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Prenatal multiple micronutrient supplementation in the Parepare district, Indonesia; population characteristics and intake adherence

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Abstract

Background Micronutrient deficiencies among pregnant women remain highly prevalent in low and middle-income countries. Multiple micronutrient supplementation (MMS) has been proven more beneficial than standard iron-folic acid supplementation in reducing adverse pregnancy outcomes. Limited data on adherence to MMS in pregnant women in programmatic settings is available. Therefore, our study aims to assess adherence to the recommended intake of a multiple micronutrient supplement (UNIMMAP-MMS) in relation to demographic characteristics alongside a community-based MMS program.

Method A prospective longitudinal study was performed in the Parepare district, South Sulawesi province, Indonesia, including 1216 participants. MMS was provided at the first antenatal care visit and women were followed up until delivery. The number of MMS tablets consumed, the start of MMS intake and information regarding possible intake determinants were recorded. Adherence was defined as ≥ 90 tablets. Binary logistic regression was used to assess associations between characteristics of women and adherence.

Results Among the 655 women (53.9%) who started MMS intake in the first trimester, approximately 90% continued using MMS in the following trimesters and 75.3% consumed MMS ≥ 90 tablets. Among the 41.2% of women who started in the second trimester, 90% continued intake in the third trimester and 32.3% consumed ≥ 90 tablets. Only 4.9% started MMS in the third trimester. Overall adherence to MMS was 53.9%. Factors that impacted MMS intake were pregnancy interval ≤ 2y (AOR = 0.65, 95% CI 0.46, 0.92), start of MMS use in the second trimester and third trimester (AOR = 0.15, 95% CI 0.12, 0.20) and (AOR = 0.01, 95% CI 0.00, 0.04) respectively, being overweight (AOR = 1.44, 95% CI 1.04, 2.00) and experiencing no side effects (AOR = 3.46, 95% CI 1.82, 6.58).

Conclusion Implementation of MMS via community health centers resulted in high adherence once supplementation started. As many women started MMS late, attention to antenatal visit planning earlier in pregnancy can be further improved.

Keywords Multiple micronutrient supplementation, Adherence, Pregnant women, Intake, Trimester

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Background

Micronutrient deficiencies among pregnant women are highly prevalent in both developed and low- and middle-income countries (LMICs) [1, 2]. Iron deficiency anaemia, the most common micronutrient deficiency, affects 36.5% of pregnant women, most of them live in South Asia and Africa [3]. A recent study that re-analyzed national data from multiple regions revealed that 69% of women of reproductive age (WRA) suffered from deficiencies in one of three micronutrients, of which approximately 57% lived in the Southeast Asia and Pacific region [1]. Another study that reviewed micronutrient intake in LMICs revealed that among women of reproductive age 63.2% were vitamin D deficient, 41.4% were zinc deficient, 22.7% were folate deficient, and 15.9% were vitamin A deficient [4]. Entering pregnancy with these deficiencies makes it even more challenging for women to meet adequate micronutrient status during the pregnancy due to an increased need for these nutrients for placental development, to maintain mother's health, and to support the growing fetus [2, 5].

Failure to meet micronutrient requirements during pregnancy increases the risk of pregnancy complications and adverse health outcomes in both mothers and babies. Iron deficiency anaemia, for example, is associated with decreased birth weight, an increased risk of neural tube defects, and other adverse pregnancy outcomes [4–6] Similarly, inadequate essential micronutrients such as vitamins A, B, D, E, zinc, and calcium can also result in poor pregnancy outcomes, impaired fetal growth, and adverse child health outcomes [6, 7]. A recent study investigating the effect of a multi-micronutrient supplement starting during the pre-pregnancy period and continued throughout pregnancy showed a 56% reduction in the incidence of preterm birth [8]. A lancet systematic review published in 2019 estimated that 15 million babies were born preterm [9] and about 20.5 million were low birth weights and of them 91% were born in LMICs [5]. These children were at high risk of stunting, impaired cognitive development and cardiovascular diseases in adulthood [7, 10]. Supplementation with multiple micronutrient supplement (MMS) has been proposed to be an effective approach to reduce these problems, particularly in LMICs [2].

Several studies using prenatal United Nations International Multiple Micronutrient Antenatal Preparation (UNIMMAP-MMS) which contains 15 essential micronutrients including iron and folic acid suggested that this supplement may be a safe and cost-effective approach, and positively affects maternal health and pregnancy outcomes [6, 11–13]. A recent systematic review and meta-analysis showed that MMS may provide more benefits compared to iron-folic acid (IFA) supplementation on low birth weight, preterm birth, and small for gestational age incidence [11, 14, 15]. Although the supplement has not yet been recommended as a universal approach by the World Health Organization (WHO) to replace IFA, the current recommendation states that MMS might be used in areas where a high prevalence of multiple micronutrient deficiencies exists [7].

Given emerging evidence suggesting that MMS is superior to IFA, several developing countries, including Indonesia, have started to explore the possibility of shifting from IFA to MMS as part of standard antenatal care services (ANC). This early phase of local implementation provides a unique opportunity to assess effectiveness of MMS in programmatic setting as suggested by a WHO recommendation [7]. We therefore investigated the adherence to MMS alongside the community-based MMS initiative by recruiting and follow up women in the Parepare district in Indonesia after MMS introduction via the community health care system. The data allow exploration of factors that potentially affect adherence and would provide early insights into possible barriers. Moreover, this information can be useful for stakeholders to optimize the utilization of the MMS program as a part of routine ANC in further large-scale nationwide implementation programs.

Methods

Study design and setting

This prospective longitudinal study was conducted in Parepare, South Sulawesi province, Indonesia from August 2021 to November 2022. This medium urban area is approximately 99.3 km^2 in size with a population density of 1.530 per km^2; most of the population (78.9%) works in the services sector, and only 4.3% works in the agriculture sector. Parepare consists of four subdistricts, has four hospitals and eight community health centers (puskesmas). A puskesmas is a major source of primary health care, referral services, health promotion and community services. It is staffed by general practitioners, dentists, nurses, midwives, pharmacists, nutritionists, and laboratory analysts. Antenatal care services (ANC) are provided by midwives and regular visits are scheduled every month. Information related to the pregnancy is recorded in the Maternal and Child Health Book (MCHB). The start of our study coincided with the start of the local MMS implementation program to replace IFA supplementation in Parepare. The MMS program has been integrated into ANC services at the puskesmas level.

Study population

Participants were identified from antenatal records which were available in community health center facilities. The inclusion criteria were women who were willing to consume MMS. Women who had started MMS before

inclusion were also allowed to participate if the start of MMS use was documented in the MCHB. The former was determined by asking these women during the first ANC whether they wanted to consume the MMS and participate in this study, whereas the latter was determined by checking the remaining tablets in their current prescription bottle to check intake up to the recruitment visit. Participating women were required to be planning to stay in the town during pregnancy, and to have a MCHB. As not all pregnant women had the same gestational age at the time of their first ANC visit, the recruitment was done at any gestational age. The late MMS introduction for part of the included population was partly explained by the prevailing covid 19 pandemic, during which the government imposed restrictions for health care visits and only allowed pregnant women who were experiencing complication or serious symptoms to seek face to face medical attention. All women were then followed up from enrolment until delivery. Written informed consent was obtained from all participants.

Data collection

Data were collected through a paper-based structured questionnaire (Supplementary file 1) after which the data were entered into a corresponding electronic version of the questionnaire on mobile devices. These devices were regularly synchronized with the secure database constructed using REDCap (Research Electronic Data Capture, projectredcap.org). Data collection was performed by midwives who underwent a comprehensive training program. During the training session, the topics addressed thorough understanding and familiarity with the questionnaire content, the way to perform the interview, strategies to minimize response bias, and ensuring data accuracy and completeness. In addition, a practical exercise was provided to ensure that the midwives were well prepared for data collection process. Two midwives were assigned to each community health center facility. They started data collection by identifying potential participants from the registered cohort record, which contained brief information about pregnant women attending ANC in the community. Midwives were chosen to perform data collection because they were frontline in delivering services to pregnant women and also were in close contact with them. To ensure data was collected correctly and timely, the researcher performed weekly supervision and regularly visited the midwives. This involved randomly re-interviewing a few pregnant women who had already been interviewed by midwives as well as cross-checking their data as recorded in the MCHB.

MMS distribution and exposure

The MMS, provided by the Vitamin Angels organization (https://vitaminangels.org) to Hasanuddin University, was donated by Kirk Humanitarian. The distribution of the MMS tablets was incorporated into the existing antenatal care program. Women were recruited into the study between August 2021 and November 2022. During the ANC visit at which participants were enrolled, midwives provided 30 tablets of MMS in a bottle and the women were instructed to take one tablet each day. The gestational age at start of MMS consumption was recorded in the MCHB. The pregnant women were asked to record the date when they took the first MMS on their MCHB and to bring back the bottle during the next ANC visit to be replenished with another 30 tablets. At each following ANC visit, the number of tablets consumed was verified before replenishment by the midwives by comparing the number of tablets indicated in the MCHB with the number of remaining tablets in the bottle. If there was a discrepancy between the number of missing tablets from the bottle and what was recorded in the MCHB, the calculation would be based on missing tablets. The duration of MMS exposure was determined by the gestational age of pregnant women at first time of consuming MMS until the gestational age at third trimester when the interview was done. The total number of MMS consumed were counted by the number of missing tablets from the bottle and categorized into adherence if at least 90 tablets were consumed and as non-adherence if less than 90 tablets.

Demographic characteristics, pregnancy outcomes and covariates

Data used in this study was obtained from direct interviews with the participants in the third trimester and from the maternal and child health handbook (MCHB) which contains health records of pregnant women and their babies. The former data include water and sanitation, housing conditions, diet diversity, mental health, and physical activity. The latter covered the mother's characteristics such as occupation, education, gestational age, history of reproductive health, number of MMS received and consumed, and anthropometrics of mother and newborns. A structured questionnaire was used to obtain these data. The gestational age at delivery, method of delivery, birth weight, birth length, head circumference of newborn were obtained by asking the women to take a photograph of the relevant page in the MCHB and sending it to midwives via WhatsApp.

Outcome variable

The primary outcome for analysis was adherence to MMS consumption which was defined by the total number of tablets consumed during the entire pregnancy. Women who consumed ≥ 90 tablets were categorized as adherent

group, whereas those who took < 90 tablets were considered as non-adherent. The cut-off of at least 90 tablets was based on the current IFA national policy recommendation for pregnant women in Indonesia [16]. In addition, we also performed an analysis with a cut-off of 180 tablets as MMS recommended dose [4]. Finally, variables that could be associated with MMS intake adherence including maternal age, education, parity, occupation, BMI status, height, side effects and health insurance ownership were assessed.

Statistical analysis

The sample size calculation for the cohort was not based on adherence, but on the estimated difference in MMS consumption between low birthweight and normal birthweight children. To this end, we used the following assumptions: estimated proportion of low birthweight was 5% and an effect size for MMS consumption of 0.4 to 0.5. With a 5% two-sided alpha level we would have 80% power to detect this effect size, indicating lower MMS exposure in low birthweight children, with a minimum of 1260 mother-infant pairs, 60 low birthweight children and 1200 normal weight children.

Data were analyzed using SPPS Statistics for windows version 28.0. Descriptive analysis including percentage, mean, and standard deviation was calculated to describe participants' characteristics. We performed bivariate analysis to assess the association between adherence and each independent variable. Next, multivariable logistic regression was performed to examine the factors that independently associated with adherence. Variables with p values < 0.05 were included in the multivariable model.

Results

Among 1216 pregnant women who consumed MMS, 53.9% started MMS in the first trimester, 41.2% started in the second trimester and only 4.9% delayed start taking MMS into the third trimester (Table 1). The mean age of the participants was 27.9 years. Most participants were between 20 and 30 years old, had diploma/polytechnic education, no job, had health insurance, were multiparous, had normal pre-pregnancy BMI, height > 150 cm, and experienced no side effects. Additionally, there were no clear differences among the first, second and third MMS started groups for any of the characteristics.

Figure 1 shows MMS consumption patterns based on the time of MMS introduction, excluding women who started only in the third trimester. Women who started MMS consumption in either the first or the second trimester showed largely similar pattern. Once they started taking MMS, most continued taking it until birth. Only < 10% of women did not take MMS regularly (Fig. 1).

Logically, the range in number of MMS tablets consumed differed by the trimester of initiation. The earlier the women started taking MMS, the more MMS were consumed in total. Approximately 75.3% of women who started taking MMS in the first trimester consumed ≥ 90 tablets during pregnancy. This proportion dropped to 31.5% when participants started in the second trimester and was only 1.66% for those who started in the third trimester (Fig. 2). Based on the cut off adherence of 90tablets during the entire pregnancy, approximately 53.9% of women were considered adherent. However, when taking into account the recommended dose for MMS (≥ 180 tablets) which follows the same recommendation as IFA [17] only 39 women (3.2%) met the recommendation and all of them started consumption in the first trimester.

Associations between participant characteristics and adherence are summarized in (Table 2). In the multivariable logistic regression analysis, variables significantly associated with adherence ($p < 0.05$) on univariable analysis were included. In the adjusted model, a shorter inter-pregnancy duration and late MMS introduction were negatively associated with adherence, whereas being overweight and experiencing no side effects had a positive association with adherence. Women with previous pregnancy duration ≤ 2y were 35% (AOR = 0.65, 95% CI 0.46, 0.92) less likely to be adherent than those with longer pregnancy interval. Participants who started taking MMS in the second and third trimester were 85% (AOR = 0.15, 95% CI 0.12, 0.20) and 99% (AOR = 0.01, 95% CI 0.00, 0.04) less likely to be adherent than those in the first trimester. In addition, being overweight was 44% more likely to be adherent (AOR = 1.44, 95% CI 1.04, 2.00) than those with normal BMI. Also, participants experiencing no side effects were 3.46 times more likely to be adherent than another (AOR = 3.46, 95% CI 1.82, 6.58). Overall, late MMS introduction was the highest risk factor for non-adherence.

As the effect of the MMS introduction was strong, we performed a separate analysis for each trimester, and the findings showed a slightly different result between two groups concerning the variables associated with adherence. In the first trimester group, shorter inter-pregnancy duration and experiencing side effects were associated with non-adherence, whereas in the second trimester group, only the mother's occupation was related to non-adherence with MMS use (Supplementary file 1).

Discussion

In the present longitudinal study, monitoring MMS implementation in the community health care system, women's adherence with the 90-day MMS intake recommendation was 53.9%. Women who initiated MMS consumption earlier during their pregnancy were more likely to take it consistently and demonstrated higher

Table 1 Maternal characteristics according to the timing of multiple micronutrient supplementation introduction among pregnant women

Characteristics	Multiple micronutrient supplementation started							
	Total		1st trimester		2nd trimester		3rd trimester	
	n	%	*n*	%	*n*	%	*n*	%
No.of participants	1216		655	53.9	501	41.2	60	4.9
MMS consumed								
Mean ± SD	92.7 ± 42.3		115.4 ± 38.9		69.8 ± 27.7		36.3 ± 14.5	
Age (year)								
Mean ± SD	27.9 ± 5.9		27.9 ± 5.7		28.3 ± 6.1		26.4 ± 6.1	
<20	72	5.9	33	5.0	31	6.2	8	13.3
20-<30	700	57.6	393	60.0	270	53.9	37	61.7
30–35	290	23.8	157	24.0	124	24.8	9	15.0
>35y	154	12.7	72	11.0	76	15.2	6	10.0
Educational level								
Junior high school	136	11.2	65	9.9	66	13.2	5	8.3
Senior high	222	18.3	111	16.9	99	19.8	12	20.0
Diploma/Polytechnic	494	40.6	270	41.2	202	40.3	22	36.7
University	364	29.9	209	32.0	134	26.7	21	35.0
Occupation								
No job	973	80.0	514	78.5	413	82.4	46	76.7
Has Job	243	20.0	141	21.5	88	17.6	14	23.3
Inter pregnancy duration								
First pregnancy	397	32.6	213	32.6	153	30.5	31	51.7
≤2y	350	28.8	181	27.6	152	30.3	17	28.3
>2y	469	38.6	261	39.8	196	39.2	12	20.0
Parity								
Nulliparous	397	32.6	213	32.5	153	30.5	31	51.7
Multiparous	819	67.4	442	67.5	348	69.5	29	48.3
Previous abortion								
Yes	190	15.6	102	15.6	80	16.0	8	13.3
No	1026	84.4	553	84.4	421	84.0	52	86.7
Pre-pregnancy BMI								
Mean ± SD	23.3 ± 4.3		23.5 ± 4.4		23.2 ± 4.3		22.1 ± 3.7	
Underweight	139	11.4	69	10.6	63	12.6	7	11.7
Normal	706	58.1	372	56.8	293	58.5	41	68.3
Overweight	282	23.2	164	25.0	108	21.5	10	16.7
Obesity	89	7.3	50	7.6	37	7.4	2	3.3
Maternal height								
Mean ± SD	152.7 ± 5.1		152.6 ± 5.4		152.7 ± 4.8		154.4 ± 5.1	
<150 cm	304	25.0	166	25.5	126	25.1	12	20.0
≥150 cm	912	75.0	489	74.5	375	74.9	48	80.0
Side effects								
Yes	57	4.7	29	4.4	26	5.2	2	3.3
No	1159	95.3	626	95.6	475	94.8	58	96.7
Owning Health Insurance								
Yes	1161	95.5	634	96.8	471	94.0	56	93.3
No	55	4.5	21	3.2	30	6.0	4	6.7

adherence. Also, being overweight and not experiencing any side effects were associated with a higher adherence rate. Conversely, delayed initiation of MMS and shorter pregnancy intervals were associated with a decreased adherence.

MMS adherence in our study was much higher than the reported adherence for the regional and national existing prenatal IFA supplementation [18]. One of the possible explanations was the method used to monitor adherence, e.g. in this study pregnant women were asked to bring back the bottle to be replenished with MMS

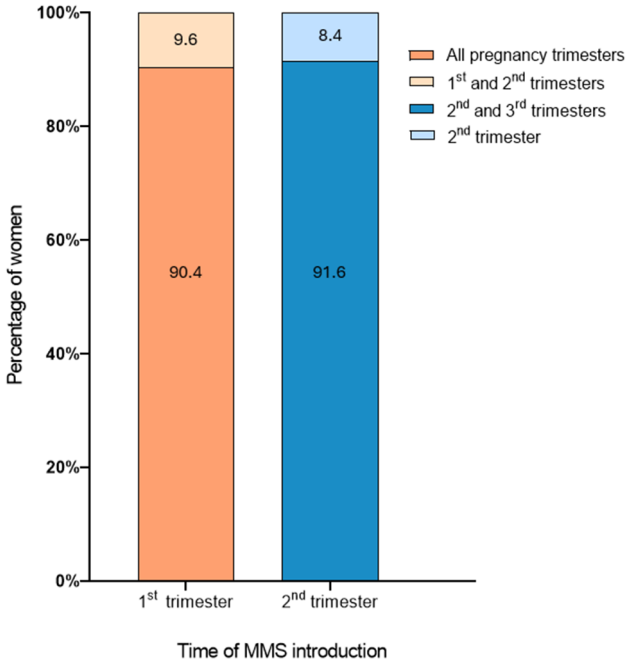

Fig. 1 Percentage of women based on trimester of start of MMS intake (x-axis) and percentage of women continuing MMS intake during subsequent trimesters (y-axis)

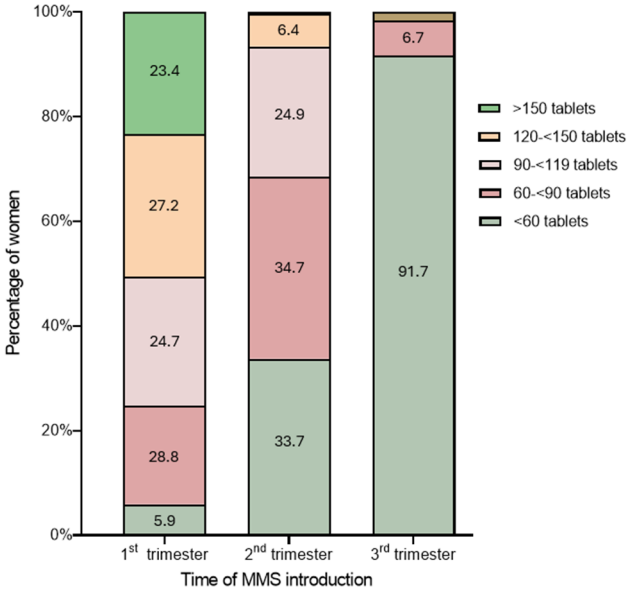

Fig. 2 The percentage of women per trimester according to the total number of MMS consumed

and also to record the date when they took the MMS on the supplementation monitor form in the MCHB. This approach may provide an opportunity to reinforce the importance of adherence to MMS intake. Before this program was initiated all midwives were informed about the supplement, possibly facilitating clear and understandable information sharing of the benefit of the MMS with the participants. Indeed, several IFA studies showed high adherence when mothers were equipped with sufficient information on the benefits of supplementation [19–21].

Compared to previous clinical studies conducted across several developing countries including Indonesia, the adherence in our study was much lower. Previous studies compared MMS and IFA adherence and revealed high adherence (> 80%) with no difference between groups [22–26]. One possible explanation could be the RCT setting, e.g. fully controlled settings, involving community facilitators and local health workers to do home visits to distribute, monitor and encourage MMS consumption. In contrast, the present study investigated MMS intake in a real-world observational setting, where delivery of MMS relied more on the frequency of ANC service contacts as MMS was only available in community health centers. This approach likely reflects the actual setting outside a clinical research study setting more accurately.

As we expected, women starting to consume MMS early in their pregnancy had a higher total number of MMS consumed than those who started later. This finding was consistent with the results of IFA adherence studies [27, 28] showed that women who started taking IFA in the first trimester consumed more IFA than those who started in the second or third trimester. This could be attributed to the longer duration of supplementation leading up to delivery. Furthermore, women who initiated MMS earlier may have a greater awareness of their health and fetal well-being, contributing to better adherence to the supplementation regimen. Interestingly, once women started to take MMS, they tended to continue throughout pregnancy. The national recommendation of having at least four ANC visits during pregnancy, did not ensure higher adherence in the present study. This result is in line with the Indonesia national data showing that the proportion of pregnancies with at least 4 times of ANC visits was 88.8%, but the adherence of IFA intake was low [18]. Increasing the number of regular ANC visits could strengthen women's motivation through ongoing encouragement from health care provides to consistently take the supplements [29]. Therefore, pregnant women should be encouraged to have at least eight ANC visits as advised per WHO recommendation [8] to increase the chance of consuming at least 90 tablets or even 180 as an ideal requirement. More importantly, the first ANC planned within the first trimester of pregnancy should be used to initiate MMS intake as this may drive higher total intakes.

Some factors appeared to affect adherence. Pregnant women with birth intervals < 2y tended to be less adherent. In contrast, women with longer birth intervals might have greater health awareness or different caregiving responsibilities leading to better adherence. Therefore, it may be worth investigating if increasing awareness of pregnant women about the appropriate interval of a

Table 2 Factors associated with adherence to multiple micronutrient supplement among pregnant women

Characteristics	Non-adherence (*n* = 560)		Adherence (*n* = 656)		Univariable analysis		Multivariable analysis	
	n	%	*n*	%	OR	95% CI	AOR	95% CI
Age (y)								
<20	40	7.2	32	4.9	1.00		1	
20-<30	334	59.6	366	55.8	1.37	0.84, 2.23	1.23	0.68, 2.21
30–35	111	19.8	179	27.3	2.01	**1.19**, **3.39***	1.87	0.97, 3.61
>35	75	13.4	79	12.0	1.31	0.75, 2.31	1.21	0.59, 2.49
Educational level								
Junior high school	71	12.7	65	9.9	1.00			
Senior high school	99	17.7	123	18.8	1.36	0.88, 2.08		
Diploma/Polytechnic	228	40.7	266	40.5	1.27	0.87, 1.86		
University	162	28.9	202	30.8	1.36	0.91, 1.91		
Occupational status								
No job	461	82.3	512	78.0	1.00			
Has Job	99	17.7	144	22.0	1.31	0.98, 1.77		
Inter pregnancy duration								
First pregnancy	187	33.4	210	32.0	0.77	0.59, 1.01	0,96	0.66, 1.37
≤2y	182	32.5	168	25.6	0.63	**0.48**, **0.84****	0.65	**0.46**, **0.92***
>2y	191	34.1	278	42.4	1.00			
Parity								
Nulliparous	187	33.4	210	32.0	1.00			
Multiparous	373	66.6	446	68.0	1.06	0.82, 1.35		
Previous abortion								
No	476	85.0	550	83.8	1.00			
Yes	84	15.0	106	16.2	1.09	0.80, 1.49		
MMS introduction								
1st trimester	162	29.0	493	75.2	1.00			
2nd trimester	339	60.5	162	24.6	0.16	**0.12**, **0.20****	0.15	**0.12**, **0.20****
3rd trimester	59	10.5	1	0.2	0.01	**0.00**, **0.04****	0.01	**0.00**, **0.04****
Body mass index								
Undernourished	65	11.6	74	11.3	1.12	0.77, 1.61	1.34	0.87, 2.05
Normal	350	62.5	356	54.3	1.00			
Overweight	109	19.5	173	26.3	1.56	**1.17**, **2.06****	1.44	**1.04**, **2.00***
Obese	36	6.4	53	8.1	1.45	0.92, 2.22	1.36	0.**81**, 2.29
Height (cm)								
<150	139	24.8	165	25.2	1.02	0.80, 1.34		
≥150	421	75.2	491	74.8	1.00			
Side effects								
Yes	39	7.0	18	2.7	1.00			
No	521	93.0	638	97.3	2.65	**1.50**, **4.69****	3.46	**1.82**, **6.58****
Owning health insurance								
Yes	526	93.9	635	96.8	1.96	**1.12**, **3.40***	1.59	0.84, 3.02
No	34	6.1	21	3.2	1.00			

OR = odds ratio, AOR = adjusted odds ratio

*$P < 0.05$, **$P < 0.001$

subsequent pregnancy can help to improve adherence which in turn can also contribute to reducing the risk of adverse maternal and pregnancy outcomes [30].

Interestingly, overweight women were more likely to be adherent compared to normal weight women, but the underlying drivers are unclear. This finding highlights the need to further research to explore strategies for improving adherence among underweight or other BMI categories as these groups may also be at risk of micronutrient deficiencies. A study on the adherence to preconception and prenatal supplement revealed that underweight women were less likely to be adherent before pregnancy, but no association was found during pregnancy [31].

Women who did not experience side effects (pregnancy-related vomiting, nausea) were also more likely

to be adherent. This finding was consistent with some studies on IFA supplementation showed that experiencing unpleasant side effects was associated with lower pill consumption [32, 33]. Moreover, the lower iron dosage in MMS, which contains only 30 mg compared to 60 mg in IFA supplementation, may help reduce the side effects associated with this supplement. Other studies, however, found no association between side effects and adherence [28, 31]. The absence of an association in the latter study was attributed to inadequate supplement availability which was not the case in the current study.

As nausea and vomiting are also common in early pregnancy and possible independent of any supplement intake, providing sufficient information on mitigating these symptoms [7] is necessary. Educating women about the temporary nature of morning sickness and its typical resolution in the second half of pregnancy could potentially encourage and empower women to start and continue taking MMS [34]. Studies found that if women understand about the temporary of these symptoms and benefits of supplements, they are more likely to adhere [19, 35]. Therefore, health workers play an important role in effectively communicating the benefits during counseling of pregnant women early in pregnancy to ensure the information is understood. This can be achieved through in-person meetings during ANC visit or by sending regular reminders via mobile phone, given the widespread cellphones usage among pregnant women.

As (early) adherence plays an important role in determining the program's effectiveness, improving MMS adherence through the community health care system is essential. However, addressing issues only related to pregnant women may be insufficient. A more comprehensive approach involving multi-sector involvement may be required to prevent the MMS program from encountering the same challenges previously faced by IFA programs. Such a comprehensive strategy encompasses policies, production, delivery, quality and behavioral change as outlined in the logic model for micronutrient intervention in public health by WHO/CDC [36]. Moreover, continuous monitoring and evaluation of the three key indicators which are supply, coverage and intake of MMS (adherence) are essential for the success of the MMS supplementation program [37].

The strengths of the study include the prospective design coupled with the measurement of adherence based on the number of MMS missing from the bottle provided during ANC visits and the note taken from the recorded maternal health book. This approach provided a relatively reliable method compared to adherence measurements which rely on the women's recall/memory. These current findings may also be of interest to stakeholders who plan to implement an MMS supplementation program in their region. Our study also had some limitations including monitoring focus on implementation in an urban setting, that may not represent or predict any outcomes at a national level. Therefore, these findings cannot be generalized to all pregnant women in Indonesia. Further study on MMS should encompass broader geographical regions with a more representative population, including rural settings, and adopt a comprehensive approach. This will help to provide insights and generalize results that may contribute to a better understanding of the potential barriers of the MMS program before large-scale implementation. Additionally, qualitative studies may be necessary to gain a more holistic understanding of underlying causes of non adherence.

Implication

The potential learnings from this observational study are that it might be quite relevant to encourage women to do antenatal care visits as early as possible. This will allow women to get access to the MMS supplement, education and support as early as possible and for the health care worker to be able to explain that nausea and vomiting are normal effects that commonly exist during early pregnancy and should not delay supplementation. In addition, the present study findings may serve as a starting point for the development of large-scale intervention trials in urban areas to increase adherence.

Conclusion

Implementing MMS program to pregnant women via health centers during standard ANC visits resulted in high adherence once supplementation was started. A high percentage of women (75.3%) successfully achieved an intake of ≥90 tablets during pregnancy, especially those who started intake during the first trimester. However, as many women still started MMS late, attention to antenatal visit planning earlier in pregnancy can be further improved.

Abbreviations

ANC	Antenatal care
BMI	Body mass index
IFA	Iron folic acid
LMIC	Low middle income countries
MCHB	Maternal child health book
MMS	Multiple micronutrient supplementation
RCT	Randomized control trial
WHO	World health organization

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions
S.M.B, E.v.d.B, and H.G conceptualized and designed the study. S.M.B handled data collection, data entry, validation, and the draft manuscript writing. S.M.B and H.G conducted data analysis and visualisation. E.v.d.B and H.G supervised, reviewed, and edited the manuscript. All authors read and approved the final version of the manuscript.

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Data availability
Data used are available from the corresponding author upon reasonable request.

Declarations

Competing interests
The authors declare no competing interests.

Ethical approval
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Following the declaration of Helsinki and all procedures involving human participants, the Institutional Ethical Review Board was approved by the University of Hasanuddin (7267/UN4.14.1/TP.01.02/2021). The Investment and Integrated One-stop Services Agency of Parepare (Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu) granted access to antenatal records and permission to conduct the study in this region.

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