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Effect of Moringa Leaves Podwer Enriched with Royal Jelly on the Anthropometric Measurements of Neonates in Central Sulawesi, Indonesia

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ABSTRACT

Background: Moringa oleifera and Royal Jelly have been studied for their benefits in pregnant women. Our study investigated the non-pharmacological potential of Moringa oleifera enriched with Royal Jelly (MRJ) on newborn anthropometric measurements, including birth weight, birth length, head circumference, and chest circumference, in pregnant women in Central Sulawesi Province, Indonesia.

Materials and Methods: This study was a randomized, single-blind, controlled trial involving 160 pregnant women (divided into two groups). The intervention group received two MRJ capsules daily, while the control group consumed one Multi Micronutrient Supplement (MMS) tablet daily. The intervention lasted for six months. Data analysis using SPSS 28 using statistical methods such as Chi-square test, Fisher's exact test, Kolmogorov-Smirnov, Mann-Whitney, Independent t-test, and ANCOVA. The level of significance is $p < 0.05$.

Results: Most pregnant women in this study were aged 20-25 years, with 139 (86.9%) and 108 (67.5%) multiparous mothers. All variables measured were not significantly different at baseline except maternal BMI ($p = 0.31$). However, at birth, there was a significant difference in BW (3174.81 ± 396.81 g for the MRJ group vs. 3073.40 ± 477.08 g for the MMS group) and BL (48.96 ± 0.97 cm for the MRJ group vs. 49.23 ± 2.22 cm for the MMS group) ($p < 0.05$). This study showed that BW was higher in the MRJ group compared to the MMS group. Even after controlling for BMI in the analysis, the MRJ intervention had a significant impact on BW ($p < 0.05$). In contrast, birth length was more significant in the MMS group than in the MRJ group.

Conclusions: This study found that MRJ supplementation during pregnancy resulted in newborn size comparable to MMS, a multinutrient supplement designed to improve newborn anthropometric outcomes. Future studies are needed to refine the supplementation design.

Keywords: Birth length , Birth weight, Moringa Oleifera , Newborn, Pregnant women, Royal Jelly

INTRODUCTION

Maternal and child mortality is a serious problem, especially in developing countries such as Indonesia, highlighting the shortcomings of health systems because many of these deaths are preventable (Hyre et al., 2019). According to the Sustainable Development Goals (SDG) regions and subregions, around 87% (253,000) of the estimated global maternal deaths occur in Africa and Asia (WHO, 2023). Indonesia is one of the developing countries that is working towards achieving the third SDG, which is to reduce maternal and child mortality by 2030 (Kementerian PPN/Bappenas, 2020). However, progress is hampered by the high prevalence of malnutrition among mothers, which leads to increased maternal mortality and impacts on infants. Specific data shows that 50% of pregnant women are anemic, around 16.7% are underweight, and 33.3% are stunted (Ministry of Health Republic of Indonesia, 2018).

Pregnancy significantly increases nutritional needs due to additional stress, which affects maternal health and pregnancy outcomes, including lactation (Brink et al., 2022). Poor nutrition can lead to serious health problems and is a major cause of maternal mortality, affecting both the mother and the fetus (Tafara et al., 2023). Maternal nutritional status has been associated with adverse outcomes in anthropometric measurements at birth such as birth weight (BW), birth length (BL), head circumference (HCM), and chest circumference (CCM), which can have long-term impacts on development (Jamshed et al., 2020; Komatsu et al., 2023; Miele et al., 2022; Woldeamanuel et al., 2019).

During pregnancy, it may be difficult to meet all nutritional needs through diet alone (Jouanne et al., 2021). Supplements and fortified foods prescribed by a healthcare provider are needed to meet these increased nutritional needs (Mousa et al., 2019). Previous studies have shown that taking a variety of micronutrient supplements (MMS) improves maternal and child health (Keats et al., 2021). Moringa Oleifera (MO), or Moringa oleifera, is a highly nutritious plant that thrives mostly in tropical regions of low- and middle-income countries, and has significant potential in addressing malnutrition (Rotella et al., 2023). Nutritional analysis has revealed that MO leaves are rich in essential compounds, including protein, vitamins, calcium, iron, and ascorbic acid as well as powerful antioxidants such as carotenoids, flavonoids, and phenols (Islam et al., 2021). They also contain all essential amino acids, including two important amino acids, arginine, and histamine, which are essential for maternal health and fetal development (Yadav et al., 2022).

A narrative review conducted by Hadju et al., (2020), examined the effects of moringa, honey, or both as nutritional supplements compared with iron-folic acid supplements in pregnant women. The review concluded that moringa leaf extract and moringa leaf powder increased hemoglobin levels and birth weight and prevented cell damage. A study involving pregnant women compared the effects of moringa leaf powder capsules plus royal jelly (MRJ), moringa leaf extract, and placebo on hemoglobin levels. Although no significant differences were found, the MRJ group had a slight advantage with an increase in hemoglobin of 1.36 g/dL, compared with 0.75 g/dL for moringa leaf extract and 0.71 g/dL for placebo (Yulni et al., 2020). In a study in South Sulawesi, anemic pregnant women who took MRJ supplements showed increased birth weight and newborn weight compared with pregnant women who took moringa capsules or iron-folic acid supplements alone (Mandasari et al., 2020).

Previous studies on the benefits of moringa leaf powder on pregnancy outcomes and newborn anthropometry were still based on small sample sizes. In addition, there has been no further research investigating newborn head and chest circumference measurements. Therefore, this study aims to replicate the effects of moringa capsules plus royal jelly in pregnant women on birth weight, birth length, head circumference, and chest circumference of newborns in Central Sulawesi Province, Indonesia.

Subjects and Methods

Ethical approval

Ethical considerations were followed as this study complies with the Declaration of Helsinki guidelines and has received ethical approval from the Health Research Ethics Committee of the Faculty of Public Health, Hasanuddin University (Reference Number: 5517/UN4.14.1/TP.01.02/2023). All pregnant women and their guardians were fully informed about the study and gave their informed consent.

Study design and setting

This study used a Randomized, Single-blind, Controlled Trial method with a control group design. This study was conducted in Banggai Regency, Central Sulawesi Province, Indonesia (coordinates 0.957091°S and 122.558593°E), and lasted for six months (July 2022 to January 2023).

Study participants and sampling

The study population consisted of 126 pregnant women from Moilong District, covering nine villages, and 116 pregnant women from Batui Selatan District, covering 15 villages. The sample size for this study was determined using a formula designed to compare the mean values of numerical data from two independent groups. Using a significance level (α) of 5% for a two-sided hypothesis ($z = 1.96$) and a Standard Value (β) of 80% (1.64), an additional 10% was added to the sample size to ensure adequate statistical power and to reduce the impact of potential dropouts. The final result was obtained, the final sample consisted of 80 pregnant women for each group, resulting in a total of 160 pregnant women. The inclusion criteria for this study included healthy first trimester pregnant women without any pathological pregnancy conditions. Candidates should not be diagnosed with certain diseases, such as gestational diabetes, serious illnesses, or mental health disorders. They must indicate their willingness to participate by signing an informed consent. Exclusion criteria included mothers who moved during the study, those who did not take the prescribed supplement during the week prior to the study, and those who refused to continue the supplementation protocol. Of the 160 eligible participants, 80 were randomly selected. The first selected participant was assigned to the intervention group, which received two capsules of Moringa Oleifera combined with Royal Jelly (MRJ) per day, containing 490 mg of Moringa leaf powder and 10 mg of Royal Jelly. The remaining participants, the control group, received one tablet of Multiple Micronutrient Supplementation (MMS) daily (see Figure 1 for more details).

Data collection and tools

Prior to the intervention, we conducted a follow-up survey of all pregnant women in Banggai, Moilong, and South Batui Districts. This survey included filling out a network checklist during the interview. We used a questionnaire for the e-cohort and ANC interviews. Nutritionists measured weight, height, Mid-Upper Arm Circumference (MUAC) and calculated Body Mass Index (BMI) and midwives measured blood pressure. In addition, we collected secondary data from reports on the target number of pregnant women, cases of anemia, and Chronic Energy Deficiency (CED) as part of research support from the health center.

The researchers used a proactive approach to ensure continued adherence to the intervention materials. This involved daily reminders via a dedicated WhatsApp group created by the researchers, encouraging participants to consume the intervention materials every morning. Furthermore, weekly check-ins were conducted with a team of health enumerators (dieticians) to monitor participants' consumption of the intervention capsules. After each week of the intervention, the researchers carefully reviewed any unconsumed intervention materials and assessed each participant's adherence to the inclusion criteria.

Statistical data analysis

Data analysis was performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA), specifically version 28 for Windows. Cross-tabulation analysis was used to evaluate differences in categorical variables across groups, combining Chi-square/Fisher's test as appropriate. Data distribution was assessed for normality using the Kolmogorov-Smirnov test. Continuous variables were summarized as means with standard deviations (mean ± SD). For comparative analysis between groups, the Mann-Whitney U test or Independent Student's t test was used, depending on the nature of the data and analysis of confounding variables using ANCOVA on the BMI variable at baseline. A p value < 0.05 (two-tailed) was considered statistically significant.

Results

Figure 1 shows the total number of participants initially amounted to 160 pregnant women. The results showed no statistically significant difference in demographic characteristics between the two groups (p > 0.05). The majority of pregnant women were aged 20-35 years (134, 87.6%) (p = 0.519), had a high school education (94, 61.4%), and were housewives (136, 88.9%) (p = 0.391) in both groups. In addition, in both groups, the highest blood pressure frequency distribution was normal (132, 86.3%) (p = 0.423), and the parity status was multiparous (102, 66.7%) (p = 0.303). In addition, maternal anthropometric measurements, including MUAC, were within the normal range (145, 94.8%) (p = 0.163), and BMI showed a similar distribution of overweight and obesity (51, 33.3%) (p = 0.095) (Table 1).

Table 1. Characteristics of Respondents in both groups

Variable	MRJ (n=80)		MMS (n=80)		Total (n=160)		P-value*
	n	%	n	%	n	%	
Age (Years)							
< 20	6	3.8	5	3.1	11	6.9	0.757
20–35	68	42.5	71	44.4	139	86.9	
> 35	6	3.8	4	2.5	10	6.3	
Education							
Elementary school (≤6 years)	7	4.4	15	9.4	22	13.8	0.152
Junior high school (7–9 years	18	11.3	10	6.3	28	17.5	
Senior high school (9–12 years)	49	30.6	48	30	97	60.6	
College (> 12 years)	6	3.8	7	4.4	13	8.1	
Maternal Occupation							
Housewife	72	45	69	43.1	141	88.1	0.463
Occupation	8	5	11	6.9	19	11.9	
Parity							
Primipara	29	18.1	23	14.4	52	32.5	0.311
Multipara	51	31.9	57	35.6	108	67.5	
Blood Pressure							
Hypertension (>120/80 mmHg)	10	6.3	14	8.8	24	15	0.376

Normal (≥110/70–120/80 mmHg)	70	43.8	66	41.3	136	85	
MUAC							
CED (<23.5cm)	6	3.8	2	1.3	8	5	0.147
Normal (≥23.5cm)	74	46.3	78	48.8	152	95	
BMI							
Underweight (<18.5)	0	0	3	1.9	3	1.9	**0.031**
Normal (18.5–25)	26	16.3	23	14.4	49	30.6	
Overweight (25–27)	6	3.8	16	10	22	13.8	
Obese (≥ 27)	48	30	38	23.8	86	53.8	

Bold values denote statistical significance at the P < .05 level *Chi-squared/Fisher's exact test.

In Table 2, the data showed that after 6 months of intervention, the MRJ group had significantly higher birth weight compared to the MMS group (p < 0.05), with a mean difference of 129.17 ± 62.38 g. In addition, the mean birth length in the MMS group was significantly higher than that in the MRJ group (p < 0.05), with a mean difference of 0.37 ± 0.23 cm. However, there was no significant difference in mean chest and head circumference between the groups (p = 0.813 and p = 0.731).

Table 2. Average birth weight, birth length, chest circumference, and head circumference in both groups

Variable	MRJ (n=80)	Min-Max	MMS (n=80)	Min-Max	Difference	P value
Birth weight	3174.81±396.81	2400-4190	3073.40±477.08	2100-4600	101.81±69.34	**0.029***
Birth length	48.96±0.97	46-52	49.23±2.22	44-52	0.37±0.23	**0.029***
Chest circumference	33.95±1.94	30-38	33.66±1.40	31-38	0.28±0.24	0.594*
Head circumference	32.91±1.58	30-37	32.68 ±1.18	29-35	0.23±0.24	0.591*

Bold values denote statistical significance at the P < .05 level; *Mann Whitney test

ANCOVA analysis, after adjusting for different maternal BMI during pregnancy as a factor that affects the birth weight and length of newborns. Based on the results of the ANCOVA test, only the birth weight variable showed significant differences after the intervention of supplementation in the MRJ and MMS groups. as a control until the end of the study (p = 0.029). Analysis of the effect of the intervention on the average results of body weight and length after being controlled by the BMI variable is summarized in Table 3.

Table 3. Average birth weight and birth length in both groups

Variable		Mean (SD)	Min-Max	Adj. Mean [a](95% CI)	F(df)	P value [a]
Birth weight						
	MRJ (n=80)	3174.81 ± 396.81	2400-2190	3165 .43	4.859	**0.029**
	MMS (n=80)	3073.40±477.08	2100-4600	3082.37	(1,157)	
Birth length						
	MRJ (n=80)	48.96±0.97	46-52	48.97	0.517 (1,157)	0.475
	MMS (n=80)	49.23±2.22	44-52	49.21		

Bold values denote statistical significance at the P < .05 level; [a] ANCOVA after controlling for BMI to analyze the variables of Birth weight and Birth length separately.

DISCUSSION

The findings of this study strengthen previous findings which stated that the intervention of administering Moringa through MRJ capsules had a positive impact on pregnancy outcomes, namely that the group that received the Moringa leaf intervention had a lower incidence of LBW, normal birth length and normal head circumference results.(Nurdin et al., 2018; Nadimin et al., 2019;Rahma et al., 2023). Consuming moringa leaves in the daily diet, especially in LMIC, significantly improves health, especially for pregnant women. The high folate and omega fatty acid content in moringa leaves also specifically helps reduce anemia during pregnancy, thereby increasing breast milk in breastfeeding mothers, resulting in better infant health (Alegbeleye, 2018).

This study found a mean birth weight of 3174 ± 396 g, lower than previous studies Hadju, et al., (2020), reporting a mean of 3390 ± 383 g after a three-month intervention, while Arundhana et al., (2018), a six-month intervention resulted in 3240 ± 454 g. This inconsistency may be partly due to variations in study design, differences in the dosage of the mixture between moringa and honey, and population characteristics, such as dietary habits and genetic background (Yang et al., 2022). Both previous studies did not report BMI characteristics in early pregnancy. In this study, the mean BMI of pregnant women was 27.45 ± 4, which is included in the classification of obesity for the Indonesian population (Balanced Nutrition Guidelines, 2014). Birth weight is generally influenced by several maternal factors, including genetics, nutritional and hormonal status, and the ability of the placenta to transport nutrients (Garcia-Santillan et al., 2022).

In our study, the mean birth weight of the MRJ group was statistically significantly greater than that of the MMS group, which served as a control ($p < 0.05$). This difference may be attributed to the wider variability observed in the MMS group. Specifically, the control group included three LBW infants and five macrosomic infants, whereas the MRJ group included only one LBW infant and two macrosomic infants. The terms "macrosomia" and "Large for Gestational Age" (LGA) is often used interchangeably in the literature; however, the term LGA is more accurately defined and widely accepted. LGA refers to neonates whose birth weight is at or above the 90th percentile for gestational age. (Hong & Lee, 2021)This distinction is supported by a cohort study conducted in China, which identified that maternal obesity (BMI ≥ 27.5 kg/m², a specific criterion for Asian populations) significantly increased the risk of having both LGA and "Small for Gestational Age" (SGA) infants (Chen et al., 2019). Furthermore, a prospective cohort study conducted in Poland found that mothers who were considered obese (BMI ≥ 30 kg/m²) showed a three-fold increased risk of having a macrosomic infant (AOR = 3.21; 1.69−6.1, $p < 0.001$). In addition, this study revealed a significantly higher risk of LBW associated with maternal obesity (AOR = 17.42; 1.5−202.6, $p = 0.022$) (Lewandowska, 2021).

The group receiving MMS in this study showed a statistically significant increase in mean birth length compared to the MRJ group, with a mean difference of 0.37 ± 0.23 cm. The birth length observed in this MMS group was also greater than that reported in the MRJ group in a previous study by Mandasari et al., (2020), which reflected a mean of 48.97 cm compared to 47.50 cm. In addition, as a control group, MMS showed a higher mean birth length compared to the control group associated with the (Iron folic acid ; IFA) group, in the same study, which reported a mean of 49.23 cm and 44.80 cm. These benefits included reduced cortisol and erythropoietin levels, and reduced obstetric complications when compared to IFA supplementation, the standard of care in Indonesia (Zavala et al., 2022). The authors suggest that MMS has a greater impact on pregnancy outcomes, particularly regarding fetal body length, than MRJ, primarily due to the presence of vitamin D in MMS, which is absent in MRJ. Vitamin D, a fat-soluble micronutrient, is essential in enhancing intestinal calcium absorption and maintaining homeostasis of serum calcium and phosphorus levels, thereby contributing to optimal bone growth and development (Xiao et al., 2023).

These findings are consistent with previous meta-analyses, which have described the positive effects of combining more than four micronutrients in a single product to improve maternal and child health outcomes. This forms the basis for ongoing discussions about the possible replacement of IFA with MMS.(Keats et al., 2021;Gomes, et al., 2022; Oh et al., 2020). The results of this study emphasize the importance of micronutrient supplementation as a necessary, cost-effective, and supportive strategy to improve pregnancy and birth outcomes in LMICs (Bourassa et al., 2019). Achieving adequate nutrition through a variety of foods in sufficient quantity and quality is a significant challenge due to limited access and high costs (Gomes, et al., 2022). Since no single micronutrient deficiency can be solely blamed for the adverse outcomes associated with malnutrition, addressing a single deficiency may not be effective in addressing other nutrient deficiencies. Therefore, it is important to implement multi-supplementation strategies to effectively address this complex problem (Ballestín et al., 2021).

In this study, the MRJ group showed lower rates of abnormal fetal growth indicators such as LBW and macrosomia, likely due to a more balanced intake of macronutrients and micronutrients compared to the MMS group, which only had micronutrients in the form of essential vitamins and minerals. According to the nutritional guidelines for pregnant women, maintaining an appropriate balance of energy and nutrients is essential, as excessive or unbalanced intake during pregnancy can lead to adverse outcomes (Clark, 2018). Comprehensive nutritional supplementation (balanced protein-energy supplementation plus various micronutrients) has been associated with improved birth outcomes in malnourished pregnant women, resulting in a decrease in LBW rates (Marshall et al., 2022). A study in China corroborated these findings, showing that increased protein intake was correlated with increased birth weight and a decreased risk of LBW, SGA, and "Intrauterine Growth Restriction" (IUGR) (Yang et al., 2022). In addition, MRJ contains dietary fiber, which has been shown to increase satiety and is associated with decreased weight gain and a lower incidence of LGA in several prospective epidemiological studies (Englund-Ögge et al., 2019).

Systematic analysis showed that MMS was more effective in reducing preterm birth, SGA, and LBW compared with IFA supplementation in pregnant women. (Keats et al., 2019). Current evidence suggests that MMS, combined with micronutrients or Balanced Energy Protein (BPE)—meaning a diet with less than 25% of energy from protein along with essential macronutrients—provides more significant health benefits than individual micronutrient supplementation (González-Fernández et al., 2024; Ota et al., 2015). In addition, there is a significant gap in research examining dietary intake during pregnancy, particularly regarding the adverse effects associated with specific macronutrient and micronutrient groups. Furthermore, evidence from limited studies conducted in Africa suggests that BPE or lipid-based supplementation (LBS) may be more effective than individual micronutrient supplementation in meeting the nutritional needs of pregnant women in low- and middle-income countries (LMICs) (González-Fernández et al., 2024).

The strength of this study lies in the comprehensive examination of MRJ supplementation with MMS as a comparative control in a similar capsule form in our specific geographic area. The study carefully considered compliance and demonstrated high compliance in both groups. Another strength is the potential for multivitamin supplementation in capsule form to serve as an alternative or complement to standard interventions provided by community health centers, particularly in addressing pregnancy-related problems in pregnant women, fetuses, and children. This study supports the addition of comprehensive, non-pharmacological multi-micronutrient supplements such as MRJ capsules, or the implementation of MMS to public health efforts in LIMC to help achieve the SDGs of reducing child mortality by 2030.

This study had several limitations, including the fact that no significant differences were observed in neonatal head circumference and chest circumference between MRJ and MMS capsules. The capsules may not have had a significant effect for several reasons: most women had BMIs that were in the overweight to obese range. In addition, both groups adhered to a generally healthy maternal diet during the study; however, specific dietary data were not available to make a conclusive assessment.

CONCLUSION

Our study investigated the effects of daily double MRJ capsule administration from the second trimester until delivery. The study revealed a significant increase in newborn weight among subjects receiving MRJ supplementation compared to those receiving MMS. Furthermore, the results for newborn head and chest circumference after MRJ supplementation were comparable and positively aligned with the results observed in the MMS group. In contrast, infants in the MMS group had a longer birth length. Overall, the data from this study support the benefits of multi-nutrient supplementation during pregnancy in improving certain aspects of newborn anthropometry.

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Conflict of Interest

There are no conflicts of interest.

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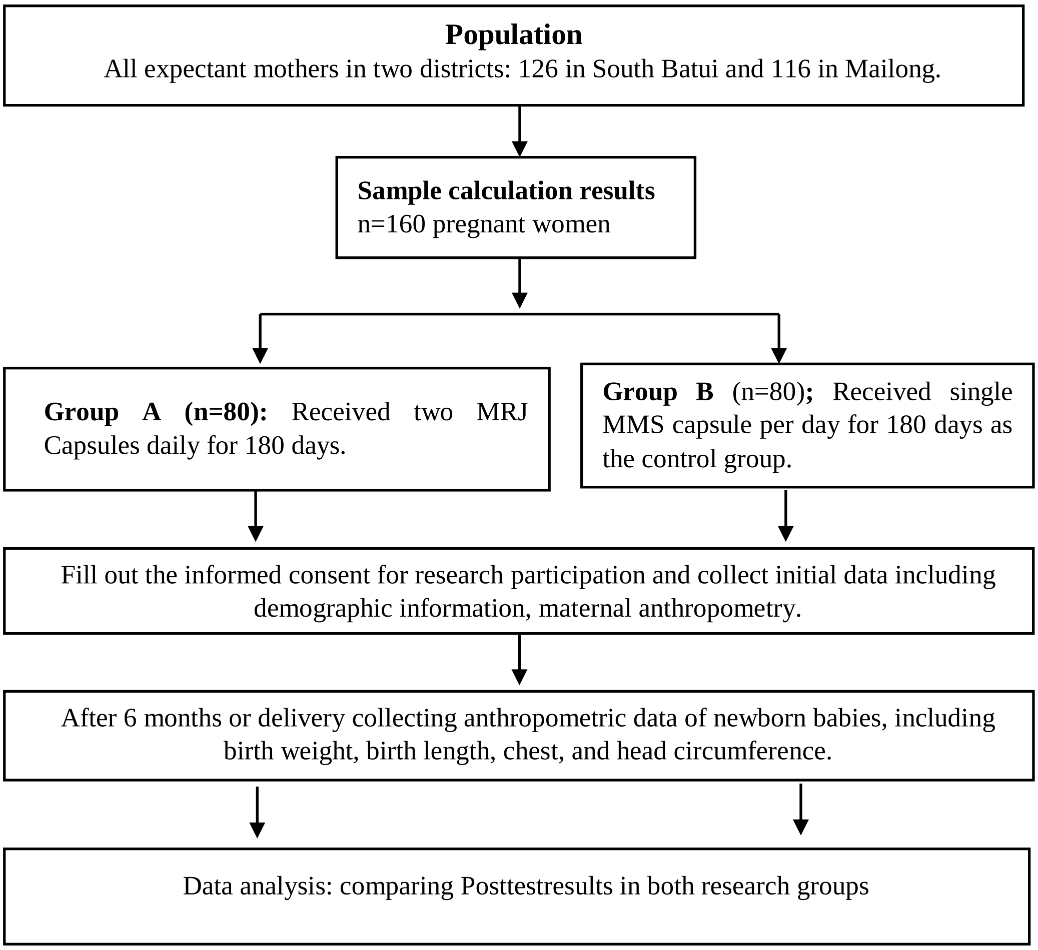

Figure 1: Consort follow intervention diagram