ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

INNOVARE ACADEMIC SCIENCES
Knowledge to Innovation

Vol 18, Issue 2, 2025

Online - 2455-3891
Print - 0974-2441

Research Article

THE ROLE OF IRON FOLIC ACID AND MULTIPLE MICRONUTRIENTS IN TYPE OF CHILDBIRTH DELIVERY: ECONOMIC AND HEALTH IMPLICATION

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Received: 24 November 2024, Revised and Accepted: 08 January 2025

ABSTRACT

Objective: Pregnancy is a critical period that can pose nutritional challenges, such as chronic energy deficiency and anemia, increasing maternal mortality risk. The World Health Organization recommends iron and folic acid supplements to mitigate these risks. This study compared labor types and associated costs between iron-folic acid (IFA) and multiple micronutrient (MMN) supplementations during pregnancy.

Methods: An economic evaluation was conducted retrospectively at Semen Padang Hospital, analyzing data from January to December 2021. A total of 201 pregnant women were included, with 128 undergoing cesarean delivery. Cost data were collected from the hospital's perspective and analyzed to identify differences between supplementation groups.

Results: Total direct costs did not differ significantly between the IFA and MMN groups (p=0.82). However, medical costs varied substantially, with cesarean delivery costs being approximately 5 times higher than normal delivery costs.

Conclusion: This study emphasizes the economic burden of cesarean deliveries compared to normal births and highlights the need for further evaluation of micronutrient supplementation's cost-effectiveness. Findings advocate for policies that optimize maternal health outcomes and reduce delivery-related costs, addressing the high incidence of elective cesarean sections.

Keywords: Dietary, Pregnancy, Labor, Cesarean, Costs.

 DOI: http://dx.doi.org/10.22159/ajpcr.2025v18i2.53549. Journal homepage: https://innovareacademics.in/journals/index.php/ajpcr

INTRODUCTION

Pregnant women are a group vulnerable to malnutrition. The inability of pregnant women to fulfill nutritional needs during pregnancy will cause chronic energy deficiency and anemia, as well as an increased risk of morbidity and death in pregnant women [1]. Lack of iron intake in pregnant women can cause anemia, which will increase the risk of bleeding and giving birth to babies with low birth weight [2–4]. Several previous studies have shown that providing supplements containing vitamins and minerals such as Vitamin A, iron, zinc, calcium, and folic acid can improve the health status of pregnant women and their babies [5].

Research conducted in South Asia shows that pregnant women experience a folic acid deficiency of around 12–26% [6]. Folic acid belongs to the B Vitamin group. This vitamin is formed from three components: pteridine derivatives, p-aminobenzoate, and one or more glutamate [7,8]. Folic acid has an important role during pregnancy, for example, in preventing neural tube defects, which are very dangerous for subsequent development [9-12]. In 2004, the Centers for Disease Control and Prevention estimated that the number of pregnancies with neural tube defects had decreased following the 1998 mandatory program of cereal products with folic acid [9]. This substance is really needed in the 1st weeks of pregnancy for embryo growth. Folic acid itself also has the function of preventing anemia in mothers and reducing the baby's weight [13]. The body cannot store folic acid, so mothers must consume folic acid or foods that contain lots of folic acid during pregnancy. The body needs 4–5 times the normal amount of folic acid during pregnancy. It is recommended to take folic acid tablets as 0.5–0.8 mg (500–800 mcg) of folic acid orally once a day [7].

Pregnant women need iron to prevent anemia and maintain optimal fetal growth [14]. Iron makes blood healthy and prevents anemia. Pregnant women need a lot of iron to get enough energy, prevent heavy bleeding during childbirth, ensure that the fetus can form healthy blood, and store iron for the first few months after giving birth. Even if they eat iron-rich foods daily, pregnant women will find it difficult to get enough iron, so mothers must drink iron tablets or syrup.

Normal delivery is the process of giving birth to a baby that occurs at a full-term gestational age (more than 37 weeks) without any complications, namely with the mother's own power, without the help of tools, and without injuring the baby and mother. Spontaneous labor generally lasts 24 h. Abnormal delivery is vaginal delivery with tools or through the abdominal wall by cesarean section [15].

At present, the Indonesian government recommends pregnancy supplements in the form of iron and folic acid. Several other pregnant women choose to consume folic acid, iron, and other food supplements (multiple micronutrients [MMN]) as per World Health Organization recommendations. In previous research by Shankar, it was known that the use of MMN could reduce infant mortality rates in Indonesia. Meanwhile, research conducted by Fitria also states that the use of MMN can reduce the disability-adjusted life year rate in pregnant women [1]. Another thing that must be considered is the effectiveness of therapy from an economic perspective because the economy changes every year. Cost-effectiveness analysis is important in evaluating treatment strategies' relative costs and benefits [16].

These findings highlight the potential of MMN as a superior supplementation strategy, yet questions remain regarding its cost-

effectiveness, particularly in the context of delivery outcomes such as cesarean sections. Cesarean deliveries, while often necessary, are associated with higher medical costs and increased risks compared to normal deliveries, further emphasizing the importance of evaluating supplementation strategies from both clinical and economic perspectives. Therefore, research on cost analysis of the use of MMN in the form of delivery, especially in cesarean delivery, needs to be carried out. This study is novel in its focus on the economic evaluation of MMN supplementation compared to traditional iron-folic acid (IFA) supplementation, with particular attention to delivery type and associated costs. By retrospectively analyzing data from a hospital perspective, this research seeks to fill a critical gap in the literature: the lack of robust cost-effectiveness analyses of prenatal supplementation strategies in Indonesia. Previous studies have largely focused on clinical outcomes without considering the economic burden on health-care systems and families. Given the dynamic economic environment and rising health-care costs, this study is timely and essential for informing policies aimed at optimizing maternal health outcomes while minimizing costs.

This study aims to determine the value of the cost and effect of adding food supplements during the pregnancy process. Furthermore, it is hoped that this research will help health personnel and the wider community who expect effective treatment with minimal costs. The findings of this study are expected to provide actionable insights for health-care providers and policymakers. By identifying the most cost-effective supplementation strategy, this research can guide resource allocation, improve maternal and neonatal health outcomes, and reduce the financial burden on families and health-care systems. Moreover, it can serve as a foundation for future research exploring broader economic and therapeutic implications of prenatal care interventions in Indonesia and other low-to-middle-income countries.

METHODS

Time and location

The research was conducted at Semen Padang Hospital, Padang, in the Medical Records section. This research focuses on analyzing a specific subset of pregnant women at Semen Padang Hospital over the course of the year 2021.

Research design

The research is descriptive-observational with retrospective data collection.

Sample and inclusion criteria

The primary sample includes all pregnant women who delivered at this facility from January to December 2021. To refine the study group further, several inclusion criteria were applied, which were: participants were selected based on their payment category, specifically those under the "general" payment classification. This criterion helps to standardize economic variables that might influence access to and types of received health-care services. The study exclusively considered pregnant women who received food supplements solely from Semen Padang Hospital, excluding any external nutritional aids or interventions. This approach ensures that the nutritional variables are consistent across the sample, allowing for a clear assessment of the impact of the hospital-provided supplements on the health outcomes of cesarean deliveries. By maintaining strict control over the sample population and inclusion criteria, the study aims to generate reliable data on the effects and costs of MMN consumption during pregnancy in a hospital setting, providing valuable insights for health-care policies and practices.

Standard and intervention

In this study, pregnant women who received additional food supplements (MMN) were a new group, and pregnant women who received iron and folic acid were the standard group. MMN itself consists of a combination of neurotropic, calcium, zinc, and Vitamin C. Hence, in total, the new treatment group received a combination of folic acid, iron, neurotropic, calcium, zinc, and Vitamin C.

Data analyse

Data were analyzed descriptively and then grouped into Microsoft Excel®. After the data have been grouped, the medical costs for each patient are calculated. The mean difference results from the two groups observed will be compared using T-test [17], and more than two groups will be compared using the One-way ANOVA test [18]. The association between categorical variables in sociodemographics was tested using the Chi-square test [19].

Research procedures

The research procedure for this study is illustrated through a systematic flowchart. Initially, the process begins with obtaining permission from the hospital, ensuring compliance with ethical and institutional regulations. Following this, the population is defined as all pregnant women at Semen Padang Hospital. From this population, a sample of pregnant women is selected to represent the study group. The next step involves collecting patient data, which includes both clinical and economic information relevant to the study objectives. Subsequently, the direct medical costs incurred by the patients are calculated, providing the foundation for the economic analysis. Finally, the collected data are used to compute the incremental cost-effectiveness ratio (ICER), generate a Tornado Diagram for sensitivity analysis, and create a Cost-Effectiveness Diagram to visually represent the outcomes. This structured approach ensures a comprehensive evaluation of both the economic and clinical aspects of supplementation strategies during pregnancy, contributing valuable insights for optimizing maternal health-care practices.

RESULTS

This research analyzed the cost-effectiveness of pregnant women who used supplements for pregnant women at Semen Padang Hospital, Padang, in the period January–December 2021. The supplements looked at in this study were folic acid, iron, and MMNs (neurotropic, calcium, zinc, and Vitamin C). From January to December 2021, 151 patients with national insurance and 272 general-category patients gave birth at Semen Padang Hospital. Patients who met the inclusion criteria in this study were 201 patients, with details of 73 patients giving birth normally and 128 patients giving birth by cesarean section.

Sociodemographic characteristics

This study grouped sociodemographic data by age, treatment class, and type of supplement. Table 1 depicts sociodemographic characteristics.

The table compares the characteristics of normal and cesarean deliveries. Most participants were aged 20–35 years, with no significant difference between groups (p=0.161). Class distribution shows the majority in class 1 for both normal (69.86%) and cesarean (64.85%) deliveries, with no significant variation (p=0.667). Regarding supplements, IFA was more commonly used than MMN in both groups, with no significant difference observed (p=0.767). These findings highlight similar demographic and supplement usage patterns between delivery types.

Direct medical cost

Direct costs are those directly related to health care, including drug costs (and health supplies), doctor consultation costs, nurse service costs, use of hospital facilities (inpatient rooms and equipment), laboratory tests, informal service costs, and other health costs [20]. Table 2 shows direct medical costs in this study. The table compares the costs of normal and cesarean deliveries with different supplement regimens (MMN and IFA). For normal deliveries, MMN costs IDR 398,638,769, whereas IFA is higher at IDR 676,493,151. Cesarean deliveries are also more expensive, with MMN totaling IDR 1,501,540,763, and IFA at IDR 2,210,547,389. The total direct costs for MMN are IDR 1,900,179,532, and for IFA, they amount to IDR 2,887,040,540. These costs encompass administration, in-patient care, supplements, and delivery charges.

Table 3 compares costs incurred by type of birth in the IFA and MMN groups. There was no significant difference in delivery costs between

the two groups. Meanwhile, differences in costs paid for each mode of delivery are shown in Table 4.

The table presented a comparison of costs associated with IFA and MMN, showing the mean±standard deviation (SD) and p-values for different categories. For outpatient and inpatient administration costs, both regimens have the same cost (IDR 25,000 and IDR 75,000, respectively), with p-values of 1.00, indicating no significant difference. The medical cost for IFA (IDR 1,239,178.03±833,964.66) is significantly higher than for MMN (IDR 802,244.17±573,757.45), with a p-value of 0.00, indicating a statistically significant difference. The delivery cost is almost identical between the two groups (IFA: IDR 22,520,661.16±7,174,432.82, MMN: IDR 22,850,000±7,392,435.40) with a p-value of 0.74, showing no significant difference. The total direct cost for both groups is equal (IDR 23,859,839.18±7,239,564.76) with a p-value of 0.82, indicating no significant difference between the two regimens in terms of total cost.

Table 4 shows spontaneous deliveries incur significantly lower costs than cesarean sections in both delivery and total direct costs (p=0.00). Outpatient and inpatient administration costs are consistent across all groups at 25,000 IDR and 75,000 IDR, respectively (p=1.00). Medical costs show no statistically significant differences (p=0.26) but vary between groups, with spontaneous deliveries and unspecified cesarean sections being the least and most costly, respectively. Elective and emergency cesarean sections have higher delivery and total costs compared to spontaneous deliveries, highlighting a significant financial disparity between delivery types.

Incremental cost-effectiveness ratio (ICER) for cesarean in low resource setting

Using the ICER formula, it was obtained $\Delta cost / \Delta effect$, as $-\text{IDR}986{,}861{,}008 / -24$.

The ICER is equal IDR 41,119.208. Based on the table's results, the cost-effectiveness plane can be analyzed. Fig. 1. shows ICER value on the effectiveness plane of adding food supplements to pregnant women.

The ICER value, represented by a diamond marker, is positioned in Quadrant III, with a negative incremental cost of approximately -986.861 million IDR and a negative incremental effect of −24. This placement indicates that the food supplementation intervention results in lower costs and reduced effectiveness for cesarean deliveries compared to the comparator (e.g., standard care or IFA). The figure suggests that while the intervention reduces costs, it is less effective, raising questions about its overall value in improving maternal health outcomes.

DISCUSSION

Semen Padang Hospital implements a policy where general patients are categorized into five distinct classes: VVIP class, VIP class, class 1, class 2, and class 3. Each class is divided based on the facilities offered. Each class has a different cost. The highest cost for normal delivery is the VVIP class, with a cost range of IDR 15,000,000 to IDR 20,000,000, and the lowest cost for class 3 starts from IDR 3,000,000 to IDR 10,000,000. Meanwhile, the highest range for delivery by cesarean section is the VVIP class, with a cost range of IDR 30,000,000 to IDR 37,000,000. Cesarean delivery with the lowest cost range is class 3 with IDR 18,000,000 to IDR 23,000,000. These costs are incurred from entering the hospital until being allowed to go home.

Table 1: Description of sociodemographic characteristics

Characteristics	Attribute	Normal delivery (n=73), n (%)	Cesarean delivery (n=128), n (%)	p
Age (year)	20–35	62 (84.93)	116 (90.62)	0.161[a]
	>35	11 (15.07)	12 (9.38)	
Class	VVIP	0	3 (2.34)	0.667[b]
	VIP	15 (20.55)	26 (20.31)	
	1	51 (69.86)	83 (64.85)	
	2	7 (9.59)	16 (12.50)	
Type of supplements	MMN	28 (38.36)	52 (40.63)	0.767[a]
	IFA	45 (61.64)	76 (59.37)	

[a]Chi-square, [b]Fisher. Study from 201 patients. MMN: Multiple Micronutrient, IFA: Iron folic acid

Table 2: Direct medical cost calculation

Category	Costs (IDR)				
	Administration	In-patient	Supplements	Delivery	Total
Normal delivery (MMN)	700,000	2,100,000	19,994,522	289,000,000	398,638,769
Normal delivery (IFA)	1,125,000	3,375,000	54,482,218	617,000,000	676,493,151
Cesarean (MMN)	1,300,000	3,900,000	42,340,763	1,454,000,000	1,501,540,763
Cesarean (IFA)	1,900,000	5,700,000	94,947,389	2,108,000,000	2,210,547,389
Total direct cost of MMN					1,900,179,532
Total direct cost of IFA					2,887,040,540

Study from 201 patients. MMN: Multiple Micronutrient, IFA: Iron folic acid

Table 3: Comparison of costs incurred by type of birth in iron folic acid and multiple micronutrient groups

Type of cost	IFA (mean±SD)	MMN (mean±SD)	p
Outpatient administration costs	25,000±0.00	25,000±0.00	1.00[a]
Inpatient administration costs	75,000±0.00	75,000±0.00	1.000[a]
Medical cost	1,239,178.03±833,964.66	802,244.17±573,757.45	0.00[b],*
Delivery cost	22,520,661.16±7,174,432.82	22,850,000±7,392,435.40	0.74[b]
Total direct cost	23,859,839.18±7,239,564.76	23,859,839.18±7,239,564.76	0.82[b]

*Significant level at p<0.05, [a]The (SD) of both groups are 0, [b]*t*-test. Study from 201 patients. SD: Standard deviation, MMN: Multiple Micronutrient, IFA: Iron folic acid

Table 4: Differences in costs paid for each mode of delivery

Type of cost	Spontaneous delivery (n=73)	Cesarean section			p
		Emergency (n=25)	Elective (n=96)	Unspecified (n=7)	
Outpatient administration costs	25,000±0.00	25,000±0.00	25,000±0.00	25,000±0.00	1.00[a]
Inpatient administration costs	75,000±0.00	75,000±0.00	75,000±0.00	75,000±0.00	1.00[a]
Medical cost	1,052,492.07±740,177.22	1,211,755.53±769,936.08	1,072,769.89±80,8621.42	572,622.29±320,641.49	0.26[b,*]
Delivery cost	13,575,342.47±1,420,756.91	27,340,000.00±26088958.92	27,895,833.33±2,739,493.48	28,642,857.14±1,951,800.14	0.00[b]
Total direct cost	14,727,834.54±1,553,896.24	28,651,755.53±2,622,045.33	29,068,603.22±2,912,911.17	29,135,479.43±1,852,537.90	0.00[b]

*Significant level at p<0.05, aThe SD of both groups are 0, [b]One-way ANOVA. Study from 201 patients. SD: Standard deviation

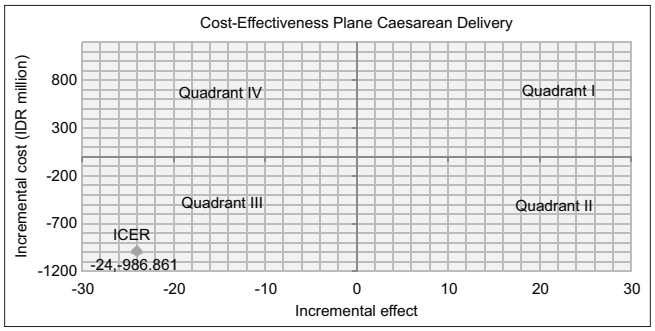

Fig. 1: Incremental cost-effectiveness ratio value on the effectiveness plane of adding food supplements to pregnant women

There were no baseline differences in sociodemographics in either the MMN or IFA groups. In the overall results of sociodemographic data, there was no significant difference in the number of patients who consumed dietary IFA or MMN. However, if we look at the details of the costs incurred in each group, there are several significant differences, especially in drug costs and childbirth costs, which result in differences in the total costs incurred.

It can be seen here that the cost of a cesarean operation is more than five times the cost of a normal birth. This is because the ratio of the number of mothers who gave birth normally and by cesarean section is not significantly different. Only medical costs had a significant difference between the IFA and MMN groups because whatever the multiplier factor, the MMN price will still be much more expensive than the IFA [21].

The interesting thing is the large number of pregnant women who want an elective cesarean section. The high number of elective cesarean sections is caused by previous C-sections, medical conditions, advanced maternal age, and multiple pregnancies. Social factors such as patient preference for convenience, fear of labor pain, cultural influences, and the scheduling flexibility of C-sections also contribute [22]. In addition, health-care system practices, provider recommendations, and concerns over legal risks play a significant role in the increasing rates of elective cesarean deliveries [23,24].

ICER calculates the ratio between the difference in costs and the difference in effects that will result (in this case, cesarean delivery) from the two interventions to be assessed. Interventions can be placed on this diagram according to their costs and additional benefits [25]. The cost difference is placed on the y-axis (vertical), and the effect difference is on the x-axis (horizontal). Fig. 1 shows the ICER value on the effectiveness curve of adding food supplements to pregnant women.

The Cost Effectiveness Diagram for cesarean delivery shows that the ICER is at the point (-24; -986,861,000), meaning Δ cost, which is worth -IDR. 986,861,000 and the difference in the number of cesarean deliveries in the MMN group and the IFA group is 24 patients. It can be seen in the diagram that the ICER point is in quadrant III. In quadrant III, this means that the costs in the MMN group were lower than those in the IFA group because the results of the difference were negative, whereas the MMN group had fewer effects than the IFA group. These results indicate that policies with the MMN group must be re-evaluated. The number of cesarean deliveries in the MMN group was smaller than cesarean deliveries in the IFA. According to the US Food and Drug Administration, pregnant women need MMNs that are more complete than just IFA alone [1].

The results obtained in this study were found for ICER for normal delivery in quadrant III and ICER for cesarean delivery in quadrant III. The difference in the number of normal deliveries in the MMN group was not as big as the difference in the number of cesarean deliveries in the MMN group. The fairly high range of delivery costs also influences the results obtained.

The use of various dietary supplements during pregnancy has been studied for a variety of impacts, including maternal health, and mode of delivery, potentially reducing complications that can lead to cesarean delivery [26-28]. Micronutrients, including iron, folic acid, zinc, calcium, and vitamins, play an important role in supporting maternal and fetal health [7]. Adequate nutritional intake can support the normal growth and development of the fetus and help prevent conditions such as anemia in the mother, which is associated with a higher risk of adverse pregnancy outcomes [1].

Similar studies have shown that supplementation with various micronutrients can provide several benefits compared to iron and folic acid supplementation alone, potentially increasing birth weight and reducing maternal anemia rates [26,29,30]. However, the relationship between micronutrient supplementation and mode of delivery (such as cesarean section) is complex and influenced by many factors, including maternal health status, nutritional status, the presence of pregnancy-related complications, and health-care practices [6].

For specific data regarding the cost-effectiveness analysis of the use of several micronutrients. However, the relationship between micronutrient supplementation and mode of delivery (such as cesarean section) is complex and influenced by many factors, including maternal health status, nutritional status, the presence of pregnancy-related complications, and health-care practices. On the outcomes of cesarean delivery, it is necessary to consult the most recent clinical trials, systematic reviews, or health economic studies published in scientific journals or reports from health organizations. These studies will analyze the costs associated with administering MMN supplements to pregnant women compared to the outcomes of cesarean delivery, taking into account factors such as reduced cesarean section rates, improved maternal and infant health, and long-term health benefits for mother and child [6]. When the ICER is in the Southeast quadrant, this indicates that the new intervention is more effective and cheaper than the

comparison intervention. This situation is considered very favorable in health economics because it shows that the new intervention is the "dominant" option [31].

Cesarean operations are significantly more expensive than normal births, and medical costs differ notably between IFA and MMN groups due to MMN's higher price. Elective cesarean sections are common and influenced by medical and social factors. Cost-effectiveness analysis (ICER) showed that MMN is less cost-effective than IFA, requiring policy reevaluation. The ICER for cesarean deliveries in the MMN group indicated lower costs but fewer benefits compared to the IFA group. This suggests that while micronutrient supplements can support maternal and fetal health, their cost-effectiveness and impact on delivery methods are complex and need further assessment through comprehensive studies.

The study highlights several discrepancies, limitations, and implications for future research regarding the cost-effectiveness of micronutrient supplementation (MMN) compared to IFA during pregnancy. A notable discrepancy lies in the wide cost variation for deliveries across hospital classes, with cesarean deliveries costing significantly more than normal births. This variation introduces confounding factors unrelated to supplementation, potentially distorting cost-effectiveness analyses. In addition, the ICER findings, which place both normal and cesarean deliveries in quadrant III, suggest that MMN is less cost-effective than IFA. However, this result may reflect external influences, such as MMN pricing policies or health-care practices, rather than intrinsic efficacy differences. Furthermore, while MMN is associated with fewer cesarean deliveries, its higher cost raises questions about whether the clinical benefits justify the increased economic burden, revealing inconsistencies between clinical outcomes and cost-effectiveness.

The study is limited by its single-site design, which restricts the generalizability of findings to broader health-care contexts. In addition, key confounding factors such as maternal age, nutritional status, and health-care provider practices were insufficiently controlled, which could have significantly influenced outcomes. The scope of outcomes assessed was narrow, focusing primarily on delivery costs and methods without considering long-term maternal and infant health outcomes. Non-medical costs, such as transportation and lost productivity, were also excluded, limiting the comprehensiveness of the analysis.

Future research should address these gaps by conducting multicenter studies in diverse health-care settings to enhance generalizability. Comprehensive evaluations should include long-term health outcomes for mothers and infants and account for indirect costs to provide a holistic perspective. Controlling for confounding factors is essential to isolate the true effects of MMN and IFA supplementation. Finally, investigating pricing strategies to reduce MMN costs and exploring broader health economics frameworks, such as cost-utility analyses, can inform policies to optimize maternal and child health interventions effectively.

CONCLUSION

Cesarean deliveries are notably more expensive than normal births, with medical costs differing significantly between the IFA and MMN groups due to MMN's higher price. Elective cesarean sections, influenced by medical and social factors, exacerbate this cost disparity. ICER analysis indicates that MMN is less cost-effective than IFA, particularly for cesarean deliveries, highlighting the need for policy reevaluation regarding micronutrient supplementation. While MMN supports maternal and fetal health, its higher cost and complex relationship with delivery methods call for further investigation. The study also reveals discrepancies and limitations, including the wide variation in delivery costs across hospital classes and external factors impacting MMN pricing, which may confound ICER findings. Despite MMN's association with fewer cesarean deliveries, its higher cost raises concerns about whether the clinical benefits justify the economic burden. Limitations such as single-site design, insufficient control of confounding factors, and a focus on short-term outcomes restrict generalizability and comprehensiveness. Future research should address these gaps through multicenter studies in diverse settings, controlling for maternal and provider factors, assessing long-term maternal and infant outcomes, and including indirect costs. Exploring pricing strategies and adopting cost-utility frameworks could optimize maternal and child health interventions by balancing clinical benefits with economic sustainability.

AUTHORS CONTRIBUTION

NF designed the study. SPA conducted the fieldwork. NF and HN supervised data collection in the field. NF checked conceptual variables and wrote the manuscript. NF checked the statistical value. AM checked the cost evaluation part. All authors read and approved the final version.

CONFLICT OF INTEREST

The author(s) declare no conflict of interest regarding this manuscript.

FUNDING

No funding for this study

ETHICAL APPROVAL

This research has received ethical approval from the Faculty of Medicine, Andalas University, with Number 748/UN/16.2/KEP-FK/2022.

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