

Adherence to Multiple Micronutrient Supplementation in Pregnancy: A Systematic Review Integrating HBM, TPB, and PRECEDE-PROCEED

Feni Riandari*, Elviera Gamelia, Eri Wahyuningsih

Master of Public Health Study Program, Faculty of Health Sciences, Universitas Jenderal Soedirman, Purwokerto, Indonesia

Corresponding author: feniriand@gmail.com

ARTICLE INFO

Article history

Submitted:
22 July 2026

Revised:
18 August 2026

Accepted:
28 August 2026

Keywords:

Anemia;
Antenatal care;
Birth weight;
Health promotion;
Self-efficacy;

ABSTRACT

In the 2018 national survey, almost half of pregnant women in Indonesia were anemic (48.9%), and the national program is shifting from iron-folic acid (IFA) to multiple micronutrient supplements (MMS). This study aims to synthesize evidence on determinants of MMS adherence among pregnant women through the Health Belief Model (HBM), the Theory of Planned Behavior (TPB), and the PRECEDE-PROCEED framework, and to describe how adherence levels are associated with maternal and neonatal outcomes. This study used a systematic review following PRISMA 2020 with narrative thematic synthesis. Nine databases and two organizational portals yielded 487 records; 27 were included, namely 16 evidence-contributing studies (one individual participant data [IPD] meta-analysis of 15 randomized trials with 61,204 women, two other systematic reviews/meta-analyses, one literature review, and 12 primary studies) and 11 supporting documents. Study quality was appraised with JBI, CASP, and AMSTAR-2 tools. In the IPD meta-analysis, MMS increased birth weight relative to IFA by 56 g (95% CI: 45–67) among women with $\geq 90\%$ adherence, but by only 9 g (95% CI: –17 to 35) at $<60\%$ adherence. In observational analyses among MMS recipients, adherence $<75\%$ (versus 75–90%) was associated with a higher risk of maternal anemia (RR 1.26; 95% CI: 1.11–1.43) and stillbirth (RR 1.43; 95% CI: 1.12–1.83). Perceived benefits and perceived barriers were the most consistently reported psychological determinants, followed by self-efficacy and perceived behavioral control. Enabling factors (tablet availability, distance, cost, employment) and reinforcing factors (husband and family, cadres, midwives) shaped whether intention became consumption. Higher adherence is associated with better maternal and neonatal outcomes, and individual beliefs, perceived control, and the service and social environment jointly shape adherence.



This work is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).

INTRODUCTION

Almost one in two pregnant women in Indonesia was anemic when the 2018 Basic Health Research (Riskesdas) was conducted, a prevalence of 48.9% (Kementerian Kesehatan Republik Indonesia (Kementerian Kesehatan RI, 2018). Anemia and poor maternal nutrition are linked to small-for-gestational-age (SGA) birth and low birth weight (LBW) (Keats et al., 2019; World Health Organization, 2020), which is why national policy is moving from iron-folic acid (IFA) tablets toward multiple micronutrient supplements (MMS). Containing 15 vitamins and minerals, MMS covers maternal metabolic needs more broadly than IFA (WHO, 2020), and it lowers the risk of LBW and SGA relative to IFA (Keats et al., 2019; Smith et al., 2025). Indonesia began its national rollout on 17 October 2024 in 15 priority provinces, with every province to be reached by 2026 (Vitamin Angels, 2024), while a registered trial is evaluating antenatal MMS in Indonesia (ClinicalTrials.gov, 2025).

Supplements that are distributed but not swallowed confer little, and here the evidence on MMS becomes less comfortable. In a pooled analysis of 15 randomized trials, the extra birth-weight benefit of MMS over IFA was concentrated among women who took most of their tablets (Smith et al., 2025). Programs, however, tend to count what is handed out rather than what is

consumed. In rural Kebumen, the gap was tied to distance and limited access (Riandari, 2025); in urban Surabaya, to employment and pregnancy-related complaints (Buanasita et al., 2025). Two settings, two explanations, and neither reduces to supply logistics.

Existing syntheses each illuminate one corner of the problem. Smith et al. (2025) showed how adherence modifies the effect of MMS on birth outcomes but said little about why women do or do not adhere. Desta et al. (2019) examined determinants of IFA adherence in Ethiopia, a different supplement in a different health system. Mufidah et al. (2025) examined MMS adherence through the HBM and TPB yet left system-level factors and clinical outcomes aside, and local work such as Riandari (2025) applied PRECEDE-PROCEED within a single district. The theories are themselves partial in complementary ways. The HBM centers on individual beliefs about threat, benefit, barriers, and self-efficacy (Rosenstock, 1974); the TPB adds attitude, subjective norm, and perceived behavioral control as predictors of intention (Ajzen, 1991); PRECEDE-PROCEED situates behavior among predisposing, enabling, and reinforcing conditions in the health system and community (Green & Kreuter, 2005). Their constructs overlap, so relying on any single theory leaves part of the behavior unexplained, while stacking them naively risks double-counting the same determinant.

Figure 1 shows how the HBM, which addresses individual psychological dimensions, combines with PRECEDE-PROCEED, which maps determinants at the health-system level. Predisposing factors call for a different reading of perceived benefit: not merely raising hemoglobin, but comprehensive nutritional support for placental growth and fetal development. Enabling factors describe service readiness, including consistent MMS stock, geographical access, transport cost, and the quality of antenatal care (ANC) counseling. Husband and family support, along with monitoring by Posyandu (integrated health post) cadres and village midwives, are reinforcing factors that act as cues to action and sustain self-efficacy. Barriers range from physiological side effects such as nausea and vomiting to local myths and simple forgetfulness.

The TPB enters through conceptual links rather than as a separate branch of the figure. Self-efficacy (HBM) maps onto perceived behavioral control (TPB), subjective norm (TPB) resembles the reinforcing factors of PRECEDE-PROCEED, and perceived barriers (HBM) correspond to enabling factors. Table 3 sets out the determinants assigned to each construct.

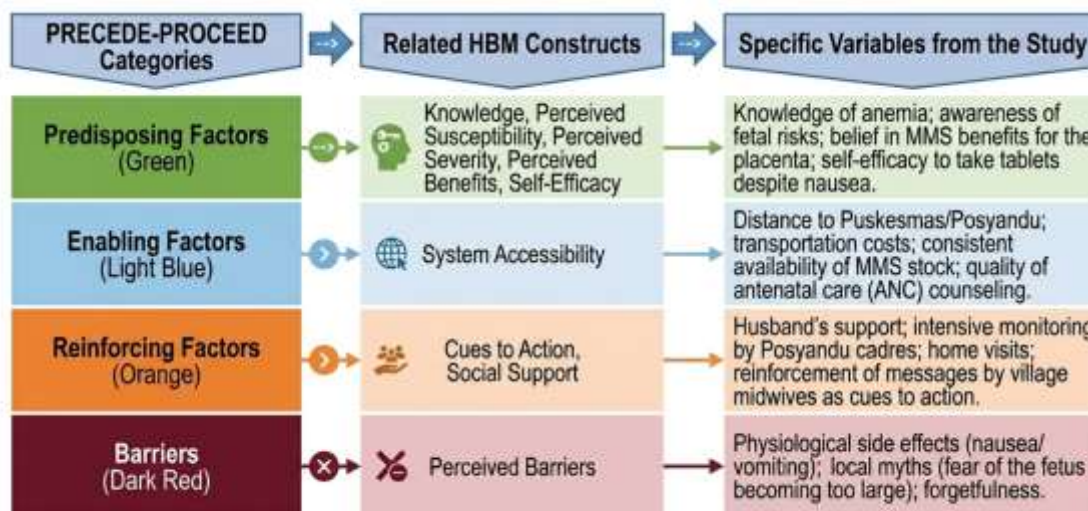


Figure 1. Integrated Conceptual Framework (HBM and PRECEDE-PROCEED)

This review adds an integrated reading rather than another single-theory account. It places the HBM, TPB, and PRECEDE-PROCEED in one framework, ties the behavioral determinants to evidence on how adherence relates to clinical outcomes, and contrasts urban and rural determinants within Indonesia. Two questions guide the analysis: which psychological and ecological factors are reported to shape adherence to MMS among pregnant women, and how is adherence level associated with maternal and neonatal outcomes?

METHOD

This systematic review uses narrative thematic synthesis and is designed to accommodate quantitative, qualitative, and mixed-methods evidence. Reporting follows the PRISMA 2020 statement (Page et al., 2021), and the handling of mixed evidence draws on the Joanna Briggs Institute (JBI) guidance for mixed-methods systematic reviews (Lizarondo et al., 2020). The design suits the topic because supplement adherence is shaped by biological, psychological, social, cultural, and health system factors (Buanasita et al., 2025; Riandari, 2025; Smith et al., 2025). The review questions are those stated in the Introduction.

Records were eligible if they met the following criteria:

1. Population: pregnant women, or health workers and stakeholders involved in delivering MMS for qualitative studies;
2. Exposure or intervention: MMS (alone or compared with IFA), with adherence, compliance, or utilization explicitly measured;
3. Outcomes: determinants (barriers and facilitators) of adherence, or maternal and neonatal outcomes reported by adherence level;
4. Designs: syntheses of randomized trials, systematic reviews, observational, quasi-experimental, qualitative, and mixed-methods studies;
5. Setting: low- and middle-income countries (LMICs), including Indonesia; and
6. Publication period: studies published up to the date of the last search; the included studies were published between 2019 and 2026.

Records using designs that could not yield data on adherence or its determinants were excluded, as were those that did not measure adherence explicitly or were set outside LMICs. A named theory was not required; studies had to report determinants or outcomes that could be mapped onto HBM, TPB, or PRECEDE-PROCEED constructs, and records with nothing mappable were removed at screening (Figure 2). Guidelines, theoretical works, and methodological sources were kept as supporting documents for context and did not contribute effect estimates.

A systematic search was run in PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, ScienceDirect, Embase, Google Scholar, and Garuda, along with the official portals of WHO and UNICEF. The last search was conducted in August 2026. Keywords and Boolean operators combined terms for population (pregnant women, pregnancy), exposure (multiple micronutrient supplementation, MMS, iron folic acid, IFA), outcome (adherence, compliance, uptake), determinants (determinants, barriers, facilitators, antenatal care), and theory (Health Belief Model, HBM, Theory of Planned Behavior, TPB, PRECEDE-PROCEED). An illustrative string was: ((pregnant OR pregnancy) AND ("multiple micronutrient supplement" OR MMS OR "iron folic acid") AND (adherence OR compliance OR uptake) AND (determinants OR barriers OR facilitators)).

Records were exported to a reference manager and de-duplicated. Titles and abstracts were screened first, followed by full-text assessment against the eligibility criteria, and reasons for exclusion at the full-text stage were recorded (Figure 2). The first author performed screening and data extraction, and the second and third authors checked them; disagreements were resolved by discussion until consensus was reached. For each included study, the design, setting, sample, definition and measurement of adherence, reported determinants, and outcome estimates with 95% confidence intervals (CIs) were extracted.

Adherence was defined as the proportion of recommended MMS tablets actually consumed during the recommended supplementation period. In the IPD meta-analysis, high adherence was $\geq 90\%$ of tablets, low adherence was $< 60\%$, and observational analyses used a $< 75\%$ category (Smith et al., 2025). Program-level targets of at least 90 tablets, 180 tablets as the optimal cumulative intake, and initiation before 20 weeks of gestation were extracted as additional indicators (Smith et al., 2025; World Health Organization, 2020). Studies measured adherence by self-report, pill counts, or records in the maternal and child health (KIA) handbook and ANC registers. Because these methods differ, adherence figures from different studies are compared descriptively and are not pooled.

Methodological quality was assessed with instruments matched to each design: the JBI critical appraisal checklists for observational studies (Joanna Briggs Institute, 2020), the Critical Appraisal Skills Programme (CASP) checklist for qualitative studies (Critical Appraisal Skills Programme,

2018), and AMSTAR-2 for systematic reviews and meta-analyses (Shea et al., 2017). Risk of bias was assessed for the validity of adherence measurement, sample representativeness, control of confounding, clarity of analysis, attrition, and consistency of reporting (Page et al., 2021).

Because designs and adherence measures varied, authors used a narrative thematic synthesis. The authors reported quantitative results as published (odds ratios, adjusted odds ratios, relative risks (RR), prevalence ratios, or mean differences) with 95% CIs where available, and grouped qualitative findings into themes of barriers and facilitators (Puspitasari et al., 2026). The authors then mapped determinants onto HBM and TPB constructs and onto the predisposing, enabling, and reinforcing categories of PRECEDE-PROCEED (Ajzen, 1991; Green & Kreuter, 2005; Rosenstock, 1974).

To convey how consistent the evidence is for each construct, authors attached a simple label based on the number of sources reporting a concordant direction of association: Consistent (three or more), Moderate (two), and Limited (one). The labels indicate convergence of findings, not certainty about causation, and no formal GRADE assessment was undertaken.

The 27 included records fall into three tiers of evidence, deliberately kept apart to avoid double counting. The IPD meta-analysis pooled 15 randomized trials and counts as one record, and its sample of 61,204 women belongs to that record alone (Smith et al., 2025). The Cochrane review (Keats et al., 2019) may share trials with the IPD meta-analysis, so estimates from the two syntheses were never summed or pooled and are reported separately with their sources. The remaining studies are independent primary observational, qualitative, or mixed-methods studies that sit outside those trials.

RESULTS

Literature selection flow (PRISMA)

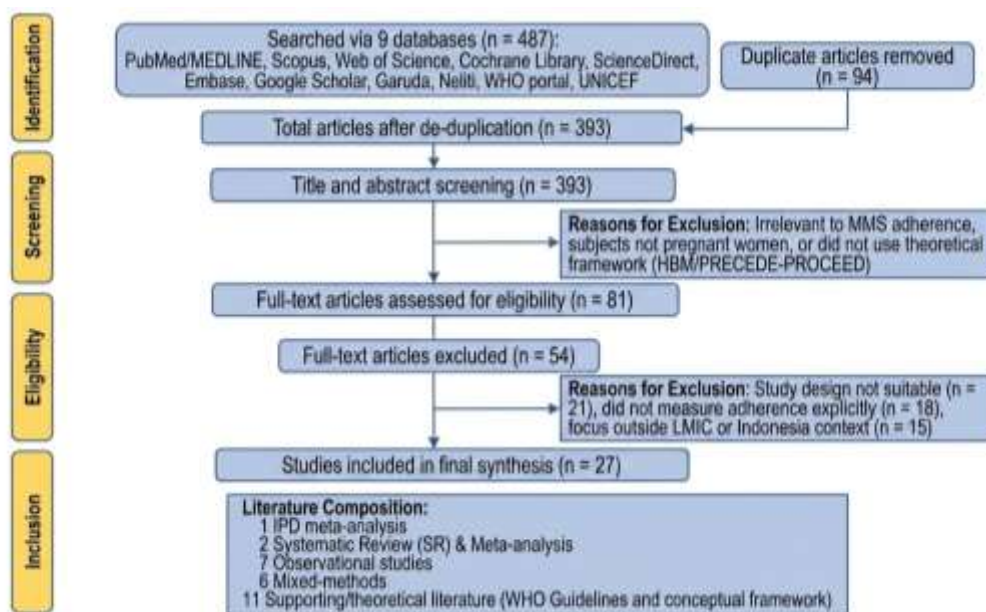


Figure 2. PRISMA 2020 Flow Diagram (Literature Selection Process)

The search returned 487 records. After removing 94 duplicates, 393 records remained for title and abstract screening; 312 were excluded because they did not address MMS adherence, did not involve pregnant women, or did not use a theoretical framework (HBM or PRECEDE-PROCEED) in a way that allowed mapping of determinants. Of 81 full-text reports assessed, 54 were excluded for inappropriate study design (n = 21), adherence not explicitly measured (n = 18), or a setting outside LMICs and Indonesia (n = 15). The 27 remaining records (Figure 2) comprised 16 evidence-contributing studies and 11 supporting documents, namely guidelines

and theoretical or methodological sources. The 15 trials within the IPD meta-analysis count as a single record.

Characteristics of the included studies

Table 1 lists the 16 evidence-contributing studies: one IPD meta-analysis, two systematic reviews/meta-analyses, and 13 observational, mixed-methods, qualitative, quasi-experimental, or review studies (Figure 2). Outside the three syntheses, most studies were conducted in Indonesia (including Surabaya, Parepare, Kebumen, and Kulon Progo), and the rest were conducted in Ethiopia, Mali, Cambodia, and Bangladesh. Sample sizes appear only where they could be verified in the source publication.

Table 1. Characteristics of the included evidence-contributing studies

Author (year)	Design	Setting	Sample/population	Primary focus
Smith et al. (2025)	IPD meta-analysis of 15 RCTs	LMICs (global)	61,204 pregnant women	Effect of MMS vs IFA by adherence and timing of initiation
Keats et al. (2019)	Systematic review and meta-analysis (Cochrane)	Global (trials)	Trials of MMS vs iron±folic acid	Effect of MMS on birth outcomes
Desta et al. (2019)	Systematic review and meta-analysis	Ethiopia	Studies of IFA supplementation	Pooled IFA adherence and its determinants
Mufidah et al. (2025)	Literature review	Indonesia	Published studies on MMS adherence	Adherence interpreted with HBM and TPB
Abidah & Sumarmi (2024)	Observational	Mulyorejo PHC, Surabaya	Pregnant women	Adherence to MMS vs IFA
Buanasita et al. (2025)	Cross-sectional (explanatory)	Surabaya, East Java	810 pregnant women, 63 PHCs	Employment, pregnancy complaints, gestational age and adherence
Battung et al. (2025)	Observational	Parepare, Indonesia	Pregnant women receiving MMS	Population characteristics and intake adherence
Riandari (2025)	Observational / mixed-methods (thesis proposal)	Ambal II PHC area, Kebumen	Pregnant women	Determinants of adherence using PRECEDE-PROCEED
Puspitasari et al. (2026)	Qualitative case study	Kulon Progo, Yogyakarta	13 informants (8 pregnant women, 2 midwives, 2 pharmacists, 1 Health Office)	Product acceptance and providers' role in monitoring
Katili (2025)	Quasi-experimental	Indonesia	Pregnant women given MMS	Change in anemia status and hemoglobin
Alfaqeeh et al. (2025)	Cross-sectional	Indonesia	1,022 pregnant women (main analysis)	Knowledge, attitudes and acceptance of MMS
Abebe et al. (2025)	Community-based cross-sectional, mixed-methods	Rural Ethiopia (five regions)	410 pregnant and lactating women; 5 FGDs; 15 key informant interviews	Acceptance of MMS and IFA utilization
Ba et al. (2025)	Qualitative evaluation	Bamako, Mali	Not extracted	Strategies supporting MMS introduction
Labonté et al. (2025)	Qualitative	Cambodia	Not extracted	Factors affecting MMS adherence
Kraemer et al. (2023)	Knowledge-attitude-practice survey	Bangladesh	Pregnant women and health care providers	Knowledge, attitudes and practices on multivitamins

Author (year)	Design	Setting	Sample/population	Primary focus
Zhong et al. (2025)	Retrospective cohort	Not extracted	Not extracted	MMS and prevention of anemia in pregnancy

Note: PHC = public health center; FGD = focus group discussion. "Not extracted" indicates that the item was not recorded in the extraction used for this table.

Clinical impact of adherence (Global IPD evidence)

The IPD meta-analysis by Smith et al. (2025) contains two kinds of evidence that should not be read alike. The trial-based component shows that the benefit of MMS over IFA grew with adherence (P for interaction < 0.05). The observational component compares outcomes across adherence categories among women who received MMS and is therefore open to confounding, since women who adhere well may simply be healthier or better supported. Table 2 labels the evidence type of each estimate for this reason.

Table 2. Adherence level and neonatal and maternal outcomes in the IPD meta-analysis

Outcome	Comparison/adherence category	Estimate (95% CI)	Evidence type
Birth weight	MMS vs IFA among women with adherence $\geq 90\%$	+56 g (45 to 67)	Trial-based (IPD of 15 RCTs)
Birth weight	MMS vs IFA among women with adherence $< 60\%$	+9 g (−17 to 35); not significant	Trial-based (IPD of 15 RCTs)
Birth weight	Adherence $\geq 90\%$ among MMS recipients	+44 g (31 to 56)	Observational
Low birth weight	Adherence $\geq 90\%$ among MMS recipients	RR 0.93 (0.88 to 0.98)	Observational
Small-for-gestational-age	Adherence $\geq 90\%$ among MMS recipients	RR 0.95 (0.93 to 0.98)	Observational
Maternal anemia	Adherence $< 75\%$ vs 75–90%	RR 1.26 (1.11 to 1.43)	Observational
Stillbirth	Adherence $< 75\%$ vs 75–90%	RR 1.43 (1.12 to 1.83)	Observational

Note: RR = relative risk. Reference categories for the $\geq 90\%$ observational estimates are those defined by Smith et al. (2025).

The birth-weight estimates show that the added benefit of MMS over IFA was 56 g among high adherers, whereas it did not differ significantly from IFA among low adherers. That 56 g is a difference between MMS and IFA within an adherence stratum; it does not compare high with low adherers. A relative risk of 1.26 for anemia and 1.43 for stillbirth means a 26% and 43% higher relative risk among women with adherence below 75% than among those at 75–90%. The stillbirth interval is wide, and its lower bound sits close to 1, which argues for caution.

Figure 3 summarizes these findings schematically. The curve between the plotted points is illustrative only, and the exact estimates are those in Table 2.

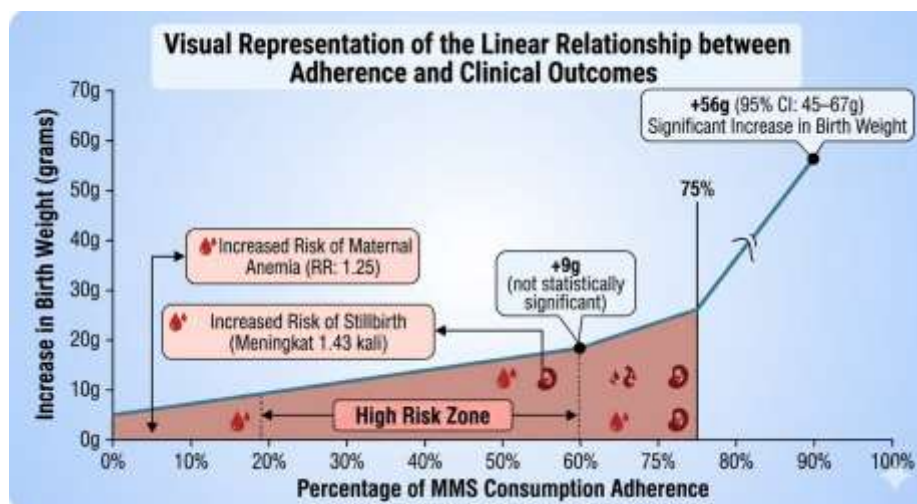


Figure 3. Visual representation of the linear relationship between adherence and clinical outcomes (schematic)

Psychological, enabling, and reinforcing determinants (HBM, TPB, PRECEDE-PROCEED)

Individual psychological factors and system-level conditions were reported side by side as influences on whether intention became consumption. Table 3 maps the determinants onto the three frameworks and indicates how consistently each was reported.

Table 3. Mapping of HBM, TPB, and PRECEDE-PROCEED constructs to MMS adherence

Framework	Construct	Key findings and relation to adherence	Evidence consistency (n sources)	Sources
HBM	Perceived benefits	Belief that MMS gives tangible benefits for blood formation, fetal growth, and immunity was associated with higher adherence.	Consistent (3)	Mufidah et al., 2025; Abidah & Sumarmi, 2024; Buanasita et al., 2025
HBM	Perceived barriers	Nausea, vomiting, tablet size and aroma, boredom, and concerns about harm to the fetus were associated with lower adherence.	Consistent (3)	Puspitasari et al., 2026; Buanasita et al., 2025; Smith et al., 2025
HBM	Self-efficacy	Confidence in continuing to take MMS despite side effects was associated with continued use.	Moderate (2)	Mufidah et al., 2025; Ba et al., 2025
TPB	Attitude and subjective norm	A favorable attitude toward MMS and the expectations of significant others (husband, family, health workers) were described as shaping intention.	Limited (1)	Mufidah et al., 2025
TPB	Perceived behavioral control	Perceived control over taking MMS was lower with employment, pregnancy complaints, and advancing gestational age.	Moderate (2)	Mufidah et al., 2025; Buanasita et al., 2025
PRECEDE-PROCEED	Enabling factors	Physical access, transport cost, and consistent MMS stock at health facilities were linked to uninterrupted consumption.	Moderate (2)	Riandari, 2025; Smith et al., 2025
PRECEDE-PROCEED	Reinforcing factors	Husband and family support, monitoring by Posyandu cadres, quality of midwife counseling, and creative reminders were linked to adherence.	Consistent (3)	Battung et al., 2025; Abidah & Sumarmi, 2024; Puspitasari et al., 2026

Note: Consistent = three or more sources; Moderate = two sources; Limited = one source (Section 2.7). Labels describe convergence of findings, not causal certainty. Mufidah et al. (2025) is a review and may overlap with some primary studies.

Enabling and reinforcing factors by domicile (urban vs. rural)

Environmental and system factors influenced the translation of intention into consumption, and their balance differed between the urban and rural settings studied (Table 4).

Table 4. Enabling and reinforcing factors by domicile (urban vs. rural)

Domicile	Main barriers	Reinforcing factors	Sources
Urban (e.g., Surabaya)	Employment status (working mothers had lower behavioral control) and pregnancy complaints such as nausea and vomiting.	Closer access to health facilities (inferred; not directly tested in the included studies).	Buanasita et al., 2025; Abidah & Sumarmi, 2024
Rural (e.g., Kebumen)	Geographical distance to the Puskesmas (community health center), transport limitations, and road infrastructure constraints.	Home visits and interpersonal communication by Posyandu cadres and village midwives.	Riandari, 2025

Note: Urban–rural contrasts rest on a small number of single-site studies and are interpretive.

DISCUSSION

Synthesis of evidence and regional variations in adherence

Table 1 pairs trial-level evidence on whether MMS works with local studies on why women do or do not take it. The IPD meta-analysis supplies the clinical rationale; the Indonesian studies show how unevenly that rationale translates into daily practice. In Surabaya, Buanasita et al. (2025) found program uptake of 81.5% but adherence, judged against gestational age, of only 23.6%, with working mothers and women troubled by nausea and vomiting faring worst. Battung et al. (2025) in Parepare recorded 75.3%, which was attributed to supplementation starting in the first trimester.

Setting those two numbers side by side invites a misleading comparison. The studies operationalized adherence differently (against gestational age in one, as tablets taken in the other), drew on different samples, differed in the share of urban and working women, and probably in supply as well. Because both are cross-sectional, early initiation cannot be isolated as the reason for the Parepare figure, and much of the gap may be artefact. The qualitative study in Kulon Progo adds what the surveys cannot: tablet aroma, taste, and boredom over a long course are felt as real sensory barriers (Puspitasari et al., 2026), which helps explain why complaints erode adherence. Education alone is unlikely to be enough when the tablet itself is hard to tolerate.

Adherence and clinical outcomes

Trial results indicate that MMS yields greater birth-weight gain than IFA when adherence is high (+56 g at $\geq 90\%$) than when it is low (+9 g, not significant at $< 60\%$) (Smith et al., 2025). This fits the wider evidence that MMS reduces LBW and SGA compared with IFA (Keats et al., 2019). A broader range of micronutrients plausibly supports placental function and uteroplacental perfusion, though no included study tested this mechanism, so it remains an interpretation. For anemia, a quasi-experimental study in Indonesia reported mean hemoglobin rising from 10.6 to 12.2 g/dL after MMS (Katili, 2025); this before–after change cannot be separated from other influences.

The associations of adherence below 75% with maternal anemia (RR 1.26) and stillbirth (RR 1.43) come from observational analyses (Smith et al., 2025). They are consistent with the idea that sustained consumption matters, yet confounding and healthy-adherer effects may inflate them, and they do not show that raising adherence would lower stillbirth by the same proportion. The authors of the IPD analysis conclude that programs should promote early initiation alongside

high adherence (Smith et al., 2025). Starting before 20 weeks is therefore a reasonable programmatic target, and it ties adherence strategies to first-trimester ANC contact.

Integrating psychological determinants: HBM and TPB

The HBM and TPB describe different parts of one decision. Women who believed MMS offered concrete benefits and trusted themselves to continue despite side effects adhered better (Abidah & Sumarmi, 2024; Mufidah et al., 2025). The TPB adds that such beliefs become behavior only when a woman also holds a favorable attitude, feels supported by those around her, and feels able to act (Ajzen, 1991). In the included studies, perceived behavioral control was weakened by employment, pregnancy complaints, and the tablet's sensory qualities (Buanasita et al., 2025; Puspitasari et al., 2026), showing how a woman can intend to adhere but still not do so.

Evidence for attitude and subjective norm is thinner than for the HBM constructs and rests mainly on one review (Mufidah et al., 2025). The integration of the three frameworks (Figure 1 and Table 3) is better treated as a scheme for organizing findings, and as a guide for primary studies that measure all three sets of constructs in the same sample, than as a tested model. Where the frameworks converge, as with self-efficacy and perceived behavioral control (similar capability) or subjective norm and reinforcing factors (similar social influence), the overlapping constructs are counted once rather than as independent determinants.

Structural and social factors (PRECEDE-PROCEED)

Program success depends as much on the service environment as on individual readiness. Two PRECEDE-PROCEED categories carry most of that weight.

1. Enabling factors: accessibility and service systems
 - Geographic access and infrastructure: in rural Kebumen, variation between coastal, lowland, and hilly areas created structural barriers, and long distances, transport costs, and poor roads were associated with delayed ANC visits and supplement collection (Riandari, 2025).
 - Supply consistency: stable MMS stock at service points is a precondition for continuous consumption, and stock-outs may undermine trust in the program (Riandari, 2025; Smith et al., 2025).
 - Socioeconomic and occupational characteristics: working mothers had less control over their time to follow a daily regimen than housewives (Buanasita et al., 2025).
2. Reinforcing factors: social support and communication
 - Cadres and health workers: Posyandu cadres and village midwives connect health facilities with families, and home visits, monitoring, and personal communication were associated with stronger commitment (Battung et al., 2025; Puspitasari et al., 2026).
 - Family and husband support: reminders and help with food while taking the tablets were described as a dominant reinforcing factor, and without family support women were more susceptible to boredom and forgetfulness over a long course (Abidah & Sumarmi, 2024).
 - Innovative communication: creative media such as an MMS song and storytelling adapted to local culture have been used to reinforce messages (Vitamin Angels, 2024), and mHealth reminders by WhatsApp or SMS are a low-cost option whose effect on MMS adherence still needs to be evaluated in Indonesia.

These findings point to interventions that pair logistical availability at village level with active family and community support. Since the studies behind Table 4 are few and single-site, the urban-rural contrast is best read as a hypothesis.

Implications and recommendations

Most evidence on determinants is observational, so the following suggestions for program planners and health workers carry that caveat:

- a. Multimodal strategy: combine interpersonal counseling by midwives with a defined role for Posyandu cadres as supporters of daily tablet-taking.

- b. Managing physical barriers: give practical counseling on handling nausea and choosing a suitable time of day to take the tablet, which targets perceived barriers and behavioral control.
- c. Reminder technology: pilot and evaluate mobile reminders (WhatsApp or SMS), particularly for working mothers in urban areas.
- d. Early initiation: aim to start MMS before 20 weeks of gestation by strengthening first-trimester (K1) ANC contact.
- e. Monitoring: shift program indicators from distribution coverage to adherence coverage, and secure stock availability at facility level to avoid interruptions in consumption.

Strengths and limitations

This review follows PRISMA 2020, combines three complementary theories through explicit conceptual links, uses a reproducible rule for labeling evidence consistency, and keeps trial-based and observational estimates separate. Its limits are real. The included studies differ in design and in how they defined and measured adherence (self-report, pill count, or records), so no pooled estimate was produced and cross-study comparison remains descriptive. Most findings on determinants and on adherence–outcome relations are observational and open to confounding, and should be read as associations. Evidence on TPB constructs is limited, and several Indonesian studies come from Java, which narrows generalizability. Publication bias was not formally assessed; regional databases and organizational portals were searched, but one source is an unpublished thesis proposal, which may add variability in quality. The Cochrane review and the IPD meta-analysis may also include shared trials, so their estimates were not combined.

CONCLUSION

Adherence to MMS among pregnant women emerges from the interplay of individual beliefs (perceived benefits, perceived barriers, self-efficacy), perceived behavioral control, and the enabling and reinforcing conditions of the health system and community. Higher adherence was associated with a larger birth-weight benefit of MMS over IFA (+56 g at ≥90% adherence against +9 g, not significant, at <60%), and observational analyses linked adherence below 75% to higher risks of maternal anemia and stillbirth. These relationships rest largely on observational evidence and should be read as associations, not proven causal effects.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

FR: Conceptualization, investigation, formal analysis, writing original draft, visualization. **EG:** Supervision, validation, review, and editing. **EW:** Supervision, validation, review, and editing.

Funding

The authors self-funded this research and received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials

All data analyzed were taken from the published sources cited in the reference list. The data extraction sheet is available from the corresponding author on reasonable request.

Competing interests

The authors declare no competing interests.

ACKNOWLEDGEMENT

The authors thank Universitas Jenderal Soedirman (UNSOED) and the Faculty of Health Sciences for the institutional and academic support needed to complete this systematic review. The authors also thank the researchers, health cadres, and midwives whose studies in various regions made this synthesis possible.

REFERENCES

- Abebe, F., Kidanemariam, Y. T., Tsegaw, M., Birhanu, Z., Abdi, A., Chitekwe, S., Sharma, R., Getachew, H., Noor, R., Aden, A. H., Chuko, T., Dejene, T., & Dawd, A. M. (2025). Acceptance of multiple micronutrient supplementations (MMS) and iron and folic acid supplement utilisation among pregnant and lactating women in the rural part of Ethiopia, 2022: A cross-sectional study. *BMJ Open*, 15(1), e081359. <https://doi.org/10.1136/bmjopen-2023-081359>
- Abidah, N., & Sumarmi, S. (2024). A comparison of adherence levels of pregnant women to consuming multiple micronutrient supplements and iron folic acid at Mulyorejo Public Health Center, Surabaya. *Amerta Nutrition*, 8(1), 17–25. <https://doi.org/10.20473/amnt.v8i1.2024.17-25>
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Alfaqeeh, M., Suwantika, A. A., Postma, M. J., Nugrahani, A. D., Setyani, R. A., & Zakiyah, N. (2025). Maternal perspectives on multiple micronutrient supplementation (MMS) in Indonesia: A cross-sectional study of knowledge, attitudes, and acceptance. *BMC Public Health*, 25, 4062. <https://doi.org/10.1186/s12889-025-24885-5>
- Ba, A., Fox, M. J., Keita, A. M., Hurley, K. M., King, S. E., Sow, S., ... Winch, P. J. (2025). Qualitative evaluation of a package of implementation strategies codesigned to support the introduction of multiple micronutrient supplementation (MMS) for pregnant women in Bamako, Mali. *Maternal & Child Nutrition*, 21(1), e13712. <https://doi.org/10.1111/mcn.13712>
- Battung, S. M., Groen, H., & van der Beek, E. M. (2025). Prenatal multiple micronutrient supplementation in the Parepare district, Indonesia; population characteristics and intake adherence. *BMC Public Health*, 25(1), 983. <https://doi.org/10.1186/s12889-025-22129-0>
- Buanasita, A., Sumarmi, S., Loh, S. P., & Redjeki, K. S. (2025). Factors affecting adherence of multiple-micronutrient supplement consumption among pregnant mothers in Surabaya, East Java, Indonesia. *Malaysian Journal of Medicine and Health Sciences*, 21, 124–133. https://medic.upm.edu.my/upload/dokumen/20250909143331MJMHS_1360.pdf
- ClinicalTrials.gov. (2025). *Antenatal multiple micronutrient supplementation (MMS) in Indonesia (NCT06225791)*. Johns Hopkins Bloomberg School of Public Health. <https://clinicaltrials.gov/study/NCT06225791>
- Critical Appraisal Skills Programme. (2018). *CASP qualitative studies checklist*. United Kingdom. <https://casp-uk.net/casp-tools-checklists/>
- Desta, M., Kassie, B., Chanie, H., et al. (2019). Adherence of iron and folic acid supplementation and determinants among pregnant women in Ethiopia: A systematic review and meta-analysis. *Reproductive Health*, 16, 182. <https://doi.org/10.1186/s12978-019-0848-9>
- Green, L. W., & Kreuter, M. W. (2005). *Health program planning: An educational and ecological approach* (4th ed.). McGraw-Hill. <https://library.wur.nl/WebQuery/titel/1769237>
- Joanna Briggs Institute. (2020). *Critical appraisal tools*. Australia: Adelaide University. <https://jbi.global/critical-appraisal-tools>
- Katili, D. N. O. (2025). Effect of giving MMS (multiple micronutrient supplement) tablets on changes in anemia status in pregnant women: A quasi-experimental study. *Jurnal Kesehatan*, 16(2), 68–80. <https://doi.org/10.35730/jk.v16i2.1345>
- Keats, E. C., Haider, B. A., Tam, E., & Bhutta, Z. A. (2019). Multiple-micronutrient supplementation for women during pregnancy. *Cochrane Database of Systematic Reviews*, 2019(3), CD004905. <https://doi.org/10.1002/14651858.CD004905.pub6>

- Kementerian Kesehatan Republik Indonesia. (2018). *Hasil utama Riskesdas 2018*. Jakarta: Badan Penelitian dan Pengembangan Kesehatan.
- Kraemer, K., Beesabathuni, K., Askari, S., Khondker, R., Khan, T. U., Rahman, M., ... Tshering, P. P. (2023). Knowledge, attitudes and practices of pregnant women and healthcare providers in Bangladesh regarding multivitamin supplements during pregnancy. *Healthcare*, 11(5), 713. <https://doi.org/10.3390/healthcare11050713>
- Labonté, J. M., Hoang, M. A., Panicker, A., Kroeun, H., Sokchea, M., Sambo, S., ... Karakochuk, C. D. (2025). Exploring factors affecting adherence to multiple micronutrient supplementation during pregnancy in Cambodia: A qualitative analysis. *Maternal & Child Nutrition*, 21(1), e13745. <https://doi.org/10.1111/mcn.13745>
- Lizarondo, L., Stern, C., Carrier, J., Godfrey, C., Rieger, K., Salmond, S., Apostolo, J., Kirkpatrick, P., & Loveday, H. (2020). Mixed methods systematic reviews. In E. Aromataris & Z. Munn (Eds.), *JBIM manual for evidence synthesis*. JBI. <https://doi.org/10.46658/JBIMES-20-09>
- Mufidah, Y., Herawati, H., Sauqi, H., Noor, M. S., & Rahman, F. (2025). Literature review: Analysis of pregnant women's compliance with multiple micronutrient supplement (MMS) consumption (interviewed from the Health Belief Model theory and theory of planned behavior). *Indonesian Journal of Global Health Research*, 7(6), 1177–1186. <https://doi.org/10.37287/ijghrv7i6.1034>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Puspitasari, K., Kandarina, B. J. I., & Ratrikaningtyas, P. D. (2026). Exploring the acceptance of multiple micronutrient supplement (MMS) among pregnant women: A case study in Kulon Progo District. *Amerta Nutrition*, 10(1). <https://doi.org/10.20473/amnt.v10i1.2026.96-105>
- Riandari, F. (2025). Analysis determinant compliance consumption of multiple micronutrient supplement (MMS) tablets among pregnant women in community health center areas Ambal II Regency Kebumen. [Thesis]. Banyumas: Universitas Jenderal Soedirman.
- Rosenstock, I. M. (1974). Historical origins of the Health Belief Model. *Health Education Monographs*, 2(4), 328–335. <https://doi.org/10.1177/109019817400200403>
- Shea, B. J., Reeves, B. C., Wells, G., Thuku, M., Hamel, C., Moran, J., ... Henry, D. A. (2017). AMSTAR 2: A critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*, 358, j4008. <https://doi.org/10.1136/bmj.j4008>
- Smith, E. R., Gomes, F., Adu-Afarwuah, S., et al. (2025). Contribution of maternal adherence to the effect of multiple micronutrient supplementation during pregnancy: A systematic review and individual participant data meta-analysis. *Advances in Nutrition*, 16(7), 100455. <https://doi.org/10.1016/j.advnut.2025.100455>
- Vitamin Angels. (2024). *How Indonesia is transforming maternal nutrition with MMS*. Los Angeles. <https://www.vitaminangels.org/news/how-indonesia-is-transforming-maternal-nutrition-with-mms/>
- World Health Organization. (2020). *WHO antenatal care recommendations for a positive pregnancy experience: Nutritional interventions update: Multiple micronutrient supplements during pregnancy*. Switzerland: World Health Organization.
- Zhong, J., Li, N., Chen, J., Liu, J., Li, Z., Wang, J., & Liu, X. (2025). The effect of multiple micronutrients supplementation on preventing anemia during pregnancy: A retrospective cohort study. *Nutrition & Metabolism*, 22(1), 62. <https://doi.org/10.1186/s12986-025-00944-x>