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# DEVELOPMENT AND PSYCHOMETRIC VALIDATION OF A QUESTIONNAIRE ON PREGNANT WOMEN'S INTENTIONS TO USE MULTIPLE MICRONUTRIENT SUPPLEMENTATION (MMS): A CONFIRMATORY FACTOR ANALYSIS

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**ABSTRACT**

Adherence to multiple micronutrient supplementation (MMS) during pregnancy remains challenging, whereas intention is a primary antecedent of health behavior. A theoretically grounded, psychometrically validated instrument is needed to assess pregnant women's intention to use MMS. The aim is to develop and validate a questionnaire measuring pregnant women's intention to consume MMS by integrating the health belief model and the theory of planned behavior. Methods: A sequential mixed-methods design was employed. The items were generated from focus group discussions and a literature review and then tested among 216 pregnant women (second trimester). Construct validity was evaluated via confirmatory factor analysis (CFA), and reliability was assessed via Cronbach's alpha and composite reliability (CR). Convergent and discriminant validity were examined via average variance extracted (AVE) and the Fornell–Larcker criterion. Results: A five-construct model demonstrated marginal yet acceptable fit ($\chi^2/df \approx 3.278$; RMSEA $\approx 0.103$). The final scale comprises 17 items: susceptibility (4), severity (2), benefits (3), motivation (5), and intention (3). All factor loadings were significant (≈0.53–0.95). Reliability was adequate (most α and CR $\geq$ 0.70). The AVE criteria were met for four constructs; severity fell slightly below the threshold but was retained on substantive grounds. The questionnaire has good validity and reliability for measuring the likelihood of using MMS among pregnant women. It is suitable for the early identification of women with low intention, targeted intervention planning, and evaluation of supplementation programs in primary care settings.

**Keywords**: Intention, pregnancy, health belief model, theory of planned behavior, confirmatory factor analysis

## INTRODUCTION

Maternal health remains a global priority given that most maternal deaths are largely preventable. In 2020, an estimated 287,000 women worldwide died from complications of pregnancy and childbirth, with approximately 95% occurring in low- and middle-income countries (WHO, 2025). Postpartum hemorrhage and infection remain the leading causes of maternal death, accounting for nearly three-quarters of all maternal mortality (Say et al., 2014). This burden is compounded by anemia during pregnancy, which substantially increases the risks of postpartum hemorrhage, preterm birth, low birth weight, and maternal death, as documented in global anemia estimates and adverse pregnancy outcomes (Haider et al., 2011; WHO, 2023).

Anemia during pregnancy continues to pose a significant public health challenge worldwide. The WHO reports that more than one-third (35.5%) of pregnant women globally are anemic, with the highest prevalence in developing countries (WHO, 2023). Its impact is not merely short-term; anemia can also fuel an intergenerational cycle of stunting through impaired fetal and child growth (Mildon et al., 2023). To address this problem, iron–folic acid (IFA) supplementation has long been recommended. However, recent evidence suggests that multiple micronutrient supplementation (MMS) is superior in improving hemoglobin concentrations, reducing anemia incidence, and lowering the risk of low birth weight (LBW) and small-for-gestational-age (SGA) births (Haider & Bhutta, 2017; Sudfeld & Smith, 2019). In line with these recommendations, several countries, including Indonesia, have begun adopting MMS within their national maternal health policies to support accelerated reductions in anemia and stunting (Faris et al., 2021).

Although the potential benefits of multiple micronutrient supplementation (MMS) are well established, program success largely depends on pregnant women's intentions and adherence to consistent use. Several studies have shown that women with stronger intentions exhibit better adherence to supplementation than those with weaker intentions (Nabizadeh et al., 2018; Sun et al., 2022). Within the theory of planned behavior (TPB), intention is the strongest predictor of behavior, including supplement use (Ajzen, 1991). Similarly, the health belief model (HBM) posits that preventive behaviors are shaped by perceived susceptibility, severity, benefits, barriers, and cues to action (Rosenstock et al., 1988). Integrating the TPB and HBM offers a more comprehensive approach: the TPB incorporates social norms and perceived behavioral control, whereas the HBM captures individual risk–benefit appraisals. This integrated approach has proven effective in improving supplementation adherence during pregnancy across various nutrition education interventions (Beressa et al., 2024; Fatima & Sharma, 2025).

Integrating the TPB and HBM offers a more comprehensive approach: the TPB incorporates social norms and perceived behavioral control, whereas the HBM captures individual risk–benefit appraisals. This integrated approach has proven effective in improving supplementation adherence during pregnancy across various nutrition education interventions (DiStefano & Hess, 2005; Prudon, 2015). Integrating the TPB and HBM offers a more comprehensive approach: the TPB incorporates social norms and perceived behavioral control, whereas the HBM captures individual risk–benefit appraisals. This integrated approach has proven effective in improving adherence to supplementation during pregnancy across various nutrition education interventions.

## MATERIALS AND METHODS

### STUDY DESIGN

This study employed a sequential explanatory mixed-methods design. The first, exploratory qualitative phase aimed to develop the initial questionnaire items, which were grounded in theory and informed by in-depth discussions with multiple stakeholders. The second, quantitative phase adopted a cross-sectional approach to examine the instrument's psychometric properties, with particular emphasis on confirmatory factor analysis (CFA).

### SETTING

The study was conducted in Bone Bolango Regency, Gorontalo Province, Indonesia. The site was selected because it is a focal area for maternal nutrition and health interventions, offering a relevant context in which to assess the intention to use MMS. Quantitative data were collected purposively across several Puskesmas (primary health centers) and Posyandu (integrated community health posts) that routinely serve pregnant women with diverse sociodemographic profiles, thereby capturing the target conditions of interest.

### PARTISIPAN

The quantitative sample size was determined via commonly applied rules of thumb for SEM/CFA, which recommend that a minimum of 5–10 respondents per parameter to be estimated (Hair et al., 2013). On the basis of these guidelines and the initial 22-item questionnaire, a target sample of 216 pregnant women was established. This size was considered adequate to yield stable CFA solutions and reliable parameter estimates (Kline, 2016).

The inclusion criteria were pregnant women at 13–26 weeks gestation (second trimester); willing to participate and provide written informed consent; no communication impairments that would hinder questionnaire completion; and residing within the catchment areas of the participating Puskesmas. The exclusion criterion was severe pregnancy complications requiring inpatient care.

A purposive sampling strategy was employed, selecting participants from the population of pregnant women who met the inclusion criteria and attended antenatal care (ANC) visits at the selected health facilities during the study period (January–March 2025).

### Instrument development

The instrument was developed systematically in two main stages to ensure content validity and local contextual appropriateness. Initial items were generated on the basis of the integrated frameworks of the theory of planned behavior (TPB) and the health belief model (HBM) (Ajzen, 1991; Rosenstock et al., 1988). A focus group discussion (FGD) was conducted with 10 pregnant women (not included in the quantitative sample) to assess comprehension, linguistic clarity, and contextual relevance. The lead investigator facilitated the discussion, and the outputs were thematically analyzed to refine items that were unclear or misaligned with the local context. These findings informed the reviewers and produced a questionnaire version that was ready for quantitative testing. Several items were editorially revised on the basis of FGD feedback; however, no constructs or core items were removed at this stage, leaving 22 items prior to confirmatory factor analysis. The 22 initial items covered five theoretical constructs: perceived susceptibility (4 items), perceived severity (3 items), perceived benefits (4 items), motivation (7 items), and intention (4 items). Each statement was rated on a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). All the item statements are presented in the supplementary material.

The draft questionnaire was subsequently evaluated through expert review. A panel of five experts (an epidemiologist and a public nutrition specialist, an academic in maternal and child health, a practicing midwife, a representative from the district health office, and a representative from Vitamin Angels) assessed the relevance, clarity, and ambiguity of each item via a 4-point scale (1 = not relevant to 4 = highly relevant). Items with an item-level content validity index (I-CVI) < 0.78 were revised or removed (Polit et al., 2007).

### Data collection

The quantitative data were collected via a paper-based questionnaire that was developed and refined during the qualitative phase. The questionnaire was self-administered by pregnant women who provided written informed consent. Trained enumerators supported data collection to ensure procedural consistency and to offer clarification when respondents encountered difficulties interpreting items without influencing their responses.

### Data analysis

The analyses proceeded in several steps to evaluate the instrument's psychometric properties. Demographic characteristics were summarized via descriptive statistics. Confirmatory factor analysis (CFA) with maximum likelihood estimation was conducted in AMOS version 24.0 to examine construct validity and the instrument's dimensional structure. Model fit was assessed via multiple indices: the chi-square/df ($\chi^2$/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), Tucker–Lewis index (TLI), normed fit index (NFI), incremental fit index (IFI), root mean square error of approximation (RMSEA), and root mean square residual (RMR). The criteria for acceptable fit were $\chi^2$/df < 5, GFI > 0.90, AGFI > 0.90, CFI > 0.90, TLI > 0.90, NFI > 0.90, IFI > 0.90, RMSEA < 0.08, and RMR < 0.08 (Kline, 2016).

Convergent validity was evaluated via the average variance extracted (AVE), with a threshold of 0.50. Construct reliability was assessed via Cronbach's alpha and composite reliability (CR), with a value of ≥ 0.70 indicating adequate internal consistency (Fornell & Larcker, 1981). Discriminant validity was examined via the Fornell–Larcker criterion, which requires the square root of each construct's AVE to exceed its correlations with other constructs (Hair et al., 2013). Multicollinearity was assessed via the variance inflation factor (VIF) with a threshold of < 5.0. All the statistical tests used a significance level of $\alpha = 0.05$.

### Ethical considerations

Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Hasanuddin (2108/UN4.14.1/TP.01.02/2024). All participants in both study phases provided written informed consent after receiving information on the study's objectives, benefits, and data confidentiality.

## RESULTS

### Participant characteristics

A total of 216 pregnant women participated in this study. Most respondents were aged 20–34 years (83.3%), had secondary education (44.0%), were employed (89.4%), and had primigravida status (98.6%), with an interpregnancy interval of either <2 years or >5 years. characteristics are presented in Table 1.

### Confirmatory Factor Analysis (CFA) Results

CFA was conducted to test the five-factor structure of the instrument measuring the intention to use MMS. The measurement model demonstrated marginal fit, with $\chi^2$/df = 3.278 and RMSEA = 0.103. Although several fit indices (GFI, AGFI, CFI, TLI, NFI, and IFI) were below the optimal recommended threshold (>0.90), a $\chi^2$/df below five and an RMSEA < 0.110 are still considered acceptable for exploratory research in public health contexts [1,2]. All factor loadings were statistically significant ($p < 0.05$) and ranged from 0.53--0.95. The complete goodness-of-fit indices are presented in Table 2.

On the basis of the CFA results (Table 3), item selection was conducted using the criteria of factor loading ($\lambda$) ≥ 0.50 and statistical significance ($p < 0.05$). A total of five items were eliminated for not meeting these thresholds, except for item Severity 3 ($\lambda = 0.466$; $p = 0.027$), which was retained on theoretical grounds. The final instrument comprises 17 items distributed across five constructs: perceived vulnerability (4 items), perceived severity (2 items), perceived benefits (3 items), motivation (5 items), and intention (3 items). The full set of final questionnaire items is provided in both English and Indonesian in the Supplementary Material. The factor loadings and item retention/elimination decisions are presented in Table 3.

### RELIABILITY AND VALIDITY

Reliability was assessed via Cronbach's alpha and composite reliability (CR). The Cronbach's alpha values across the constructs ranged from 0.58-0.92, whereas the CR values ranged from 0.62--0.94. The perceived severity construct showed marginal reliability ($\alpha = 0.58$; CR = 0.62), which is acceptable given the small number of items (two) and the statistical significance of its factor loadings. Convergent validity was achieved for four constructs (AVE > 0.50), whereas perceived severity had an AVE of 0.44, retained on substantive grounds. Discriminant validity was confirmed via the Fornell–Larcker criterion, whereby the square root of each construct's AVE exceeded its correlations with other constructs. The full reliability and validity results are presented in Tables 4.

## DISCUSSION

The instrument was designed by integrating the theory of planned behavior (TPB) and the health belief model (HBM), two widely used behavioral theories in public health for explaining and predicting individual behavior change, including supplement use during pregnancy (Ajzen, 1991; Rosenstock et al., 1988). Combining the TPB and HBM enables a broader examination of the determinants of intention, encompassing perceived risk, perceived benefits, self-efficacy, subjective norms, and perceived behavioral control (Abd Rahman et al., 2021; Beressa et al., 2024). Moreover, meta-analytic evidence indicates that HBM variables are effective predictors of health behavior (Carpenter, 2010).

Confirmatory factor analysis (CFA) indicated that the five-factor structure—perceived susceptibility, perceived severity, perceived benefits, motivation, and intention—achieved acceptable model–data fit. High CFI and TLI values, along with adequate factor loadings, support the theoretical model specification. Although the RMSEA slightly exceeded the conventional <0.08 threshold, the result remains acceptable under alternative recommendations for multidimensional model fit (Brown, 2015). These CFA findings also align with studies that have validated similar dual-theory instruments, including among pregnant women in Asian and African settings (Holliday, 2011). For transparent reporting, the model's index profile was $\chi^2/df = 3.278$ and RMSEA = 0.103, indicating marginal fit.

Most indicators loaded above 0.50, with composite reliability and Cronbach's alpha averaging >0.80, demonstrating good internal consistency (Williams et al., 2010). The motivation and benefits dimensions contributed most strongly to the intention construct, corroborating prior evidence that perceived benefits and intrinsic motivation are principal predictors of micronutrient supplement use during pregnancy (Nabizadeh et al., 2018; Sun et al., 2022). The emphasis on motivation is consistent with the theoretical foundations of intrinsic motivation (Deci & Ryan, 2013), and the dominance of perceived benefits accords with recommendations favoring multiple micronutrient supplementation during pregnancy (Haider & Bhutta, 2017).

In addition to statistical considerations, item development accounts for local and cultural contexts. For example, although one item within the perceived severity dimension had a factor loading below 0.50, it was retained because it substantively reflects mothers' concerns about infant death due to micronutrient deficiency—an issue that is socially and emotionally salient in the Indonesian context (DiStefano & Hess, 2005; Prudon, 2015). This approach aligns with the instrument-development literature, which recommends a combination of theoretical and contextual considerations. Clinically, anemia during pregnancy increases the risk of postpartum hemorrhage, preterm birth, low birth weight (LBW), and mother–infant mortality; therefore, measuring perceived severity remains crucial (WHO, 2023).

In practice, the instrument can be used in primary care as a rapid assessment tool to identify pregnant women with a low intention to use MMS. Prior studies underscore that program success in supplementation is strongly determined by individual intention and adherence (Beressa et al., 2025; Sudfeld & Smith, 2019). Within nutrition education interventions, a theoretically grounded, validated instrument is essential for planning and evaluating behavior-based programs, including efforts to prevent anemia and stunting (Haider & Bhutta, 2017; Sun et al., 2022). Consistent with recent evidence, MMS outperforms single-nutrient supplementation in improving hemoglobin and reducing adverse outcomes, further reinforcing the urgency of assessing intention and adherence (Haider & Bhutta, 2017; Sudfeld & Smith, 2019).

This instrument also shows potential for broader use through culturally and linguistically appropriate adaptation. Evidence from Ethiopia suggests that the simultaneous application of TPB and HBM in nutrition education yields significant improvements in diet diversity, birth weight, and adherence to supplementation (Beressa et al., 2024). Similar findings have been reported in Malaysia, where instruments have been developed and validated to measure the intention to use iron-based supplements and fortified foods (Abd Rahman et al., 2021). Additional validation studies among pregnant populations (Kianfard et al., 2022; Sarkis et al., 2022) further support cross-cultural adaptation.

However, this study has several limitations. Geographic representation was limited to a single administrative area, thereby restricting generalizability to other contexts. Additionally, the cross-sectional design limits causal inference among the constructs. Future studies should incorporate longitudinal assessments and employ advanced structural approaches, such as exploratory structural equation modeling (ESEM), to accommodate more complex model structures. The marginal goodness-of-fit profile also warrants cautious interpretation and supports the exploration of alternative modeling strategies in subsequent research.

## CONCLUSION

The intention-to-use multiple micronutrient supplementation (MMS) instrument for pregnant women, developed within an integrated HBM–TPB framework, demonstrated adequate construct validity and good reliability across five constructs (susceptibility, severity, benefits, motivation, and intention). Item selection yielded a 17-item final scale with significant factor loadings (~0.53–0.95), marginal yet acceptable overall fit ($\chi^2/df \approx 3.28$; RMSEA ≈ 0.103), and Cronbach's α and composite reliability values predominantly ≥0.70. These findings support the instrument's utility for rapid intention screening and planning nutrition education interventions in primary care. Replication across regions, cultural–linguistic adaptation, and further longitudinal studies employing ESEM/advanced SEM are recommended to increase measurement precision.

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**STATEMENT ON CONFLICT OF INTEREST (if any):** None.

**NOTES ON APPENDICES:** The complete appendices of this study are provided in a separate file, which is submitted together with this manuscript.

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**APPENDIX A**

Table 1. Participant characteristics (N = 216)

| Characteristic | n | % |
|---|---|---|
| Age (years) | | |
| 20–34 | 180 | 83.3 |
| <20 or ≥35 | 36 | 16.7 |
| Education | | |
| Primary education | 72 | 33.3 |
| Secondary education | 95 | 44.0 |
| Higher education | 49 | 22.7 |
| Occupation | | |
| Working | 193 | 89.4 |
| Not working | 23 | 10.6 |
| Parity | | |
| Primigravida (0–1 birth) | 213 | 98.6 |
| Multipara (2–4 births) | 2 | 0.9 |
| Grand multipara (≥5 births) | 1 | 0.5 |
| Birth interval (years) | | |
| ≥2–5 | 98 | 45.4 |
| <2 or >5 | 118 | 54.6 |

Table 2. Goodness-of-fit indices of CFA (N = 216)

| Fit Index | Cutoff value (criteria) | Result | Evaluation |
|---|---|---|---|
| $\chi^2$/df | ≤ 3.00 (good), ≤ 5.00 (acceptable) | 3.29 | Acceptable |
| GFI | ≥ 0.90 | 0.782 | Below threshold |
| AGFI | ≥ 0.90 | 0.731 | Below threshold |

| | | | |
|---|---|---|---|
| CFI | ≥ 0.90 | 0.823 | Below threshold |
| TLI | ≥ 0.90 | 0.801 | Below threshold |
| NFI | ≥ 0.90 | 0.766 | Below threshold |
| IFI | ≥ 0.90 | 0.825 | Below threshold |
| RMSEA | ≤ 0.08 (good), ≤ 0.10 (marginal) | 0.103 | Marginal |
| RMR | ≤ 0.08 | 0.220 | Poor |

$\chi^2$/df = chi-square divided by degrees of freedom; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index; CFI = Comparative Fit Index; TLI = Tucker–Lewis Index; NFI = Normed Fit Index; IFI = Incremental Fit Index; RMSEA = Root Mean Square Error of Approximation; RMR = Root Mean Square Residual.

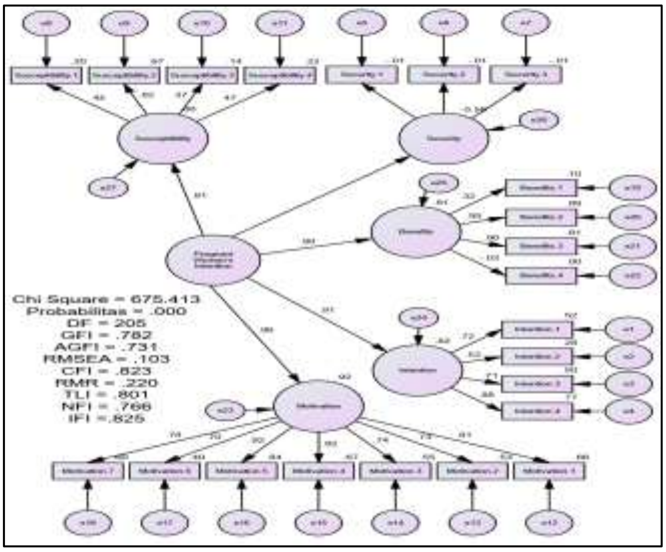


Figure 1. Structural equation model (SEM) integrating the health belief model (HBM) and theory of planned behavior (TPB) for determinants of pregnant women's intention to use multiple micronutrient supplementation (MMS).

Table 3. CFA Results per Item (Final Model)

| Construct | Item | λ (stand.) | S.E. | CR. | p | Decision |
|---|---|---|---|---|---|---|
| Vulnerability | Vuln.1 | 0.814 | – | – | – | Retained |
| | Vuln.2 | 0.726 | 0.269 | 5.837 | 0.000 | Retained |
| | Vuln.3 | 0.744 | 0.201 | 4.063 | 0.000 | Retained |
| | Vuln.4 | 0.816 | 0.230 | 4.708 | 0.000 | Retained |
| Severity | Sev.1 | 0.817 | – | – | – | Retained |
| | Sev.2 | 0.370 | – | – | – | Eliminated |
| | Sev.3 | 0.466 | 2.045 | 2.212 | 0.027 | Retained |
| Benefits | Ben.1 | 1.000 | – | – | – | Retained |
| | Ben.2 | 0.694 | 0.148 | 4.707 | 0.000 | Retained |
| | Ben.3 | 0.689 | 0.147 | 4.685 | 0.000 | Retained |
| | Ben.4 | -0.021 | 0.058 | -0.362 | 0.717 | Eliminated |
| Motivation | Mot.1 | 0.918 | – | 11.972 | 0.000 | Retained |
| | Mot.2 | 0.700 | 0.085 | 11.972 | 0.000 | Retained |
| | Mot.3 | 0.776 | 0.081 | 12.374 | 0.000 | Retained |
| | Mot.4 | 0.317 | 0.072 | 14.105 | 0.000 | Eliminated |
| | Mot.5 | 0.946 | 0.070 | 16.880 | 0.000 | Retained |
| | Mot.6 | 0.900 | 0.082 | 11.413 | 0.000 | Retained |
| | Mot.7 | -0.026 | 0.075 | 13.117 | 0.000 | Eliminated |
| Intention | Int.1 | 0.530 | – | – | – | Retained |
| | Int.2 | 0.706 | 0.115 | 7.384 | 0.000 | Retained |
| | Int.3 | 0.876 | 0.104 | 9.842 | 0.000 | Retained |
| | Int.4 | 0.445 | 0.098 | 12.026 | 0.000 | Eliminated |

λ = standardized factor loading; S.E. = standard error; C.R. = critical ratio; p = significance level. [a] = item eliminated due to low factor loading (<0.50).

Table 4. Reliability, Convergent Validity, and Discriminant Validity of Constructs (N = 216)

| Construct | Items | α | CR | AVE | √AVE | Vulnerability | Severity | Benefits | Motivation | Intention |
|---|---|---|---|---|---|---|---|---|---|---|
| Vulnerability | 4 | 0.85 | 0.88 | 0.60 | 0.78 | – | 0.48 | 0.52 | 0.58 | 0.55 |
| Severity | 2 | 0.58 | 0.62 | 0.44 | 0.66 | 0.48 | – | 0.42 | 0.45 | 0.40 |
| Benefits | 3 | 0.79 | 0.87 | 0.65 | 0.81 | 0.52 | 0.42 | – | 0.60 | 0.57 |
| Motivation | 5 | 0.92 | 0.94 | 0.73 | 0.85 | 0.58 | 0.45 | 0.60 | – | 0.62 |
| Intention | 3 | 0.77 | 0.84 | 0.52 | 0.72 | 0.55 | 0.40 | 0.57 | 0.62 | – |

α = Cronbach's alpha; CR = Composite reliability; AVE = Average variance extracted; √AVE = square root of AVE shown on the diagonal (bold). Discriminant validity is established when √AVE (diagonal) is higher than inter-construct correlations.