

Accumulating evidence has shown that increased magnesium intake improved insulin release and sensitivity, alleviated dyslipidemia, mitigated endothelial cells dysfunction, and reduced thrombotic risk and vascular contractility.[9] A recent meta-analysis revealed that, compared to a placebo, magnesium supplementation enhances glucose and insulin sensitivity markers in individuals with diabetes or conditions that increase the risk of developing diabetes, such as obesity.[10] Some studies have demonstrated that magnesium supplementation is associated with improved glycemic control and could prevent chronic complications of diabetes. However, other studies have not demonstrated such results.[11,12] The available clinical trials are still insufficient to establish guidelines for clinical practice. Therefore, this study was conducted to evaluate the effect of magnesium supplementation on glycemic control in patients with type 2 diabetes.

Clinical question

P : Type 2 diabetes mellitus patients
I : Magnesium supplementation
C : Placebo
O : Glycemic control
Clinical Question: Could magnesium supplementation help control glycemia in patients with type 2 diabetes mellitus?

Methods

A literature search was performed using a combination of MeSH terms and Title/Abstract across three large databases: PubMed, Cochrane Library, and EBSCOhost. The search was conducted on September 10th, 2024. The keywords used were blood glucose, glycated hemoglobin, glycemic control, magnesium supplementation, and type 2 diabetes mellitus. Critical appraisal tools and determination of the level of evidence were created based on the Oxford Centre for Evidence-Based Medicine.

Eligibility criteria

The inclusion criteria consist of subjects aged 18 years or older with type 2 diabetes mellitus who received magnesium supplementation. Eligible studies must be randomized controlled trials (RCTs), systematic reviews, or meta-analyses that report glycemic control outcome, were published between 2020-2024, and were written in English. The exclusion criteria encompass patients with type 1 diabetes mellitus, pregnant or lactating women, patients with malignancy, animal studies, and articles without full-text availability.

Results

The author found 35 articles in the PubMed database, 17 articles in the Scopus database, and 6 articles in EBSCOhost (**Table 1**). Duplicate removal was conducted using *Covidence.* The articles were evaluated for eligibility based on PICO and the eligibility criteria (**Figure 1**), resulting in the selection of three studies. The characteristics of these studies are detailed in **Table 2,** and their levels of evidence are presented in **Table 3**. All selected studies relevant to answering the clinical question are presented in **Table 4**.

Discussion

Type 2 diabetes mellitus is a chronic metabolic disorder caused by impaired insulin secretion by pancreatic β-cells, insulin resistance in target organs, or both, resulting in hyperglycemia. Although individual susceptibility to type 2 diabetes due to non-modifiable risk factors like ethnicity and family history has a strong genetic basis, epidemiological studies suggest that many cases of type 2 diabetes can be prevented by improving the key modifiable factors such as obesity, physical activity, and unhealthy diet.[14] Mechanisms for development of microvascular and macrovascular complications due to hyperglycemia include endothelial dysfunction, advanced glycation end-product formation, hypercoagulability, increased platelet reactivity, and sodium-glucose co-transporter-2 (SGLT-2) hyperexpression. The incretin effect, alterations in the gut microbiome, immune dysregulation, and inflammation have been identified as significant pathophysiological factors. Compared with individuals without diabetes, patients with type 2 diabetes have a 15% increased risk of all-cause mortality. This is twice as high in young individuals, particularly those younger than 55 years of age with glycated haemoglobin (HbA1c) levels of 6.9% or lower, compared with individuals without diabetes.[15]

Magnesium is the second most abundant intracellular cation after potassium and the fourth most common mineral in the human body after calcium, potassium, and sodium.[4,15] As a cofactor of >600 enzymes, magnesium plays a role in various metabolic pathways, such as glycolysis, β-oxidation, and insulin signaling.[16] The kidneys regulate normal plasma magnesium levels within the range of 1.7 to 2.4 mg/dL.[6] Magnesium deficiency can occur without hypomagnesemia. However, when hypomagnesemia is present, it typically indicates a significant systemic magnesium deficiency.[4,15] Signs and symptoms of

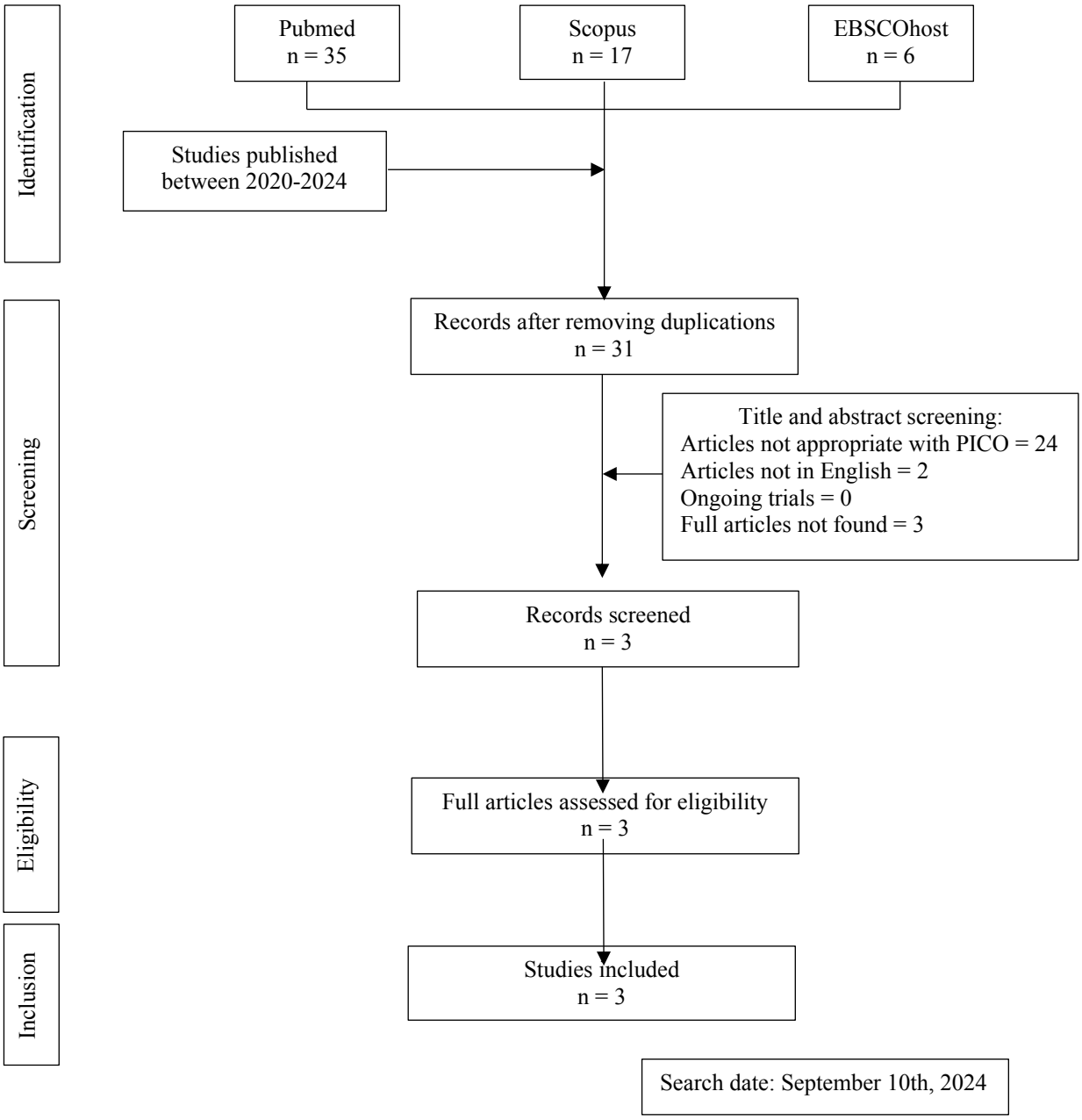

Figure 1. Prisma's flow chart

Table 1. Resources and search strategy

Database	Terminology	Hits	Eligible
Pubmed	(((diabetes[MeSH Terms]) OR (diabetes[Title/Abstract])) AND ((((magnesium supplementation[MeSH Terms]) OR (Mg supplementation[MeSH Terms])) OR (magnesium supplementation[Title/Abstract])) OR (Mg supplementation[Title/Abstract]))) AND (((((((blood glucose[MeSH Terms]) OR (plasma glucose[MeSH Terms])) OR (glycated hemoglobin[MeSH Terms])) OR (glycemic control[MeSH Terms])) OR (blood glucose[Title/Abstract])) OR (plasma glucose[Title/Abstract])) OR (glycated hemoglobin[Title/Abstract])) OR (glycemic control[Title/Abstract])) Filters: Meta-Analysis, Randomized Controlled Trial, Systematic Review	35	3
Scopus	TITLE-ABS-KEY (diabetes AND mellitus) AND TITLE-ABS-KEY (magnesium) AND TITLE-ABS-KEY (blood AND glucose OR plasma AND glucose OR glycemic AND control OR glycated AND hemoglobin) AND TITLE-ABS-KEY (randomized AND controlled AND trial OR systematic AND review OR meta-analysis)	17	1
EBSCOhost	magnesium AND diabetes mellitus AND (glycemic control or HbA1c or glycated hemoglobin or blood glucose) AND (systematic review or meta-analysis or randomized control trial)	6	1

Table 2. Study characteristics

No.	Author	Study design	Population characteristics	Number of subjects	Outcomes	Results
1.	Asbaghi et al. (2022)	Systematic review and meta-analysis	Adults with type 2 diabetes who received an oral elemental magnesium dose ranging from 36.49 to 500 mg/day for 4 to 24 weeks	1097 (18 RCTs)	-HbA1C -Fasting blood sugar	The estimated mean difference in HbA1c at 500 mg/d was −0.73% (95% CI: −1.25, −0.22, *p*= 0.004). Fasting blood sugar (FBS) at 360 mg/d was −7.11 mg/dl (95% CI: −14.03, −0.19, *p*=0.092). The mean difference in FBS and HbA1c at 24 weeks was estimated to be −15.58 mg/dl (95 % CI: −24·67, −6·49, *p*=0.034) and −0.48% (95% CI: −0.77, −0.19, *p*=0.001), respectively.
2.	Albaker et al. (2022)	RCT, double blind	Adults with type 2 diabetes and normal baseline magnesium levels who received magnesium chloride added to desalinated drinking water and were distributed into three groups: group A (0 mg/L), group B (20 mg/L), and group C (50 mg/L) for 3 months	102	-HbA1C -HOMA.IR -Insulin level -Fasting blood glucose -C-peptide	The median level of HbA1c showed a significant improvement (8.0 vs 8.2%, *p*=0.04) along with median insulin levels (7.5 vs 9.9 µIU/mL, *p*=0.03), and homeostasis model assessment- estimated insulin resistance (HOMA-IR) (2.5 vs 2.9, *p*=0.002) in group C (high dose) after three months compared to baseline value. However,

No.	Author	Study design	Population characteristics	Number of subjects	Outcomes	Results
						there were no significant changes in FBS level C-peptide.
3.	Drenthen et al. (2024)	RCT, double blind	Adults (aged ≥18 years) with type 2 diabetes who had been treated with insulin for at least 1 year and had a serum magnesium concentration ≤0.79 mmol/l received oral magnesium gluconate or placebo as a liquid solution (50 mL) three times a day (equivalent to 360 mg) for 6 weeks	14	-Mean glucose infusion rate (GIR) during the final 30 min of the clamp (*M* value) -Continuous glucose monitoring outcomes, HbA1c, insulin dose, lipid profile and blood pressure	The *M* value of the glucose clamp did not differ between the magnesium and placebo study arms (4.6 ± 0.5 vs 4.4 ± 0.6 mg/kg/min, *p*=0.108). Glucose monitoring outcomes, HbA1c, insulin dose, lipid profile, and blood pressure also did not differ, except for a lower HDL-cholesterol concentration after magnesium supplementation compared with placebo (1.14 ± 0.08 vs 1.20 ± 0.09 mmol/l, *p*=0.026).

Table 3. Validity criteria

	Study design	Number of patients	Randomization	Similarity treatment and control	Blinding comparable treatment	Domain	Determinant	Measurement of outcomes	Quality of evidence	Level of evidence
Asbaghi *et al.* (2022)[12]	+	+	+	+	+	+	+	+	Moderate	1A
Albaker et al. (2022)[8]	+	+	+	+	+	+	+	+	Moderate	1B
Drenthen *et al.* (2024)[13]	+	+	+	+	+	+	+	+	Moderate	1B

* Quality of evidence according to GRADE guidelines, https://www.ncbi.nlm.nih.gov/pubmed/21208779
**Level of evidence according to Oxford Center of Evidence-based Medicine (CEBM), http://www.cebm.net.
+ clearly mentioned in the article; - not done; ? Not stated clearly
- Systematic review and meta-analysis with troublesome heterogeneity

Table 4. Relevance Criteria

Article	Similarity Population	Similarity determinant/intervention /indicators	Similarity outcome
Asbaghi et al. (2022)[12]	+	+	+
Albaker et al. (2022)[8]	+	+	+
Drenthen et al. (2024)[13]	+	+	+

hypomagnesemia usually appear when serum magnesium levels drop below 1.2 mg/dL. Various factors can negatively affect magnesium balance in the body, including reduced magnesium intake from food or water, increased magnesium loss through the kidneys, and prolonged use of certain medications that induce hypomagnesemia.[15]

Hypomagnesemia is associated with insulin resistance, decreased pancreatic insulin secretion, impaired cellular glucose transport, impaired glucose tolerance and rapid decline in kidney function. Consequently, hypomagnesemia in diabetes patients can accelerate disease progression and risk of end-stage kidney disease, cardiovascular disease, nephropathy, retinopathy and foot ulcers.[12,16] Intracellular magnesium plays a critical role in regulating glucokinase, K-ATP channels, and L-type Ca^{2+} channels in pancreatic β-cells, which are essential for insulin secretion. Moreover, the autophosphorylation of insulin receptors relies on intracellular magnesium levels, making magnesium a key factor in the development of insulin resistance. Conversely, insulin is an important regulator of magnesium homeostasis. In the kidney, insulin activates the transient receptor potential melastatin type 6 (TRPM6) channel which controls urinary magnesium excretion. Therefore, patients with type 2 diabetes and hypomagnesemia enter a vicious cycle in which hypomagnesemia leads to insulin resistance and insulin resistance reduces serum magnesium concentration.[7,8]

Previous studies have shown that oral magnesium supplementation significantly decreased the fasting and postprandial plasma glucose, glycated hemoglobin, fasting insulin levels and homeostatic model assessment-insulin resistance (HOMA-IR) score in type 2 diabetes patients.[9,17]

We reviewed 1 meta-analysis and 2 RCTs to address the clinical question of the effectiveness of magnesium supplementation on glycemic control in patients with type 2 diabetes.

Asbaghi et al. conducted a recent meta-analysis in 2022 to evaluate the effects of magnesium supplementation on glycemic control in individuals with type 2 diabetes, including 18 studies published between 1989 and 2019. The oral magnesium supplementation in these studies ranged from 36.49 to 500 mg/day with intervention duration varying between 4 and 24 weeks. At a dosage of 500 mg/day, the estimated mean difference in HbA1c was −0.73% (95% CI: −1.25, −0.22) suggesting a modest improvement in HbA1c with strong evidence (p=0.004). Meanwhile, a dose of 360 mg/day resulted in a fasting blood glucose reduction of −7.11 mg/dl (95% CI: −14.03, −0.19), suggesting minimal improvement with weak evidence (p= 0.092). Over a 24-week period, the estimated mean differences in fasting blood glucose and HbA1c were −15.58 mg/dl (95% CI: −24.67, −6.49) and −0.48% (95 % CI: −0.77, −0.19), respectively, suggesting modest improvement in fasting blood glucose (p=0.034) and HbA1c (p=0.001) with strong evidence.[12]

The strength of this present meta-analysis was in performing correct analysis in the homogenous populations, rather than relying on pooled individual data analysis. The limitations are high heterogeneity among the studies and the effects of the confounding variables, including the genetic background and lifestyle factors, were ignored. Although the health benefits of oral magnesium supplementation have been reported, caution is warranted when administering it in certain medical conditions, such as chronic kidney disease and end-stage renal disease. Additionally, it may pose unsafe for patients using certain diuretics and heart medications.[12]

In a randomized controlled trial (RCT) conducted by Albaker et al. in 2022, involving 102 diabetic patients on any anti-diabetic therapy, the addition of magnesium chloride to desalinated bottled water led to significant improvement in the median HbA1c level (8.0 vs 8.2%, p=0.04), median insulin level (7.5 vs 9.9 μIU/mL, p=0.03), and homeostasis model assessment-estimated insulin resistance (HOMA-IR) (2.5 vs 2.9, p=0.002) in the high-dose group after three months compared to baseline. However, no significant changes were observed in fasting blood glucose and C-peptide levels. The intervention (bottled water) contained sodium, potassium, calcium, chloride, and bicarbonate. Each water bottle had a volume of one litre, and the participants consumed one litre of the supplied water per day for three months.[8]

The strength of this study is the inclusion of a relatively large number of patients and the evaluation of different doses of magnesium supplement. However, the limitations include the sole measurement of serum magnesium levels, which may not accurately reflect intracellular magnesium stores, and the relatively low magnesium doses administered.[8]

In an RCT by Drenthen et al. in 2024, involving 14 participants with insulin-treated type 2 diabetes and low serum magnesium level, magnesium supplementation increased both mean serum magnesium level (0.75 ± 0.02 vs 0.70 ± 0.02 mmol/l, p=0.016) and urinary magnesium excretion (magnesium/creatinine ratio, 0.23 ± 0.02 vs 0.15 ± 0.02, p=0.005), compared to placebo. The primary outcome in this study was the mean glucose infusion rate during the final 30 minutes of a hyperinsulinemic-euglycemic clamp, also referred to *M* value. The *M* value of the glucose clamp did not differ between the magnesium and placebo study arms (4.6 ± 0.5 vs 4.4 ± 0.6 mg/kg/min, p=0.108). Variables of glucose control are secondary outcomes, including HbA1C and continuous glucose monitoring. There were no differences in HbA1C and continuous glucose monitoring. Despite a slight increase in magnesium levels, oral magnesium supplementation does not appear to improve insulin sensitivity in individuals with insulin-treated type 2 diabetes and low magnesium levels.[13]

The strengths of the study include its randomized, placebo-controlled, double-blind, crossover design, the use of the glucose clamp technique which is the gold standard for measuring insulin sensitivity, and the inclusion of a study population clearly identified as insulin resistant. However, the limitations include the lack of dietary intake monitoring, participants' magnesium levels remained at the lower end of the normal range, and a relatively small sample size.[13]

Magnesium does not naturally exist in its pure elemental form. Instead, it forms 'salts' when combined with other substances. Magnesium supplements are available in various forms, including magnesium lactate, magnesium citrate, magnesium glycinate, magnesium chloride, magnesium gluconate, and magnesium oxide. The term 'elemental magnesium' refers to the actual amount of magnesium present in each compound.[18] Several studies have found that magnesium in citrate, glycinate, chloride, and gluconate has higher bioavailability than magnesium oxide. Among these, magnesium gluconate has the highest oral bioavailability of magnesium salts and is recommended for magnesium supplementation due its superior absorption and lower likelihood of causing diarrhea. Magnesium chloride salts are highly soluble in water, but they have a bitter and astringent. In contrast, magnesium gluconate has a milder taste and less bitter taste. However, palatability can still vary depending on the dosage and the formulation whether in tablet, powder, or liquid form.[19]

Conclusion

Based on a critical review of the studies, magnesium supplementation may have beneficial effects on glycemic control in patients with type 2 diabetes by modulating carbohydrate metabolism and insulin function. The recommended oral elemental magnesium dose ranges from 36.49 to 500 mg/day for 4 to 24 weeks. However, further research is needed to determine the optimal dosage and the most effective form of magnesium supplementation for improving glycemic control in patients with type 2 diabetes.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

Relationship between protein intake and nutritional status with response therapy of intensive phase in pulmonary tuberculosis patients in Dili and Oecusse

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Abstract

Tuberculosis (TB) infection triggers a decrease in appetite and disrupts protein metabolism. Protein provides the main source of amino acids for immune system formation and tissue repair, both of which are impaired in tuberculosis patients. Intensive phase anti-tuberculosis therapy aims to boost immunity, reduce bacterial load, and improve nutritional status. Pulmonary TB is the leading cause of death in Timor Leste (94% mortality rate by 2021), yet few studies have explored the relationship between nutrition and treatment response. This study investigated the relationship between protein intake, nutritional status, and treatment response in pulmonary TB patients undergoing intensive therapy in Dili and Oecusse. Using a cross-sectional research design, 104 participants were recruited using consecutive sampling. Data collection included primary and secondary data. Analyses were conducted using independent sample t-test, Mann-Whitney, Fisher's Exact Test and nutrisurvey 2007 to analyse protein intake. There are 66.3% at risk of malnutrition based on upper arm circumference, a mean body mass index of 17.86 kg/m². The median daily protein intake was 1.07 g/kgBW/day, with lower intake of animal protein compared to plant protein (0.44 g/kgBW/day vs. 0.59 g/kgBW/day). The study found no significant relationship between protein intake and nutritional status in response to the intensive phase therapy ($p>0.05$).

There is no significant relationship between protein intake and nutritional status with response therapy of intensive phase in pulmonary TB patients. Further research with a case-control study design is needed to confirm findings and evaluate factors affecting unbalanced therapy response.

Keywords: tuberculosis, protein intake, nutritional status and respons therapy

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Introduction

According to the Global Report Tuberculosis (TB) (2021), there were 10.6 million TB incidents with a mortality rate of 1.6 million. Timor Leste is one of the developing countries with the second highest TB incidence and mortality in the South East Asian Region (SEARO) in 2021 with an incidence of 486/100,000 and a mortality rate of 94/100,000 population. The national strategic plan to end TB by 2030 in Timor Leste is in line with the End TB strategy which has become a global commitment.[1,2] The years 2022-2026 are a crucial period with various intervention programs and comprehensive activities as well as targets to reduce TB cases by achieving a TB treatment success rate of 94% by 2022. This research was conducted in Dili, the capital city with the largest population of 324,269 people and the highest TB incidence of 1862 cases, as well as Oecusse with a total population of 80,725 with a TB incidence of 469 cases.[2]

Tuberculosis infection leads to an increase in pro-inflammatory cytokines, characterized by a hypermetabolic state that raises energy requirements, which are met by using the body's protein reserves in the form of amino acids.[3,4] The reduction in protein reserves hinders the process of protein synthesis (anabolic block phenomenon), resulting in malnutrition. Side effects of anti-tuberculosis drugs are also a factor causing gastrointestinal problems, leading to reduced nutrient intake, including protein. Limited understanding and low income, which restrict access to a balanced and nutritious diet, are other factors influencing malnutrition in TB patients.[5,6] Research on malnutrition in adults due to infectious diseases is still very limited.[7,8] Previous studies have suggested that inadequate nutritional status in TB patients is correlated with insufficient nutrient intake, particularly protein, which serves as a crucial source of nutrition for recovery, growth, and the body's defense mechanisms. Once consumed, protein is degraded into amino acids that play essential roles in the body's metabolic processes.[9]

To determine eating patterns and levels of nutritional intake, especially protein intake, with the response to intensive phase therapy, the Semi Quantitative-Food Frequency Questionnaire (SQ-FFQ) technique was used.[10] This technique uses a questionnaire regarding the types of plant and animal protein foods consumed by TB patients in the last month during the intensive phase of treatment. Assessment of nutritional status using body mass index (BMI) measurements based on World Health Organization (WHO) Asia Pacific and Mid-upper arm circumference (MUAC) as an ideal alternative to assess fat-free mass in conditions of muscle atrophy due to malnutrition.[11,12] Tonder et al., concluded that MUAC is a better method to identify malnutrition with a sensitivity of 89.3% and specificity of 82.3%.[13]

Based on the high incidence of TB and malnutrition and research in Timor Leste regarding the relationship between nutrition and response to therapy in the intensive phase of TB, this research aims to determine the relationship between protein intake and nutritional status and response to intensive therapy. phase therapy in pulmonary TB patients in Dili and Oecusse.

Methods

This study used an observational analytical method with a cross-sectional study design to determine the relationship between protein intake and nutritional status and response to intensive phase therapy in pulmonary TB patients in Dili and Oecusse - Timor Leste. The sample is a population diagnosed with TB and in the intensive phase of pulmonary TB for the period February – May 2024 in Dili and Oecusse.

Ethical Approval

The study has been approved by the Unit of Ethical Research and Development of Timor-Leste with letter approval number of 05/INSP-TL/UEPD/II/2024. All participants in this study were treated based on Declaration of Helsinki and gave spoken, written informed consent before participating this study.

Participants

Participants were 104 people aged over 18 years, and bacteriologically confirmed case of pulmonary TB in the intensive phase for 2 months/56 days taken in outpatient/inpatient settings in Dili (Comunity Health Center (CHC) Comoro, CHC Becora and Bairopite clinic) and Oecusse (4 CHCs and 1 Referral Hospital). Subjects were excluded if they were pregnant, in critical condition, had defects or abnormalities in the upper extremities that affected the MUAC and BMI examination process and results, as well as patients with incomplete data.

Data Collection

Data collection for this study was conducted from February to May 2024. Primary data was obtained through interviews using a socio-demographic characteristics questionnaire and the SQ-FFQ to assess protein intake, along with anthropometric measurements of the research subjects. Secondary data, including laboratory examination results such as Acid-Fast Bacilli (AFB) sputum smear tests, Rapid Molecular Testing with GeneXpert, Human Immunodeficiency Virus (HIV) testing, and chest radiography results, were gathered from the medical records of research subjects at each health facility that served as a research site.

Socio-Demographic Characteristics

Socio-demographic variables consist of age, gender, education, income level, comorbidity, HIV status, AFB sputum smear examination results, adverse effects, and medication adherence. The characteristics of subject were collected from medical records.

Total protein intake

Total protein intake data was collected through interviews using a SQ-FFQ which contains a list of types of plant and animal protein food sources along with portions and frequency of food consumption. This questionnaire was previously pretested to assess validity by knowing the types of food sources of protein consumed daily according to the research location. Training and calibration were conducted between the researcher and the enumerators on using a food photo book with portion sizes based on household measurements. Protein intake assessment data were analyzed with Nutrisurvey 2007.

Nutritional Status

The nutritional status of TB patients was assessed using two key anthropometric measurements: MUAC and BMI. Based on these measurements, the patients were classified into two categories: at risk of malnutrition or not at risk. MUAC was measured using a WHO-standard MUAC tape for adults and BMI was calculated as weight in kilograms divided by the height in metres squared (kg/m^2). The BMI is categorized according to the asian-pasific cut-off points: severe underweight ($< 16.0\ kg/m^2$), underweight ($< 18,5\text{-}16.0\ kg/m^2$), normal weight ($18,5\text{-}22,9\ kg/m^2$), overweight ($23\text{-}24.9\ kg/m^2$), obese ($\geq 25\ kg/m^2$). Weighing body weight (BW) and measuring height using a SECA branded measuring instrument. Training and calibration were conducted between the researcher and the enumerators on anthropometric measurements. To determine the consistency of the anthropometric measurements of the enumerators, the Kappa test was used and the results of the kappa coefficient were 1.00 or > 0.6. Thus it was considered that the perception between the researcher and the enumerators was the same or consistent.

Response Therapy of Intensive Phase

We evaluate the response to TB therapy during the intensive phase is based on the results of bacteriological examination for AFB at the health facility. If the follow-up bacteriological examination shows no conversion of Mycobacterium Tuberculosis (AFB positive), the therapeutic response is considered unsuccessful. Otherwise, if no TB bacteria are detected (AFB negative), the therapeutic response is considered successful. Bacteriologic results for AFB are taken from medical records.

Statistical analysis

Furthermore, all data were analyzed with the Statistical Package for Social Sciences (SPSS) version 29. Statistically significant differences if $p > 0.05$ between groups were analyzed using Chi-Square and independent T-test to compare means of subjects' numerical data.

Results

The target population includes all patients diagnosed with pulmonary TB, the facilities involved 6 CHC, 1 Sponsored Clinic (Bairopite Clinic) and 1 general hospital. Total subjects in this study is by a physician in various healthcare facilities in Dili and Oecusse, specifically 104 subjects. The findings of this study, as summarized in Table 1, highlight key demographic and clinical characteristics of the subjects. The majority were in the productive age group, with an average age of 31 years, and males comprised 53.8% of the total population. Most subjects (61.5%) had a high level of education, predominantly completing high school or its equivalent. Economically, 89.4% of the participants earned below the minimum wage in Timor Leste. After the intensive phase of TB therapy, 92.3% of subjects tested negative for AFB on sputum examination. Despite 84.6% reporting side effects from anti-TB drugs, adherence to therapy was commendably high, with 91.3% of participants demonstrating good adherence. Comorbid conditions were identified in only 20.2% of the subjects, and 2.9% tested positive for HIV/AIDS. Overall, 92.3% of the participants successfully completed the intensive phase of treatment based on AFB test results.

The nutritional status of the subjects based on upper arm circumference measurements, 66.3% were found to be at risk of malnutrition. The mean body weight among the subjects was 44.6 kg with a BMI of 17.9 kg/m², indicating the prevalence of underweight individuals in the group. Categorization results based on WHO Asia Pacific, 33.7% had normal/excess nutritional status, 47.1% were underweight and 19.2 % were severe underweight.The analysis of this study revealed that a significant majority of the study subjects (63.5%) had inadequate protein intake. The median value of total protein intake among the subjects was 1.07 grams/kgBW/day. This amount represents the combined intake of animal and plant protein sources which were 0.44 gr/kgBW/day and 0.59 gr/kgBW/day respectively.

Total Protein Intake with Nutritional Status

The relationship between protein intake with nutritional status during the intensiven phase of TB treatment was explored by Chi-square with Fisher's Exact Test and there was no significant result (**Table 2**).

Relationship between protein intake and nutritional status with response therapy

The relationship between protein intake and nutritional status with response therapy during the intensiven phase of TB treatment was explored by Chi-square test with Fisher's Exact Test. The findings from this analysis revealed no significant relationship between the levels of protein and nutritional status with response therapy during the intensive phase (**Table 3**)

Discussion

Protein is critical in supporting the immune response and overall recovery during the intensive phase of TB therapy. It is a fundamental macronutrient that supports tissue repair, immune function, and the synthesis of enzymes and hormones vital for maintaining body processes, especially under stress or disease conditions like TB.[14,15] It helps the body combat the infection and recover during and after treatment. Protein malnutrition can compromise the immune response, delay recovery, and worsen the overall prognosis. Inadequate protein intake leads to malnutrition which potentially leading to poorer health ouctomes and nutritional status. Studies consistently show that malnourished TB patients, particularly those with low protein intake, have poorer treatment outcomes. Malnutrition can lead

Table 1. Characteristics of the subjects

Variables	N	%	Mean ± SD / Median (min-max
Age (years)			31 (18-75)
Gender			
Female	48	46.2	
Male	56	53.8	
Education level			
High	64	61.5	
Low	40	38.5	
Socio Economic level			
High	11	10.6	
Low	93	89.4	
Adverse effect			
No	14	15.4	
Yes	88	84.6	
Medical Adherence			
High	95	91.3	
Low	9	8.7	
Comorbidity			
No	83	79.8	
Yes	21	20.2	
HIV-AIDS status			
Negative	101	97.1	
Positive	3	2.9	
Response therapy			
Succeed (AFB test negative)	96	92.3	
Failed (AFB test positive)	8	7.7	

Related to **table 1**. Characteristics of the subjects

Variables	N	%	Mean ± SD / Median (min-max)
Protein intake			
gr/kgBW/day			1.07 (0.29-3.69)
Adequate	38	36.5	
Inadequate	66	63.5	
Animal-based protein (gr/kgBW/day)			0.44 (0.01-3.12)
Plant-based protein (gr/kgBW/day)			0.59 (0.09-2.26)
Weight (kg)			44.6 ± 6.65
Height (cm)			157.6 ± 0.07
Malnutrition (MUAC)			
Not at risk	35	33.7	
At Risk	69	66.3	
BMI (kg/m^2) before therapy			17.3±1.94
Normal/overweight	30	28.8	
Underweight	46	44.2	
Severe underweight	28	26.9	
BMI (kg/m^2) After therapy			17.9±1.93
Normal/overweight	35	33.7	
Underweight	49	47.1	
Severe underweight	20	19.2	

Table 2. Relationship Between Total Protein Intake With Nutritional Status

Variable	Total Protein intake		*p value*
	Inadequate	Adequate	
	n (%)	n (%)	
Nutrition Status: BMI (kg/m^2)			0.399[a]
Well-Nourished	19 (54.3)	16 (45.7)	
Malnourished	44 (63.8)	25 (36.2)	

[a] Fisher's Exact.

Table 3. Relationship between protein intake and nutritional status with response therapy

Variable		Response therapy				*p*
		Succeed (Negatif)		Failed (Positif)		
		n (%)	Mean ± SD/ Median (Max-Min)	n (%)	Mean ± SD/ Median (Max-Min)	
Total Protein intake	Adequate	38 (92.7)		3 (7.3)		1.00[c]
	Inadequate	58 (92.1)		5 (7.9)		
	gr/kgBW/ day		1.09 (0.29-3.69)		0.88 (0.45-2.22)	0.86[a]
Animal-based protein	gr/kg BW/day		0.44 (0.01-3.12)		0.32 (0.06-1.19)	0.55[a]
Plant-based protein	gr/kgBW/ day		0.59 (0.09-2.26)		0.64 (0.23-1.03)	0.53[a]
Malnutrition	Not at risk	32 (91.4)		3 (8.6)		1.00[c]
	At risk	64 (92.8)		5 (7.2)		
BMI	Kg/m2		17.85 ± 1.93		18.05 ± 2.12	0.78[b]
	Normal/ overweight	32 (91.4)		3(8.6)		
	Underweight	46(93.9)		3(6.1)		
	Severe underweight	18(90.0)		2(10.0)		

[a]Mann Whitney, [b] T-test, [c] Fisher's Exact

to delayed sputum conversion, increased side effects from medication, and a higher likelihood of treatment failure.[16-19] A study from Ethiopia highlighted a significant relationship between nutritional status and treatment outcomes after the intensive phase of TB therapy ($p<0.05$), underlining the importance of proper nutrition during TB treatment.[9]

Based on the WHO 2013 guidelines, the recommended protein requirement is around 15-30% of energy or 1.2 - 1.5 g/kgBW/day, which translates to approximately 75-100 gr/day.[20,21,22] According to Mahan et al.[23] to prevent muscle tissue damage and accelerate recovery in patients with chronic infections, the required protein intake is 15% of energy needs. In severe infection conditions, this requirement can increase to 2.0 g/kgBW/day to support the immune system against infections. The Indonesian Ministry of Health's recommended dietary allowance (RDA) for 2019 was used in this study.[24]

The analysis of this study revealed that a significant majority of the study subjects (63.5%) had inadequate protein intake. This aligns with the findings of Ren et al., who reported a median protein intake of 43.15 grams per day.[5] However, the results different from those of Yunda et al., who found an average protein intake of 55.35±19.38 gr/day.[25] Additionally, Alaina et al.[26] reported a much lower average protein intake

of 24.61±9.91 gr/day. The median intake of plant-based protein among the subjects was 0.59 gr/kgBW/day . Common sources of plant-based protein included rice or porridge (from rice), soy beans, and red beans. The median intake of animal-based protein was 0.44 gr/kgBW/day . Major sources of animal protein were processed milk products and imported chicken, which is affordable and readily accessible.

The statistical analysis indicates that the majority of patients consumed more plant-based protein compared to animal-based protein. This trend can be attributed to several factors:

1. Economic Factors:

The relationship between TB and poverty is complex and mutually reinforcing. Poverty increases the risk of malnutrition and TB severity, while TB exacerbates poverty by draining families of economic resources. This study found that 89.4% of subjects (TB patients) had incomes less than the minimum wage in Timor Leste. It is inline with Multidimensional Poverty Index (MPI) for Timor-Leste in 2023 estimates that 48.3% of the population is classified as multidimensionally poor.[27] Low income of familiy with the high living costs limit their access to food, especially animal protein sources which are more expensive in Timor Leste.[9] As a solution, the government of Timor Leste, through the TB Programme, has provided food subsidies and material assistance to some TB patients with low economic status. However, a large proportion of TB patients still struggle to meet their balanced nutritional needs due to low income compared to the high cost of living. According to various studies, these economic constraints force many households to rely on more affordable sources of plant-based protein.[28,29]

2. *Food Insecurity and Dietary Diversity*:

The 2019 survey on food security in Timor-Leste highlighted that while almost all households (94%-100%) could meet their energy needs, only a small proportion (15%-37%) could afford a nutritious diet.[8,30] Consequently, diets are heavily reliant on carbohydrate-rich staple foods like rice, corn and tubers such as sweet potato, cassava, taro, and sago. Vegetables are consumed in minimal quantities, and the intake of animal protein and other nutritious foods is very limited. The affordability and accessibility of plant-based proteins make them the primary choice in daily diets, especially in economically constrained setting. Also, Inadequate and poorly diversified diets are directly linked to malnutrition, which impairs the body's ability to function effectively, particularly in vulnerable groups such as children and patients with chronic conditions like tuberculosis.[30] The consequences of inadequate and poorly diversified diets in this study, based on the analysis of the relationship between total protein intake and nutritional status, showed that most subjects had inadequate protein intake, both among malnourished subjects (63.8%) and well-nourished subjects (54.3%) (Table 2).

The results indicated that there was no significant relationship between nutritional status and the response to therapy during the intensive phase. A similar study by Amalia et al, used Chi-square analysis and found no significant relationship (p=0.960) between nutritional status and the response to tuberculosis therapy during the intensive phase.[31] A different outcome was observed in a study conducted in Kupang City, which focused on the changes in patients' nutritional status after the intensive phase of tuberculosis therapy. The study found significant changes in nutritional status after the intensive phase. The percentage of subjects with normal nutritional status increased to 40.5% after the intensive phase and the percentage of subjects with poor nutritional status decreased from 72.6% before treatment to 59.5% after the intensive phase.[14] This suggests a significant improvement in overall nutritional status following the intensive phase of treatment, in contrast to the previous studies that did not find a significant relationship between nutritional status and treatment response.[26] Several previous cross-sectional studies have described how nutritional status significantly affects the response to therapy, treatment outcomes, and recovery rates during the intensive phase for TB patients.[32] The proportion of patients affected ranged from 45.8% to 55.86%, which has been associated with

increased disease severity and unfavorable treatment outcomes, while some studies did not find a direct significant relationship between nutritional status and response to treatment during the intensive phase of tuberculosis. There is evidence suggesting that the treatment itself can lead to improved nutritional status.[32,33,34] This indicates that health improvements from tuberculosis therapy may help enhance patients nutritional status. In this study, a high rate of medication adherence (91.3%) was observed, as evaluated using the Chinese version of the Morisky Treatment Adherence Scale.[35] Observations and interviews identified several key factors contributing to this exceptional adherence, including government subsidies, the proactive involvement of healthcare workers, and strong family support in monitoring patients throughout the treatment period. This high adherence level significantly improved the subjects' nutritional status and respons therapy of intensive phase in pulmonary TB patient. This was evident from the results of the subject's nutritional status analysis, which showed a mild improvement of 4.9% after the intensive phase of therapy (**Table 1**).

This is the first study to investigate the relationship between protein intake and nutritional status with the response to intensive phase therapy in pulmonary tuberculosis patients in Timor-Leste. Additionally, it introduces the use of SQ-FFQ to measure protein intake in future study in Timor-Leste. Additional studies with consistent methodologies and larger sample sizes are needed to better understand the relationship between nutritional status and response therapy to tuberculosis pulmonary . Regardless of the differing results, it is crucial to consider good nutritional management during tuberculosis therapy to support the overall recovery of patients.

Conclusion

There is no significant relationship between protein intake and nutritional status with the response therapy of intensive phase in pulmonary TB patients in Dili and Oecusse. However, understanding this relationship is crucial for designing better treatment protocols and nutritional support systems to improve patient outcomes during the intensive phase of TB therapy.

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Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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CASE REPORT

Leucine-included liquid diet as medical nutrition therapy improved handgrip strength and mid-upper circumference in clinically malnourished pulmonary tuberculosis patient with high neutrophil lymphocyte ratio: A case report from Universitas Indonesia hospital

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Abstract

Background and objectives: Muscle weakness delays clinical improvement in pulmonary tuberculosis patients. Higher neutrophil lymphocyte ratio, low handgrip strength, mid-upper arm circumference indicates bad clinical outcome. Weight loss must be managed from the start of treatment. Good muscle condition has benefits to the recovery rate. Leucine provides benefits in increasing the synthesis of muscle mass so as the clinical conditions. Unfortunately, leucine has not been the routine part of medical nutrition therapy in tuberculosis patients.

Methods: This is a case report of a female patient with body weight 42 kg and height 150 cm, admitted to Universitas Indonesia Hospital, with lung tuberculosis. Leucine given, started from 1.95 g/day to the maximum amount of 7,34 g/day through the hospital tailored-made liquid food. There was an improvement of clinical signs and symptoms during 14 days of hospitalization. Mid-upper arm circumferences at day 1, 8, and 15 were 21.1, 21.4, and 12.9 21.9 cm in a row. The right and left handgrip strength at day 1, 8, and 15 were 9.7 kg and 8.1 kg, 10.9 kg and 8.9 kg, 15.1 kg and 13.4 kg, respectively. While the neutrophil lymphocyte ratio at day 0, 6, and 9 were increasing, at 6.89, 6.89, and 13.8, in a row.

Conclusions: Leucine 1.95–7.34 g/day, in tailored-made liquid food, as part of tuberculosis management therapy, though the NLR 13.8, can improve the mid-upper arm circumference, handgrip strength, clinical signs and symptoms in 14 days of hospitalization.

Keywords: tuberculosis, leucine, muscle mass

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Introduction

Southeast Asia ranks fourth in the world's tuberculosis burden in 2021. Specifically,

Indonesia is in second place with a tuberculosis burden of 969,000 or 354 per 100,000 population.[1] Tuberculosis patients are vulnerable to malnutrition as a result of the course of the disease. Carlwile et al found that undernutrition is the main risk factor for tuberculosis with a population attributable fraction of 15%.[2] The World Health Organization (WHO) states that increasing calories and protein in tuberculosis patients can provide better recovery rates.[3] The strength of respiratory muscle mass has decreased in tuberculosis patients due to increased tumor necrotizing factor (TNF)-α and other pro-inflammatory cytokines.[4]

Leucine is a branched-chain essential amino acid which has the function of activating the mammalian target of rapamycin complex-1 (mTORC1) signaling pathway in skeletal muscles.[5] This activation causes the initiation of translation and protein synthesis.[5] Leucine is expected to improve the condition of respiratory muscle mass in particular and body muscles. Overall, in people with tuberculosis, the improvement of breathing strength can improve clinical conditions. There are various leucine dosage recommendations to date. In general, adding 4–5 grams of leucine to each main meal can stimulate muscle protein synthesis.[5] The tuberculosis patient in this case report was given liquid food prepared by the hospital, containing leucine, in divided doses in increasing amounts every day. Clinical improvement occurred in this patient. Unfortunately, leucine has not been included as a routine part in nutrition management for the inward patients. This case report shows the benefit of leucine in medical nutrition therapy.

Patient's history

A woman, 53 years old, came to the University of Indonesia Hospital Depok, October 2024, was diagnosed with pulmonary tuberculosis in the 9th month of medication, came with complaints of increasingly severe shortness of breath since the previous five days with a cough with phlegm that was difficult to expel. The patient's weight was 42 kg, and her height was 150 cm. The body mass index showed 18.7 kg/m^2. Muscle wasting occurs in almost every part of the body. The patient has been undergoing treatment at another hospital for the past four days. The clinical condition at that time was compatible with using a nonrebreathing mask of 9 liters/minute (liter per minute). Current laboratory parameters were leukocytes 5,830 10^3/L (N.150–410), neutrophils 81.2% (N. 52–76), blood urea and creatinine respectively 57 mg/dL (N. 15–40) and 0.65 mg/dL (N. 0.5–1). Serum albumin level was 3.2 g/dL (N. 3.5–5.2). Blood gas analysis showed pH 7.345 (7.35–7.45), pCO_2 52.8 mmHg (N. 35–45), HCO_3 29.1 mmol/L (N. 21–25), oxygen saturation 97.6% (N. 95–98), pO_2 105.6 mmHg (N. 75–100). Blood sodium levels were 135 mEq/L (N. 132–147), blood potassium 5.26 mEq/L (N. 3.3–5.4), and chloride 102 mEq/L (N. 94–111). A plain chest radiograph as below shows infiltrates to consolidation and multiple stasis cells in the lower middle field of the right lung, right pleural effusion and left massive pleural effusion.

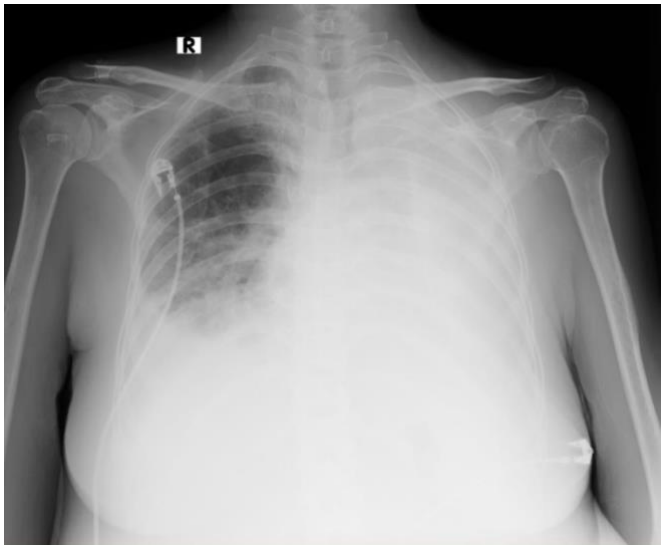

Figure 1. Plain chest radiograph shows infiltrates in the lower middle field of the right lung, right pleural effusion, and left massive pleural effusion

At the start of treatment, the patient experienced severe shortness of breath. She was given a 15 liter per minute of oxygen through the nonrebreathing mask with a breathing frequency of 25 times/minute and the oxygen saturation was 93%. Medical nutrition therapy was given in the form of hospital standard liquid food via a nasogastric tube of 600 kcal or 14 kcal/kg BW with 30 grams of protein or 0.7 g/kg BW/day, and a ratio of nitrogen

to non-protein calories was 1: 100. The patient had not been given leucine that day. On the following day, the patient still experienced shortness of breath and was still using a non-rebreathing mask with a breath of 15 liter per minute, oxygen saturation was 96% with a respiratory rate of 25 times/minute. Nutrition was provided in the form of liquid food prepared by the hospital nutrition team, around 500 kcal or 13 kcal/kg BW, with 26 grams of protein or 0.6 g/kg BW/day and nitrogen to non-protein calories was 1:105. Leucine had been started to be given in the amount of 1.95 grams/day. The specific regimens of the Universitas Indonesia Hospital liquid-diet was made of natural food sources of carbohydrate, fat from vegetable oil, and amino acids powder (as leucine included). Each disease has its own specific content of regimen with certain amount of macronutrients, based on individualized calculation.

On the second day of treatment, the patient still experienced shortness of breath. She was still on a non-rebreathing mask of 15 liter per minute, respiratory rate 24 times per minute, oxygen saturation 98%. The calories amount was increased to 800 kcal or 18 kcal/kg BW/day in hospital-specific liquid food with a protein amount of 44 g or 1 g/kg BW. Leucine was increased to 3.06 g. The ratio of nitrogen to non-protein calories is 1:89. The third day of treatment, the shortness of breath got worse. The patient was still in a nonrebreathing mask, 15 liter per minute, breathing frequency 26 times/minute, with oxygen saturation was 93%. The calories was still maintained at 800 kcal, and the protein amount of 1 g/kg BW/day, while the leucine of 3.06 grams. On the fourth day of treatment, the breathing apparatus was changed to a high flow nasal cannula, 40 liter per minute, and oxygen fraction 65%. Respiratory frequency 30 times per minute. Oxygen saturation 97%. Leucine was still being given at 3.06 grams/day.

Then the patient experienced clinical improvement from dyspnea on the fifth day. Breathing was still assisted with a high flow nasal cannula, 40 liter per minute, oxygen fraction 65%. Respiratory frequency 29 times/minute, with oxygen saturation 98%. Nutrition continued to be provided in the form of liquid food with a specific leucine mixture with a leucine amount of 4.08 g. At that time, the total nutrition was 1000 kcal or 23 kcal/kg BW, protein 59 grams or 1.4 g/kg BW with a ratio of nitrogen to non-protein calories of 1:81. At the sixth day of treatment, the patient's shortness of breath improved with the respiratory rate 20 times per minute. She was still in the high flow nasal cannula and the oxygen fraction of 65%, while the oxygen saturation increased to 99%. Nutrition was given at 23 kcal/kg BW with protein 1.5 g/kg BW/day and leucine 4.08 g/day.

The shortness of breath was more improving on the seventh day, while she was still using a high flow nasal cannula with an oxygen fraction of 65%, oxygen saturation of 99%. Hospital-specific liquid food with leucine is given at 1200 kcal or 28 kcal/kg BW/day with a protein amount of 70 g or 1.7 g/kg BW. Leucine reached 4.9 g/day, with a ratio of nitrogen to non-protein calories of 1:82. At the day 8–9 of treatment, the patient was getting better. Breathing had been assisted by a nonrebreathing mask of 10 liter per minute, respiratory frequency of 21 times/minute and oxygen saturation of 99%. She was given 1200 kcal, with a leucine amount of 4.9 g/day through the liquid food, a hospital-specific leucine concoction.

On day 10, she felt less shortness of breath. The speed of oxygen through the non-rebreathing mask was reduced to 9 liters per minute, with oxygen saturation of 99% and respiratory rate 20 times/minute. The route of nutrition delivery was still through enteral route and the calories increased to 1400 kcal or 33 kcal/kg BW/day. The amount of protein was higher to 80 g or 1.9 g/kg BW and leucine is increased to 5.6 g. The nitrogen to nonprotein calories ratio was nearly 1:83. On the eleventh day, the patient was using a simple mask with very minimal shortness of breath. Respiratory frequency 22 times/minute, with oxygen saturation 98%. Nutrition was given to 1600 kcal or 38 kcal/kg BW/day. Protein 93 grams or 2.2 g/kg BW/day and leucine was getting higher to 6.6 g per day. On the 12th day of treatment, the patient was using a nasal cannula with an oxygen saturation of 96%. The nutrition was given around 1800 kcal or 43 kcal/kg BW. The content of protein 104 g or 2.5 g/kg BW/day with high leucine of 7.34 g/day.

At the treatment day 13–15, clinically, the patient was getting much better. Maximum nutrition is given, via oral and enteral, of 1800 kcal or 44 kcal/kg BW/day with a protein amount of 104 grams or 2.5 g/kg BW/day and a leucine amount of 2.45–6.36 g/day. The patient then was dismissed from the hospital. Below in **Table 1** are the results of specific examinations of upper arm circumference and hand grip strength using a CAMRY dynamometer:

Table 1. The upper midarm circumferences, handgrip strength, and neutrophil-lymphocyte ratio changes during hospital days

Period of Hospitalization	Neutrophil Lymphocyte Ratio (NLR)	Mid-upper Arm Circumferences (cm)	Right Handgrip Strength (kg)	Left Handgrip Strength (kg)
Day 0	6.89	-	-	-
Day 1	-	21.1	9.7	8.1
Day 6	6.89	-	-	-
Day 8	-	21.4	10.9	8.9
Day 9	13.8	-	-	-
Day 15	-	21.9	15.1	13.4

Discussion

Tuberculosis infection is caused by *Mycobacterium tuberculosis* which can be life threatening. Sarcopenia, namely a decrease in muscle mass and strength, is often found in tuberculosis sufferers, especially the elderly.[6] Failure of pulmonary tuberculosis therapy can increase the risk of morbidity, drug resistance, bacterial transmission and mortality. Diallo et al (2018) concluded that weight loss that occurs from the time of diagnosis until the first sputum smear examination is related to failure of tuberculosis therapy (aORL 2.5). Therefore, weight loss must be managed from the start of treatment.[7] Paton et al found that tuberculosis patients had low body weight, fat-free mass and fat mass. Areas of fat-free mass that experience a decrease are the torso and extremities.[8]

Tuberculosis infection can increase the production of interleukin-6 (IL-6) which will reduce body weight, including muscle mass.[9] A decrease in respiratory muscle mass can typically be found in tuberculosis patients with chronic obstructive pulmonary disease.[10] The muscle mass index at low levels are closely related to decreased immune function and are a risk factor for tuberculosis infection.[11] The patient's body mass index in this case was 18.7 kg/m^2. According to the Asia-Pacific BMI criteria, the patient was still in normoweight status, while the malnutrition perse can be based on the Global Leadership Initiative on Malnutrition (GLIM) criteria by ESPEN. The muscle wasting of this patient was found in all areas of the body. It was clearly also found with the measurement of right and left handgrip strength at first day of hospitalization were 9.7 kg and 8.1 kg respectively. The muscle strength of tuberculosis patients was previously found decreased when the patients were initiated with the antituberculosis medication.[12] While other study conducted in 2017 by Choi et al, found that tuberculosis survivors had increased risk of sarcopenia and osteoporosis.[13]

Leucine given to patients is a minimum of 1.95 g/day (on the first day of treatment) and a maximum of 6.36 g/day (on the last day of treatment). According to Volpi, the leucine dose can be given at 3-4 grams per meal or according to Casperson and Murphy, leucine can be given at 4-5 g combined with regular food. The recommended dose of leucine by WHO is 39 mg/kg BW/day and Canada is 34 mg/kg BW/day, which is still relatively low compared to actual needs, based on research by Szwiega et al, which can reach 120 mg/kg BW/day.[14,15,16]

Based on the rule of thumb from Canada and WHO, this patient should only be given 1428 mg (1,428 g) and 1638 mg (1,638 g) of leucine per day. However, according to Szwiega et al, leucine can reach 120 mg/kg BW/day or 5050 mg (5.05 g) per day. The patient in this case received a minimum of 1.95 g of leucine per day, exceeding the recommended dose of leucine by Canada, by 136%, and by WHO by 119%. Leucine comes from many sources naturally, such as leucine content per 100 g of these are chiken's breast 1,955 g of leucine, lamb 1,532 g of leucine, cod contain 1,484 g of leucine, bread contains 0,691 g of leucine.[14] While in this case report, the leucine came from the

commercial amino acid powder product to be included in as the tailored-made of liquid food. The upper limit of safe intake for leucine amino acid for healthy adults is 530 mg/kg BW/day and up to 550 mg/kg BW/day.[17,18, 19,20]

The patient's clinical improvement during the treatment period was visible day by day, with improvements in respiratory effort, respiratory frequency, oxygen saturation, and rapid weaning, changing breathing aids from high flow nasal cannula to non-rebreathing mask, then simple mask, and nasal cannula. At the early phase of clinical onset, this patient experienced shortness of breath. It was as considered with the study conducted by Aytac et al, that the subjects reported tiredness after diagnosis of tuberculosis. They were examined for the Piper Fatigue Scale.[21] With the adequate supply of the amino acid leucine in this patient, the maximum administration reached 7.34 g/day. This dose is reached within 12 days of treatment. Eventually, there was an improvement of clinical signs and symptoms of this patients.

Leucine has a main function in activating the mammalian target of rapamycin complex (mTORc)-1 signaling pathway so that the respiratory muscles of these patients can also be stimulated to initiate translation and protein synthesis. Apart from being linked to muscle mass, leucine also has anti-inflammatory effects. This can be seen in research by Nicastro et al. which shows a decrease in the cytokine interleukin (IL)-6, tumor necrotizing factor alpha (TNF alpha) and increased anti-inflammatory cytokine interleukin (IL)-10 by amino acids leucine in eight healthy men.[22] There has been no further research regarding the anti-inflammatory effects of the amino acid leucine in tuberculosis patients. In this case, the levels of IL-6, TNF-alpha, and IL-10 were not checked. The patient was given the tuberculosis drug 2 fixed-dose combination (FDC) 1 times 3 tablets at 9th month for 9th month of medication. Tuberculosis regimens that are available as fixed-dose combination and separate tablets, make the patients adhere more so they can complete the tuberculosis treatment.[23]

Neutrophil-to-lymphocyte ratio (NLR) may be a helpful method for risk categorization in the adult latent tuberculosis infections in the United States.[24] Sormin et al confirmed that there was a significant difference of NLR between bacteriological confirmed tuberculosis patients and multidrug resistant tuberculosis patients, while the value of NLR <2.91 was suggestive for multidrug resistant tuberculosis.[25] Study from Yin et al, mentioned that the NLR >2.53 is predictive of pulmonary TB retreatment.[26] This was found in this case report that at the early period of being hospitalized, the NLR of this patient was 6.89. In tuberculosis meningitis patients, the NLR value is an independent predictor of short-term prognosis in patients with tuberculosis, especially tuberculous meningitis. Patients with NLR values >9.99 have poor survival.[27] This patient at day 9 of hospitalization, the NLR increased to 13.8. It is quite interesting that this NLR is in high value that would result in worse prognosis and survival.

However, the patient experienced clinical improvement, with the provision of adequate nutrition good, especially the high amount of the amino acid leucine, namely 7.34 g/day in hospital-specific leucine-concocted liquid food. This also had some beneficial effect in the upper midarm circumferences during hospitalization period. This patient had an increase in circumferences, from 21.1 cm to 21.9 cm in 14 days. The mid-upper arm circumferences can be a useful tool for a fast assessment of the nutrition status.[28] Arm has components such as subcutaneous fat and muscle. Decreament of mid-upper arm circumferences reflects that there is muscle loss or subcutaneous tissues. Changes in mid-upper arm circumferences can be a tool also for the successful of medical nutrition therapy.[29] According to study initiated by Tungdim, et al, said that the prevalence of undernutrition based on mid-upper arm circumference <22 cm was found to be 64.8% of Indian tuberculosis patients.[30] Tuberculosis patients were found in severe malnourished conditions, accelerated with the low of mid-upper arm circumferences length.[31.32,33,34] and also the reduction muscle strength.[35,36] There was an improvement of handgrip strength in tuberculosis patients who got the antituberculosis therapy, whom was evaluated at the 2nd and 6th month after the therapy was started.[37] Low handgrip strength also associated with nontuberculous mycobacterial

pulmonary disease.[38,39] The functional capacity especially for the muscle mass, reflected by the measurement of right and left handgrip strength, were improved. As leucine supplementation is safe and effective to enhance muscle protein synthesis and reduce loss of lean mass in catabolic situations, such as infection.[40]

Conclusion

As this patient in this case report was given medical nutrition therapy, as the part of tuberculosis management, as early as she was admitted to the hospital. Leucine 1.95–7.34 g/day, in tailored-made liquid food, as part of tuberculosis management therapy, though the NLR 13.8, can improve the mid-upper arm circumference, handgrip strength, clinical signs and symptoms in 14 days of hospitalization.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

Evaluation of the prevalence, and relationship between nutritional status, malnutrition, and quality of life in cancer patients undergoing chemotherapy in Mashhad, Iran in 2023

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Abstract

Introduction: Cancer patients face high risks of malnutrition, low muscle mass, and sarcopenia due to decreased intake and treatment side effects. This malnutrition can lead to longer hospital stays, higher mortality, lower quality of life, and poor treatment tolerance. The purpose of this study is to evaluate the prevalence and relationship between nutritional status, malnutrition and quality of life in cancer patients undergoing chemotherapy in Mashhad, Iran in 2023.

Method: In a cross-sectional study, we evaluated 237 cancer patients from Razavi, Nazeran, Qhaem, and Omid Hospitals using the Patient-Generated Subjective Global Assessment (PG-SGA). Data analysis was conducted with SPSS version 21.

Results: Among the 237 patients assessed, 61.6% were identified as female. The PG-SGA scores indicated that the prevalence of malnutrition and the risk of malnutrition were 89.9% (n=213) and 7.2% (n=17), respectively. Our findings revealed significant differences in physical function, role function, and emotional status dimensions between the malnourished group and the normal/at-risk malnutrition group ($P < 0.001$). In contrast, no significant differences were found in cognitive function and social function. Furthermore, there were significant variations in fatigue, pain, and appetite levels between the malnourished group and the normal/at-risk malnutrition group, as assessed by the QoL questionnaire.

Conclusion: It was determined that 89.9% of cancer patients across all treatment modalities were malnourished and required immediate care. Gastrointestinal cancer was found to have the highest malnutrition rates when compared to other cancer types.

Keywords: malnutrition, chemotherapy, PG-SGA, quality of life

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Introduction

Cancer is the second leading cause of death in the world.[1,2] The prevalence of cancer is increasing, with an estimated 19.3 million new cases and 10 million cancer-related deaths in 2020 alone.[3] The prevalence of malnutrition in cancer patients is 40 to 80 percent. Almost 20% of cancer deaths are due to malnutrition in these patients, not the disease itself.[4] It also affects quality of life, reduced immune response, treatment and survival, length of hospital stays, and patient costs. Complications of malnutrition, including weakness and lethargy, affect the daily activities of patients and reduce the quality of life of these people.[3,5,6]

There are various treatment methods for cancer patients based on the individual's specific cancer type, stage, general health, and overall medical history, which include surgery, chemotherapy, radiotherapy, or a combination of them. Chemotherapy is a critical treatment option for cancer patients, involved in killing cancer cells or slowing down their growth. The prevalence of chemotherapy varies depending on the type and stage of cancer. According to research reports, approximately 60% of cancer patients receive chemotherapy as part of their treatment regimen.[3] Chemotherapy treatment can result in several nutritional side effects include nausea, vomiting, loss of appetite, taste alterations, difficulty swallowing, and gastrointestinal problems.[7,8] Some studies reported that 45-55% of patients undergoing chemotherapy were malnourished.[9-11] A study by Ravasco et al.[12] examined the nutritional status of colon cancer patients undergoing chemotherapy. The results showed that body weight, body mass index (BMI), and muscle mass decreased significantly during the treatment period and a high percentage of them experienced protein-energy malnutrition. Another study by Isenring et al.[13] focused on the nutritional status of patients with head and neck cancer receiving chemotherapy. The findings revealed that these patients experienced significant weight loss and a decline in dietary intake during treatment. High prevalence of weight and muscle loss also found in lung cancer patients undergoing chemotherapy.[8]

Also, chemotherapy affects the quality of life of patients. Quality of life includes various aspects including physical, mental, social, and emotional well-being. Understanding and addressing factors affecting the quality of life in cancer patients undergoing chemotherapy is very important to provide comprehensive care and improve patient outcomes.[14-16]

Given the high prevalence of malnutrition and its crucial role in treatment process of patients undergoing chemotherapy, the present study was conducted with the aim of investigating the prevalence and relationship between nutritional status, malnutrition and quality of life in cancer patients undergoing chemotherapy in Mashhad, Iran in 2023.

Material and Methods

Study design and subjects

An analytical cross-sectional study was conducted from January 2023 until March 2023 in the chemotherapy department of Razavi, Nazeran, Ghaem, and Omid Hospitals in Mashhad, Iran. The subjects were 237 adult cancer patients undergoing chemotherapy for any type of cancer. The study protocol was approved by Mashhad University of Medical Sciences with approval ID "IR.MUMS.REC.1401.326". Ethical approval was granted to each person, and all the patients gave written consent.

Sample Size

Regarding the malnutrition prevalence of 69% based on the study by Pazzini Maia[17], which uses the same questionnaire, the confidence interval is 95%, and considering a 10% error, the minimum sample size is 192 people, based on the formula to determine the sample size:
$n= z^2 \times p \times (1-p) \div d^2$.

Inclusion and exclusion criteria

The inclusion criteria were adults > 18 years old in both sexes, confirmation of any type of cancer by an oncologist, undergoing at least two cycles of

chemotherapy, access to information on weight changes in the last 6 months, and willingness of the patient to attend the study. The exclusion criteria of the study were unstable clinical conditions, cognitive disorders, and neurodegenerative movement disorders (e.g., Parkinson's disease, stroke, severe myopathy, and severe arthritis).

Nutritional assessment and Quality of life

We used the patient-generated subjective global assessment (PG-SGA) for the Iranian population to measure malnutrition.[18,19] It is a common tool for assessing the risk of malnutrition in oncology and other chronic catabolic settings. Four patient-generated historical components weight history, food intake, symptoms, and activities build up the PG-SGA. Patients were divided into three groups according to their responses to the questionnaire: A (proper nutrition), with a score of 0–1, B (high risk or suspected malnutrition), with a score of 2–8, and C (malnutrition), with a score of 9. Likewise, variables like recent weight loss, dietary changes, complaints about nutrition, physical activity, and clinical observations were surveyed.

The QLQ-C30 version 1.0 (QLQ-C30 (V1)) includes five functional scales (physical, role, cognitive, emotional, and social), three symptom scales (fatigue, pain, and nausea or vomiting), a global health status scale, and several single items assessing additional symptoms frequently reported by cancer patients (dyspnea, decrease in appetite, insomnia, constipation, and diarrhea), as well as the perceived financial impact of the disease. The scores for all scales and single-item measurements range from 0 to 100. A high scale score indicates a higher level of response. So, a high score on a functional scale indicates a high level of functioning that qualifies as healthy, whereas a high score on a global health status scale reveals a high quality of life. However, a high score on a symptom scale shows a more severe problem.[20]

Anthropometric measurements

Participants wearing light clothing without shoes were subjected to an anthropometric measurement. using a scale (Seca 760) and wall-mounted stadiometer (Seca 206 stadiometer, Germany) to the nearest 0.5 kg and 0.5 cm, body weight and height measurements at recruitment. Body mass index (BMI) was computed as weight (in kilograms) divided by height (in meters squared). The percentage of unintentional weight loss over the last 6 months was calculated in the following patient reports.

Statistical Analyses

After collecting the data, it is analyzed by SPSS version 21 statistical software. Providing qualitative data in the form of numbers and percentages and testing with the Chi-square test. Regarding quantitative data, the Kolmogorov-Smirnov test will be used first to measure the normality of the data. The Independent sample t-test and if necessary, a non-parametric equivalent, Mann-Whitney U, will be used. All tests are analyzed at a significance level of $P \leq 0.001$.

Results

Among 237 paints examined, 61.6 % were female. The mean age and weight of participants were 53±81 years, and 65±93 kilograms. The data on the demographic and clinical characteristics of patients are presented in **table 1**.

Prevalence of different cancer types, including female cancer, gastrointestinal (GI), lung, hematology, and other cancers, were 35.9%, 32.9%, 8.4%, 6.8%, and 16%, respectively (**Table 1**). Most of the participants (84%) were patients who had been diagnosed as cancer patients for more than 8 weeks.

The PG-SGA scores indicated that the prevalence of malnutrition and risk of malnutrition among patients were 89.9% (n=213) and 7.2% (n=17) respectively. The nutrition status of patients was significantly different ($P < 0.001$) between the cancer groups (GI cancer was the most with 94.9% malnourished patients) (**table 2**).

Table 1a. Demographic and clinical characteristics of cancer patients undergoing chemotherapy in Mashhad hospitals (n=237)

Variable		Number (%)
Sex	Female	146 (61.6)
	Male	91 (38.4)
Marriage	Unmarried	19 (8)
	Married	188 (79.3)
	Widow	26 (11)
	Divorced	4 (1.7)
Education level	Illiterate	46 (19.4)
	Primary	99 (41.8)
	Diploma	59 (24.9)
	postgraduate	33 (13.9)
Residence	Mashhad	157 (66.2)
	Other Cities	80 (33.8)
Living Arrangements	Alone	15 (6.3)
	With Family	202 (85.2)
	With others	20 (8.4)
Type of Cancer	Female Cancer	85 (35.9)
	GI	78 (32.9)
	Lung	20 (8.4)
	Hematology	16 (6.8)
	Other	38 (16)
Cancer Diagnosis	Less than two weeks	4 (1.7)
	2-8 weeks	34 (14.3)
	More than 8 weeks	199 (84)

Table 1b. Demographic and clinical characteristics of cancer patients undergoing chemotherapy in Mashhad hospitals (n=237)

Treatment History	Chemotherapy	125 (52.7)
	Surgery and Chemotherapy	78 (32.9)
	Radiotherapy and Chemotherapy	20 (8.5)
	Surgery, Chemotherapy, and Radiotherapy	14 (5.9)
Hospital	Omid	41 (17.3)
	Ghaem	80 (33.8)
	Razavi	30 (12.7)
	Nazeran	86 (36.3)

GI: Gastrointestinal

We found that there was a significant correlation between different parts of body fat and muscle mass, and malnutrition in cancer patients undergoing chemotherapy ($p<0.001$) except temporal muscle which was not significant ($p=0.007$). According to the PG-SGA score, a significant 78.9% of patients experience a reduction in fat mass. The areas most affected include the region around the eyes, with 67.6% of patients showing loss, followed closely by the triceps at 67.2%, and the intercostal muscles at 51.6%. In terms of muscle mass reduction across various body regions, the legs are impacted in 70.8% of patients, followed by the calves at 64.8%, shoulders at 64.3%, interosseous muscles at 60.2%, clavicle at 59.2%, scapula at 58.6%, and the temporal region at 47.9%.

In addition to PG-SGA, the QoL questionnaire was completed for all patients. Our finding indicated significant differences between the malnourished group and the normal/at-risk malnutrition group in physical function, Role function, and emotional status dimensions ($P < 0.001$), while no significant differences in cognitive function, and social function were denoted (Table 3). There is a significant difference between the malnourished group and the normal/at-risk malnutrition group in fatigue, pain, and appetite rates as symptoms classified on the QoL questionnaire.

Our findings indicated significant associations between the score of all quality-of-life dimensions and malnutrition status. However, associations between the score of constipation, diarrhea, and the score of malnutrition were not reported due to minor association (R^2).

There is a significant positive correlation between the score of malnutrition and the score of fatigue, nausea / vomiting, pain, dyspnea, Insomnia, Appetite, Constipation, and Diarrhea. Furthermore, there is a significant reverse correlation between the score of malnutrition and the score of physical function, Role function, emotional function, social function, and QoL total score. (**table 4**)

Discussion

According to the findings of this study, 89.9% of cancer patients admitted to Omid, Ghaem, Razavi, and Nazeran hospitals were malnourished, and 7.2% were at risk of malnutrition based on their PG-SGA score which

is consistent with another research on a similar subject. Van Tap n et al.[21] performed a descriptive cross-sectional study on 118 cancer patients who were receiving inpatient care in Vietnam in 2020, and the results revealed an overall malnutrition rate of 84.8%, of which 33.0% had severe malnutrition and 51.7% had mild-moderate malnutrition. According to a 2019 study by Gebremedhin TK et al.[10] among a sample of 281 patients receiving chemotherapy in a cancer center in Ethiopia, 58.4% of adult cancer patients were malnourished. A study done by Shadmand et al.[18] on 113 cancer patients in Mashhad, Iran, demonstrated that the prevalence of severe malnutrition was 96.4%, while a cross-sectional study conducted by Movahed et al.[22] reported the prevalence rate to be 38.5% in cancer outpatients. In one case, Allahyari et al.[23]'s meta-analysis demonstrated that the prevalence of malnutrition among different types of cancer ranged from 44.6 to 98%. In another study, Khoshnevis et al.[24] in Tehran used the PG-SGA to determine the prevalence of malnutrition in 416 cancer patients. According to the aforementioned study, 53.1% of the patients (n=221) had malnutrition, with 29.1% and 24% diagnosed with moderate and severe malnutrition, respectively. Reviewing the earlier mentioned studies, concluded that Iran has a high prevalence rate of malnutrition. Most previous studies in Iran have been conducted on cancer outpatients, whereas our sample population was made up of chemotherapy-treated cancer patients with severe conditions.

Table 2. Nutritional status of cancer patients undergoing chemotherapy based on PG_SGA in Mashhad hospitals (n=237)

Nutritional Status / Cancer type	Normal/At-risk of malnutrition n (%)	Malnourished n (%)	Total number of patients (n)	p-Value
Female Cancer	6 (7.1%)	79 (92.9%)	85	
GI	4 (5.1%)	74 (94.9%)	78	
Lung	3 (15%)	17 (85%)	20	< 0.001
Hematology	7 (43.8%)	9 (56.3%)	16	
Other Cancers	4 (10.5%)	34 (89.5%)	38	

PG-SGA: patient generated-subjective global assessment; GI: Gastrointestinal
Fisher test

Table 3. Comparing the average domains of quality-of-life dimensions according to nutritional status in cancer patients undergoing chemotherapy in Mashhad hospitals (n=237)

Quality of life Dimensions	Nutritional status	Normal/At-risk malnutrition (n=24) (First quartile, Third quartile) median	Malnourished (n=213) (First quartile, Third quartile) median	P-Value
Functional Scale	Physical	(93.3, 80) 86.7	(40, 80) 60	< 0.001
	Role	(66.7, 100) 100	(41.7, 100) 83.3	< 0.001
	Emotional status	(68.7, 91.7) 83.3	(33.3, 79.2) 58.3	< 0.001
	Cognitive	(70.8, 100) 91.7	(50, 100) 83.3	0.087
	Social	(66.7, 100) 100	(33.3, 100) 66.7	0.039
Symptom Scale	Fatigue	(0.0, 22.2) 22.2	(22.2, 77.8) 55.6	< 0.001
	Nausea	(0.0, 12.5) 0.0	(0.0, 16.7) 0.0	0.043
	Pain	(0.0, 16.7) 0.0	(16.7, 66.7) 33.3	< 0.001
	Dyspnea	(0.0, 33.3) 0.0	(0.0, 33.3) 0.0	0.185

	Insomnia	(0.0, 33.3) 0.0	(0.0, 66.7) 33.3	0.023
	Decrease in Appetite	(0.0, 0.0) 0.0	(0.0, 66.7) 33.3	< 0.001
	Constipations	(0.0 , 0.0) 0.0	(0.0 , 66.7) 0.0	0.016
	Diarrhea	(0.0, 0.0) 0.0	(0.0, 0.0) 0.0	0.112
Quality of life		(75, 100) 83.3	(91.7, 58.3) 75	0.009

Qol; Quality of life
Mann-Whitney test

Table 4. Multiple linear regression analysis for the association between malnourished cancer patients undergoing chemotherapy in Mashhad hospitals (n=213) malnourished with QoL dimensions

	Malnourished (R^2)	Malnourished (β (95% CI))	Malnourished (P-value)
Physical function	0.279	-0.79 (-0.98, -0.60)	< 0.001
Role function	0.242	-.94 (-1.17, -0.70)	< 0.001
Emotional function	0.174	-0.66 (-0.89, -0.43)	< 0.001
Cognitive function	-	-0.30 (-0.52, -0.07)	0.01
Social function	0.155	-0.71 (-0.97, -0.45)	< 0.001
Fatigue	0.326	1.03 (0.81, 1.25)	< 0.001
Nausea/vomiting	0.171	0.52 (0.33, 0.71)	< 0.001
Pain	0.202	0.79 (0.54, 1.05)	< 0.001
Dyspnea	0.283	0.45 (0.20, 0.70)	< 0.001
Insomnia	0.128	0.77 (0.45, 1.09)	< 0.001
Appetite	0.301	1.21 (0.95, 1.48)	< 0.001
Constipation	-	0.58 (0.29, 0.86)	< 0.001
Diarrhea	-	0.40 (0.20, 0.60)	< 0.001
Financial difficulty	0.154	0.28 (0.14, 0.42)	< 0.001
Qol	0.169	-0.60 (-0.78, -0.41)	< 0.001

Table 4 Adjusted for age, sex, education, insurance

Numerous studies have found that malnutrition negatively impacts the quality of life (QoL) in cancer patients undergoing chemotherapy.[25,26] Malnutrition may struggle with muscle, cardio-respiratory, and gastrointestinal functions. It also causes weight loss due to depletion of fat and muscle mass, including organ mass. A study conducted by Nakayama et al.[27] indicates that approximately half of individuals with ovarian cancer experience a decline in skeletal muscle mass and fat mass during primary debulking surgery and subsequent chemotherapy, aligning with our observations. Nevertheless, the precise causal relationship underlying this phenomenon remains ambiguous. During periods of simple starvation, the body utilizes fat stores as the primary energy source, leading to a reduction in fat mass that typically occurs prior to muscle loss.[28] Conversely, the depletion of skeletal muscle is a defining characteristic of cancer cachexia.[29] In cases of cachexia, metabolic and inflammatory alterations are triggered, resulting in skeletal muscle wasting that occurs independently of fat mass loss. The advancement of cancer cachexia is associated with a poorer prognosis. Furthermore, research by Halpern et al.[30] indicates that severe nutritional status is the sole factor significantly correlated with fat-free mass (FFM) loss, even after adjustment for tumor location and disease stage. Based on these results,

improving cancer patients' nutritional status may enhance their clinical outcomes and quality of life.

Many research investigations have demonstrated the correlation between the severity of malnutrition in patients and the type, stage, and location of the tumor. In our study, we found GI cancers as the most relevant cancer type to malnutrition. This is mostly due to the decrease in appetite caused by changes in the secretion of digestive hormones from the digestive tract, or changes in digestion, absorption, and less calorie intake. In advance, various studies have suggested that patients with lung cancer and gastrointestinal cancer are at a higher risk of malnutrition.[31,32] In addition to the type of cancer and the body part affected, cancer in the head, neck or gastrointestinal system can affect your ability to swallow or digest your food which causes weight loss and malnutrition.

Studies have suggested that malnutrition, excess body fat, loss of muscle mass, and other symptoms are significantly associated with poor QoL in patients with cancer.[33,34] According to the results, the amount of muscle mass and fat mass reduction was extremely high in cancer patients undergoing chemotherapy based on the PG-SGA scores. The reduction rate of the mass around the eyes and legs was higher than the others. In this study, the difference between QoL and nutritional status was significant in certain domains of QoL: physical, emotional, and role functions in malnourished patients scored less compared to normal and at the risk of malnutrition patients (**table 3**). We did not find any significant difference between cognitive function, social function, and malnutrition in this study, but these connections were occasionally seen in other studies, which could be due to the age difference and economic conditions of the people who participated in our study. A cross-sectional study accomplished by Badrasawi et al.[26] between 2018 and 2019 on chemotherapy patients identified weight loss caused by chemotherapy has a negative impact on physical and social functioning, whereas weight gain with some treatment regimens has a positive impact on emotional and social functioning, these findings were in line with our results. Also, patients experience weakness and often stop their regular activities, which negatively impacts their QoL.[26,35]

The current study found that fatigue, decrease in appetite, and pain were the most frequent complaints among cancer patients (**table 3**). This is consistent with earlier research that suggested the main complaints of cancer patients were anorexia, xerostomia, and pain.[32,36] A study done by Viana et al.[1] concluded anorexia, nausea, constipation, mouth sores, strange tastes, vomiting, dry mouth, swallowing difficulties, pain, and mouth sores were the most frequent symptoms. Controlling these complaints could therefore improve the nutritional intake of cancer patients, though the effects should be carefully examined in future research.

Despite the positive aspects of this study, including its attention to the important issue of malnutrition in cancer patients undergoing chemotherapy, there were still limitations to the study. Heterogeneity of the sample cancer types with different mechanisms of malnutrition and differences in stage and treatment protocols based on dosage and duration, may have confounded the results and influence nutritional and functional outcomes. The measurement of muscle and fat mass was only done via clinical visual inspection which is less accurate in comparison with objective techniques like bioelectrical impedance analysis (BIA) or dual-energy X-ray absorptiometry (DEXA). Also, this study was conducted as an analytical cross-sectional study that only examined the relationship between malnutrition and chemotherapy. If it was possible to follow up patients in longitudinal studies, more useful data could be obtained about the effect of malnutrition in these patients and its role in the treatment process. Through which practical nutritional recommendations can be reached to improve the condition of patients undergoing chemotherapy.

Conclusion

According to our findings, which were based on the PG-SGA, 89.9% of cancer patients in all

treatment settings were malnourished and requiring immediate attention. In contrast to other cancer types, GI cancer had the highest rate of malnutrition. A substantial percentage of patients exhibit a decrease in both fat and muscle mass due to malnutrition, as indicated by the PG-SGA score. Eventually, it strongly encouraged that ongoing nutritional assessment and intervention must be initiated during chemotherapy, which may considerably decrease the prevalence of malnutrition and improve QoL.

Availability of Data and Material

Data and materials used in this study are available upon request. please contact the corresponding author for inquiries regarding access to the dataset and the research materials.

Authors' Contributions

AZ, HK, ARB, and MD designed this study. AZ and HK performed the study and entered data. HK and AB conducted the library search, wrote the manuscript, and drafted and edited the manuscript. AB designed the study tables. SHS participated in the statistical analysis. All authors have read and approved the final manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest.

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ORIGINAL ARTICLE

Correlation of energy and protein intake with nitrogen balance changes in late acute phase critically ill patients

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Abstract

Background: The hypercatabolic process due to metabolic stress in critically ill patients, especially in the acute phase, is very high, causing protein degradation. Inadequate intake and high protein losses will result in a negative nitrogen balance.
Objective: To analyze the correlation of energy and protein intake in the late acute phase with nitrogen balance changes.
Methods: This study's method was cross−sectional with consecutive sampling, conducted in the ICU of the university of Indonesia hospital. Energy and protein intake were assessed for 7 days. On days 3 and 7 of treatment, 24−hour urine urea nitrogen levels and nitrogen balance (NB) were assessed. Twenty three subjects participants in this study.
Results: There was a positive correlation between energy and protein intake with NB on day 3 (r=0.5, p=0.01 ;r=0.6, p=0.003). The mean nitrogen balance changes was positive, namely 3.8 g. There was a significant correlation between energy and protein intake with NB changes (p>0.01)
Conclusion: Energy and protein intake were positively correlated with nitrogen balance in the early acute phase. The results show that the administration of energy and protein starting at low intake in the early acute phase and gradually reaching the target intake during the late acute phase leads to an improvement in nitrogen balance.

Keywords: critically ill patient, protein intake, energy intake, nitrogen balance changes

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Introduction

Critical illness is a state of multiorgan dysfunction that disrupts homeostasis and requires intensive medical intervention in the intensive care unit.[1] Critically ill patients vary widely due to factors like disease phase, level of metabolic stress, inflammation, other complicating conditions, and the severity of organ dysfunction.[2] The Society of Critical Care Medicine (SCCM) states that more than 5 million patients are admitted to the Intensive Care Units (ICUs) each year in the United States.[3] The recent COVID-19 pandemic has increased deaths due to critical illness in almost all countries and caused a 2-time increase in ICU demand. Critically ill patients in Indonesia in 2019 reached 33.148 with an ICU mortality rate of 36.5%. In 2021, ICU demand in Indonesia reached 52.719 beds.

Nutritional status and intake, particularly energy and protein intake, can lead to longer hospital stays and decreased functional capacity, including muscle function. Length of stay in the ICU is associated with higher mortality, morbidity, and medical costs.[5] In critical illness, metabolic stress increases catabolism to provide healing substrates and repair tissues, particularly during the acute phase, which lasts about 7 days. This phase includes an early acute phase (1-3 days) with high mortality risk and a late acute phase (up to 7 days). The body requires significant energy for catabolism, and if glycogen stores run out, proteins are broken down into amino acids for gluconeogenesis. The balance between intake and degradation of protein can be evaluated from the nitrogen balance. Nitrogen balance, often negative in critically ill patients during this phase, indicates protein losses exceed intake.[6-8]

Nitrogen balance is one of the most frequently used indicators to identify protein metabolic rate in critically ill patients. During proteolysis, amino acids produce ammonia, which the liver converts to urea for kidney excretion. A 24-hour urine urea nitrogen (UUN) test can assess protein excretion. Studies show a positive correlation between energy and protein intake with nitrogen balance in the early acute phase. While inflammation is intense in this phase, patients who survive may experience regression, allowing anabolic processes to balance catabolism.[9-11] This study needs to be conducted to explore the correlation between energy and protein intake with nitrogen balance changes in the late acute phase.

Methods

This study was performed in the ICU of the University of Indonesia Hospital from December 2023 to May 2024 with a cross-sectional design. Inclusion criteria: ICU patients aged 18-60 years, getting protein intake in the first 48 hours of treatment, and having a written family representative statement stating that they were willing for the subjects to be included in the research. Exclusion criteria: urine output <0.5 ml/kgBW/hour starting on day 2, receiving renal replacement therapy, chronic liver disease, BMI <18.5, or ≥30 kg/m2, APACHE II score >30, pregnant, and receiving norepinephrine treatment >0.3 mcg. Dropout criteria were subjects who had an average protein intake on days 3 to 7 <0.5 g/kgBW/day and died before the 7th day of treatment. The sample size was calculated using the sample size formula for correlative analytical research. The required sample size was 19 subjects and considering the dropout rate of 20%, the minimum sample size was 21 subjects. This study was approved by the Health Research Ethics Commission of the Faculty of Medicine, University of Indonesia / Dr. Cipto Mangunkusumo National General Hospital no. KET-1176/UN2.F1/ETIK/PPM.00.02/2023 and research permit no. ND-743/DIKLATLIT/RSUI/XI/2023 from University of Indonesia Hospital.

The data used in this research are primary and secondary data. Data on energy and protein intake as well as route for intake were obtained from medical records and interviews with the nutritionist on duty and collected during 7 days of treatment. Energy intake data was presented in % energy expenditure (EE). The calculation of EE as a target energy intake was 25 kcal/kgBW/day using actual body weight or adjusted body weight for subjects with a BMI >25kg/m2. Protein intake data was presented in g/kgBW/day based on actual body weight or ideal body weight for

subjects with a BMI >25kg/m2. The nitrogen balance value was obtained from the formula: (Protein Intake/6.25) - (UUN 24 hour+4). In subjects with burn trauma, nitrogen loss was multiplied by 1.25 as an estimate of nitrogen loss through the wound.[10,12] The UUN 24-hour results were obtained from laboratory tests conducted twice, namely on day 3 and day 7 of treatment. Nitrogen balance changes were derived by subtracting the nitrogen balance on day 7 with that on day 3.

Descriptive data were reported as percentages for categorical data while numerical data were reported as means and standard deviation (SD), or median and min-max if non-normally distributed. This study was analyzed using SPSS 26. Bivariate analysis methods used include independent samples T test or Mann-Whitney test, one-way ANOVA or Kruskal-Wallis test, paired T-test or Wilcoxon test, and Pearson or Spearman correlation test.

Results

In total 23 subjects met the inclusion and exclusion criteria for the study, 2 subjects dropped out due to death before day 7 of the study, leaving 21 subjects for analysis. The characteristics of the study subjects are presented in **Table 1**.

Patients' average age was 45 years. Patients' sex were predominantly female (57%) while men were 43%. The number of medical and surgical patients were nearly equal. The mean APACHE II score was 16. Patients with APACHE II scores between 11 to 20 were more dominant (62%). Patients' IMT were predominantly normal. Patients who received a combination of oral and enteral nutrition were highest at 52.4%. The majority of patients did not receive mechanical ventilation support (62%).

The mean energy and protein intake for the first 3 days were 78% EE and 0.8 g/kgBW/day. The mean energy and protein intake for day 3 to day 7 were 110% EE and 1.1 g/kgBW/day. The mean UUN 24h levels and nitrogen balance on day 3 were 8.1 g and -5.3 g. On day 7, the data were presented as median due to non-normally distributed with one outlier. The median UUN 24h levels and nitrogen balance on day 7 were 4.2 g and -0.4 g. The mean nitrogen balance changes was positive, namely 3.8 g.

Significant differences were found in nitrogen balance between males and females on days 3 and 7 ($p < 0.05$). This result was slightly influenced by body composition, as skeletal muscle mass in males was greater than in females. The differences in metabolism caused by underlying diseases had a more significant effect on the nitrogen balance of critically ill patients, as evidenced by the APACHE II scores in male subjects being higher than in female subjects, at 19 and 13, respectively. There was no significant differences in nitrogen balance among groups of admission diagnosis, APACHE II score, BMI, routes of administration, and mechanical ventilation (**Table 2**)

The differences in mean energy intake and protein intake between day 3 and day 7 were analyzed using paired T tests, and significant differences were found ($p<0.0001$). There was a strong positive correlation between energy intake and protein intake on day 3 and day 7, $p < 0.001$ (**Figure 1**).

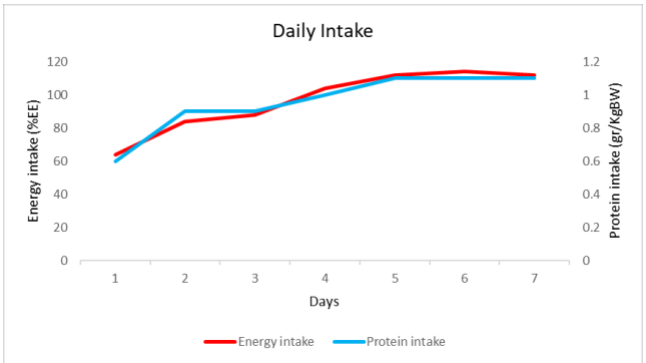

Figure 1. Daily Intake graph

Table 1. Subject characteristics

Characteristics	n(%)	n=21 Mean±SD /Median (min-max)
Age (years)	-	45.5±11.3
Gender		
Male	9(42.9)	-
Female	12(57.1)	-
Admission diagnosis		
Surgical	11(52.4)	-
Medical	10(47.6)	-
APACHE II score		16.3±4.8
0-10	2(9.5)	-
11-20	13(61.9)	-
21-30	6(28.6)	-
BMI (kg/m^2)		
Normal	10(47.6)	-
Overweight	4(19)	-
Obese I	7(33.4)	-
Routes of administration		
Enteral only	7(33.3)	-
Oral + Enteral	11(52.4)	-
Oral+Enteral+Parenteral	3(14.3)	-
Mechanical ventilation		
Yes	8(38.1)	-
No	13(61.9)	-
Energy intake (% EE)		
Day 1-3	-	78.6±26.0
Day 4-7	-	111.0±20.5
Protein intake (g/kgBW/day)		
Day 1-3	-	0.8±0.2
Day 4-7	-	1.1±0.2
UUN 24h (g)		
Day 3	-	8.1±5.2
Day 7	-	4.2(1.5-24.9)
Nitrogen balance (g)		
Day 3	-	-5.3±5.7
Day 7	-	-0.4(-22.6-6.9)
Nitrogen balance changes (g)		3.8±5.3

Significant differences were found in nitrogen balance, but there was no significant differences in UUN levels. However, if the analysis of UUN levels excluded one outlier, significant differences would be found with a p-value <0.05. There was no significant correlation between energy and protein intake with UUN levels on day 3 or day 7 (p>0.05). However, a strong positive correlation was found between energy and protein intake from day 1 to day 3 with nitrogen balance on day 3 (p<0.05), but no significant correlation was found between intake and nitrogen balance on day 7. Further analysis was conducted to assess the correlation between mean intake from day 4 to day 7 with nitrogen balance changes, but no significant correlation was found (p>0.05).

Discussion

In this study, the mean energy intake for the first 3 days was 78% EE, increasing to 110% EE from day 4 to day 7. This intake was slightly higher than the European Society for Clinical Nutrition and Metabolism (ESPEN) recommendation of <70% EE during the early acute phase and 80-100% EE after day 3.[13] The findings align with Koekkoek et al.,[14] who reported <80% in the early phase and 80-110% in the late phase, but are lower than Bendavid et al.,[15] report of 88% EE. During the early acute phase, the administration of nutrition focuses on providing optimal energy while avoiding overfeeding, aiming to provide energy for the catabolism of macronutrient storage in the body. In the late acute phase, protein intake is increased to mitigate muscle wasting.[16,17] Nutritional intake also considers the patient's hemodynamic status and gut function. In this study, the most common administration method was a combination of oral and enteral feeding, in line with ESPEN guidelines that prioritize oral intake when possible. Enteral feeding is preferred within 48 hours if oral intake isn't feasible, and parenteral nutrition considered from days 3 to 7 if enteral feeding is contraindicated.[13]

Table 2.The nitrogen balance (NB) comparisons of each variable group

Variable	Day 3		Day 7	
	NB (g)**	p	NB (g)***	p
Gender				
Male	-8.2±6.8		-3.4(-22.6-6.9)	
Female	-3.1±3.9	0.04*	1.7(-6.1-3.3)	0.02*
Admission diagnosis				
Surgical	-6.5±6.0		0.9(-9.5-3.3)	
Medical	-3.9±5.4	0.3	-0.5(-22.6-6.9)	0.6
APACHE II score				
0-10	-2.6±1.8		2.4(1.6-3.3)	
11-20	-5.0±5.8		-0.6(-22.6-3.0)	
21-30	-6.7±6.7	0.6	-0.5(-4.0-6.9)	0.3
BMI				
Normal	-4.3±6.3		1.2(-9.5-6.9)	
Overweight	-7.0±6.7		-3.7(-6.1-3.0)	
Obese I	-5.6±4.9	0.7	-1.6(-22.6-3.3)	0.3
Routes of administration				
Enteral only	-5.5±8.1		0.6(-9.5-6.9)	
Oral + Enteral	-4.9±4.5		-0.6(-7.2-3.3)	
Oral+Enteral + Parenteral	-5.8±5.6	0.9	1.6(-22.6-2.8)	0.7
Mechanical ventilation				
Yes	-7.7±6.8		-1.1(-9.5-6.9)	
No	-3.7±4.7	0.1	0.6(-22.6-3.3)	0.9

*significant (p<0.05); **mean±SD; ***median(min-max)

Table 3. The Differences in energy intake, protein intake, UUN 24h, and nitrogen balance between day 3 and day 7

Variable	Day 3	Day 7	p
Energy intake (% EE)**	78.6±26.0	110.7±19.8	0.000*
Protein intake (g/kgBW/day)**	0.8±0.2	1.1±0.2	0.000*
UUN 24h (g)***	8.1±5.2	4.2(1.5-24.9)	0.2
Nitrogen balance (g)***	-5.3±5.7	-0.4(-22.6-6.9)	0.004*

***significant (p<0.005); **paired T test; ****Wilcoxon test*

Table 4. Correlation test results of energy and protein intake with UUN 24h, nitrogen balance, and nitrogen balance changes

			UUN 24h		Nitrogen balance		Nitrogen balance changes**
			Day 3**	Day 7***	Day 3**	Day 7***	
Day 1-3	Energy intake	r	-0.2	-0.02	0.5	0.1	
		p	0.2	0.9	0.01*	0.7	
	Protein intake	r	-0.2	0.1	0.6	-0.001	
		p	0.2	0.4	0.003*	0.9	
Day 4-7	Energy intake	r		-0.2		0.3	0.3
		p		0.4		0.1	0.2
	Protein intake	r		0.004		0.2	0.3
		p		0.9		0.3	0.1

*significant (p<0.05); **Pearson correlation test; ***Spearman correlation test

The mean protein intake for the first 3 days in this study was 0.8 g/kgBW/day, increasing to 1.1 g/kgBW/day from day 4 to 7. Some participants did not exceed 0.8 g/kg BW/day due to kidney dysfunction, following Kidney Disease Outcomes Quality Initiative (KDOQI) recommendations.[18] Hoffer and Bistrian noted that many critically ill patients received less than half the recommended protein intake in the first week. The mean protein intake in Bendavid et al.,[15] study was lower, at 0.64 g/kg BW/day.[15]

The mean 24-hour urine urea nitrogen (UUN) level in this study decreased from 8.1 g on day 3 to 7.2 g on day 7, and the mean nitrogen balance significantly improved from -5.3 g to -1.5 g, with an average change of 3.8 g. Seventeen of 21 subjects showed a more positive nitrogen balance. Higher UUN levels were reported in studies by Dupuis et al.,[19] likely due to differences in patient populations and disease severity, which impact protein degradation and nitrogen excretion. This explains that the severity of the disease, severe infection, and inflammatory status play crucial roles in increasing protein degradation and thus increasing urinary nitrogen excretion.[7,17,20]

There was a strong positive correlation between energy and protein intake and nitrogen balance on day 3, but not on day 7. While Ferrie et al. observed better nitrogen balance on day 3 with higher protein intake, no significant differences were noted on day 7.[11] Arabi et al.,[21] found no improvement in nitrogen balance on days 1, 7, and 14 with protein intakes of ≤0.8 g/kg BW and >0.8 g/kg BW. Additionally, no significant correlation existed between energy or protein intake during the late acute phase and nitrogen balance changes. This suggests that factors like inflammatory status, renal function, and comorbidities may influence protein degradation in this phase, despite anabolic processes and regression of inflammation.[20,21] During the early acute phase, the catabolic process is very high. Anabolic processes will begin to strive for balance in the late acute phase, although catabolism still predominates. The inflammatory process generally decreases during this phase, which should lead to improvements in nitrogen balance and positive nitrogen balance changes.[22] However, the severity of underlying diseases and the condition of kidney function in patients can disrupt this process, resulting in a negative nitrogen balance. In some patients, inflammation remains high even in the late acute phase.[23] Research results indicated a trend of improved nitrogen balance in most subjects; however, among the four subjects with worsening nitrogen balance, two had sepsis and two had diabetes-related complications. The high level of inflammation in these conditions could lead to catabolism being far more dominant than anabolism in patients. This had an impact on the overall results in a small sample. Nevertheless, energy and protein intake in this study could generally be associated with improvements in nitrogen balance, with significant increases in intake accompanied by improvements in nitrogen balance during the acute phase.

This study has limitations including a smaller number of subjects compared to other similar studies; as a result, even slight differences in data among subjects have a significant impact on the final analysis results. Additionally, UUN 24-hour and nitrogen balance were not calculated in the first 24 hours as a baseline metabolic rate, energy expenditure calculation did not use indirect calorimetry which is the gold standard, and there was no periodic assessment of kidney function and inflammation status to assess other factors that can influence the catabolism in the study subjects. Future research is expected to address these limitations, especially in the late acute phase.

Conclusion

There is a strong positive correlation between energy and protein intake in the early acute phase with nitrogen balance on day 3, but no correlation was found between intake with nitrogen balance changes during the late acute phase. Starting with a low intake of energy and protein in the early acute phase and gradually increasing to the target intake during the late acute phase contributes to improving nitrogen balance.

Conflict of interest

No conflict of interest was declared

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ORIGINAL PAPER

Correlation between body mass index and 25(OH)D levels in pregnant women

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Abstract

Background: Vitamin D is a vitamin that has a positive effect on maternal and infant health. The mother's nutritional status affects vitamin D levels, where one of nutritional status is expressed in body mass index (BMI). It has been assumed that BMI has the potential to influence the mother's vitamin D levels.

Objective: This study analyzes the correlation between BMI and 25(OH)D levels in pregnant women.

Methods: This observational analytical study examines data from the medical records of pregnant women who underwent antenatal examinations at the AMS Clinic Kemang from January 2022 to December 2023. The data analyzed were maternal age, gestational age at the time of vitamin D examination, gestational age at delivery, 25(OH)D levels, and maternal BMI. The Pearson correlation or Spearman Rank test was used in bivariate analysis, with a significance level of $p<0.05$.

Results: The mean maternal age was 33.45±6.24 years, with the median gestational age at the time of vitamin D examination being 6.5 mg. The median gestational age at birth was 39 weeks, with vitamin D levels of 20.8 ± 7.8, and a median BMI of 24.22 kg/m2. Based on the results of the Spearman statistical test analysis, there is a strong negative significant correlation between body mass index and levels of 25(OH)D in pregnant women (r -0.747; p=0.008).

Conclusion: Pregnant women's body mass index correlates negatively with levels 25 (OH)D. Therefore, it is recommended that pregnant women maintain a BMI within the normal range.

Keywords: body mass index, vitamin D, pregnancy

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Introduction

Vitamin D is a vitamin that has recently received attention because of its effects on health. Vitamin D's primary role is to maintain calcium and phosphorus homeostasis. However, nearly all human cells and tissues contain vitamin D receptors, suggesting that this vitamin has extra-

skeletal effects, particularly on the immune and cardiovascular systems.[1] Many studies show a high prevalence of vitamin D deficiency globally, including in Indonesia.[2]

Several factors influence vitamin D levels, including sun exposure, ethnicity, altitude, season, use of sun protection, and body mass index (BMI).[3] Serum concentrations of 25(OH)D can be used for both D2 and D3 to evaluate an individual's vitamin D nutritional status. Research reports show that 25–55% of pregnant women experience vitamin D deficiency.[4] The fetus is dependent on the mother's 25(OH)D concentration level, which affects the transfer of calcium, phosphorus, hormones, and immune balance, all of which are critical for bone growth processes and fetoplacental integrity.[5] Observational studies have found a link between low levels of 25(OH)D during pregnancy and more problems for the mother, such as pre-eclampsia, gestational diabetes[6], bacterial vaginosis, osteomalacia[7], and needing a primary cesarean section. Similarly, the fetus will also experience complications, such as impaired fetal growth, increased risk of allergies, premature birth, abortion, neonatal hypocalcaemia, and obesity over the long term.[8]

Although the number of studies is limited, observational studies show that obese pregnant women (BMI >30 kg/m^2) have significantly lower vitamin D levels than non-obese pregnant women.[9] Andersen et al.[10] reported that every 5 kg increase in BMI/m^2 is associated with a decrease in vitamin D levels of 1.48 ng/mL in pregnant women. Karlsson et al.[9] reported that despite consuming higher vitamin D levels in the diet and using the same vitamin D supplements, obese pregnant women had lower vitamin D levels than normal-weight pregnant women in the first trimester. Among women, the obese group exhibited decreased mean vitamin D levels compared to both the overweight and normal weight groups during winter and summer, frequently attaining vitamin D insufficiency status (<10 ng/mL).[11]

Other studies revealed different and conflicting results. Study in West Sumatra indicating a higher prevalence of vitamin D deficiency in pregnant women with low pre-pregnancy weight.[12] Similarly, Shen et al.'s study in southeast China at the first-trimester phase revealed a correlation between a higher pre-pregnancy BMI and higher 25(OH)D levels, a pattern that continues into the second and third trimesters.[13] Some studies show there is no relationship between pre-pregnancy BMI and vitamin D deficiency, as seen in the research of Woon et al.[14] The differences in results from these studies were caused, among other things, by different subject populations, differences in vitamin D calcification based on 25 (OH)D levels, and differences in sampling times, especially in the study area with four seasons.

Even though maintaining optimal levels of vitamin D in the body is important in theory, research has not shown conclusive results. Only a few publications in Indonesia describe vitamin D levels in pregnant women, specifically in West Sumatra[11]. Jakarta is the province with the highest prevalence of obesity among women aged over 18, namely 38.8%.[15] This can put women in the Jakarta area at risk of experiencing high pre-pregnancy BMIs and weight gain during pregnancy. This study aims to determine the correlation between BMI and 25(OH)D levels. The data can be used to recommend that pregnant women maintain BMI to improve vitamin D levels.

Methods

The Trisakti University Faculty of Medicine Ethics Committee no. 036/KER/FK/I/2024 granted ethical approval for the research. This research is an observational analytical study. Secondary data was collected from the medical records of pregnant women who had antenatal visits at AMS Kemang Clinic, South Jakarta, from January 2022 to December 2023. Inclusion criteria: medical records of pregnant women who underwent antenatal examinations from January 2022 to December 2023, maternal age between 21- and 35-years during pregnancy, data on body mass index before pregnancy in the medical record, and data on 25(OH)D examination results in medical records during pregnancy. Exclusion criteria: medical records of pregnant women with kidney disorders or hyperparathyroidism, taking atorvastatin and thiazide diuretics. Samples were selected based on consecutive sampling.

All data will be edited, coded, and entered into the computer. SPSS for Windows version 20.0 will be used for data analysis. Univariate analysis will be carried out to determine the distribution of all variables. The normality test will be carried out using the Kolmogorov-Sminov test with a p-value >0.05 as normally distributed data. For continuous data, it will be presented in mean ± standard deviation, and for categorical data, data will be presented in n (%) for those that are normally distributed and geometric data median (min, max) for those that are not normally distributed. For bivariate analysis, the Pearson correlation test will be used if the data is normally distributed or the Spearman Rank test if the data is not normally distributed with a significance if p-value <0.05.

Results

This study obtained data from 155 respondents who met the inclusion criteria in accordance with the minimum sample size required. The characteristics of the subject can be seen in **Table 1.**

Table 1. Subject characteristics

Variables	Mean±SD /median (min, max)	95% CI
Mother's age (age)	33.45±6.24	29.27 – 37.95
Gestational age at Vitamin D examination (weeks)	6.5 (5, 22)	6.26 – 13.03
Gestational age at labor (weeks)	39 (37, 40)	38.09 – 39.18
25(OH)D level (mg/dL)	20.8±7.8	15.56 – 26.04
Body mass index (kg/m^2)	24.22 (20.22, 41.62)	21.9 – 30.4

The mean maternal age is 33.45±6.24 years, with the median gestational age at the time of vitamin D examination being 6.5 mg. Gestational age during pregnancy with a median of 39 weeks, vitamin D levels 20.8±7.8 with a median BMI of 24.22 kg/m^2.

Table 2 shows the correlation of variables with 25(OH)D levels. Based on the Spearman statistical test analysis results, a strong negative significant correlation exists between body mass index and 25(OH)D levels in pregnant women (r -0.747; p = 0.008).

Table 2. Correlation of independent variables with 25(OH)D levels in pregnant women

Variables	25(OH)D level (mg/dL)	
	r	p
Mother's age	0.132	0.652^p
Gestational age at Vitamin D examination	-0.163	0.579^s
Gestational age at labor	0.038	0.897^s
Body mass index	-0.747	0.008*^{s}

p, Pearson correlation test; s, Spearman correlation test; *p<0,05

Discussion

The mean age of mothers in this study was 33.45±6.24; this age was in the range of 20-35 years, which corresponds to the ideal pregnancy age. WHO recommends that women be between 20 and 35 years old when experiencing pregnancy and childbirth. Pregnant women who are less than 20 years old or older than 35 years old are particularly vulnerable because their uterus and pelvis have not yet reached adult size, making pregnancy and childbirth more prone to complications, including miscarriage. As the uterus gets older (more than 35 years old), pregnancy complications will easily occur, and the incidence of chromosomal abnormalities will also increase.[16]

The gestational age at the time of vitamin D examination in this study was a median of 6.5 weeks, with a minimum gestational age of 5 weeks and a maximum of 22 weeks. According to the

literature, increasing gestational age will affect vitamin D levels, and early pregnancy is an essential window for preventing vitamin D deficiency in pregnancy, which affects perinatal outcomes, including preeclampsia and spontaneous premature birth.[17] There are no recommendations for when is the best time to check vitamin D levels in pregnant women. However, maternal 25(OH)D levels progressively decrease during pregnancy due to the fetus' increased physiological needs.[18] However, there is insufficient evidence to support the recommendation to screen all pregnant women for vitamin D deficiency.

The median gestational age is 39 mg; this shows that the gestational age at parturition is within normal limits, namely 37-40 weeks. These new gestational age categories were suggested by the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine in 2012. They are early term (37 0/7 weeks of gestation to 38 6/7 weeks of gestation), full term (39 0/7 weeks of gestation to 40 6/7 weeks of gestation), late-term (41 0/7 weeks of gestation to gestational age 41 6/7 weeks), and post-term (gestational age 42 0/7 weeks and beyond) to more accurately describe births that happen at or after 37 0/7 weeks of gestation.[19]

The 25(OH)D level is in an insufficiency condition, namely 20.8±7.8 mg/dL. Several studies show that pregnant women worldwide have a high prevalence of vitamin D deficiency in each trimester of pregnancy.[20] Factors determining 25(OH)D concentrations in pregnant women include skin pigmentation, UV radiation, extensive use of skin coverings due to religious or cultural reasons, and, more significantly, social deprivation. Several studies link low 25(OH)D levels with an increased risk of preeclampsia (PE), gestational diabetes mellitus (GDM), indications for cesarean section, premature birth, low birth weight (LBW), and small for gestational age (SGA). Vitamin D status is also critical for the fetus in pregnant women. Early in pregnancy, 25(OH)D crosses the placenta from mother to fetus, and levels measured in cord blood at birth depend on maternal status, averaging 80% of maternal values.[21] If the mother is deficient, the same happens to the fetus.[22] The placenta and fetal tissues express 1α-hydroxylase, which produces bioactive vitamin D in the fetal circulation.

Late hypocalcemia and nutritional rickets are the classic effects of vitamin D deficiency during pregnancy and in the neonate. Some studies suggest that prenatal vitamin D status affects offspring's susceptibility to developing asthma later in life.[23] It may also contribute to destroying pancreatic beta cells due to its action on lymphocytes and type 1 helper cytokines.[24] Vitamin D deficit during maternal pregnancy may also be a risk factor. Early brain development, which plays a relevant role in neuronal differentiation and synaptic function, causes multiple sclerosis in adulthood. The Body Mass Index (BMI) during vitamin D examination showed a median of 24.22 kg/m^2, which indicates that the mother was already overweight at the start of pregnancy. Bivariate analysis showed that of the various variables, only BMI showed a significant, strong negative correlation with 25(OH)D levels. This is in accordance with the theory, which states that an individual's body fat can influence vitamin D levels. Research from Giacoia et al. shows that obesity (BMI >30 kg/m^2) in pregnant women indicates a severe vitamin D deficit risk.[25] 25(OH)D levels <20 ng/mL are considered an indication of vitamin D deficiency, although the Endocrine Society and another expert group consider vitamin D insufficiency if the 25(OH)D level is 20–29 ng/mL and sufficient if the level is ≥30 ng/mL as sufficient; for non-classical measures, some authors suggest achieving levels >40 ng/mL.

Savard et al.'s research on 79 pregnant women showed that in the first and third trimesters, pregnant women with a pre-pregnancy BMI ≥30 kg/m^2 had lower total serum 25(OH)D concentrations than women with a pre-pregnancy BMI <25 kg/m2.[26] Serum total 25(OH)D concentration was inversely related to pre-pregnancy BMI in all trimesters but more strongly in the first trimester. Vitamin D supplement intake is adequate in improving vitamin D status among pregnant women with a higher pre-pregnancy BMI.[26] In assessing vitamin D status, BMI is important because obesity and adiposity are associated with higher total serum 25(OH)D

concentrations, and because most women now enter pregnancy with a long-term BMI in the overweight or obese range. Obese adults also often require larger doses of vitamin D to achieve a serum total of 25(OH)D concentrations, similar to adults with a BMI in the recommended range.[27]

From the results of this study, it can be concluded that the need to maintain normal 25(OH)D levels is useful for preventing pregnancy complications. There was also a significant, strong negative correlation between BMI and 25(OH)D levels. This demonstrates a strong correlation between pregnant women's higher BMI and lower 25(OH)D levels. This study has several limitations. This study utilized secondary data, which may have biases and inaccuracies on pre-pregnancy BMI. Secondly, the sample size of this study is limited, requiring bigger sample sizes in further studies. The evaluation of maternal vitamin D levels occurred primarily during the first trimester of pregnancy, rendering the fluctuations in vitamin D status during early gestation uncertain. These constraints may influence the applicability of the findings to different populations. Additional potential factors influencing vitamin D levels, including skin type, physical activity, season, and genetic background, necessitate more investigation.

Conclusion

The results of this study suggest that women entering pregnancy should maintain their nutritional status in normal conditions, characterized by a normal BMI, in order to maintain 25(OH)D levels. Optimal 25(OH)D levels lead to optimal pregnancy outcomes for both the mother and the baby. Future studies using randomized controlled trials with more subjects and more factors influencing vitamin D are strongly recommended.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Socio-demographic, exercise, and anthropometric profiles of adults participating in fitness exercise programs in Vhembe district, Limpopo province, South Africa

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Abstract

Introduction Adults in Vhembe district participate in fitness exercise programs for optimal health. However, the nutritional profiles of these participants remain unknown.

Aim: To assess the socio-demography, calculate BMI and measure WC of adults participating in fitness exercise programs around Vhembe district, Limpopo Province.

Method: A cross–sectional study design was conducted to assess socio-demographic and anthropometric profiles of 112 adults participating in fitness exercise programs around Vhembe district, Limpopo Province. Ethical clearance was obtained from TREC and written consent by the participants. Socio-demographic profile included, for example, age, education status, duration and frequency of training. Anthropometry included weight and height to calculate BMI, and waist circumference. Data were analyzed using SPSS (v29). The Chi-square test, with a p-value of <0.05, was used to determine the association among variables.

Results: Males were aged 36.3±9.3 and females 32.1±8.7 years; training three times per week for two hours in aerobics and bodybuilding programs. Most participants had bachelor's degrees (males, 35.5%; females, 29.8%) and diplomas (males, 32.3%; females, 27.7%). Unemployment was higher (57.4%) among females compared to males (38.5%). Aerobic participants were overweight (males, 27.8±4.7; females 28.8±4.8 kg/m²) whereas those in bodybuilding were obese (31.0±16.9, males and 37.5±0.0 kg/m², females). Participants in both programs had optimal waist circumferences (<102 cm, males and <88 cm, females). Anthropometry was associated (p<0.05) to demography among the aerobic exercise participants.

Conclusion: Participants trained once per day, three times a week for two hours. The majority had higher education qualifications, however, unemployed. Participants were overweight with acceptable waist circumference values

Keywords: demography, anthropometry, exercise, aerobics, bodybuilding

Introduction

Anthropometry is one of the other parameters used to determine the nutritional status of an individual[1]. The technique involves a methodical measurement of the body's physical attributes and provides crucial details about body size, health, and shape[2,3] crucial as diagnostic standards for obesity[4]. Physical activity in the form of exercise improves anthropometric components such as weight and

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body composition[5,6,7], reduces body fat, serum lipids, maintains blood pressure and glucose within acceptable standards, and maintains nutritional status[8]. Sociodemographic profile, on the other hand, is viewed as another aspect having an impact on health outcomes and life expectancy[9]. Some of these medical and socio demographic aspects are recorded as major population health concerns in Limpopo province[10]. Residences of this province are urged to participate in Fitness Exercise Programs (FEP) possibly to maintain optimal health status including anthropometry. Currently, the demographic and exercise profiles of these residences are reported in the Limpopo Socioeconomic Review and Outlook (SRO) (2018/2019) and South Africa's Disease Burden of Physical Inactivity[10,11] reports respectively.

According to SRO report, Vhembe is the third highest district in Limpopo province with unemployment rate and second highest (52%) below poverty lines[10]. Additionally, the life expectancy between males and females was projected to increase from 56.4 and 62.8 to 58.6 and 65 years between 2016 and 2021 respectively. On the other hand, report by Patricios and Saggers[11] showed that males from the rural provinces such as Mpumalanga and Limpopo participated in physical activity programs and were more physically fit compared to females. It is possible that a portion of these physically fit men reported from Limpopo province by the latter researchers could be emanating from the Vhembe district. However, precisely the developments around the sociodemographic, anthropometric and exercise profiles of adult population in Limpopo province, particularly Vhembe district, remain unknown. In this district, several adults were observed participating in FEP for recreational purposes[12] with lack or absence of guidance from sport and health practitioners.

The researchers, therefore, aimed at investigating these parameters (demographic, exercise, BMI and WC profiles) to highlight the importance of maintaining optimal health while engaging in exercise. Findings may, therefore, serve as baseline record upon which guidance or interventions towards exercise and optimal health standards are constructed. At the national level, the current research contributes towards achieving the prevention or reduction of non-communicable diseases (diabetes mellitus and cardiovascular diseases) and improving mental health. The latter, therefore, contribute to the achieving sustainable development goal number three "Achieving good health and well-being" with a specific focus on subgoal three point four (3.4) "Reduce mortality from non-communicable disease and promote mental health". Health practitioners, researchers and the community at large might find the content of this research quite interesting.

Exercise recommendations

Exercise is a systematic process of preparing for a certain physical goal[13]. Benefits related to exercise include increased strength, build self-esteem and increases athletic performance[14], loss of body fat, improved mood, and decreased risk of chronic diseases such as diabetes mellitus and heart diseases[15]. For the non-athletic population, a minimum of 150–300 minutes per week of moderate aerobic exercise or 75–150 minutes per week of intense aerobic exercise or a combination of both is regarded sufficient[16]. Additionally, the American College of Sports Medicine[17] advises individuals to participate 2 – 3 times a week in exercise programs. On the other hand, guidelines by the World Health Organization (WHO)[18] on physical activity and sedentary behavior encourages physical activity for 150 – 300 minutes throughout the week. For non-athletic adult South Africans, exercise guidelines used are included within the South African Food Based Dietary guideline, as "Be active"[19,20]. These guidelines were created for recreational purposes. There remain, therefore, a need for participants to develop appropriate exercise schedules that are contextualized or personalized using sport nutrition practitioners or coaches.

Methods

Researchers undertook a cross–sectional study design to assess the anthropometric status of 112 adults engaging in FEP in gymnasiums (gyms) around Vhembe district, Limpopo province. Four

main gyms available in the district were used to recruit participants in aerobic fitness dance and fitness bodybuilding programs.

During the recruitment, participants were provided with information sheet explaining the aim, objectives and entire data collection method two weeks before data collection. Ethical clearance was obtained from the Turfloop Research Ethics Committee (TREC/346/2022: PG) while consent to participate was obtained in a written form by the participants.

The socio-demographic profile of the participants included, for example, age, gender, education level and employment status while the exercise profile covered type of exercise program, and the frequency of training. Measurements of anthropometric variables included the weight and height to calculate body mass index (BMI), and waist circumference (WC). Standards stipulated by Lee & Nieman[21] were followed during the measurements of anthropometric variables. The BMI was then calculated by dividing the weight in kilograms by the height in meters square. The WHO[22] BMI and WC classifications were used to interpret the results.

The anthropometric data were loaded on to the Statistical Package for Social Sciences (SPSS) program (version 28) for analysis. Descriptive statistics (percentages, mean and standard deviation [±SD]) were used to report the findings. Chi-square test was used to determine the association tests between the demography, exercise and anthropometric profiles. A probability value (P) of ≤ 0.05 was a criterion on which variables were considered significant.

Results

The characteristics of participants as summarized in **Table 1** show that males (58%, n=65) dominated over females (42%, n=47) with the majority classified as young adults (36.1±8.7, males & 31.6±10.8 yrs.). Most males had bachelor's degree (35.4%, n=23) and diplomas (32.3%, n=21) compared to females. About 20% (n=13) and 29% (n=14) of males and females had grade 12 qualification respectively. Only a few males (9.2%, n=6) and females (6.4%, n=3) studied up to grade 10 qualification. However, most males were employed (n=25; 38.5%) compared to most females who were unemployed (n=27; 57.4%) and employed (n=14; 29.8%). Of those employed males and females, a few (n=18; 27.7% and n=6; 12.8%) were self-employed.

Table 1. Characteristics of participants

Gender	Exercise program	N (112)	Age (M±SD)
Males	Aerobic dance	52 (46%)	37.5±13.7
Females	Aerobics dance	46 (41%)	32.3±10.8
Male	Fitness Bodybuilders	13(12%)	34.7±3.8
Females	Fitness Bodybuilders	1(1.0%)	31.0±0.0
Gender	**Education level**	**N (112)**	**Percentage (%)**
Males	High school	6	9.2
	Matric	13	20.0
	Diploma	21	32.3
	Degree	23	35.4
	Other (postgraduate)	2	3.1
Females	High school	3	6.4
	Matric	14	29.8
	Diploma	13	27.7
	Degree	14	29.8
	Other (postgraduate)	3	6.4
Gender	**Employment status**	**N (112)**	**Percentage (%)**
Males	Employed	25	38.5

	Unemployed	22	33.8
	Self employed	18	27.7
Females	Employed	14	29.8
	Unemployed	27	57.4
	Self employed	06	12.8

Table 2 shows that males were involved in FEP for 2 years compared to a year (1.7±1.0 yrs.) for females exercising for an hour per day. However, aerobic dance participants exercised for average of three hours per week while male fitness bodybuilders exercised longer (3.8±1.0 times). Participants spent on average two hours during their exercise.

Table 2. Exercise profile of participants

Program	Gender	Years involved	Frequency of exercise		Duration during exercise
			per day	week	
Aerobics	Males	2.5±1.6	1.3±0.6	3.2±0.8	2.0±0.6
	Females	1.7±1.0	1.2±0.4	3.1±1.0	1.6±0.5
Bodybuilding	Males	2.8±1.7	1.1±0.3	3.8±1.0	2.1±0.8
	Females	1.0±0.0	1.1±0.1	3.0±0.1	1.0±0.3

The BMI values of the participants are reported in **Table 3**. According to this table, aerobic dance participants were overweight (males, 27.8±4.7; females 28.8±4.8 kg/m²) while those in fitness bodybuilding program were classified obese (≥30 kg/m²).

Table 3. Participants' BMI values

Program	Gender	Weight (kg)	Height (m)	BMI (kg/m^2)
Aerobic fitness	Males	81.3±17.1	1.73±0.06	27.8±4.7
	Females	73.4±18.2	1.61±0.11	28.8±4.8
Bodybuilding	Males	93.9±13.3	1.74±0.08	31.0±16.9
	Females	102.3±0.0	1.65±0.0	37.5±0.0

Table 4 shows that majority of the participants in the aerobic dance program had optimal WC classifications (<102 cm, males and <88 cm, females). Only females in the fitness bodybuilding program had WC values above acceptable standards. However, there were a few males who presented with WC above (108.8±6.6 cm) the normal standards in fitness bodybuilding program.

Table 4. Participants' WC values

Program	Gender	Min	Max	Mean±SD (kg/m^2)
Aerobic fitness	Males	70.0	120.0	93.2±12.2
	Females	69.0	129.0	89.7±12.8
Bodybuilding	Males	84.0	121.0	101.9±10.3
	Females	104.0	104.0	104.0±0.0

Table 5 below shows a significant association between BMI with age ($p<0.01$), marital status ($p=0.010$) and frequency of training per day ($p=0.044$) of aerobic dance participants. Similarly, there was correlation between the WC with age ($p<0.01$) of aerobic dance participants.

Table 5. Correlation

Exercise Program	Age	Gender	Educational level	Employment status	Marital status	Years involved in exercise	Exercise frequency per day	Exercise frequency per week	Duration of exercise
BMI and Demography									
Aerobic Dance	<0.01	0.794	0.589	0.181	0.010	0.239	0.044	0.138	0.773
Fitness Bodybuilding	0.240	0.611	0.916	0.233	0.621	0.082	0.675	0.600	0.298
Waist circumference and demography									
Aerobic Dance	<0.01	0.405	0.413	0.120	0.411	0.337	0.301	0.650	0.447
Fitness Bodybuilding	0.358	0.173	0.767	0.345	0.368	0.170	0.448	0.414	0.420

Discussion

The aim of the study was to determine the sociodemographic, exercise and anthropometric profiles of adults engaging in fitness exercise programs around Vhembe district, Limpopo province to determine health status of participants. This study was, to some extent, important to understand part of human population in Vhembe district to identify health related problems (through anthropometry) thus informing policy makers on intervention strategies[23]. This study found that participants were young adults who engaged in FEP for average of two years, exercising three times per week for an hour. Most participants were males engaging in aerobic fitness dance and bodybuilding fitness program. These training programs are cardiovascular exercises of low intensity performed for stronger muscles in the presence of oxygen[24].

These participants were classified overweight by BMI with acceptable WC values. More males in the current study attended the fitness exercise programs at various gyms compared to females. Another study by Aristides et al. found similar results of males and females attending gyms more frequent than their counterparts in rural areas of Portugal[25]. Our results are somewhat unusual as females are generally known to be more concerned of their body weights than males[6], thus engaging in intervention programs such as exercise. Generally, females in the Vhembe district are statistically higher, contributing 54% of the total population than males (46%). However, we suspect that a lesser number of females participating in FEP may partly be contributed by some household commitments of these women as 51% of the households in the Vhembe district are women headed[26]. The socioeconomic status of females (unemployment, 57.4%) in the current study could also explain the reason for a few females affiliating to the gyms as funds might be dedicated to basic household needs[9]. The current results contradict those reported by the International Health, Racquet

& Sports club Association (IHRSA)[27], which found that just above half (51%) of participants at the gym were females.

The ages of the participants were also investigated in the current study and found that male and female adults engaged in FEP in Vhembe district were aged 36.3±9.3 and 32.1±8.7 years respectively. These age groups are within the majority (51%) of those contributing to the total population in Vhembe district[26]. These ages are, however, slightly higher to those reported by statistics SA (15 – 34 years) that contribute to the majority of the population in Limpopo[28]. The results of the current study are comparable to those of older adults (41.0 years) reported for physical activity engagement among participants by Renner (2019)[29].

Participants in the current study exercised three times per week for one to two hours daily. The latter is supported by the American College of Sports Medicine[30] recommending frequency of exercise per week at two to three times per week for healthy adults. The participants in our study adhered to both the South African Food Based Dietary guideline which states "Be active"[19] and Physical Activity Policy[20] as used to guide or motivate adults to engage in exercise. Lastly, participants in the current study may have adopted other exercise guidelines stated by the WHO on sedentary behaviour[18]. One example of these principles is that which encourages physical activity for 150 – 300 minutes spread throughout the week. This roughly works to about 20 – 45 minutes in four to five days. In all these fitness exercise guidelines, the current group fairly adheres.

In terms of anthropometry, the majority (60.7%) of the participants had overweight BMI. It is possible that this BMI status may have served as a motivating factor for these adults to participate and continue exercising. The latter is found elsewhere in the literature as suggested in one study[6]. For some, the level of the participants' education might have also conscientized them of the risks related to overweight. These results are somewhat similar to those by Pienaar et al.[31] who found that 48% of their participants were either overweight or obese. In another study by Uchai et al.[32], the majority of the participants were also obese. This is a concern as overweight and obesity is a public health problem that requires immediate multidisciplinary interventions[8]. However, BMI should be interpreted with great caution[1] especially for participants in the bodybuilding (competitive) programs as the aim of the participants is to develop increased muscle structure[33]. Although the practices of ergogenic substances among the current exercise participants was beyond the scope of this research as exercises were for recreation, it should be highlighted that, it is a common practice among bodybuilders[34]. This practice greatly influences body weight among athletes, particularly those aiming for improved physique.

The WC of the most participants was within acceptable standards which implies reduced risk for development of diabetes mellitus, cardiovascular diseases and improved quality of life[35]. These results are congruent to those by Shozi et al.[36] who found that a few (5%) of females had higher than normal values of WC. Another study done by Armstrong et al.[37] found that aerobic exercise program decreased WC by 3.2 cm among participants. These results suggest that exercise has a positive contribution towards maintaining the WC within acceptable standards[38].

Lastly, the current study found correlations between anthropometric variables (BMI and WC) with some demographic variables such as age of participants especially in the aerobic dance program. A cohort study investigating changes in body mass index by age, gender, and socio-economic status among a cohort of Norwegian men (n=581) and women (588) showed that minimal influence of socio-economic status on changes in BMI over time[39]. In another cross-sectional study investigating the correlation between BMI and age at menarche, no significant association (p=0.458) was found among Jatinangor female adolescents[40]. Although studies show insignificant association between BMI and some demographic variables, it is, however, important to understand the association between these variables to estimate health risks that are likely to exist[41].

Conclusion

The study was aimed at determining the demographic profile and anthropometric status of adults participating in fitness exercise programs around Vhembe district, Limpopo Province. Participants were classified as older adults and have been engaging in FEP for an average of two years, training three times per week for an hour. Males dominated and mostly engaged in aerobic dance and fitness bodybuilding program.

Most of the participants were overweight. However, participants had WC values that are within acceptable standards. Overweight is a risk for cardiovascular conditions such as high blood pressure and myocardial infarction. Therefore, intervention in the form of nutrition education, meal plans and exercise programs that need to be followed could be of importance in this case. Body composition and dietary intake study using the same participants is warranted to validate these BMI results and associated outcomes with intake respectively.

Lastly, involvement of other sport practitioners such as biokineticists may be important to determine the impact of these exercise programs on the health status of the participants.

A few number of gyms in the Vhembe district resulted in a small number of participants used in this study. Another limitation was the time allocated two years to complete this study as this was part of the master's degree program.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL PAPER

Association between mother's purchase intention of iron-fortified infant cereal and iron intake among children aged 6-23 months in Tangerang, Indonesia

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Abstract

Background: Iron deficiency can lead to anemia, negatively impacting children's cognitive and physical development. Mothers' knowledge of iron and the benefits of fortified complementary foods may have influenced their purchase intentions and decisions.
Objective: This study aimed to investigate the association between mothers' purchase intentions, actual purchases of iron-fortified infant cereals, and iron intake in children aged 6–23 months in Tangerang, Indonesia. Research on this topic remained limited, emphasizing the need for further studies to strengthen the existing evidence.
Methods: This study employed a cross-sectional design involving 162 mothers in pairs with their children aged 6–23 months, recruited consecutively. Data were collected using validated questionnaires. Data analysis was performed using the non-parametric Mann-Whitney test to compare groups and Spearman's correlation test to assess the strength of relationships between variables. A p-value < 0.05 was considered statistically significant.
Results: Mothers showed positive attitudes and intentions towards purchasing iron-fortified cereals, with a notable 51.9% having made recent purchases. While these purchase intentions correlate with actual purchases, they did not directly influence children's iron intake. Instead, factors such as mother's education, occupation, and household income played significant roles in determining iron intake levels.
Conclusion: Purchase intentions were associated with actual purchase intention; however, factors such as gender, mother's education, occupation, and household income did not exhibit a direct relationship with children's iron intake. This study indicates that while mother's purchase intentions are associated with actual purchases, they do not directly impact children's iron intake.

Keywords: iron intake children, iron-fortified cereal, purchase intention

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Introduction

Iron deficiency is common in children under two during the transition from milk to solid foods, as rapid growth depletes fetal iron reserves[1]. This period of rapid growth, coupled with the depletion of fetal iron reserves, significantly increases the needs for dietary iron. Ensuring adequate iron intake between 23-36 months is crucial for optimal child development before preschool[2]. Globally, iron deficiency affects millions of children, leading to impaired cognitive and motor development, weakened immune function, and increased susceptibility to infections[3]. According to the World Health Organization (WHO), around 42% of children under the age of five worldwide suffer from anemia, primarily due to iron deficiency. In Southeast Asia, the prevalence of anemia in children is particularly high, with approximately 50% of children under five affected[4]. In Indonesia, the situation is similarly alarming, where about 48.9% of children under five are reported to have anemia, reflecting the ongoing public health challenge of iron deficiency in the region[5].

The transition between 6-23 months represents a particularly vulnerable period for iron deficiency due to the increasing reliance on complementary foods that may not provide sufficient iron to meet the needs of rapid growth and development. In this period, cereals and dairy products are primary sources of iron and energy in toddler diets, accounting for 31% and 33%, respectively[6].

The quality of additional food intake and dietary diversity have a significant effect on children under two's iron intake. Iron deficiency and anaemia can be avoided with a diversified diet that includes foods high in iron, such as meat and fortified cereals. To improve iron status, supplemental foods should be introduced at six months along with ongoing nursing. In order to provide sufficient iron intake for the best possible growth and development, other important factors include socioeconomic position and the timing of the introduction of iron sources[7]. Consumption of commercially produced complementary food (CPCF) is prevalent in Germany, with 60% of infants consuming CPCF. The market survey identified 1,057 products, indicating a reliance on CPCF over homemade options, which may limit dietary variety in young children[8].

An initiative to enhance iron intake is the fortification of commercially produced complementary foods with iron. The introduction of iron-fortified foods, such as infant cereals, presents a potential strategy to address iron deficiency in this vulnerable population. The nutritional composition of commercially produced complementary foods (CPCF) has a considerable impact on consumer choice, particular iron, which is essential for children's growth and cognitive development. According to study , many CPCF are marketed as iron-fortified; nevertheless, the real iron content frequently falls below recommended levels[9,10] .

Studies in different countries showed that the prevalence of children at risk of low dietary iron intake was higher among toddlers (aged 6-23 months) as compared to other children. Market surveys in Southeast Asia indicate a high consumption of commercially produced snacks, with 55% of children in Phnom Penh and 82% in Bandung regularly consuming such products. These fortified foods have the potential to significantly boost micronutrient intake[12], provided that they are properly integrated into the child's diet. Nonetheless, over reliance toward consumption of commercially produced complementary foods (CPCF) have been shown to reduce dietary diversity[13]. CPCF provides convenience for parents, factors influencing CPCF consumption include maternal employment, wealth status, and exposure to marketing, with higher consumption linked to non-exclusive breastfeeding and promotional activities[9,10,11].

The Theory of Planned Behavior (TPB) model identifies key factors influencing the purchase intention of iron-fortified infant cereal, including attitudes, subjective norms, perceived behavioral control, and information-seeking behavior, which collectively shape consumer decisions[14,15]. Many factors influence decision making of food purchases, particularly food for children. Parental knowledge, attitudes, and behaviors are critical determinants of children's dietary intake, with mothers often serving as the primary decision-makers in household food purchases. In Jakarta,

17.1% of mothers use electronic media to learn about complementary foods, influenced by socioeconomic factors, education, and income[16].

This study, aim to investigate the association between mothers' purchase intentions, actual purchases of iron-fortified infant cereals, and iron intake in children aged 6–23 months in an Indonesian population, i.e. Tangerang City. Tangerang City is a rapidly growing urban areas, which saw a population growth of 1.16% in 2021[17]. According to the 2023 profile, the Baja Public Health Center serves 4% of Tangerang City's total population, highlighting the importance of prioritizing nutrition and health services for this population [17,18]. A study on complementary feeding practices in Tangerang found that only 17.8% met the recommended standards, indicating poor complementary feeding practices[19]. There remains a notable lack of research on complementary feeding practices and iron intake in the region as well as in Indonesia.

Methods

This cross-sectional study was conducted at a health center in an urban area of Tangerang City, a rapidly expanding municipality in Indonesia's Banten province, located approximately 26 kilometers from Jakarta. The health center was selected for its recognition as an exemplary facility, having earned third place nationally and first place in Tangerang during the 2023 National Health Day.

The study population comprised mothers and their children aged 6-23 months. The inclusion criteria for participants were mothers paired with apparently healthy children in this age range who provided informed consent for participation. Exclusion criteria included mothers with children requiring special diets due illnesses.

A convenience consecutive sampling method was employed to recruit respondents from mothers attending *posyandu* (community health services) for child growth monitoring. Data collection took place between February 20 and March 20, 2024. The sample size was determined to test the hypothesis regarding the relationship between mothers' purchase intentions of iron-fortified infant cereal and their children's iron intake, with a 95% confidence interval. Based on a previous study that found a correlation (r = 0.59) between purchase intention and sugar-related attitudes, the estimated sample size was 59. Accounting for a design effect (DEFF = 2) and an expected response rate of 80%, the total required sample size was 148 participants.

The study involved a detailed review of existing literature, online resources, and consumer surveys to gather information on different brands and types of iron-fortified infant cereals. The consumption of various brands of commercially produced complementary foods (CPCF) was measured using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) to estimate the children's iron intake.

Data collection tools included the SQ-FFQ and structured questionnaires on sociodemographic characteristics, nutritional knowledge, attitudes, subjective norms, and actual purchases of iron-fortified cereals. A pilot test involving 30 respondents was conducted prior to the main study to evaluate the reliability and validity of the questionnaires. Trained enumerators carried out the interviews to ensure data consistency.

Data were analyzed using IBM SPSS Statistics 26, with extensive data cleaning to ensure the accuracy of the dataset. Multiple linear regression analysis was applied to assess the influence of sociodemographic factors and maternal behaviors on purchase intentions and their subsequent impact on children's iron intake.

Setting and population

The study focused on mothers in pair of children aged 6–23 months who met the inclusion criteria: children without congenital diseases, not undergoing any specific diets, and whose mothers signed the informed consent. The exclusion criteria included respondents who did not complete the questionnaires. Sampling was conducted using a consecutive sampling method at 10 (ten) integrated health post, commonly known as *Pos Pelayanan Terpadu or Posyandu*, under the Baja Public Health Center work areas.

Sample size

Sample size was estimated to test the hypothesis of association between mothers' purchase intentions of iron-fortified infant cereal and iron intake among children aged 6-23 months in Tangerang, using sample size for correlation with 95% confidence interval. Assuming correlation between mothers' purchase intention of iron-fortified infant cereal and sugar-related attitude of 0.59[20], considering the design effect (DEFF=2) to account for the increased variation due to not using a simple random sampling technique and an 80% response rate, the minimum sample size for this study is 148 respondents. Nonetheless, the final sample of the study was 162 mothers, which can be seen in the participant selection flowchart (**Figure 1**).

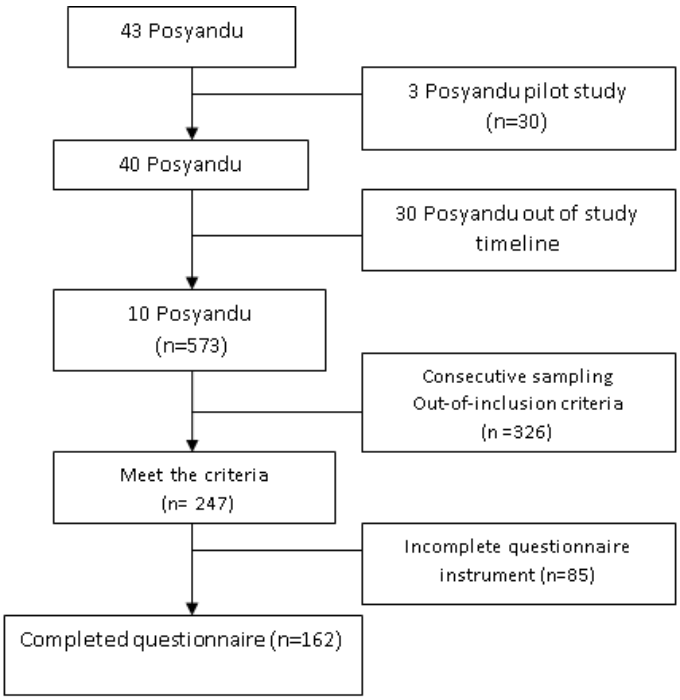

Figure 1. Participant selection

Variable measured

Data were collected using various tools. including questionnaires adapted from the Theory of Planned Behavior (TPB). The questions included mothers' purchase intention of iron-fortified infant cereals, which had been validated (Purchase Intentions: KMO = 0.509; Bartlett's test: p = 0.000) and measured using a Likert scale.

Sociodemographic characteristics were explored through structured interviews. Mothers' knowledge of nutritional claims on fortified cereals and iron-rich food sources was also assessed through structured interviews utilizing validated questionnaires. Children iron intake was assessed using Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Additionally, an actual purchase questionnaire, supplemented by online searches and retail store visits, was used to identify the most frequently purchased iron-rich infant cereals.

Enumerators was trained to ensure consistent data collection. All questionnaires used in the study were validated based on the previous pilot study[21].

Statistical analysis

The data were analyzed using IBM SPSS Statistics 26. A Mann-Whitney test was conducted to examine the association between mothers' purchase intentions, actual purchases of iron-fortified infant cereals, and iron intake in children aged 6–23 months in Tangerang, Indonesia. Subsequently, multivariate analysis was performed to identify potential confounding factors.

Ethical approval

The study has been approved by the Unit of Ethical Research, Medical Research Unit, Universitas Indonesia (KET-110/UN2.F1/ETIK/PPM.00.02./2024).
All participants in this study provided written informed consent before participated.

Results

Iron intake among children 6-23 months in Tangerang

Table 1 showed an overview of the sociodemographic characteristics of mothers and their children, highlighting factors that might influence iron intake among children aged 6–23 months. It underscored the role of mother's education and nutrition knowledge about iron nutrition claim, as well as household income and

mother's employment status. More than half of the participants (n= 84, 51.9%) reported to actually purchasing infant cereal. The data revealed disparities in children's iron intake, with a notable proportion not meeting the recommended levels despite high rates of food purchases. These findings suggest that, beyond access to food, other factors such as mother's knowledge and socioeconomic conditions may play a critical role in ensuring adequate nutrition for children in this age group.

Table 1. Sociodemographic characteristic of mothers' and children's iron intake 6-23 month

Variable	Median (min-max)	n%	
Age mother (n%)			
< 25 years		22	13.6 %
≥ 25 years		140	86.4 %
Education of mother (n%)			
Primary/Junior /Senior high school		86	53.1%
Diploma/University/ Postgraduate		76	46.9%
Household income (n%)			
< Rp. 5.000.000 ($ 306.20)		59	36.4 %
Rp. 5.000.000 ($ 306.20)– Rp. 10.000.000 ($ 612.40)		80	49.4 %
> Rp. 10.000.000 ($ 612.40) – Rp. 15.000.00 ($918.60)		20	12.3%
> Rp. 15. 000.000 ($918.60)		3	1.9 %
Occupation (n%)			
Working mother		80	50.6%
Non-working mother		82	49.4%
Mother Iron Nutrition Claim Knowledge (n%)			
Not good knowledge (score < 70)		69	42.6%
Good Knowledge (score ≥ 70)		93	57.4%
Actual purchase			
Purchase (n%)		84	51.9%
Not Purchase (n%)		78	48.1%
Gender (n%)			
Boys		86	53.1%
Girls		76	46.9%
Age Children (n%)			
6-11 months		41	25.3%
12-17 months		62	38.3%
18-23 months		59	36.4%
Children Iron Intake			
6-11 mo (≥ 11 mg/day)	7(1-29)		
Meet		14	34.1%
Below		27	65.9%
12-23 mo (≥ 7 mg/day)	9 (1-37)		
Meet		77	63.6 %
Below		44	36.4%

Association between mother's purchase intention of iron-fortified infant cereal and iron intake

The findings of the association analysis between mother's purchase intention of iron-fortified infant cereal and iron intake in children aged 6-23 months, using the Spearman correlation test, indicate that there is no significant association between the two variables (r = 0.051, p-value=0.522).

Association between actual purchase and iron intake

The analysis of the association between actual purchase of iron-fortified infant cereal and iron intake revealed no significant association. However, it was found that the iron intake of children aged 6-23 months in the purchase category was higher than in the non-purchase category, as illustrated in the box plot in **Figure 2**.

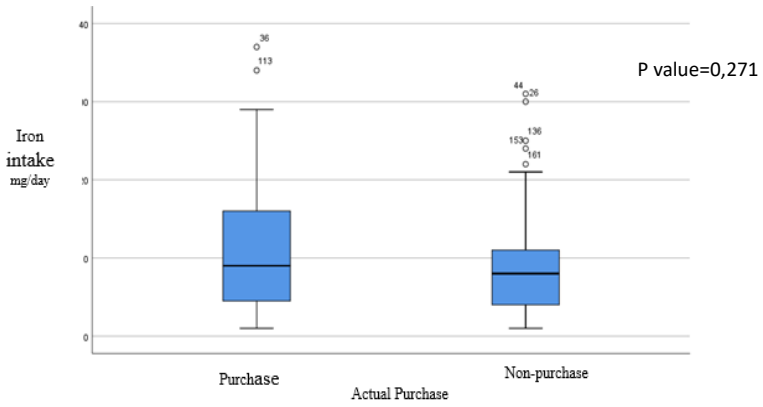

Figure 2. Association between actual purchase with iron intake

Factors associated with iron intake

Based on the analysis of respondents' characteristics and iron intake, statistically significant associations were observed in several areas. Gender appears to influence iron intake, with girls having a higher median intake than boys. Mother's education is also significant factor, as children of mothers with higher education levels tend to have better iron intake. Similarly, mother's occupation has a notable impact, with children of non-working mothers having lower iron intake compared to those of working mothers. Household income is another significant factor, with higher income levels associated with better iron intake. However, no significant associations were found between children's age, mother's age, or mothers' knowledge of iron sources and children's iron intake. These findings emphasize the importance of mother's education, employment, and socioeconomic status in improving children's dietary quality, as shown in **Table 2**.

Table 2. Children and mother's characteristics with iron intake (n=162)

Variable	Iron intake (mg/day) median(min-max)	P value
Median gender (range)		
Boy	7.50 (1-37)	0.025[mw*]
Girl	9.00 (1-34)	
Median age children (range)		
7-11 months	7(1-29)	0.654[kw]
12-17 months	8 (1-37)	
18-23 months	9 (2-31)	
Education of mothers		
Primary/Junior/Senior high school	7.5(1-37)	0.019 [a]
Diploma/University/Postgraduate	9 (2-34)	

Variable	Iron intake (mg/day) median(min-max)	P value
Mother occupation		
Work	9 (2-34)	0.009[mw*]
Non-working mother	7 (1-37)	
Age of mother		
< 25 years	7 (2-31)	0.829[mw]
≥25 years	9 (1-37)	
Mother Knowledge of Iron Source Claims		
Not good knowledge (score <70)	9 (1-37)	0.565[mw]
Good knowledge (score ≥70)	8 (1-34)	
Household income		
<Rp. 5.000.000	6(1-37)	
Rp. 5.000.000-Rp. 10.000.000	9(1-34)	0.007[kw*]
Rp. 10.000.000-Rp. 15.000.000	9(1-34)	
> Rp. 15.000.000	10(5-26)	

mw = Mann Whitney kw = Kruskall Wallis

Assessment of the confounding factors

The next step is to assess confounding, which occurs when covariates affect the association between the main risk factor and the outcome. Sociodemographic factors like gender, mother's education, occupation, income, and iron nutrition claim knowledge were included in the model. Gender was significant (p = 0.020). A second linear regression model revealed no significant effects for knowledge of iron claims, purchase intention, or actual purchase. In the third model, gender remained significant (p = 0.024, **Table 3**).

Table 3. Multivariate models to assess confounding factors (n=162)

Multivariate Models	Parameter	Parameter Estimate	Standard Error	p-value
First Model	**Intercept**	2.278	3.423	0.507
	Gender	2.828	1.204	0.020*
	Education Mother	0.218	0.324	0.502
	Occupation Mother	-0.107	1.483	0.943
	Household income	1.060	1.202	0.379
Second Model	**Intercept**	9.621	5.645	0.090
	Iron nutrition claims knowledge	1.203	1.233	0.331
	Actual purchase	-1.695	1.355	0.213
	Intention	0.198	0.740	0.790
Third Model	**Intercept**	2.936	6.567	0.655
	Gender	2.747	1.209	0.024*
	Education of mother	0.238	0.328	0.468
	Household income	0.952	1.228	0.439
	Occupation mother	0.127	1.498	0.932
	Intention	0.171	0.739	0.817
	Iron nutrition claim knowledge	0.469	1.292	0.717
	Actual purchase	-1.551	1.346	0.251

*Significance level p<0.05

Discussion

Iron intake among children 6-23 months in Tangerang

Based on the results of this research, significant differences were highlighted in maternal education, with mothers who have higher education

demonstrating a better understanding of children's iron intake needs compared to those with lower education[22]. Further findings show that household income also plays a key role, with most respondents earning between five and ten million rupiah, enabling them to effectively meet their children's nutritional needs[23]. Additional findings regarding maternal employment showed no significant impact, indicating that both working and non-working mothers can adequately fulfil their children's iron intake requirements[24].

The results on the maternal knowledge variable show a difference in the number of respondents with mothers who have better knowledge being more prepared to meet their children's iron intake needs. Most respondents with good knowledge understand the importance of adequate iron intake[25].

Regarding purchases, most respondents opted for iron-fortified cereal, reflecting a tendency to act on the need to meet children's nutritional requirements[26]. For gender, although boys require more iron due to higher activity levels, girls in this study had greater iron intake[27]. In terms of age, most respondents were children aged 12–17 months, a period marked by increasing iron needs requiring supplementation beyond breast milk. Children aged 6-11 months can fulfill their nutritional requirements solely through breast milk, whereas children aged 18-23 months need iron-enriched foods provided by multiple micronutrient powders (MNP). [28].

Association between actual purchase with iron intake

The study found no direct link between actual purchases and iron intake. However, children who made actual purchases had higher iron intake than non-purchasers (Figure 1). This aligns with studies from Singapore and the UK, which show that cereal purchasers tend to have better iron intake and status due to the fortification of cereals with iron[29]. A study in Canada found that ready-to-eat cereal consumption improved nutrient intake and diet quality across income levels, with cereal consumers showing higher iron intake[30]. In Tangerang City, formula and breast milk were the main contributors to iron intake in children aged 6-23 months[31].

Association between mother's purchase intention of iron-fortified infant cereal and iron intake

The study found no direct association between mothers' purchase intentions for iron-fortified infant cereal and children's iron intake. Instead, the association appears indirect, influenced by factors like actual purchases and household income. Another study in Banten province, Indonesia, found that families with children aged 6–23 months often struggle to meet iron intake needs, mainly due to low iron in formula milk and mother's health factors. This has increased the demand for iron-rich cereal, which is easy to consume and provides sufficient nutrition[32]. Another study explains that countries with a shortage of children's iron intake often purchase nutritional recipes from countries like Indonesia, which provides iron-rich food tailored to children aged 6-23 months, along with Egypt and Mexico. The study focuses on the purchase of iron-fortified infant cereal, noting that other foods, like breastmilk and formula, also contribute to iron intake. It highlights the strong intention in Indonesian society to buy complementary product commercial feeding (CPCF), linked to children's iron intake[33].

Factors associated with iron intake

The p-value for the association between gender and iron intake was 0.018, indicating an association. This aligns with a study in northern Ghana, which found that iron intake in children aged 6-23 months was influenced by gender. In Ghana, boys are more prone to stunting and diarrhea due to increased exploration during crawling or walking[34]. A lack of iron in children can lead to anemia. A study in Nepal found that children aged 6-23 months with insufficient iron intake, especially boys, were more likely to suffer from anemia. Another study showed that boys have a tenfold higher risk of anemia than girls, particularly at 9 months, with significant differences in hemoglobin levels between boys and girls from 4 to 9 months.[35]

The study shows that mother's education is linked to iron intake in children aged 6-23 months. Consistent with the study[41], higher mother's education leads to better knowledge, enabling mothers to provide appropriate iron intake for their children[36]. Based on a study in Jordan shows that higher mother's education is linked to better iron intake in preschool children, reducing the risk of iron deficiency anemia. Educated mothers are more likely to have knowledge of effective parenting, proper nutrition, and better access to health information [37].

A study on the link between occupation and iron intake in children aged 6-23 months found that a mother's employment status significantly affects iron intake. In southern Iran, recent research suggests that working mothers are more engaged in social life, enabling them to access information on addressing iron deficiencies in children[38]. A study in Egypt found that 88.4% of infants born to non-working mothers had iron deficiency anemia, compared to 15.4% of those born to working mothers. Similarly, a study in Indonesia suggests that a mother's employment status affects children's nutrition, child-rearing patterns, sanitation, and food security. This impacts iron intake in children aged 6-23 months. Additionally, family economic status influences a family's ability to meet the iron intake and healthy living needs of children in this age group[39].

The analysis shows an association between household income and children's iron intake, consistent with studies in Nepal, South Korea, and Toronto. Higher-income households have better access to nutritious food, while lower-income families face a higher risk of iron deficiency due to limited food budgets. A study in South Korea also found that iron, phosphorus, vitamin B9, and vitamin C intake increased with household income[40]. A study of 1245 children in Toronto found that low family income was linked to a higher risk of iron deficiency. Children from low-income households tend to have lower daily iron intake due to limited food budgets[41].

This study provides valuable insights for future research, offering a strong reference point. It uses a validated questionnaire and contributes new data on the intention to purchase iron-fortified infant products, a topic not previously studied. Limitations include insufficient data on iron-fortified infant cereals, mother's recall bias, and the need for expert input on the questionnaire. Strategies like food photo books were used to address biases. Additionally, the health status of children was not investigated due to time constraints.

Conclusion

This study highlights the association between mother's purchase intentions, actual purchases of iron-fortified infant cereals, and iron intake in children aged 6–23 months in Tangerang. While purchase intentions were associated with actual purchases, neither factor such as gender, mother's education, occupation, household income showed a direct link to children's iron intake. These findings suggest that addressing socio-economic disparities and improving mother's education could better support adequate nutrition and iron intake in children 6-23 months. Future studies should explore the indirect effects as well as cultural and environmental factors that promote the practice of providing iron-fortified complementary foods to enhance iron intake in children aged 6–23 months. The governments should collaborate with local /household entrepreneur (UMKM) to create policy to produce iron–fortified complementary food product.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

The implementation and challenges of breastfeeding counselling program in Majene district, West Sulawesi: A qualitative study among health workers

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Abstract

Background: Inadequate breastfeeding practices increase the risk of malnutrition, infant deaths, and other related developmental problems. Counselling on breastfeeding promotion is one of the most effective ways to improve breastfeeding practices. Nevertheless, challenges in implementing the counselling hinder its effectiveness. Using the logic model framework, this study examines the implementation and challenges of breastfeeding counselling programs in Majene District, West Sulawesi

Objective: This study aims to gain an in-depth understanding of experiences and perspectives regarding the implementation of the breastfeeding counselling program using the Logic Model among health workers in Majene District.

Methods: From January to June 2024, a qualitative phenomenological approach was employed. Data collection included in-depth interviews with 12 trained breastfeeding counsellors, eight key informants, and focus group discussions with 24 mothers. Thematic analysis using NVivo 12, guided by the Logic Model framework, which grouped breastfeeding counselling into input, process, outputs, and outcomes aspects.

Results: Key challenges included a shortage of trained counsellors, limited infrastructure, and budget constraints. Health workers adapted by integrating counselling into maternal health services, conducting home visits, and collaborating with *Posyandu* cadres. Exclusive breastfeeding rates showed slight improvements but remained below national targets. Beneficiaries expressed satisfaction but highlighted the need for longer and more frequent counselling sessions.

Conclusions: The program faced significant resource challenges, including a shortage of skilled counsellors, budget constraints, and limited facilities. However, adaptive strategies by health workers crucial for overcoming logistical and resource constraints resulted in beneficiaries' satisfaction and positive developments in breastfeeding rates.

Keywords: breastfeeding, counsellors, experiences, prespectives, program management

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Introduction

Breastfeeding is a vital foundation for child health, development, and survival. The World Health Organization (WHO) recommends initiating breastfeeding within the first hour after birth, exclusive breastfeeding for the first six months, and continued breastfeeding until at least 24 months.[1] Despite its proven benefits, global rates remain low, with only 41% of infants under six months exclusively breastfed in 2017.[2] Globally rates of exclusive breastfeeding in the first six months of life have increased by 10 percentage points over the past decade and are at 48% for 2023, close to the World Health Assembly target of 50% by 2025.[3]

In Indonesia, the prevalence of exclusive breastfeeding has risen from 52.5% in 2021 to 55.5% in 2023; however, it remains below the government's target of 80%.[4,5] This trend is concerning, as poor breastfeeding practices are linked to higher risks of malnutrition, increased infant mortality, and adverse developmental outcomes. Evidence suggests that improving exclusive breastfeeding rates could prevent up to 800,000 child deaths annually.[6]

Breastfeeding counselling is a key intervention to enhance breastfeeding practices. In Indonesia, integrated counselling services at primary health centres (PHCs) are supported by policies such as Presidential Regulation No. 33 of 2012 on Exclusive Breastfeeding. This regulation mandates the provision of trained counsellors and national advocacy for breastfeeding programs. However, Majene District, West Sulawesi, continues to report suboptimal exclusive breastfeeding rates, hindered by systemic barriers such as insufficient trained counsellors, inadequate infrastructure, and limited budgets.[7] Studies from Thailand highlighted similar challenges, stressing the need for structured and well-supported counselling services.[8] Existing studies on breastfeeding programs in Indonesia often focus on quantitative outcomes, such as breastfeeding rates, with limited exploration of health workers' lived experiences and challenges.[9] The application of the Logic Model framework, which examines program inputs, processes, and outcomes, is rarely utilized, leaving a gap in understanding how systemic barriers intersect with individual efforts.[10,11]

This study aims to explore the experiences and perspectives of health workers involved in implementing breastfeeding counselling programs in Majene District. Using the Logic Model framework, it examines inputs, activities, outputs, and outcomes to provide a comprehensive understanding of the program's implementation and challenges. To capture the experiences of health workers effectively, a phenomenological qualitative approach was chosen to gain a deeper insight into their perspectives and adaptive strategies.[12]

Methods

This study employs a qualitative, phenomenological approach to interpret and describe individual life experiences, providing in-depth insights into the actual encounters in Majene district. Data collection was conducted from January to June 2024 across seven PHCs, which were selected purposively due to their high prevalence of stunting and low coverage of exclusive breastfeeding.

The main informants included 12 trained breastfeeding counsellors, consisting of midwives and PHC nutrition officers who had received WHO-standard breastfeeding counselling training. Additionally, there were 32 key informants, including coordinators for Nutrition and Maternal and Child Health (NMCH) program, heads of PHCs, and mothers with children under two years old.

Interviews and focus group discussions (FGDs) utilized semi-structured questions were employed to facilitate in-depth discussions in both Indonesian and local languages. Main informants were selected considering maximum variation and purposive sampling to ensure diverse perspectives. The key informants, specifically stakeholders, were recruited purposively, while mothers of children under two were also chosen purposefully based on two criteria exclusive breastfeeding (EBF) practices (yes/no) and the child's age (0–<6 months and 6–24 months) utilizing the snowball sampling technique. Data collection methods

included in-depth interviews with health workers and stakeholders, as well as FGDs with mothers grouped by breastfeeding practices (EBF and Not EBF) and child age (0-<6 months and 6-24 months).

The sample size was determined based on data saturation, defined as the point at which no new information emerged after conducting interviews with the 12 health workers. This was supported by triangulated information obtained from other participants to reduce potential bias.

Data analysis was arranged simultaneously during the data collection in the field. All gathered information from voice recordings and field notes transcribed verbatim and imported to Microsoft Word for content analysis and further analysed as codes. NVivo software version 12 was used to assist the coding process.

This study obtained ethical approval from the Health Research Ethics Committee, Faculty of Medicine, Universitas Indonesia on December 15th, 2023, number KET-1781/UN2.F1/ETIK/PPM.00.02/2023.

Results

Characteristics of the Informants

Table 1. Characteristics of the main informants

Characteristics	Number (n=12)
Gender	
Female	12
Age	
26-35	3
36-45	7
46-55	2
Education Level	
Diploma Degree	5
Bachelor's degree	6
Master's degree	1
Profession	
Midwife	7
Nutritionist	5
Institution	
PHC	10
Auxiliary Health Centre	2
Experiences as a Counsellor	
≤1 years	5
>1 years	7

All counsellors who had been trained were female, and most of them were between 36 and 45 years old. Six informants had graduated with a bachelor's degree (**Table 1**).

Key informants consisted of seven Heads of PHC from various sub-districts in Majene, the Person in Charge of the NMCH Program at the District Health Office, along with 24 mothers who had children under two years old.

Table 2 below provides a summary of the themes about the implementation of breastfeeding counselling based on components of input, process, output and outcome of the program

Table 2. The Themes on the breastfeeding counselling implementation

Theme	Sub Theme	Category
Input	Resources	Require skilled counsellor
		Limited program budget
		Insufficient facilities and infrastructure
Process	Strategy	Flexibility in implementation of counselling session
		Collaboration and support
	Implementation of BF counselling	Lack of awareness of counsellors in implementing counselling
Output and outcome	Succes indicators	Counselling records
		Coverage
		Beneficiaries' satisfaction

Experiences and Perspectives of Component Input

All PHC's in Majene have breastfeeding counsellors with special training. A counsellor is forced, based on the data, to serve more than 20 mothers each month. This causes a high workload.

> *"Currently, even though we have five trained counsellors at the PHC, the number of mothers who need counselling is huge and continues to increase every month. We are often overwhelmed to provide counselling to all these targets." (Counsellor#12, Nutritionist, trained 2023)*

Although they have attended a 40-hour basic module training from WHO/United Nation Children's Fund (UNICEF), many counsellors feel that the training materials are not always relevant to real conditions in the field.

Counsellors expressed the need for a formal mechanism for sharing knowledge between senior and junior counsellors. Currently, knowledge transfer is done informally, resulting in variations in the quality of service between providers.

Budget for breastfeeding counselling programs at PHC in Majene generally come from the Non-Physical Special Allocation Fund (*Dana Alokasi Khusus Non Fisis/DAK Non Fisik*). However, these funds are not allocated specifically for breastfeeding counselling but are instead combined with other programs such as prenatal classes. This results in a lack of attention to the implementation of breastfeeding counselling.

> *"We don't have a special budget for breastfeeding counselling. Usually, this activity is combined with other programs, so it often gets less attention." (Counsellor#7, Midwife, Trained 2010)*

Several informants considered that budget limitations reflected the low priority of breastfeeding counselling programs at PHC. This was due to the PHCs greater focus on other programs that were supported by a larger budget.

Until 2015, all PHCs in Majene had a special breastfeeding counselling room equipped with counselling aids and educational media. However, the earthquake in 2021 caused significant damage to several PHCs, namely Ulumanda PHC lost all its space and equipment, while Malunda PHC lost its counselling aids and educational media.

In addition, several other PHCs had counselling rooms that were shared with other programs, or incomplete equipment, such as a lack of leaflets, posters, and other visual aids.

Informants assessed that the lack of facilities and infrastructure had a direct impact on the quality of counselling services. They felt that infrastructure improvements were needed to support the effectiveness of the program.

Experiences and Perspectives of Component Process

This component highlights the strategies and actions employed by counsellors to provide effective breastfeeding support. Flexibility emerged as a key strategy to overcome challenges such as time constraints, limited counsellors, and varied maternal needs. Counsellors adapted by conducting home visits, integrating counselling into mobile health centre activities, and providing spontaneous sessions at integrated health posts (Posyandu) or mother classes.

Collaboration was equally crucial, with counsellors working alongside health workers, community cadres, and families. Health workers helped identify mothers needing counselling, while community cadres mobilized participants and provided initial education. Families offered essential emotional and moral support.

Despite the existence of standardized counselling steps—introduction, breastfeeding guidance, and follow-up—numerous counsellors face difficulties. These challenges stem from limited training, a lack of refresher courses, and minimal supervision, which often emphasizes breastfeeding rates over the quality of counselling. Counsellors have expressed a strong need for regular feedback and evaluation to build their confidence and ensure their practices align with established guidelines.

Experiences and Perspectives of Components Output and Outcome

These components are essential in understanding the program's overall effectiveness and its impact felt by the community. Three main themes emerged: 1) counselling records: documentation and tracking of counselling activities; 2) coverage: the program's reach and its contribution to exclusive breastfeeding targets; and 3) beneficiaries' satisfaction: mothers' and families' experiences with and responses to counselling services.

1. Counselling Records

Counsellors primarily record activities in medical records or the Maternal and Child Health *(Kesehatan Ibu dan Anak/KIA*) Book. Some health centres use a register book in the breastfeeding counselling room. However, incomplete records remain a challenge due to high workloads. Medical records document services during antenatal and postnatal visits. *KIA* book is used to track exclusive breastfeeding practices.

Counsellors emphasized the importance of consistent and detailed recording for monitoring program success but cited barriers such as time constraints and lack of specific supervision. Informants acknowledged that supervision is limited to evaluating exclusive breastfeeding coverage, without directly assessing the quality of recorded data.

2. Coverage

Informants reported limited coverage of the breastfeeding counselling program. No specific target was set for the number of mothers to be counselled, but every mother attending antenatal or postnatal services was expected to receive counselling. Home visits and mobile health services were also conducted to reach more mothers.

Counsellors linked program success to exclusive breastfeeding rates, indirectly measured through electronic community-based nutrition recording and reporting (*elektronik pencatatan dan pelaporan gizi berbasis Masyarakat/e-PPGBM*). Despite increased exclusive breastfeeding coverage (64.8%), the figures remained below the national target (80%). Counsellors highlighted the need for structured monitoring and strategies to expand the program's reach.

3. Beneficiaries' Satisfaction

Informants observed that mothers expressed satisfaction with the counselling services. Mothers reported feeling supported and more confident in breastfeeding practices. However, short counselling sessions and lack of dedicated facilities were cited as areas for improvement. Counsellors believed satisfaction stemmed from the emotional support and information quality provided during counselling. However, they acknowledged the need for more frequent and extended sessions to address mothers' concerns comprehensively.

Discussion

The breastfeeding counselling program in Majene District, West Sulawesi, faced several significant challenges that impacted its effectiveness. One major issue was the scarcity of certified breastfeeding counsellors. Similar finding in China highlights the shortage in certified breastfeeding counsellors limits the program's reach and quality, as counsellors are often overburdened and unable to provide adequate support to mothers.[13] To address this, standardized, continuous training and mentorship programs are essential to equip counsellors with the necessary skills and knowledge, as suggested by studies that highlight the positive impact of such interventions on counsellor competence and confidence.[14,15]

The lack of dedicated funding hampers the program's ability to provide essential resources such as training materials, equipment, and staff support. Integrating breastfeeding counselling into existing maternal health programs can dilute its impact and hinder its sustainability. To overcome this, securing dedicated funding and prioritizing breastfeeding counselling within health budgets are crucial, as evidenced by research demonstrating the positive correlation between adequate funding and program effectiveness.[16]

Infrastructure limitations, particularly followed the 2021 earthquake, have further compounded the challenges faced by the program. Damaged facilities and a shortage of dedicated counselling rooms and media resources hinder the provision of effective counselling services.[17] Creating conducive counselling environments with adequate resources is essential to promote breastfeeding practices, as studies have shown that such environments can enhance mothers' understanding and engagement with breastfeeding information.[18,19]

Despite these challenges, the program has shown resilience through the implementation of flexible strategies and collaborative approaches. Counsellors have adapted to the context by providing home visits, spontaneous counselling, and mobile health services. This flexibility ensures that mothers in remote and underserved areas receive essential support, aligning with research that highlights the importance of context-specific adaptations in improving program accessibility and effectiveness.[20,21]

Furthermore, collaboration between health workers, community cadres, and family members has strengthened the program's impact. Family support plays a crucial role in promoting exclusive breastfeeding, while community health workers can extend the reach of counselling services.[22] These findings are supported by research that emphasizes the role of family and community support in improving maternal and child health outcomes.[23,24]

However, the program's effectiveness is hindered by inconsistent record-keeping and limited supervision. Accurate and timely documentation is essential for monitoring program performance and identifying areas for improvement.[25] Regular supervision and feedback can enhance the quality of counselling services and ensure adherence to guidelines. Studies have shown that effective supervision can significantly improve the quality and consistency of healthcare delivery, including counselling-based programs.[25,26]

To address challenges in breastfeeding counselling, stakeholders can implement several concrete strategies. Regular training programs should be conducted to increase the number of counsellors, with mandatory refresher courses to enhance their knowledge and confidence. Systematic evaluation and feedback protocols must be established, including consistent monitoring of counselling sessions, performance assessments based on session frequency and exclusive breastfeeding success rates, and structured monthly evaluation meetings or group case reviews to provide targeted feedback. Supervision should be strengthened by developing supplementary training programs tailored to improve counsellors' competencies and ensure adherence to best practices. Clear roles and responsibilities must be defined, with scheduled coordination meetings among health workers, community members, and families to enhance collaboration and support for breastfeeding mothers. To improve accessibility and monitoring process, digital tools like mobile health App should be integrated for remote counselling, real-time documentation, and performance tracking. Lastly, active advocacy efforts should be pursued to secure increased funding and policy support, ensuring the long-term sustainability and expansion of breastfeeding counselling programs. Successful strategies from other countries, including the Mobile Health App digital platform in Thailand and structured community-based support in Thailand[27] and Vietnam,[28] may provide valuable insights for Majene District.

While mothers' express satisfaction with the emotional support and guidance provided by counsellors, there is a need to address limitations such as short session durations and infrequent follow-ups. Longer and more frequent counselling sessions can provide mothers with adequate support and address their specific needs.[29,30] Additionally, leveraging digital health interventions, such as mobile messaging, can improve accessibility and facilitate communication between counsellors and mothers. Research has demonstrated the effectiveness of digital health interventions in improving maternal health outcomes and increasing access to healthcare information.[31] In the present study, we could not reflect whether mothers' satisfaction on the breastfeeding counselling was further manifested in the breastfeeding practices following the recommendation. Because we did not have the opportunity to assess individual breastfeeding practices of each mother participating in the FGDs. To optimize the program's effectiveness, addressing resource constraints, enhancing training and supervision, and improving record-keeping are crucial. By investing in skilled counsellors, securing adequate funding, and providing appropriate infrastructure, the program can significantly improve breastfeeding rates and maternal health outcomes in Majene District.[32,33]

This study comprehensively applies the Logic Model framework, highlights the lived experiences of health workers, an often-overlooked perspective, and provides context-specific findings to improve program implementation in resource-constrained settings. Resource constraints prevented the inclusion of more diverse informants, such as policymakers or additional community members such as *Posyandu* cadres and mothers who did not attend the counselling sessions.

Conclusion

The breastfeeding counselling program in Majene District, West Sulawesi, faced challenges due to a lack of qualified counsellors and inadequate facilities. Utilizing adaptive strategies and collaborating with local health workers and communities could help mitigate these challenges. Despite these challenges, beneficiaries' satisfaction and positive breastfeeding practices indicated progress. Increasing ongoing training and refresher course for breastfeeding counsellors, advocacy for improving commitment on resources allocation for breastfeeding counselling program, and exploring digital solutions for improving accessibility to counselling services and monitoring process are recommended for enhancing maternal and child health outcomes in Majene District.

Conflict of interest

There was no conflict of interest for this study.

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ORIGINAL PAPER

Gender, education, eating patterns, and nutritional status among high school students in the tourist area of Bukittinggi, Indonesia

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Abstract

Background: The well-being of high school students in tourist shapes their eating habits and affects their nutritional status, leading to obesity and malnutrition.
Objective: This study aims to examine the association between gender, education, eating patterns, and nutritional status among high school students in tourism areas.
Methods: This cross-sectional study was conducted in October 2023 and included 118 students aged 12–18 years from junior and senior high schools in Bukittinggi, West Sumatra. Respondents were selected through multistage stratified clustered sampling. Data on gender, age, education, and eating patterns which assessed using a food frequency questionnaire classified according to the Guttman scale. Nutritional status was determined based on BMI-for-age WHO z-scores following the Indonesian Minister of Health Regulation. Data were collected via interviews using a questionnaire on the KoboToolbox application and analyzed using Chi-square tests.
Results: Most high school students (89.8%) had poor eating patterns, with 45.8% having a normal BMI-for-age, 34.7% undernourished, and 19.5% overweight or obese. Gender was significantly associated with nutritional status (p=0.007), with thinness more common in boys and normal BMI-for-age more prevalent in girls, while education and eating patterns showed no significant association. However, frequent consumption of sugary drinks was linked to higher rates of overweight and obesity.
Conclusion: There were gender differences in nutritional status among high school students in Bukittinggi, a tourist area, underscoring the need for targeted gender-focused nutrition interventions to address healthier eating patterns in tourism regions.

Keywords: eating pattern, nutritional status, students, tourism area

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Introduction

The well-being of high school students in tourists' area is increasingly importance, as diverse food options, fast food exposure, and cultural influences shape their eating habits and impact their nutritional status.[1,2] Bukittinggi, a popular tourist destination in West Sumatra, Indonesia, is known for its rich food culture, including street food and traditional Minangkabau cuisine, which is high in

fats and carbohydrates. The abundance of food vendors, restaurants, and fast-food establishments in tourist areas may affect the eating patterns of local adolescents, who are in a crucial stage of growth and development.[3,4]

Adolescence is a critical period of physical, cognitive, and emotional development, during which students pay more attention of their body shape, weight, and height.[5] In tourist areas, adolescents are more exposed to unhealthy eating patterns, including frequent snacking, high-calorie food consumption, and irregular meal timing, which can contribute to weight-related issues.[3] Adjusting energy intake based on eating behavior is essential to maintain a healthy nutritional status.[6] Dietary habits formed during this stage can have long-term health effects, making it crucial to monitor and address adolescent nutrition.[7]

The nutritional status of adolescents (ages 5-18) is assessed using Body Mass Index-for-age (IMT/U) z-scores.[8] A z-score above +1 SD indicates increased body fat and health risks[7] while a score below -2 SD is associated with anemia, which impair immunity, concentration, academic performance, fitness, and overall productivity. In girl students, anemia also heightens the risk of maternal mortality, premature births, and low birth weight, contributing to stunting.[9]

Gender and education levels influence the nutritional knowledge and eating behaviors of high school students, affecting their nutritional status. Girl students are more likely to have negative body image perceptions,[10–12] leading to unhealthy eating behaviors such as strict dieting, skipping meals, or disordered eating which can cause nutrient deficiencies.[2] Education also plays a key role in shaping awareness and understanding of balanced nutrition,[2,13] influencing dietary choices and long-term health outcomes.[2]

High school students' eating patterns are also shaped by environmental, social, cultural, religious, and economic factors, particularly in tourism region. Social influences from family, peers, and social media, contribute to their food choices and potential nutritional issues.[14] According to the Global School Health Survey, 95.5% of high school students do not consume vegetables and fruits and 75.7% frequently eat foods with added flavorings.[15] Cultural and religious beliefs may impose dietary restrictions, while economic status affects access to nutritious foods.[2]

Despite growing concern about adolescent nutrition, limited studies have explored the impact of tourism-driven food environments on high school students' eating behaviors, and nutritional status, particularly in Bukittinggi. This research aims to examine the associations between gender, educational level, eating patterns, and nutritional status among high school students in tourists' area, providing insights for targeted nutrition interventions and health promotion strategies.

Methods

This cross-sectional study was conducted in October 2023 in Bukittinggi, a well-known tourist destination in West Sumatra, Indonesia. A total of 118 high school students aged 12–18 years old participated selected using multistage stratified clustered sampling by stratifying based on education level then randomly selecting clusters to ensure proportional representation across gender, education levels, eating patterns, and nutritional status. Total respondents were determined to use the Slovin formula, adjusted for a finite population. Eligible respondents were literate in Bahasa Indonesia while those absent or not enrolled during the study period were excluded. Written informed consent was obtained from all respondents after a full explanation of the study's purpose, and potential implications. Ethical approval was granted by the Research Ethics Committee of Dr. M. Djamil General Hospital, Padang, Indonesia (No.DP.04.03/D.XVI.XI/537/2023).

The study examined nutritional status as the independent variable with while gender, education level and eating patterns as dependent variables. Data collection included demographic information (initials, age, gender, and education) and dietary intake. Adolescents were categorized into three stages: early adolescence (10-13 years), middle adolescence (14-17 years), and late adolescence (18- 21 years).[16] Gender was classified as boy and girls while education level was categorized as junior and senior high school. Dietary intake was

evaluated using the Food Frequency Questionnaire (FFQ), which assessed the consumption of staple foods, side dishes, fiber sources, and snacks. Responses were scored as follows: a score of 50 for 'always' or daily consumption, 25 for 'often' or 4-6 times per week, 15 for 'sometimes' or 1-3 times per week, 10 for 'rarely' or 1-3 times per month, dan 0 for 'never' or less than once per month. Eating patterns were classified based on the Guttman scale, with a score of ≥296.31 indicating a good eating pattern and a score of ≤296.31 indicating a poor eating pattern.[17]

Anthropometric measurements, including weight and height, were conducted by trained research following standardized protocols. Weight was measured using a SECA weighing scale with an accuracy of 0.1 kg, while height was recorded using a calibrated microtoise with an accuracy of 0.1 cm. Nutritional status was determined using Body Mass Index-for-age (IMT/U) z-score which classified into: severely thin (< -3 SD), thin (-3 SD to -2 SD), normal (-2 SD to +1 SD), at risk of overweight (+1 SD to +2 SD), and obese (> +2 SD).[8]

Data were collected via interviews using a questionnaire administered via the KoboToolbox application. Statistical analysis was performed using SPSS Version 20.0. (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as frequencies and proportions for categorical variables and mean±SD for numerical variables. Association between variables were analyzed using Chi-square tests with a significance level set at $p<0.05$.

Results

Characteristics of respondents

This research involved 118 high school students (39% boys, 61% girls) with an average age of 16.92 years. Most were in middle adolescence (53.4%) and attended senior high school (72%). Based on the Gutmann scale, 89.8% had poor eating patterns, with only 10.2% had good eating patterns. In terms of nutritional status, 45.8% had a normal BMI-for-age, while 34.7% were undernutrition (17.8% severely thin, 16.9% thin), and 19.5% were overweight or obese (**Table 1**).

Table 1. Characteristics of respondents

Variable	n (%) or Mean ± SD
Gender	
Boy	46 (39)
Girl	72 (61)
Age (years)	16.92±1.23
Early adolescence (10 to 13)	1 (0.8)
Middle adolescents (14 to 17)	63 (53.4)
Late adolescents (18 to 21)	54 (45.8)
Education level	
Junior high school	33 (28)
Senior high school	85 (72)
Eating pattern (Gutmann scale)	
Good (≥296.31)	12 (10.2)
Poor (<296.31)	106 (89.8)
Nutritional status (BMI-for-age)	
Severely thin (<-3 SD)	21 (17.8)
Thin (-2 SD to -3 SD)	20 (16.9)
Normal (-2 SD to +1 SD)	54 (45.8)
Overweight (+1 SD to +2 SD)	15 (12.7)
Obese (>+2 SD)	8 (6.8)

Table 2 showed respondents' food consumption patterns. White rice, a local staple, was the primary carbohydrate (96.6%), while other sources were eaten more variably, and red rice was rarely consumed (93.2% never). Eggs (28.8%) and poultry, such as chicken and duck (24.6%), were the most common protein sources, with a preference for fried over unfried proteins. Soy products were consumed more often than red meat and fresh seafood, which was rarely eaten (44.9% never). Regarding fiber intake, green leafy vegetables (40.7%) and fresh fruits (28.8%) were frequently consumed, while orange/yellow-colored vegetables and canned vegetables were less common. Snacking habits showed a high intake of packaged snacks like potato chips or popcorn (42.4%), desserts such as cake, ice cream or pudding (37.3%), and sugary drinks (38.8%) while ultra-processed food (e.g., frozen food and canned food) were less frequently consumed (29.7% never).

Table 2. Food consumption of respondents

Food Consumption	n (%)				
	Always	Often	Sometimes	Rarely	Never
Staple food					
White rice	114 (96.6)	3 (2.5)	1 (0.8)	0 (0)	0 (0)
Wheat products	21 (17.8)	7 (5.9)	70 (59.3)	18 (15.3)	2 (1.7)
Tubers	14 (11.9)	7 (5.9)	57 (48.3)	26 (22.0)	14 (11.9)
Red rice	1 (0.8)	0 (0)	3 (2.5)	4 (3.4)	110 (93.2)
Side dishes					
Meat	6 (5.1)	4 (3.4)	53 (44.9)	34 (28.8)	21 (17.8)
Poultry	29 (24.6)	12 (10.2)	65 (55.1)	7 (5.9)	5 (4.2)
Fish, unfried	14 (11.9)	7 (5.9)	43 (36.4)	22 (18.6)	32 (27.1)
Meat and fish, fried	38 (32.2)	21 (17.8)	47 (39.8)	9 (7.6)	3 (2.5)
Fresh seafood	1 (0.8)	4 (3.4)	19 (16.1)	41 (34.7)	53 (44.9)
Eggs	34 (28.8)	13 (11.0)	61 (51.7)	8 (6.8)	2 (1.7)
Dairy Products	41 (34.7)	2 (1.7)	43 (36.4)	16 (13.6)	16 (13.6)
Soy products	39 (33.1)	17 (14.4)	51 (43.2)	5 (4.2)	6 (5.1)
Fiber sources					
Green leafy vegetables	48 (40.7)	11 (9.3)	45 (38.1)	6 (5.1)	8 (6.8)
Orange/yellow-colored vegetables	14 (11.9)	5 (4.2)	59 (50)	26 (22)	14 (11.9)
Canned vegetables	1 (0.8)	1 (0.8)	3 (2.5)	7 (5.9)	106 (89.8)
Fresh fruits	34 (28.8)	13 (11.0)	56 (47.5)	13 (11.0)	2 (1.7)
Snacks					
Packaged snacks	50 (42.4)	9 (7.6)	36 (30.5)	13 (11.0)	10 (8.5)
Unpackaged snacks	35 (29.7)	6 (5.1)	53 (44.9)	14 (11.9)	10 (8.5)
Sugary drinks	34 (28.8)	12 (10.2)	40 (33.9)	20 (16.9)	12 (10.2)
Ultra processed food	10 (8.5)	5 (4.2)	39 (33.1)	29 (24.6)	35 (29,7)
Dessert	44 (37.3)	8 (6.8)	42 (35.6)	14 (11.9)	10 (8.5)

Gender, education level, eating patterns and nutritional status

As presented in **Table 3**, Gender was significantly associated with nutritional status (p = 0.007), with thin being more prevalent among boys (28.3%) than girls (9.7%), while normal weight was more common among girls (55.6%) than boys (30.4%). Age and education level were not significantly associated with nutritional status. Middle and late adolescents had similar distributions, with normal weight being the most common category. Senior high school students had a higher prevalence of severe thin (21.2%) than junior high school students (9.1%). Eating patterns were not significantly related to nutritional status, although most students with poor eating habits fell within the normal BMI-for-age range (46.2%). Students with poor eating patterns had higher rates of thin (16%) and severely thin (16%) classifications. In contrast, those with good eating patterns had lower rates of overweight (0%) and obesity (8.3%) compared to those with poor eating patterns.

Eating patterns based on staple food consumption and nutritional status

Staple food consumption was not significantly associated (p>0.05) with students' nutritional status. **Table 4** showed that white rice, the most consumed staple (6.6% always), was prevalent across all BMI-for-age categories, with the highest proportion in the normal category (45.6%). Students who consumed wheat products and tubers more frequently showed varied nutritional status, but no significant trends were observed. Those who never consumed tubers had a higher proportion in the normal category (71.4%). Red rice was rarely consumed (93.2% never), with most of these students falling within the normal (46.4%) and thin (16.4%) categories.

Table 3. Gender, education level and eating patterns based on nutritional status

Variable	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
Gender						**0.007**[c]
Boy	8 (17.4)	13 (28.3)	14 (30.4)	5 (10.9)	6 (13)	
Girl	13 (18.1)	7 (9.7)	40 (55.6)	10 (13.9)	2 (2.8)	
Age						0.659 [c]
Early adolescents	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	
Middle adolescents	13 (20.6)	10 (15.9)	29 (46)	5 (7.9)	6 (9.5)	
Late adolescents	8 (14.8)	10 (18.5)	24 (44.4)	10 (18.5)	2 (3.7)	
Education level						0.296[c]
Junior high school	3 (9.1)	7 (21.2)	16 (48.5)	3 (9.1)	4 (12.1)	
Senior high school	18 (21.2)	13 (15.3)	38 (44.7)	12 (14.1)	4 (4.7)	
Eating pattern (Gutmann scale)						0.610[c]
Good (≥296.31)	3 (25)	3 (25)	5 (41.7)	0 (0)	1 (8.3)	
Poor (<296.31)	17 (16)	17 (16)	49 (46.2)	15 (14.2)	7 (6.6)	

[c]Chi-square

Table 4. Students' eating patterns based on staple food consumption and nutritional status

Eating Patterns of Staple Food	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
White rice						
Always	21 (18.4)	20 (17.5)	52 (45.6)	13 (11.4)	8 (7)	0.293[c]
Often	0 (0)	0 (0)	1 (33.3)	2 (66.7)	0 (0)	
Sometimes	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	
Wheat products						
Always	4 (19)	5 (23.8)	11 (52.4)	0 (0)	1 (4.8)	0.872[c]
Often	1 (14.3)	1 (14.3)	3 (42.9)	1 (14.3)	1 (14.3)	
Sometimes	13 (18.6)	11 (15.7)	30 (42.9)	10 (14.3)	6 (8.6)	
Rarely	2 (11.1)	3 (16.7)	9 (50)	4 (22.2)	0 (0)	
Never	1 (50)	0 (0)	1 (50)	0 (0)	0 (0)	
Tubers						
Always	1 (7.1)	6 (42.9)	7 (50)	0 (0)	0 (0)	0.290[c]
Often	2 (28.6)	1 (14.3)	4 (57.1)	0 (0)	0 (0)	
Sometimes	11 (19.3)	8 (14)	21 (36.8)	12 (21.1)	5 (8.8)	
Rarely	6 (23.1)	3 (11.5)	12 (46.2)	2 (7.7)	3 (11.5)	
Never	1 (7.1)	2 (14.3)	10 (71.4)	1 (7.1)	0 (0)	
Red rice						0.490[c]
Always	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	
Sometimes	2 (66.7)	0 (0)	0 (0)	1 (33.3)	0 (0)	
Rarely	1 (25)	1 (25)	2 (50)	0 (0)	0 (0)	
Never	18 (16.4)	18 (16.4)	51 (46.4)	15 (13.6)	8 (7.3)	

[c]Chi-square

Eating patterns based on side dishes consumption and nutritional status

Table 5 summarized students' side dish consumption patterns in relation to their nutritional status. Meat consumption showed no clear association correlation with BMI-for-age categories (p=0.300), though students who never consumed meat had higher proportions of normal weight (57.1%) and overweight (28.6%). Poultry, a

common protein source, follows a similar pattern (p=0.424), with most students in the normal BMI-for-age category (44.8%). Unfried fish moderate consumption seems to be associated with normal weight (48.8%), and the majority of those who never consumed it were classified as normal weight (46.9%) or overweight (21.9%). Meanwhile, fried meat and fish were frequently consumed across all BMI-for-age categories. Fresh seafood intake was limited, and students who never ate it had a higher proportion of normal weight (47.2%) and overweight (13.2%). Eggs and dairy products show no significant relationship with weight status (p=0.890 and p=0.387, respectively), but the highest proportion of normal-weight adolescents (49.2% for eggs and 54.3% for dairy products) consume them sometimes. Soy product consumption also does not show a strong link to weight status (p=0.623), though those who always or often consume soy products tend to fall within the normal BMI-for-age category (41.5–58.8%).

Eating patterns based on fiber sources consumption and nutritional status

There was no significant association (p>0.05) between fiber source consumption and nutritional status (BMI-for-age) among students (**Table 6**). Green leafy vegetable intake did not show a clear trend, though those who consumed it "always" had the highest proportion of normal-weight individuals (52.8%). Similarly, orange/yellow-colored vegetable consumption varied, with the "sometimes" category having the largest proportion of normal-weight students (42.9%). Canned vegetable consumption was uncommon, with most students in the "never" category, where normal BMI-for-age (40.4%) was the most prevalent. Fresh fruit intake followed a similar pattern, with the highest proportion of normal BMI-for-age (38.5%) among those who consumed it "always."

Eating patterns based on snacks consumption and nutritional status

The findings suggest that there was no significant association between snack consumption and students' nutritional status ($p > 0.05$). Normal-weight students were most prevalent in the "always" category for packaged snacks (48%), sugary drinks (50%), and desserts (54.5%). Unpackaged snacks and ultra processed foods showed no clear pattern. Among those who frequently consumed ultra-processed foods, a notable proportion were classified as severely thin (30%) or thin (20%). Additionally, a higher percentage of overweight and obese adolescents were found among those who consumed sugary drinks frequently (26.4%).

Discussion

A significant association found between gender and nutritional status (p=0.007), suggesting that girls were more likely to have a normal BMI-for-age, while boys exhibit a more diverse distribution, with higher rates of thinness and obesity. This aligns with Haney's study in Bangladesh, which found gender differences in nutritional status among 115 adolescents between 10-19 years.[11]Girls tend to be more concerned about of their food choices,[18] often striving for an ideal body image by restricting intake.[19,20] Sadowska revealed that girls with BMI above the 50th percentile were dissatisfied with their body image, while those whose BMI at or below the 50th percentile tended to feel unattractive due to overestimated their body weight.[12] In contrast, Gaylis found that although boys were more active, they consumed higher calorie foods more frequently than girls who tended to choose salad, vegetables and fruit, contributing to a higher BMI percentile among boys ($p < 0.05$).[18] These differences suggest that gender influences both undernutrition and overnutrition due to varying dietary habits, activity levels, and sociocultural factor.

The comparison of education levels showed revealed that senior high school students had a higher prevalence of overweight and obesity, whereas junior high school students had a higher rate of severely thin. This trend might have reflected changes in nutrition and lifestyle habits as students transition to higher education levels.

Table 5. Students' eating patterns based on side dishes consumption and nutritional status

Eating Patterns of Side Dishes	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
Meat (beef, lamb)						
Always	1 (16.7)	2 (33.3)	3 (50)	0 (0)	0 (0)	0.300[c]
Often	1 (25)	0 (0)	3 (75)	0 (0)	0 (0)	
Sometimes	12 (22.6)	10 (18.9)	21 (39.6)	5 (9.4)	5 (9.4)	
Rarely	4 (11.8)	8 (23.5)	15 (44.1)	4 (11.8)	3 (8.8)	
Never	3 (14.3)	0 (0)	12 (57.1)	6 (28.6)	0 (0)	
Poultry (duck, chicken)						
Always	5 (17.2)	5 (17.2)	13 (44.8)	2 (6.9)	4 (13.8)	0.424[c]
Often	0 (0)	2 (16.7)	10 (83.3)	0 (0)	0 (0)	
Sometimes	14 (21.5)	11 (16.9)	24 (36.9)	12 (18.5)	4 (6.2)	
Rarely	1 (14.3)	1 (14.3)	4 (57.1)	1 (14.3)	0 (0)	
Never	1 (20)	1 (20)	3 (60)	0 (0)	0 (0)	
Fish, unfried						0.116[c]
Always	3 (21.4)	3 (21.4)	5 (35.7)	0 (0)	3 (21.4)	
Often	1 (14.3)	0 (0)	6 (85.7)	0 (0)	0 (0)	
Sometimes	8 (18.6)	8 (18.6)	21 (48.8)	5 (11.6)	1 (2.3)	
Rarely	4 (18.2)	4 (18.2)	7 (31.8)	3 (13.6)	4 (18.2)	
Never	5 (15.6)	5 (15.6)	15 (46.9)	7 (21.9)	0 (0)	
Meat and fish, fried						
Always	6 (15.8)	8 (21.1)	16 (42.1)	5 (13.2)	3 (7.9)	0.440[c]
Often	5 (23.8)	2 (9.5)	11 (52.4)	2 (9.5)	1 (4.8)	
Sometimes	9 (19.1)	8 (17)	20 (42.6)	7 (14.9)	3 (6.4)	
Rarely	1 (11.1)	1 (11.1)	6 (66.7)	1 (11.1)	0 (0)	
Never	0 (0)	1 (33.3)	2 (66.7)	0 (0)	0 (0)	
Fresh seafood (scallop, shrimp, crab, octopus)						
Always	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0.450[c]
Often	0 (0)	0 (0)	0 (0)	4 (100)	0 (0)	
Sometimes	4 (20)	0 (0)	11 (55)	3 (15)	1 (5)	
Rarely	9 (22)	9 (22)	13 (31.7)	5 (12.2)	5 (12.2)	
Never	8 (15.1)	11 (20.8)	25 (47.2)	7 (13.2)	2 (3.8)	
Eggs						
Always	9 (27.3)	6 (18.2)	13 (39.4)	4 (12.1)	2 (6.1)	0.890[c]
Often	1 (7.7)	1 (7.7)	7 (53.8)	2 (15.4)	2 (15.4)	
Sometimes	10 (16.9)	11 (18.6)	29 (49.2)	8 (13.6)	3 (5.1)	
Rarely	0 (0)	2 (25)	4 (50)	1 (12.5)	1 (12.5)	
Never	1 (50)	0 (0)	1 (50)	0 (0)	0 (0)	
Dairy Products						
Always	8 (19.5)	9 (21.9)	16 (39)	6 14.6)	2 (4.9)	0.387[c]
Often	0 (0)	1 (50)	1 (50)	0 (0)	0 (0)	
Sometimes	8 (17.4)	6 (13)	25 (54.3)	2 (4.3)	2 (4.3)	
Rarely	4 (25)	2 (12.5)	4 (25)	3 (18.8)	3 (18.8)	
Never	1 (6.3)	2 (12.5)	8 (50)	4 (25)	1 (6.3)	
Soy products						
Always	10 (24.4)	7 (17.1)	17 (41.5)	2 (4.9)	3 (7.3)	0.623[c]
Often	3 (17.6)	2 (11.8)	10 (58.8)	2 (11.8)	0 (0)	
Sometimes	7 (14.6)	9 (18.8)	21 (43.8)	10 (20.8)	4 (8.3)	
Rarely	0 (0)	0 (0)	3 (60)	1 (20)	1 (20)	
Never	0 (0)	3 (50)	3 (50)	0 (0)	0 (0)	

[c]Chi-square

Table 6. Students' eating patterns based on fiber sources consumption and nutritional status

Eating Patterns of Fiber Sources	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
Green leafy vegetables						
Always	6 (11.3)	7 (13.2)	28 (52.8)	5 (9.4)	2 (3.8)	0.671[c]
Often	2 (14.3)	3 (21.4)	5 (35.7)	1 (7.1)	0 (0)	
Sometimes	10 (22.7)	9 (20.5)	15 (34.1)	6 (13.6)	5 (11.4)	
Rarely	0 (0)	2 (28.6)	2 (28.6)	1 (14.3)	1 (14.3)	
Never	1 (11.1)	1 (11.1)	4 (44.4)	2 (22.2)	0 (0)	
Orange/ yellow-colored vegetables						
Always	2 (12.5)	4 (25)	4 (25)	3 (18.8)	1 (6.3)	0.652[c]
Often	0 (0)	2 (40)	3 (60)	0 (0)	0 (0)	
Sometimes	13 (20.6)	6 (9.5)	27 (42.9)	8 (12.7)	5 (7.9)	
Rarely	5 (17.9)	6 (21.4)	11 (39.3)	2 (7.1)	2 (7.1)	
Never	1 (7.1)	2 (14.3)	9 (64.3)	2 (14.3)	0 (0)	
Canned vegetables						
Always	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0.669[c]
Often	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	
Sometimes	1 (33.3)	1 (33.3)	1 (33.3)	0 (0)	0 (0)	
Rarely	0 (0)	0 (0)	7 (100)	0 (0)	0 (0)	
Never	20 (18.3)	19 (17.4)	44 (40.4)	15 (13.8)	8 (7.3)	
Fresh fruits						
Always	9 (23.1)	5 (12.8)	15 (38.5)	4 (10.3)	1 (2.6)	0.574[c]
Often	1 (6.7)	1 (6.7)	8 (53.3)	2 (13.3)	1 (6.7)	
Sometimes	10 (17.2)	10 (17.2)	21 (36.2)	9 (15.5)	6 (10.3)	
Rarely	1 (7.7)	3 (23.1)	9 (69.2))	0 (0)	0 (0)	
Never	0 (0)	1 (50)	1 (50)	0 (0)	0 (0)	

[c]Chi-square

Table 7. Students' eating patterns based on snacks consumption and nutritional status

Eating Patterns of Snacks	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
Packaged snacks (potato chips, popcorn)						
Always	10 (20)	8 (16)	24 (48)	7 (14)	1 (2)	0.659[c]
Often	0 (0)	3 (33.3))	5 (55.6)	1 (11.1)	0 (0)	
Sometimes	6 (16.7)	7 (19.4)	14 (38.9)	4 (11.1)	5 (13.9	
Rarely	2 (15.4)	1 (7.7)	6 (46.2)	2 (15.4)	2 (15.4)	
Never	3 (30)	1 (10)	5 (50)	1 (10)	0 (0)	
Unpackaged snacks (doughnut, French fries, banana fries)						
Always	9 (25.7)	6 (17.1)	14 (40)	6 (17.1)	0 (0)	0.456[c]
Often	0 (0)	1 (16.7)	5 (83.3)	0 (0)	0 (0)	
Sometimes	9 (17)	11 (20.8)	22 (41.5)	5 (9.4)	6 (11.3)	
Rarely	1 (7.1)	1 (7.1)	8 (57.1)	2 (14.3)	2 (14.3)	
Never	2 (20)	1 (10)	5 (50)	2 (20)	0 (0)	
Sugary drinks (soda, coffee, tea)						
Always	3 (8.8)	5 (14.7)	17 (50)	6 (17.6)	3 (8.8)	0.539[c]
Often	1 (8.3)	1 (8.3)	7 (58.3)	1 (8.3)	2 (16.7)	
Sometimes	11 (27.5)	9 (22.5)	12 (30)	4 (10)	4 (10)	
Rarely	1 (5)	4 (20)	11 (55)	3 (15)	1 (5)	
Never	4 (33.3)	1 (8.3)	6 (50)	1 (8.3)	0 (0)	
Ultra processed food (frozen food, canned food)						
Always	3 (30)	2 (20)	3 (30)	2 (20)	0 (0)	0.862[c]
Often	1 (20)	0 (0)	3 (60)	0 (0)	1 (20)	

Eating Patterns of Snacks	Nutritional Status (BMI-for-Age) (n=118)					*p*
	Severely Thin n (%)	Thin n (%)	Normal n (%)	Overweight n (%)	Obese n (%)	
Sometimes	7 (17.9)	8 (20.5)	16 (41)	4 (10.3)	4 (10.3)	
Rarely	4 (13.8)	4 (13.8)	14 (48.3)	6 (20.7)	1 (3.4)	
Never	6 (17.1)	6 (17.1)	18 (51.4)	3 (8.6)	2 (5.7)	
Dessert (cake, ice cream, pudding)						
Always	4 (9.1)	9 (20.5)	24 (54.5)	6 (13.6)	1 (2.3)	0.075[c]
Often	1 (12.5)	1 (12.5)	5 (62.5)	1 (12.5)	0 (0)	
Sometimes	14 (33.3)	7 (16.7)	12 (28.6)	6 (14.3)	3 (7.1)	
Rarely	1 (7.1)	2 (14.3)	6 (42.9)	1 (7.1)	4 (28.6)	
Never	1 (10)	1 (10)	6 (60)	2 (20)	0 (0)	

[c]Chi-square

However, the lack of association between education level and BMI-for-age suggesting that other factors influence students' nutritional status beyond just their academic stage. Despite age and developmental differences, environmental factors had a greater impact[5] Adolescence is a critical growth period, yet dietary behaviors were often shaped by socioeconomic status, peer influence, food availability, and lifestyle choices, rather than by school level alone.[21] Nutritional outcomes depended on overall lifestyle rather than the transition between school levels.[22]

Eating patterns refer to the way individuals fulfill their nutritional needs, manifested in the consumption of various food types and meal frequencies. This study examined staple foods, fiber sources, side dishes, and snacks, with no significant correlation between eating patterns and nutritional status ($p>0.05$). White rice, the dominant staple, was consumed across all BMI-for-age categories, reinforcing previous research that staple food intake alone did not determine nutritional outcomes.[23] Notably, moderate consumption of unfried fish was linked to a higher proportion of normal-weight students, while fried meat and fish were frequently consumed across all BMI categories. This finding aligned with study highlighting an inverse association between boiled seafood intake and overweight/obesity.[24] Gaylis found that overweight/obese teens consumed red meat, processed meat and cheese more frequently than their healthy-weight peers ($p<0.05$).[18] Similarly, Mitchell identified a relationship between BMI and eating behaviors, with teenagers who frequently consumed fast food and engaged in low levels of physical activity being more prone to overweight and obesity.[25]

Snacking habits were also prevalent, with many students frequently consuming salty or sugary snacks.[26] This supported previous research linking high sugar intake to increased obesity risk. Among overweight and obese students, 26.4% frequently consumed sugary drinks, reinforcing concerns regarding their role in weight gain. Ultra-processed food consumption also showed notable trends, with a higher proportion of severely thin and thin students among frequent consumers, possibly due to differences in metabolism, food security, or unbalanced diets. Ultra processed foods became increasingly popular among adolescents due to their accessibility and affordability, and their presence in school environments encouraged frequent snacking. Additionally, these foods were often perceived by students as a means of expressing self-image and modernity.[27]

Based on Gutmann Scale, most respondents had a normal BMI-for-age but exhibited poor eating behaviors. The insignificant relationship between eating patterns and nutritional status may have been attributed to several factors, including high physical activity levels that balanced caloric intake despite poor diets, high adolescent metabolism that allowed for efficient calorie burning, irregular eating habits leading to overall lower caloric intake, genetic predispositions, and other environmental influences (e.g. family dietary habits, peer group, and socioeconomic conditions). Socioeconomic development in tourism region led to changes in eating patterns, reflecting shifts in lifestyle and living standards. Additionally,

psychological factors significantly impacted adolescent eating habits and nutritional status.[28]

The strength of this study included its cross-sectional design with a stratified clustered sampling method, ensuring a diverse representation of students across different education levels. The use of a validated food frequency questionnaire (FFQ) and WHO z-scores for BMI-for-age classification provided reliable measurements. Additionally, data collection through an online system (KoboToolbox) minimized manual errors and streamlined the process. However, the study had limitations. The cross-sectional nature prevented establishing causal relationships between eating patterns and nutritional status. Self-reported dietary data may have introduced recall bias or inaccuracies in food intake reporting. Furthermore, external factors such as socioeconomic status, physical activity, and cultural influences on eating habits were not extensively considered, potentially limiting the comprehensiveness of the findings. Future research could explore other dietary patterns and behaviors that may have a stronger correlation with nutritional status.

Conclusion

The findings highlight the impact of unbalanced eating patterns on students' nutritional status in tourism areas. The availability of processed foods, high-calorie snacks, and sugary drinks in tourist regions may contribute to poor eating patterns among students. Schools and local governments should address these challenges by promoting nutrition education and regulating food availability in and around school environments. Additionally, incorporating gender-focused nutrition education is essential to addressing differences in dietary habits, body image perceptions, and nutritional needs between boy and girl students in tourism regions. This approach can help foster healthier eating habits among high school students.

Conflict of interest

The authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

A qualitative study on the experiences of the prospective brides about nutritional preparation during the preconception period

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Abstract

Background: Stunting is still a nutritional problem in Indonesia, where maternal malnutrition is one of the causes. Studies show that prospective brides and women of childbearing age in Indonesia are not physically and knowledgeably ready for pregnancy. Nutritional preparation is crucial during preconception, as preconception nutritional status can have cross-generational impacts, yet it is often overlooked.

Objective: This study aimed to explore the experiences of prospective brides regarding nutritional preparation during the preconception period.

Methods: This qualitative research was conducted in Bogor, Indonesia, using in-depth interviews and participatory methods. The main informants of this study were 20 prospective brides selected through convenience sampling. Additionally, 21 key informants were involved for triangulation. Data analysis was conducted by coding verbatim transcripts using NVivo12 software. The results of this study used a pre-determined theme aligned with the research objectives.

Result: Almost all informants agreed that preconception nutritional preparation was crucial before marriage. Several nutritional preparation activities carried out by prospective brides emerged from this study, such as pre-pregnancy weight management and eating nutritious and healthier foods. However, many prospective brides still did not perform these activities optimally.

Conclusion: Many prospective brides were already putting efforts to undertake nutritional preparation. However, knowledge gaps and misunderstandings among brides and grooms regarding nutritional preparation persist. There is a need to improve their awareness at preconception period and ensure government programs are accessible, equitable, and effective. This study offers new insights into nutritional preparation for brides, an area that is underexplored.

Keywords: nutrition, preconception, before pregnancy, prospective brides

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Introduction

Stunting is the main nutritional problem for infants and children under 2 years in Indonesia.[1] In 2021, the Indonesian nutrition status study or Studi Status Gizi Indonesia (SSGI) revealed that 19.4% of Indonesian children under five were born with short birth length (<48 cm), and 24.4% were stunted. Indonesia's target for stunting is 14% by 2024. The percentage of stunting in West Java was 24.5%, with Bogor Regency having a higher percentage at 28,6%.[2]

Previous studies show that many prospective brides and women of childbearing age in Indonesia are unprepared for pregnancy, both physically and in terms of knowledge.[3–5] Meanwhile, maternal factors, such as nutritional status, play a significant role in stunting.[6,7] However, women often experience the most vulnerable periods for nutrition, such as before pregnancy, during pregnancy, and lactation.[9] Preconception nutritional status is closely linked to nutritional status during pregnancy and pregnancy outcomes and can have generational impacts, yet this period is often neglected.[8,9]

Improving women's nutrition and health before and during pregnancy will support optimal fetal growth, better obstetrical outcomes, and improved long-term health for both mother and child.[10] Preconception women should ensure proper nutrition before conception. Gastrulation starts in the third week of pregnancy, with organs that have developed ready for further maturation by the end of the eighth week, marking the start of the fetal phase.[11] However, pregnancy awareness typically occurs around 5.5 weeks.[12] Therefore, good preconception health and nutrition are essential for avoiding adverse pregnancy outcomes.

The Indonesian government, through the National Population and Family Planning Board (BKKBN), has begun to take serious steps in paying attention to the nutritional status of prospective brides in an effort to prevent stunting. However, there is limited information on preconception nutritional preparation. Further research is necessary to get more information and identify potential interventions. This study aims to explore the experiences of prospective brides regarding nutritional preparation during the preconception period in Bogor Regency.

Methods

This qualitative study focuses on prospective brides and grooms in Bogor Regency, Indonesia, particularly those registered at the Cibinong Subdistrict Religious Affairs Office (KUA). The office was purposively chosen because it had the highest marriage rate, according to 2016-2020 marriage data from the Central Statistics Agency (BPS) of Bogor Regency. The study was conducted from May 2022 to December 2024, with data collection taking place from June 2023 to January 2024.

The main informants were women aged 19-35 who were apparently healthy, able to communicate in Indonesian, and willing to participate. The number of main informants required was based on significant variations of the main informant characteristics and the saturation achievement. Variations considered included socio-demographic factors such as age, education level, occupation, and type of living (with parents or not). To gain a broader and deeper understanding of the social conditions under study, triangulation was used by involving key informants.

Convenience sampling was used to select informants. Researchers visited the KUA on premarital briefing days and invited all attending prospective brides and grooms to participate, ensuring the required variations were met. Interviews were conducted at the KUA, with brides interviewed ahead of the grooms. Key informants of significant others were identified through the prospective bride's recommendations and were interviewed later at a mutually agreed time and place. The study included 20 prospective brides as main informants and 21 key informants, consisting of 17 prospective grooms and 4 significant others of prospective brides.

This study used a participatory method and in-depth interviews with semi-structured questionnaires for prospective brides (main informants) and only in-depth interviews for key informants. The participatory method involved newly developed cards in this study, which were

designed to collect information through the main informants' involvement in selecting and arranging the cards. The participatory cards contained words related to the types of preparations typically or must be made before marriage. A total of 28 cards covered marriage procedures,[13] wedding ceremony preparations,[14] preparations related to nutrition and health,[15] preparations related to family readiness,[5] and 2 other things such as discussing pregnancy planning with a prospective husband and losing weight from previous research.[8,16] Main informants were asked to choose a maximum of 15 cards out of 28 cards (6 nutrition and health-related cards and 22 other cards), sorting them based on importance and preparations that have/have not been done. During the in-depth interviews, questions focused on the informants' views on nutritional preparations, nutritional preparations carried out by the prospective bride, and their general health conditions. Prior to data collection, a pilot test was conducted on three couples from the same subdistrict to refine the interview flow, clarify questions, and ensure understanding.

Interview recordings were transcribed verbatim and analyzed through coding using N-Vivo12 (Version 12.7.0 (3873)). Before being interviewed, all informants were informed about the study and signed an informed consent form to confirm their agreement to participate. The study was approved by the FKUI Ethics Committee on June 26, 2023 (877/UN2.F1/ETIK/PPM.00.02/2023).
Additionally, permits were obtained from the local authorities.

Results

Informant characteristic

A total of 20 prospective brides participated in this study, with the majority aged over 25 to 35 years. Most of the prospective brides had a high school education or lower, worked (have income), and still lived with their parents. Details of the main informants' characteristics are shown in **Table 1**. For the key informants, most prospective grooms were aged over 25 to 35 years, with a higher proportion having a high school education or lower compared to those with a diploma or higher. Most of the prospective grooms were employed in private-sector jobs. The significant others of the prospective brides were mainly family members, primarily mothers. All significant others had a high school education or lower, and most were housewives.

Table 1. Characteristics of the main informants

Characteristics	n=20
Age	
• 19-25 years	8
• Over 25 to 35 years	12
Education	
• High School or lower	12
• Diploma or higher	8
Occupation	
• Working	17
• Not working	3
Type of living	
• Living with parents	17
• Not living with parents	3

Nutritional preparation was considered important to do during the preconception period.

Based on the participatory method, researchers obtained a general picture of prospective brides' opinions regarding the nutritional and health preparations they considered important and the types of preparations they had done (**Table 2**).

According to most informants, preparations related to nutrition and health that were considered important to do before marriage included health checks and increasing the consumption of certain nutrients, such as iron and folic acid, which ranked in second place. The number of informants who considered having a healthy and balanced diet and doing physical activity/exercise regularly as important preparations before marriage was the smallest. However, not all informants who considered these preparations important carried out preparation. In fact, the healthy and balanced diet they implemented was not entirely in accordance with what the WHO defined as a healthy and balanced diet.

Table 2. Nutritional and health preparation as something that was considered important to do during the preconception period.

No	Preparation	Frequency	
		Considered it as important	Have implemented it
1.	Health check (Premarital health check)	19	12
2.	Increase consumption of certain nutrients (iron, folic acid)	18	14
3.	Avoiding caffeine, cigarettes, alcohol, and drugs	15	13
4.	Managing body weight (ideal/healthy)	13	12
5.	Healthy and balanced diet	9	8
6.	Do exercise regularly	9	9

Nutritional preparation activities during the preconception period

Most main and key informants agreed that preconception nutritional preparation was important before marriage. However, some prospective brides mentioned that nutritional preparation was only necessary if one intended to get pregnant immediately after marriage. Additionally, some prospective grooms were not sure whether preconception nutritional preparation was important.

The results of this study revealed several nutritional preparation activities carried out by prospective brides. The information that researchers obtained from triangulation was also included in the results. Although not all nutritional preparation activities were carried out by each prospective bride, details of nutritional preparation activities during the preconception period can be seen in **Table 3**.

Some prospective brides managed their weight by making various efforts, and the results varied for each individual. However, some of them admitted that they wanted to gain weight but did not know how. Even one prospective bride did it with actions that tended to be careless and risky for health, such as frequently eating instant noodles at night while rarely consuming main meals and snacking more often on biscuits and chips. As a result, she failed to gain weight. In **Table 3**, researchers categorized food-related issues as eating regularly and eating nutritious and healthier foods rather than categorizing them as a healthy and balanced diet. This was because when asked about a healthy and balanced diet, no one could answer correctly according to the concept socialized by WHO or the Ministry of Health, the majority answered that a healthy and balanced diet was "4 healthy 5 perfect", eating nutritious food, or at least including side dishes.

For prospective brides who enjoy drinking coffee, avoiding or reducing caffeine consumption was also necessary before the wedding. Most of the prospective brides did not smoke. However, one of them admitted that she was an active smoker and found it difficult to quit. She realized that smoking was dangerous for her and her fetus's health if she got pregnant later. In addition, there was still the potential for several other prospective brides to become passive smokers because their partners smoked.

Not all brides who underwent premarital health checks in the Public Health Centre received nutritional counseling, especially if their results were normal. Brides with weight issues were advised to gain or lose weight but lacked guidance on how to do so. None had searched for preconception health or nutrition information, but some sought advice on weight loss, exercise, or pregnancy-related topics from their significant others, the internet, or doctors.

Table 3. Nutritional preparation activities during the preconception period

Themes	Categories	Description
Nutritional preparation activities during the preconception period	Pre-pregnancy weight management	• Monitored weight and determined whether their weight was ideal or not. • Made efforts to control, gain, or lose weight (went on a diet such as a calorie deficit, reduced the frequency of meals, practiced intermittent fasting and followed blood type diet). • Exercise or improve physical activity.
	Eating regularly	Ate at mealtimes; ate on time anyway; had breakfast regularly.
	Eating nutritious & healthier foods	• Consumed nutritious food every day, such as rice, side dishes, vegetables, and fruit. Some also added milk or nuts to their daily diet. • Brought a packed lunch or brought healthier food for lunch at work. • Reduced buying ready-to-eat food and preferred to cook at home. • Avoided instant noodles. • Reduced the spicy level of food.
	Pay attention to the intake of certain nutrients	• Increased protein intake. • Paid attention to vitamin and mineral intake, such as increasing vegetable and fruit intake, taking supplements, and drinking milk. • Increased water intake. • Reduced fat intake, carbohydrate intake (including sugar), and salt.
	Consuming herbal medicine	• Drank the herbal medicine provided by their mother regularly
	Avoiding caffeine, cigarette, alcohol, and drugs	• Cut back on coffee or reduce caffeine by decreasing the number of cups of coffee that they drink each day and replacing it with water. • Did not smoke and avoided cigarette smoke. • Did not consume alcohol or drugs.
	Do physical activity	• Warmed up • Walked more, such as walking from the station or bus stop to the office or walking on holidays. • Did sports such as yoga, workout, treadmill, aerobic, jogging, biking, and swimming.
	Strive for physical & mental health	• Conserved of tooth root canals • Had check-ups for existing diseases and received advice for conditions such as GERD. • Consulted with a psychiatrist to treat sleep disorders, ADHD, and anxiety Gerd. • Avoided stress. • Managed sleep patterns
	Follow existing government programs	• Underwent a premarital health check (checked blood pressure, height, weight, and upper arm circumference, and conducted blood tests such as HIV/AIDS, blood sugar, cholesterol, and Hb levels) • Received tetanus toxoid immunization. • Received iron and folic acid (IFA) supplements. • Received premarital education/counseling.
	Increase knowledge of nutrition and health	• Discussed/shared with significant others or their prospective husband. • Consulted a doctor or health professional. • Read information from brochures, social media, and journals, browse the internet, and watch YouTube.

Discussion

Nutritional preparation activities during the preconception period

Not all informants agreed on the necessity of preconception nutritional preparation. Similar to other studies, many young adults lack awareness of preconception health. They often did not know what it was, why it was important, or how to prepare for pregnancy.[18] Kasim et al. found that 10.4% of young respondents disagreed that preconception care is important during reproductive years, possibly due to limited knowledge and few interactions with healthcare services.[17]

Several nutritional preparation activities carried out by prospective brides include managing their pre-pregnancy weight, eating regularly, eating nutritious and healthier foods, paying attention to their intake of certain nutrients, consuming herbal medicine, avoiding caffeine, cigarettes, alcohol, and drugs, doing physical activity, striving for physical and mental health, following existing government programs, and making efforts to increase their knowledge of nutrition and health.

Some prospective brides tried to lose or gain weight in various ways. Almost all of those who tried to gain weight complained that they did not know how. Inappropriate dietary attitudes about the value of diet, irregular mealtimes, and poor chewing were linked to obesity. In contrast, fussy eating and skipping three meals a day were linked to being highly underweight.[18] Both conditions can negatively affect pregnancy outcomes.[19–23] Therefore, it is crucial to aim for a healthy preconception weight within the normal BMI range (18.5-24.9) to reduce risks and achieve optimal health before pregnancy.[24]

Then, prospective brides made efforts to eat more regularly, consume nutritious and healthier food, and pay attention to the intake of certain nutrients. Maintaining a consistent eating and fasting schedule supports a healthy circadian rhythm and boosts metabolism, while irregular eating habits can disrupt the body's physiology and are linked to obesity, type 2 diabetes, and heart disease. So, eating at the same time each day is beneficial for health.[25]

Some prospective brides said they paid more attention to their food before marriage by eating nutritious and balanced food. However, they did not fully understand what a nutritious and balanced diet meant. They tended to try to eat nutritious food and choose healthier food to consume. Most of them said that nutritious and balanced eating was 4 healthy 5 perfect, with practices that were also not in accordance with 4 healthy 5 perfect. In line with this study, Colozza's qualitative study in Indonesia found that many participants in the groups he studied began by also citing "4 healthy, 5 perfect" when asked about healthy food.[26] However, Dyke et al. stated that knowledge to practice healthy eating, which falls under the category of "Cognitive factors." Participants often viewed it as unrealistic and ultimately trumped by the need and/or desire for convenience, a combination of external factors of food, namely the social environment and personal condition factors (psychological components).[27]

Women trying to conceive or who are pregnant are often more motivated to improve their diet due to concerns about the adverse effects of poor diet on the health of their unborn baby.[28] A study showed a significant link between mothers' dietary patterns before conception and during pregnancy.[29] Another study showed that there was an increase in consumption of water, fruit juice, and milk from before pregnancy to early pregnancy among Norwegian nulliparous women.[30] Similarly, Yonezawa et al. found that more women consumed vegetables and fruits daily or more frequently from preconception to early pregnancy.[31]

However, a cohort study in Southern Benin found no significant change in dietary diversity between the preconception period and pregnancy, suggesting that some women do not alter their diet after learning they are pregnant.[32] So, practicing a healthy and balanced diet earlier will undoubtedly have a better impact. At least those good habits on a daily basis increased

significantly from pre-pregnancy to early pregnancy.[30]

Women's health should be monitored from adolescence, not just during pregnancy. While consuming micronutrients like vitamins and minerals during pregnancy can help correct maternal malnutrition, substantial improvements in child health may be delayed if nutritional status is only addressed after conception. To improve long-term outcomes for mothers and infants, women's nutritional status should be improved before pregnancy.[33] Some prospective brides reported increasing their intake of vegetables and fruits from the time they were planning to get married. However, not all prospective brides regularly consume vegetables, fruits, and grains. A systematic review showed that women often fail to meet minimum vegetable and cereal grain intakes during the preconception and pregnancy periods.[34]

Some prospective brides started taking supplements, which may be important for meeting vitamin and mineral needs to support metabolic changes and fetal development. In this study, some prospective brides took iron and/or folate, vitamin E, C, or D. Australian research also found that 63% of women consumed one or more dietary supplements during the preconception period, with multi-micronutrient supplements being the most common. They also reported the use of supplements containing folic acid or iodine, and supplements containing single nutrients such as folic acid, omega-3 fatty acids, vitamin C, vitamin B, iron, and calcium.[35]

Ensuring adequate water intake was a practice that a number of prospective brides did. Sufficient water intake supports organ function, hormone balance, toxin removal, and, ultimately, fertility.[36] Women should develop the habit of drinking enough water before pregnancy to prepare for physiological changes. It is recommended that women of childbearing age aim for 2 liters (2,000 ml) of fluid daily.[37] Additionally, some prospective brides had started reducing their intake of fat, carbohydrates, and salt for health and appearance reasons.

Several prospective brides also consumed herbal medication as part of their nutritional preparations, using natural remedies like ginger, turmeric, lemongrass, and betel leaves to boost their immune systems and maintain health. Several medicinal plants found in Indonesia contain secondary metabolites with immunomodulatory effects.[38] A study in Brisbane found that 8.3% of women seeking obstetric care used herbal medicine during the preconception period, and about 55.8% stopped using them once they became pregnant.[39]

Some prospective brides have limited or avoided coffee consumption due to concerns about its impact on health. While opinions on coffee use during the preconception period vary, numerous studies link high coffee or caffeine intake to various health risks. A study of nulliparous women in Norway found a similar trend in beverage consumption from before to early pregnancy. The use of coffee, sugar-sweetened beverages, and artificially sweetened beverages reduced considerably from before pregnancy to early pregnancy.[30] Coffee consumption before pregnancy ≥4 servings per day (caffeine >400 mg/day) increases the risk of spontaneous abortion (SAB), especially during weeks 8-19.[40] Other studies have shown that hemoglobin levels decrease with increasing daily coffee consumption.[41] In addition, blood ferritin levels can decreased significantly with increasing total coffee and green tea intake.[42]

The prospective brides stated that they tried to avoid cigarette smoke, but they were potentially passive smokers because many of the grooms smoke. There is no safe level of exposure to cigarette smoke, and in some people, even brief exposure may immediately cause negative effects. Passive smokers can develop lung cancer, coronary heart disease, stroke, and other health issues, with women also facing reproductive health risks like low birth weight.[43]

Unfortunately, one prospective bride still smoked, which aligns with a study in the UK involving pregnant women, which found that as many as 22.9% of women smoked and 85% of women who smoked did not quit smoking in the year before pregnancy.[44] The US Centers of

Disease Control and Prevention (CDC) states that a woman should quit smoking before she becomes pregnant. However, if she is already pregnant, quitting can still help protect her and her baby from health problems.[45] However, a retrospective cohort study found that smoking during the preconception period or quitting in the first trimester can increase the risk of fetal malformations such as gastroschisis by up to 40%.[46] One prospective bride was also still undergoing psychiatric treatment and taking medications, including sleeping pills. In such a case, she and her future husband should plan the pregnancy and consult a doctor about medications that are safe during pregnancy.

Women in the preconception period are advised to engage in at least 30 minutes of light exercise a day, 5 days a week (150 minutes per week), do muscle-strengthening exercises twice a week, and minimize prolonged sitting.[47,48] However, only a few prospective brides reported regular exercise, with some increasing their activity through walking. A study in Poland found that only 27% of women were sufficiently active in the 6 months before conception.[49] Preconception physical activity strongly predicts continued activity during pregnancy, making this a critical time for behavior change.[50]

Since about half of pregnancies are unplanned, it is important to be aware of health conditions and risk factors that could affect the woman or her baby later on.[51] Some prospective brides took steps to address health issues by undergoing check-ups and consulting doctors for proper therapy, addressing both physical and mental health. Poor preconception mental health can increase the risk of pregnancy complications, such as non-live births, low birth weight, and premature births.[52]

Some prospective brides had already completed premarital health checks at the Public Health Centre. Premarital health checks are actually one of the government programs related to prospective brides and grooms besides tetanus toxoid immunization, Iron Folic Acid (IFA) supplementation, and counseling from midwives or nutritionists. These health checks include measuring blood pressure, height, weight, and upper arm circumference and conducting blood tests for HIV/AIDS, blood sugar, cholesterol, and hemoglobin levels.

The Ministry of Health of the Republic of Indonesia states that premarital health checks are essential preventive measures for prospective brides and grooms to avoid health issues for themselves, their partners, or their future children. These checks should ideally be conducted 3-6 months before marriage.[53] A scoping review showed that premarital health checks reduced at-risk marriages by 2–58% and at-risk births with β-thalassemia by 65–100%. However, the effectiveness of these checks depends on other factors as well.[54]

After a premarital health check, prospective brides would receive tetanus immunization and IFA (Iron Folic Acid) supplements. Indonesian guidelines recommend intermittent IFA supplementation (60 mg of elemental iron and 400 mcg of folic acid).[55] As a preventive measure, IFA is taken regularly, one tablet every week.[56] However, according to prospective brides and grooms, not all who underwent premarital health checks received nutritional counseling, mainly if their examination results were normal. Ideally, all individuals undergoing premarital health checks at Public Health Centres should receive nutritional counseling.

Counseling is not only about providing knowledge but should also be a collaborative process involving the individual, family, and service provider. Information is shared, and support is provided so that individuals and families can make decisions and take action to improve their nutrition.[57] WHO recommendations on preconception care for women include information, education and counseling on nutrition, promotion of exercise, iron and folic acid supplementation, and supplementation with energy and nutrient-dense foods.[57] Evidence shows that counseling during the preconception period can lead to healthier behaviors and better outcomes for both mother and infant.[58]

Some prospective brides also tried to improve their knowledge about nutrition and health. Their family, prospective husbands, and friends served

as sources of information and discussion partners regarding their health issues. A study by Shibata et al. found that family and friends were one of the primary sources of preconception care knowledge among rural Japanese women (60%), with the internet being the primary source (70%). Other sources included books and magazines, obstetricians, and primary care physicians.[59] Regarding prospective brides seeking information through social media, an Australian study showed that 40% of women used social media for general health information, 32% for preconception health advice, and 20% for pregnancy-related information.[60]

Some brides have undertaken nutritional preparation, but the efforts made have not been maximized by only doing a few types of nutritional preparation activities, such as increasing the consumption of certain nutrients and avoiding caffeine, cigarettes, alcohol, and drugs. In fact, a prospective bride who was underweight did not do any preparation at all. Although the BKKBN has potential programs such as the Family Assistance Team (TPK) and the "Electronics Ready for Marriage and Pregnancy" (Elsimil) app, they have not reached their full potential, and almost all informants were unaware of them. The TPK program and the Elsimil application have significant potential to assist prospective brides and grooms by offering health support and tracking key health indicators.[61,62]

The Cibinong Subdistrict KUA was partnered with local Public Health Centres to provide nutrition and health education during marriage guidance sessions. However, the program was not fully effective because marriage guidance was not mandatory, resulting in many prospective brides and grooms not participating. Additionally, midwives were occasionally absent, which hindered the delivery of education and counseling. At the time of data collection, premarital health checks for a marriage eligibility certificate were also not mandatory, causing many couples to skip them. In fact, both the marriage guidance sessions and post-health check counseling could have been valuable opportunities to educate couples on proper nutritional preparation before conception.

The authors acknowledged the strengths and limitations of this study. The findings of this study provided new insights for researchers and readers about nutritional preparation among prospective brides that were currently underexplored. Furthermore, the findings of this study can help policymakers improve health promotion programs, especially for prospective brides, as the target audience of the program.

This study had several limitations. First was the potential for selection bias due to the recruitment of prospective brides, grooms, and their significant others. With only four significant others (three mothers and one friend) interviewed, data saturation for non-family significant others was not achieved. Additionally, during the study report, regulations from the KUA were changed: starting in July 2024, Marriage Guidance (Bimwin) became mandatory for prospective brides and grooms, and the KUA now requires a marriage eligibility certificate from the Public Health Centre, which includes a premarital health check. These regulatory changes may address some of the issues identified in this study, although the researcher could not confirm the changes directly with prospective brides and grooms.

Conclusion

This study highlights the various nutritional preparation activities among prospective brides during the preconception period, including managing weight, eating nutritious and healthier foods, engaging in physical activity, and several other things. However, several informants lacked an understanding of the importance of preconception health. Many prospective brides still do not have a clear understanding of how to properly carry out nutritional preparation activities, such as maintaining a balanced diet and achieving an ideal body weight. Additionally, government programs that have the potential to improve the understanding of prospective brides to prepare their nutrition and

health are underutilized and have not been optimally implemented.

It is essential to ensure that existing government programs, such as premarital health checks, iron and folic acid (IFA) supplementation, and nutritional counseling, are accessible to all prospective couples and delivered effectively. Education on preconception nutrition and health needs to be improved to equip both women and their prospective husbands with the knowledge necessary to make informed decisions before pregnancy. Information from family members and the use of social media can help couples gain knowledge about nutritional preparation during the preconception period. However, the role of health workers remains critical in guiding these efforts. Socialization of the program and improvement of the implementation of programs related to prospective brides and grooms is also essential, such as the active empowerment of the TPK to assist prospective brides with education and support in preparing their nutrition and health during the preconception period.

Conflict of interest

Authors declared no conflict of interest regarding this article.

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ORIGINAL ARTICLE

Association between maternal anemia and low birth weight among stunting children 12–23 months in Dili, Timor Leste

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Abstract

Background: Stunting is a chronic malnutrition problem primarily occurring during the first 1000 days of life. Iron deficiency anemia during pregnancy can threaten fetal growth and may affect the baby's birth weight and length. According to the Timor-Leste Food and Nutrition Survey 2020, stunting in Timor-Leste is 47.1%.

Objectives: To determine the relationship between a history of anemia during the third trimester of pregnancy and low birth weight with the incidence of stunting in children aged 12-23 months in Dili city.

Methods: This study was a case-control design conducted in five health centers in Dili City, Timor-Leste. The sample consists of 180 children aged 12-23 months, with 90 stunted cases and 90 controls selected consecutively. Data collected encompasses both child-related and maternal information.

Results: Anemia during the third trimester of pregnancy OR 95%CI 7.18 (3.38-15.23) and low birth weight OR 95%CI 5.39 (2.09 – 13.90) are significantly associated with the incidence of stunting ($p < 0.01$). Based on logistic regression analysis, anemia during pregnancy and low birth weight are not significantly associated with an increased risk of stunting. However, there are characteristics of the mother and child that are significantly associated with the risk of stunting.

Conclusion: Children with a history of low birth weight are 5.3 times more likely to experience stunting, and children whose mothers had anemia during pregnancy are 7.2 times more likely to experience stunting. The results show that low birth weight and maternal anemia are related to the incidence of stunting in Timor-Leste.

Keywords: maternal anemia, low birth weight, stunted children

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Introduction

Linear growth is a good indicator of children's well-being, as it also reflects nutritional status in the past. Height-for-age is a commonly used measure to assess linear growth. Suboptimal health conditions and inadequate nutrition and care lead millions of children worldwide to fail to reach their linear growth potential. Globally, in 2020, a total of 149.2 million under five children experienced stunting, but there was a decrease in the prevalence of stunting in all regions except Africa.[1,2] Data from the Global Nutrition Report 2020 shows that Timor-Leste ranks first in the prevalence of stunting cases in Southeast Asia and fifth highest worldwide.[3] The World Health Organization (WHO) sets the maximum tolerance for stunting at 20% or one-fifth of the total number of toddlers, while Timor-Leste has a stunting prevalence of 47.1% according to data from the Timor-Leste Food and Nutrition Survey 2020 (TLFNS).[4]

The causes of stunting in toddlers are multifactorial. According to the United Nations Children's Fund (UNICEF) framework, there are several factors from mother and children contributing to stunting. Maternal factors play a crucial role in the occurrence of stunting, including anemia during pregnancy, early pregnancy, short birth intervals, multiparous pregnancies, and poor nutrition during pregnancy.[2] The prevalence of pregnant women with anemia worldwide in 2019 was 36.5%, and in Southeast Asia, it was 47.8%. Timor-Leste ranks as the fourth highest country in Southeast Asia with a prevalence of 38%, following Indonesia.[3]

Meanwhile, child-related factors associated with the occurrence of stunting include inadequate intake of energy and protein, recurrent infections, and not receiving exclusive breastfeeding. Several studies suggest a possible association between low birth weight (LBW) and stunting. The prevalence of LBW in Dili, the Capital city of Timor-Leste in 2019 was 12%, the highest among all districts, with the lowest level figured in Manatuto district at 2.1%.[5] As of now, there hasn't been any further research conducted on stunting and its risk factors in mothers and children in Timor-Leste.

This study aimed to identify the relationship between maternal anemia during pregnancy and low birth weight (LBW) with the occurrence of stunting among children aged 12-23 months in Dili, Timo-Leste.

Methods

This study was performed with a case-control study from December 2023 to March 2024. There are 180 subjects aged 12-23 months old from 5 Primary Health Care in Dili, Timor-Leste. All subjects were divided into two groups; case and control group. 90 children with confirmed stunting were included in the case group, while 90 matched healthy children served as the control group. Subjects were excluded if they did not have the Maternal and Child Health Monitoring Book, and were diagnosed with genetic or hormonal diseases that can affect growth. This information was obtained from the subject's medical records. The sample size was calculated based on unpaired t-test analysis. The research was approved by the Unit of Ethical Research and Development of Timor-Leste no.06/INSP-TL/UEPD/II/2024. All participants in this study were treated based on the Declaration of Helsinki and gave spoken, written informed consent before participating in this study.

The data used in this research were primary and secondary data. Six nutritionists with an educational background in nutrition assisted in this study. Anthropometric measurements, height-for-age z-scores were taken using the infantometer SECA 416 (Seca, Germany). A 24-hour food recall conducted through an interview with the mother was used to identify nutrient components, including energy and protein intake, to estimate the calorie intake consumed within the 24 hours prior to the interview. The hemoglobin level data, as a parameter for anemia, were secondary data obtained from the Maternal and Child Health monitoring book. All nutritionists involved in collecting anthropometric data, hemoglobin levels, and 24-hour food recalls had been trained before collecting data.

Data were analyzed using SPSS 26. Statistically significant differences between groups were analyzed using Chi-Square. Multiple Logistic

Regression analysis was performed in this study to examine the influence of subject characteristics as confounding variables

Results

A total of 180 children (90 children in each group) were enrolled in the study. **Table 1** showed the characteristics of children based on age, gender, birth weight, birth length, and breastfeeding status.

Table 1. Bivariate analysis of children's characteristics

Variable	Case (n=90)	Control (n=90)	OR (CI 95%)	p
Birth weight				
Low	25(80.6)	6(19.4)	5.39	<0.001
Normal	65(43.6)	84(56.4)	(2.09 – 13.90)	
Age (month)				
12-18	54(60)	58(64.4)	0.82	0.546
19-23	36(40)	32(35.6)	(1.50- 5.09)	
Gender				
Male	62(60.8)	40(39.2)	2.77	<0.001[a]
Female	28(35.9)	50(64.1)	(1.50- 5.09)	
Birth weight				
Low	25(80.6)	84(56.4)	5.39	<0.001[a]
Normal	65(43.6)	6(19.4)	(2.09 – 13.90)	
Birth length				
	46(82.1)	10(17.9)	5.39	<0.001[a]
Normal	44(35.5)	80(64.5)	(2.09 – 13.90)	
Breastfeeding status (BF)				
Not exclusive BF	52(61.2)	33(38.8)	2.36	0.005[a]
Exclusive BF	38(40,0)	57(60.0)	(1.30 – 4.30)	
Diarrhea history				
Yes	59(62.8)	35(37.2)	2.99	<0.001[a]
No	31(36.0)	55(64.0)	(1.63-5.48)	
Diarrhea in a month				
No	27(37.5)	45(62.5)		
<3 times	38(53.5)	33(46.5)		0.009
≥3 times	25(67.6)	12(32.4)		
Diarrhea in last 3 months				
Yes	28(68.3)	13(31.7)		0.008
No	62(44.6)	77(55.4)		
URTI history				
Yes	67(65.7)	35(34.3)	4.57	<0.001[a]
No	23(29.5)	55(70.5)	(2.42-8.64)	
URTI in a month				
No	24(30.0)	56(70.0)		<0,001[a]
<3 times	46(66.7)	23(33.3)		
≥3 times	20(64.5)	11(35.5)		
URTI in last 3 months				
Yes	45(77.6)	13(22.4)	5.92	<0.001[a]
No	45(36.9)	77(63.1)	(2.88-12.14)	
Energy intake				
<80% RDI	72(63.2)	42(36.8)		<0.001[a]
80-100% RDI	14(25.0)	42(75.0)		
>100% RDI	4(40.0)	6(60.0)		
Protein intake				
<80% RDI	62(79.5)	16(20.5)		<0.001[a]
80-100% RDI	19(31.7)	41(68.3)		
>100% RDI	9(21.4)	33(78.6)		

[a]Chi-square, significance (p<0.05)

The following characteristics among the mothers of the study are outlined in **Table 2**. A bivariate analysis was performed to investigate the relationship between third-trimester anemia during pregnancy and the incidence of stunting in children Table 3 shows a significant relationship between third-trimester anemia and stunting ($p < 0.001$). In the stunting group (cases), a higher percentage of mothers had anemia (Hb less than 11 g/dL) during the third trimester (80.4%) compared to mothers without anemia (36.3%). Mothers with a history of anemia during the third trimester had a 7.18 times greater risk of having a stunted child compared to mothers who did not experience anemia during pregnancy.

When analyzing the relationship between third-trimester anemia and stunting, it is crucial to consider the potential influence of various subject characteristics. Differences between the case group (children with stunting) and the control group (children without stunting) may affect the analysis results. Characteristics with a p-value of less than 0.25 were identified as potential confounding factors, indicating they may influence the relationship between third-trimester anemia and stunting.

Table 2. Bivariate analysis of mother's characteristics

Variable	Case (n=90)	Control (n=90)	OR (CI 95%)	p
Third-trimester anemia				
Yes	45(80.4)	11(19.6)	7.18	<0.001
No	45(36.3)	79(63.7)	(3.38-15.23)	
Age (year)				
At risk	32(61.5)	20(38.5)	1.93	0.048[a]
Non-risk	58(45.3)	70(54.7)	(1.00-3.72)	
Height				
Short	23(67.6)	11(32.4)	2.46	0.022[a]
Normal	67(45.9)	79(54.1)	(1.12-5.42)	
Education level				
Primary	13(92.9)	1(7.1)		<0.001[a]
Secondary	61(58.7)	43(41.3)		
Tertiary	16(25.8)	46(74.2)		
Income level				
Low	22(88.0)	3(12.0)	9.38	<0.001[a]
Sufficient	68(43.9)	87(56.1)	(2.69-32.6)	
MUAC during pregnancy				
Abnormal	48(70.6)	20(29.4)	4.00	<0.001[a]
Normal	42(37.5)	70(62.5)	(2.09-7.63)	
Multiparity				
Yes	19(73.1)	7(26.9)	3.17	<0.001[a]
No	71(46.1)	83(53.9)	(1.26-7.98	
Short interval between pregnancy				
Yes	26(56.5)	20(43.5)	1.42	0.305
No	64(47.8)	70(52.2)	(0.72-2.79	
Third-trimester anemia				
Yes	45(80.4)	11(19.6)	7.18	<0.001[a]
No	45(36.3)	79(63.7)	(3.38-15.27)	
Fe supplement during pregnancy				
Insufficient	26(63.4)	15(36.6)	2.03	0.051
Sufficient	64(46.0)	75(54.0)	(0.99-4.16)	

[a]Chi-square, significance ($p<0.05$)

The bivariate analysis identified several variables as potential confounders, including the child's gender, birth weight, birth length, history of exclusive breastfeeding, history of infections, energy and protein intake, as well as maternal characteristics such as maternal age, maternal height, maternal education, family income, maternal mid-upper arm circumference (MUAC), multiparity status, and iron supplementation during pregnancy, all of which had p-values less than 0.25. These variables were subsequently included in the multivariate analysis shown in Table 3 to demonstrate the relationship between third-trimester pregnancy anemia and the incidence of stunting while controlling for these confounding variables.

Table 3. Multivariate analysis between anemia during pregnancy and the incidence of stunting while controlling for confounding variables

Variable	p	OR	CI 95%
Third-trimester anemia	0.054	3.23	0.98-10.66
Gender	0.038*	3.01	1.06-5.87
Birth height	<0.001*	8.24	2.53-26.89
Breastfeeding status	0.433	1.50	0.54-4.15
History of diarrhea	0.954	1.03	0.35-3.08
URTI in last 3 months	0.017*	3.78	1.26-11.26
Energy intake	0.605	1.25	0.53-3.08
Protein intake	<0.001*	4.06	1.94-8.48
Mother's age	0.549	0.69	0.20-2.31
Mother's height	0.304	1.95	0.55-6.93
Education level	0.009*	3.97	1.29-11.09
Family income	0.792	1.38	1.27-15.38
MUAC in pregnancy	0.003*	5.14	1.75-15.06
Multiparity	0.910	1.10	0.18-6.60
Fe supplement during pregnancy	0.477	0.63	0.18-2.23

*Logistic regression, significance (p<0.05)

The bivariate analysis between low birth weight (LBW) and the incidence of stunting found a significant relationship between the two variables ($p < 0.001$). **Table 4** showed that a higher percentage of children with low birth weight, defined as less than 2500 grams, were present in the stunting group (80.6%) compared to children with normal birth weight (43.6%).

A multivariate analysis was conducted between subject characteristic data and the dependent variable, which were potential confounders (as shown in **Tables 3 and 4**). The results of the multivariate analysis were presented in **Table 4** below, indicating that there was no significant relationship between a history of LBW and the incidence of stunting. The significant confounding variables associated with the incidence of stunting in children aged 12-23 months included the child's gender, birth length, history of URTI, protein intake, maternal education, and mother's MUAC during pregnancy.

Discussion

In this study, the proportion of stunted children in Dili, Timor-Leste whose mothers had anemia during the third trimester of pregnancy is 80.4%. This study identified a significant association between

Table 4. Multivariate analysis between low birth weight and the incidence of stunting while controlling for confounding variables

Variable	P	OR	CI 95%
LBW	0.970	0.97	0.20-4.67
Gender	0.018*	3.47	1.24-9.74
Birth height	0.001*	8.19	2.44-27.52
Breastfeeding status	0.220	1.85	0.69-4.97
History of diarrhea	0.591	1.33	0.47-3.73
URTI in last 3 months	0.015*	3.79	1.30-11.08
Energy intake	0.563	1.26	0.53-2.93
Protein intake	<0.001*	4.04	1.95-8.34
Mother's age	0.729	0.81	0.25-2.60
Mother's height	0.303	1.97	0.54-7.16
Education level	0.009*	3.83	1.39-10.55
Wealthy level	0.678	1.60	0.17-15.00
MUAC in pregnancy	0.003*	4.97	1.70-14.57
Multiparity	0.522	1.77	0.30-10.25
Fe supplement during pregnancy	0.724	0.78	0.21-2.94

*Logistic regression, significance ($p<0.05$)

maternal anemia during pregnancy and the incidence of stunting in children. Specifically, it indicated that mothers with anemia were 3.2 times more likely to have stunted children compared to those without anemia. This finding differs from a study conducted in Indonesia that reported no significant association between maternal anemia and the incidence of stunting. However, it is consistent with another Indonesian study that found a significant association between maternal anemia and stunting, with a p-value of 0.001.[1] Iron intake is crucial in the third trimester, as most iron transfers to the fetus after 30 weeks.[6] Inadequate iron can lead to hemoglobin deficiency, affecting oxygen transport to both mother and fetus. Maternal anemia increases risks of premature birth, intrauterine growth restriction, and low birth weight, making children born to anemic mothers more likely to be stunted. Mei et al.[6] explain that anemia data was primarily from the first trimester, where iron needs are less critical.[6-8] Multivariate analysis revealed no significant relationship between a history of anemia during pregnancy and stunting, after controlling for confounding variables such as child's gender, birth length, ARI history, low protein intake, maternal education, and MUAC.

There was a significant relationship between birth length and stunting, indicating that children born shorter were 8.24 times more likely to experience stunting than those with normal length. This finding was consistent with Mei et al.[6] research in Indonesia, which also showed a shorter children are 3.62 times more at risk for stunting. The mother's condition during pregnancy significantly affects fetal development during the first 1,000 days of life. Nutritional deficiencies, including both macronutrients and micronutrients like iron, can lead to growth retardation in bones and soft tissues, with effects that may persist after birth.[9] There was a strong association between a mother with a MUAC of less than 23 cm and the incidence of stunting. This suggested that mothers with a MUAC less than 23 cm are 5.14 times more likely to have a stunted child. This finding aligned with research from

Ethiopia, which found that mothers with a MUAC under 23 cm are 2.54 times more likely to have stunted children.[10] Poor maternal nutrition during pregnancy can adversely affect fetal growth and limit nutrition available at birth and during breastfeeding, disrupting the child's linear growth. Bone elongation is a complex process influenced by various intrinsic factors (hormones, growth factors) and extrinsic factors (nutrition, environment). Adequate nutrition, alongside hormones and growth factors, is crucial for the elongation of limb bones.[11-12]

In this study, a significant relationship was found between low protein intake and the occurrence of stunting. This was consistent with research from Indonesia, which also identified a link between low protein intake and stunting, indicating that children with low protein intake were 3.07 times more likely to experience stunting compared to those with adequate intake. Studies from Guatemala, Congo, Zambia, and Pakistan showed that sufficient animal protein consumption was associated with lower stunting rates. Poor-quality protein diets were linked to stunting due to reduced circulation of essential amino acids, hindering growth by disrupting IGF-1 signaling at the growth plate.[12] The study also revealed a strong association between low maternal education (less than 9 years) and stunting, with mothers having low education levels being 3.97 times more likely to have stunted children compared to those with over 9 years of schooling. This finding aligned with Indonesian research indicating a significant relationship between low maternal education and stunting.[1] Meta-analyses in developing countries suggested that mothers with low education levels were 3.23 times more likely to have stunted children compared to those with higher education. Maternal education impacted mothers' knowledge and attitudes toward nutrition and health care for their families.[12-15]

Children's linear growth can be affected by both acute and chronic infections. A significant relationship was found between recurrent URTI and stunting, with a p-value of 0.01, indicating that children with URTI were 3.78 times more likely to be stunted. This aligned with research in Indonesia, which showed that a history of infections occurring more than three times consecutively in the past three months increased the risk of stunting by 3.44 times.[16] Other studies indicated that children frequently experiencing infections were 2.89 times more likely to be stunted.[17] Repeated infections can disrupt growth hormones, increase energy requirements to support immune responses, and hinder cell repair. They may also reduce appetite and cause malabsorption. Pathogens elevate cytokines TNF-α and IL-1, which are involved in inflammation, and these elevated cytokines can lower IGF-1 levels, a crucial growth hormone, thereby inhibiting children's linear growth.[18]

There was a significant relationship between gender and stunting, with male children being 3.01 times more likely to experience stunting compared to female children. This finding aligned with research in Indonesia, which showed that male children were 2.25 times more at risk of stunting than females.[19] Additionally, research from Ethiopia indicated a relationship between gender and stunting, with a p-value of 0.003. The study explained that nutritional needs are partially determined by gender due to differences in body composition, leading to varying nutritional requirements. Males typically have more muscle mass and less fat tissue than females, and muscle tissue is metabolically more active, requiring more energy.[20]

In this study, out of 180 samples, 31 children were born with LBW, while 149 children were born with normal birth weight. Among the 31 children with LBW, 80.6% experienced stunting. A significant association was found between low birth weight and the incidence of stunting, indicating that children with LBW were 5.4 times more likely to be stunted. This

finding was consistent with research from East Nusa Tenggara (NTT), which showed that children with LBW were 2.1 times more likely to experience stunting. Low birth weight is a predictor of stunting because growth delays begin in the womb. However, the relationship between a history of LBW and stunting was found to be non-significant after multivariate analysis, which controlled for confounding variables such as the child's gender, birth length, history of upper respiratory tract infections (URTI), low protein intake, maternal education, and maternal MUAC during pregnancy.

This preliminary study took place across several districts in Dili, the capital of Timor-Leste. Data were collected proportionally from all community health centers in Dili, making the results representative of the city. However, the study had limitations. Assessing children's food intake through a single 24-hour recall only reflects their status at that moment, while stunting is a result of chronic malnutrition that requires multiple recalls or a Semi-Quantitative Food Frequency Questionnaire (SQFFQ) for accurate evaluation. Additionally, matching between case and control groups was based solely on location, not other variables. Despite this, the study performed a multivariate analysis to consider the influence of confounding factors.

Conclusions

Children born to mothers with anemia during the third trimester of pregnancy in Dili, Timor-Leste had a higher risk of experiencing stunting compared to children born to mothers without anemia. Children with a history of low birth weight in Dili, Timor-Leste also had a higher risk of stunting compared to those with normal birth weight. Other factors, such as birth length, maternal mid-upper arm circumference (MUAC), children's protein intake, history of infections, and maternal education levels, needed to be considered as contributing factors to the incidence of stunting in Timor-Leste.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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