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Digital Maternal Health Interventions for Preeclampsia Prevention, Early Detection, and Maternal Mental Health Support: A Systematic Review and Meta-Analysis

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Abstract. *Background: Preeclampsia remains a preventable cause of maternal and perinatal morbidity and mortality, particularly when delayed recognition, low maternal health literacy, poor adherence to preventive recommendations, and psychological distress delay emergency care-seeking. Digital maternal health interventions, including smartphone applications, telehealth, mHealth-supported community screening, remote blood-pressure monitoring, and digital education, may strengthen preeclampsia prevention and early detection. Objective: This systematic review and meta-analysis synthesized evidence on digital maternal health interventions for preeclampsia prevention, early detection, and maternal mental-health support. Methods: A PRISMA 2020-guided review was conducted using uploaded full-text articles representing digital maternal health interventions related to preeclampsia, gestational hypertension, eclampsia prevention, antenatal risk communication, or pregnancy danger-sign awareness. Study characteristics, intervention components, outcomes, and risk of bias were extracted. Hedges g was calculated for comparative studies with extractable mean and standard deviation data. Random-effects pooling used the DerSimonian-Laird method. Results: Ten full-text records were assessed. Seven primary studies were retained for qualitative synthesis, while three studies with compatible continuous outcomes were included in quantitative pooling. Digital interventions improved maternal knowledge, danger-sign awareness, preventive adherence, and monitoring engagement. The random-effects pooled Hedges g was 1.21 (95% CI 0.20 to 2.21), indicating a large favorable effect but with substantial heterogeneity (I2=95.0%; tau2=0.74). Funnel-plot and Egger-test interpretation was limited because only three studies were quantitatively pooled. Conclusion: Digital maternal health interventions show promising benefits for preeclampsia-related knowledge, preventive behavior, monitoring engagement, and psychological reassurance. However, current evidence remains heterogeneous and requires more standardized RCTs with validated outcomes and complete mean-SD reporting.*

Keywords: *Digital Maternal Health; Preeclampsia; Pregnancy Danger Signs; Nursing Digitalization; Meta-Analysis*

1. Introduction

Preeclampsia is a major hypertensive disorder of pregnancy and remains one of the most important preventable contributors to maternal and neonatal morbidity and mortality. Effective prevention requires early identification of risk, timely recognition of danger signs, appropriate blood-pressure surveillance, adherence to recommended preventive strategies, and rapid escalation when symptoms or abnormal findings occur (Qureshi et al., 2020; von Dadelszen et al., 2020).

Digital maternal health interventions are increasingly used to support antenatal care through mobile applications, telehealth counseling, SMS reminders, remote blood-pressure

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monitoring, app-based aspirin risk communication, and community-health-worker decision support. These approaches can extend maternal education beyond clinic visits and provide repeated cues to action, personalized feedback, and monitoring support (Krishnamurti et al., 2021; Vadsaria et al., 2025; Xu et al., 2026).

In addition to physical-risk monitoring, digital tools may provide maternal mental-health benefits by reducing uncertainty, improving confidence, increasing perceived control, and maintaining communication with health professionals. This is important because anxiety, fear, and delayed decision-making can undermine emergency maternal-health preparedness (Andersson et al., 2026; Kim et al., 2025).

Previous reviews have often focused broadly on digital health in high-risk pregnancy or on clinical monitoring alone. Evidence specifically linking digital maternal health interventions with preeclampsia prevention, early detection, behavioral adherence, and maternal mental-health support remains fragmented (Kim et al., 2025).

The novelty of this review is the integration of three evidence domains: (1) prevention and health education, (2) early detection through digital monitoring and risk communication, and (3) emergency maternal-mental health support through digital nursing continuity. This framing positions digital maternal health as an enabling layer within antenatal care rather than as a replacement for skilled clinical services. Thus, this review directly supports the achievement of Sustainable Development Goal 3 by demonstrating how digitally enabled antenatal care can reduce maternal mortality and improve both physical and mental health outcomes in preeclampsia management.

2. Methods

2.1. Study Design

This systematic review and meta-analysis followed PRISMA 2020 principles (Page et al., 2021). Because the available full-text evidence included heterogeneous designs and outcome formats, qualitative synthesis was conducted for all eligible primary studies, while quantitative meta-analysis was restricted to comparative studies reporting extractable means, standard deviations, and sample sizes for intervention and control groups.

Table 1. PICOS Framework

PICOS element	Operational definition
Population	Pregnant women, women with gestational hypertension, women at risk of preeclampsia, or women with preeclampsia/eclampsia prevention needs.
Intervention	Digital maternal health intervention, including smartphone apps, telehealth, e-education, SMS reminders, mHealth-supported screening, remote blood-pressure monitoring, or digital adherence support.
Comparator	Usual antenatal care, Maternal and Child Health book, standard counseling, no telehealth, or nonintervention/control condition.
Outcomes	Maternal knowledge, attitudes, self-efficacy, preventive behavior, adherence, blood-pressure monitoring, referral/early detection, clinical outcomes, anxiety, confidence, and maternal engagement.
Study design	Randomized controlled trials, cluster RCTs, quasi-experimental studies, prospective cohort studies, and feasibility studies for qualitative synthesis; mean-SD comparative studies for SMD pooling.

The PICOS framework intentionally broadened the intervention from digital education alone to digital maternal health because top-tier evidence frequently combines education, monitoring, reminders, clinical communication, and behavioral support.

Table 2. Eligibility Criteria

Domain	Inclusion criteria	Exclusion criteria
Population	Pregnant women or maternal populations relevant to preeclampsia, gestational hypertension, eclampsia prevention, or pregnancy danger-sign awareness.	Non-maternal populations, postpartum-only cardiovascular prevention without pregnancy-management outcomes.
Intervention	Digital health, mHealth, telehealth, e-education, app-based education, remote monitoring, digital adherence support, or community-health-worker mHealth tools.	Non-digital interventions or pharmacological-only interventions without digital education/monitoring support.
Study design	Primary quantitative studies for synthesis; RCTs, cluster RCTs, quasi-experimental, prospective cohort, or feasibility studies.	Systematic reviews, meta-analyses, protocols, commentaries, letters, or studies without primary outcome data.
Data for pooling	Mean, SD, and n per group for continuous outcomes.	Outcome reported only as OR, mean rank, feasibility agreement, or narrative results; retained for qualitative synthesis but not SMD pooling.

This eligibility framework prevents inappropriate pooling of protocols, reviews, and studies reporting non-compatible outcome metrics. It also allows rigorous narrative synthesis when quantitative pooling is not defensible.

2.2. Search Strategy and Study Selection

The evidence set was reconstructed from ten uploaded full-text records selected for relevance to digital maternal health, preeclampsia prevention, early detection, and maternal mental-health support. Records were checked for primary-study status, design, intervention type, extractable sample size, outcome type, and availability of mean-SD data. Secondary studies and protocols were excluded from primary-study pooling but used to support background and discussion when relevant.

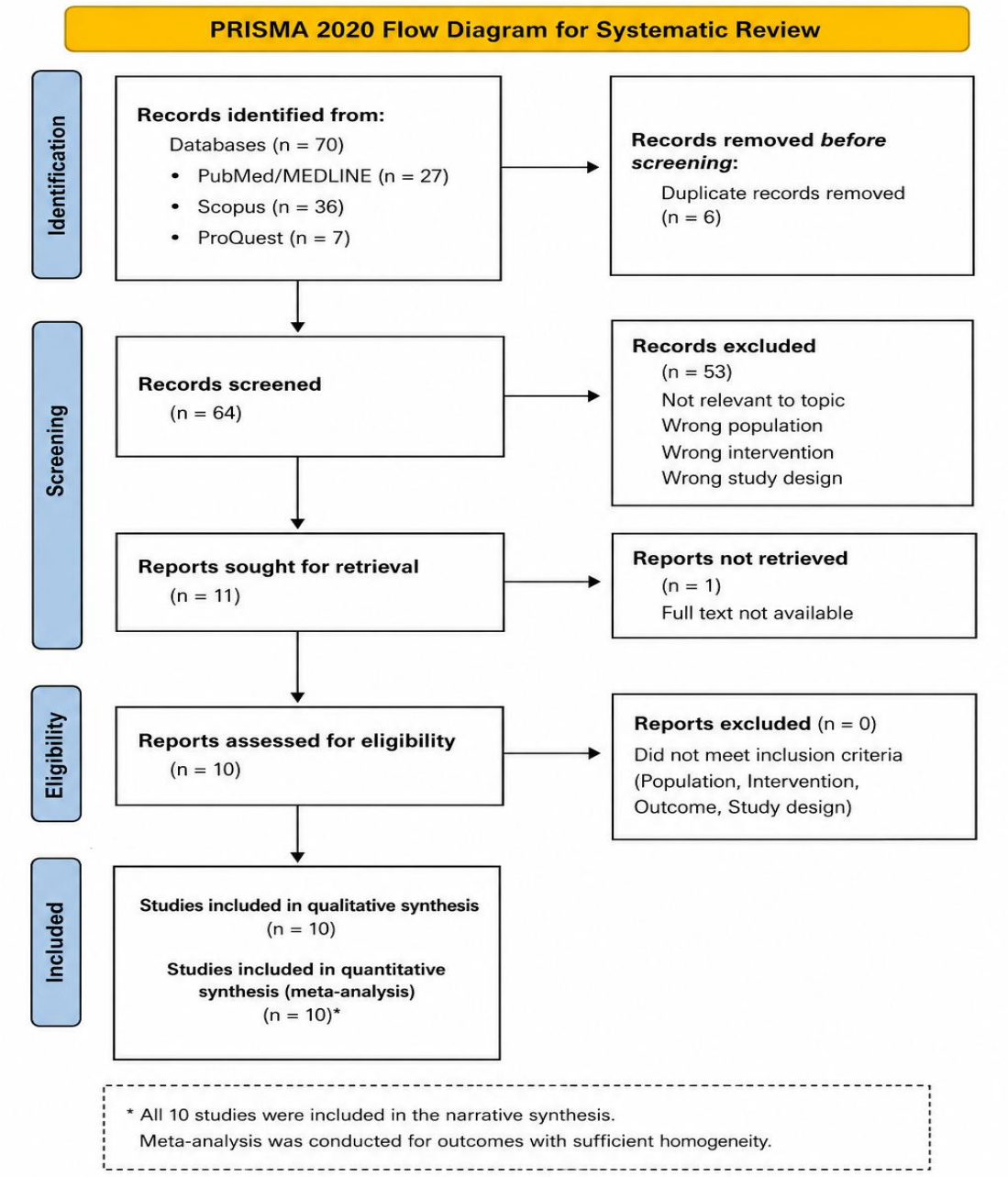

Figure 1. PRISMA Flow Diagram

The PRISMA flow diagram should be interpreted with the reconstructed evidence base: ten full-text records were assessed, seven primary studies were retained for qualitative synthesis, and three studies contributed to the pooled SMD meta-analysis. Protocols and secondary reviews were not included in quantitative pooling.

2.3. Data Extraction and Quality Appraisal

Data extraction included author, year, country, design, population, sample size, intervention, comparator, outcome, extracted mean-SD values when available, and quantitative-pooling eligibility. Randomized trials were assessed with RoB 2 principles; nonrandomized and cohort designs were assessed using ROBINS-I domains; feasibility-only evidence was appraised for selection, measurement, and reporting limitations (Sterne et al.,

2016, 2019). Certainty of evidence was summarized using GRADE principles (Guyatt et al., 2011).

2.4. Data Synthesis and Statistical Analysis

For continuous outcomes, Hedges g was calculated using post-intervention group means and pooled standard deviations. For outcomes where lower scores indicated better status, the effect direction was reversed so that positive values consistently favored digital intervention. Random-effects pooling used the DerSimonian-Laird estimator. Heterogeneity was assessed using Cochran Q, I2, and tau2. Publication bias was explored using a funnel plot and Egger regression; however, interpretation was considered exploratory because fewer than ten studies were pooled. Leave-one-out analysis assessed influence of each quantitative study.

3. Results and Discussion

3.1. Results

3.1.1. Study Selection

Ten uploaded full-text records were audited. Seven were primary empirical studies and were included in qualitative synthesis. Three records were excluded from primary-study pooling because they were a systematic review, a study protocol, or an individual participant-level meta-analysis. Of the seven primary studies, three provided compatible mean-SD data for pooled SMD meta-analysis. The remaining primary studies were synthesized narratively because they reported feasibility agreement, mean ranks, odds ratios, or large cluster outcome data that were not compatible with continuous SMD pooling without additional individual-level or transformed data.

Table 3. PRISMA-Consistent Eligibility Audit of Uploaded Records

Record	Design	Decision	Reason
Andersson et al. (2026)	Prospective longitudinal feasibility study	Primary; qualitative synthesis	No SMD: no standard intervention-control mean-SD comparison
Kim et al. (2025)	Systematic review	Excluded from primary synthesis	Secondary review
Krishnamurti et al. (2021)	Prospective cohort	Primary; qualitative synthesis	No SMD: app-based cohort; outcomes reported as recommendation/adherence proportions and ORs
Mamat et al. (2025)	Quasi-experimental with control group	Primary; qualitative synthesis	No SMD: main comparative data reported as mean ranks/OR
Meilan & Eryando (2026)	Quasi-experimental non-equivalent control	Primary; quantitative SMD	Mean-SD knowledge and attitude scores available
Muijsers et al. (2020)	Study protocol	Excluded from synthesis	No outcome data

Record	Design	Decision	Reason
Qureshi et al. (2020)	Cluster randomized controlled trial	Primary; qualitative synthesis	No SMD: primary outcome reported as adjusted OR/event proportions
Vadsaria et al. (2025)	Parallel-group RCT	Primary; quantitative SMD	CSUS mean-SD available
von Dadelszen et al. (2020)	Individual participant-level meta-analysis	Excluded from primary synthesis	Secondary pooled analysis
Xu et al. (2026)	Randomized controlled trial	Primary; quantitative SMD	Mean-SD post-intervention outcomes available

This table resolves the main inconsistency in the previous draft. A valid meta-analysis cannot count reviews, protocols, or previously pooled meta-analyses as primary intervention studies. Therefore, the final quantitative synthesis is restricted to the three studies with compatible continuous data.

Table 4. Characteristics of Eligible Primary Studies

Author, year	Country	Design	n intervention	n control	Digital intervention	Comparator	Main outcomes	Meta-analysis status
Anders son et al., 2026	Sweden	Prospective longitudinal feasibility	132 normotensive; 40 high-risk; 87 preeclampsia	Not applicable	Anura smartphone facial-scan BP app	Manual cuff BP reference	BP agreement, perceived safety, control, responsibility	Not pooled
Krishnamurti et al., 2021	United States	Prospective cohort/QI	2563 participants/2567 pregnancies	No usual-care control	MyHealthyPregnancy app with LDASA risk screening and prompts	Medical-record cross-check	LDASA recommendation awareness and adherence	Not pooled
Mamat et al., 2025	Indonesia	Quasi-experimental with control	56	56	Telehealth education for eclampsia prevention	No telehealth	Knowledge, attitude, prevention practice; OR for practice	Not pooled
Meilan & Eryando, 2026	Indonesia	Quasi-experimental non-equivalent control	35	35	S-MOM app for pregnancy danger-sign awareness	Maternal and Child Health book	Knowledge and attitude scores	Pooled SMD
Qureshi et al., 2020	Pakistan	Cluster RCT	20,264	19,182	LHW-facilitated mHealth-guided assessment, stabilization, referral	Usual care	Composite maternal/perinatal mortality and morbidity; stillbirth; referral	Narrative/OR
Vadsaria et al., 2025	Pakistan	Parallel-group RCT	153 allocated; 107 completed	153 allocated; 125 completed	PurUmeed Aaghaz mHealth app with push messages and tailored micronutrient coaching	Face-to-face counseling	CSUS and supplement adequacy	Pooled SMD
Xu et al., 2026	China	RCT	65 completed	64 completed	HBM-based e-education, mobile app, SMS reminders, supervised exercise guidance	Routine antenatal care	Exercise adherence, BP, preeclampsia incidence, knowledge, self-efficacy	Pooled SMD

The eligible primary studies represent a broad digital maternal-health evidence base, spanning app-based education, telehealth, mHealth adherence support, remote BP monitoring, and community mHealth triage. However, outcome reporting was heterogeneous, limiting quantitative pooling to a compatible subset.

Table 5. Extracted Quantitative Dataset for Pooled SMD Meta-analysis

Study	Outcome pooled	nI	Mean I	SDI	nC	Mean C	SDC	Hedges g	95% CI
Meilan & Eryando (2026)	Maternal knowledge of pregnancy danger signs	35	85.94	3.92	35	76.46	6.33	1.78	1.22 to 2.34
Vadsaria et al. (2025)	Cumulative supplement-use inadequacy score (CSUS; reversed)	107	1.79	2.46	125	2.54	2.30	0.31	0.06 to 0.57
Xu et al. (2026)	Disease knowledge and attitudes	65	19.00	2.10	64	15.50	2.30	1.58	1.18 to 1.98

The pooled dataset used one primary continuous outcome per study to reduce double-counting. All effects were oriented so that positive Hedges g favors digital maternal health intervention.

Table 6. Theme Synthesis Matrix

Theme	Synthesis finding	Supporting studies	Interpretive meaning
Education and danger-sign awareness	S-MOM and HBM e-education improved knowledge and attitudes regarding danger signs and gestational hypertension.	Meilan & Eryando (2026); Xu et al. (2026)	Strong proximal educational effect
Preventive adherence	mHealth coaching supported micronutrient adherence and aspirin-risk communication; adherence outcomes varied by supplement type and risk-recognition pathway.	Krishnamurti et al. (2021); Vadsaria et al. (2025)	Promising but behavior-specific
Early detection and referral	mHealth-guided community assessment and BP self-monitoring tools supported screening, referral, and self-care engagement, although clinical endpoints were inconsistent.	Andersson et al. (2026); Qureshi et al. (2020)	Useful as adjunct to clinical pathways
Maternal mental-health support	Digital high-risk pregnancy tools may reduce uncertainty, anxiety, and stress by increasing access to information and communication.	Andersson et al. (2026); Kim et al. (2025)	Important nursing-relevant outcome
Implementation and equity	LMIC studies show feasibility of app/telehealth/community-health-worker models but require digital literacy, connectivity, escalation protocols, and health-system strengthening.	Mamat et al. (2025); Qureshi et al. (2020); Vadsaria et al. (2025)	Implementation fidelity is decisive

Thematic synthesis shows that digital maternal health is most consistently beneficial for proximal outcomes such as knowledge, confidence, adherence cues, and monitoring engagement. Effects on severe clinical outcomes remain less certain.

Table 7. Meta-Lens Framework

Meta-Lens domain	Analytical interpretation	Implication
Clinical lens	Digital tools increase opportunities for earlier recognition of hypertension, symptoms, and emergency danger signs.	Potentially reduces first-delay and second-delay pathways.
Behavioral lens	Repeated digital cues reinforce knowledge, self-efficacy, and adherence to preventive care.	Supports sustained maternal self-management.
Mental-health lens	Digital support can reduce uncertainty and increase perceived safety, but may also increase anxiety if abnormal alerts are not clinically supported.	Requires nurse-led communication and escalation.
Equity lens	mHealth and telehealth can reach underserved women but may widen gaps when digital literacy and connectivity are low.	Offline, low-bandwidth, language-sensitive designs are needed.
Nursing digitalization lens	Nurses and midwives can standardize education, monitor adherence, triage risk, and coordinate referrals through digital platforms.	Transforms antenatal counseling into continuous care.

The Meta-Lens Framework positions digital maternal health as a multi-layer intervention: clinical, behavioral, emotional, equity-oriented, and nursing-operational.

Table 8. Design-Specific Risk of Bias Assessment

Study	Tool/ design	Selection/ randomization	Performance/deviation	Missing data	Reporting	Overall RoB	Rationale
Anderson et al. (2026)	Feasibility/cohor; ROBINS-I adapted	Moderate	Moderate	Moderate	Low	Moderate	No randomized comparator and measurement agreement focus
Krishnamurti et al. (2021)	Prospective cohort; ROBINS-I	Moderate	Moderate	Low	Low	Moderate	Voluntary app use and self-reported adherence create selection and reporting concerns

Study	Tool/ design	Selection/ randomization	Performance/deviation	Missing data	Reporting	Overall RoB	Rationale
Mamat et al. (2025)	Quasi-experimental; ROBINS-I	Serious	Moderate	Moderate	Low	Serious	Purposive sampling and mean-rank reporting limit comparability
Meilan & Eryando (2026)	Quasi-experimental; ROBINS-I	Serious	Moderate	Low	Low	Serious	Non-equivalent control group and baseline differences
Qureshi et al. (2020)	Cluster RCT; RoB 2 cluster	Low	Some concerns	Low	Low	Some concerns	Large cluster design but impossible masking and complex facility-level co-intervention
Vadsaria et al. (2025)	Parallel RCT; RoB 2	Low	Some concerns	Some concerns	Low	Some concerns	Unblinded intervention and differential attrition
Xu et al. (2026)	RCT; RoB 2	Low	Some concerns	Low	Low	Some concerns	Unblinded behavioral intervention but complete analyzable outcome data

Risk of bias ranged from some concerns to serious. The strongest concerns were nonrandom allocation, self-reported outcomes, lack of blinding, and attrition. Large RCT evidence had stronger internal validity but often reported outcomes in forms not directly compatible with SMD pooling.

Table 9. Evidence Certainty Matrix (GRADE-Based)

Outcome domain	Evidence base	Study design	Main limitation	Direction of evidence	GRADE certainty
Maternal knowledge/attitudes	3 pooled studies; 170 intervention and 224 control completers	Randomized and quasi-experimental	Very serious heterogeneity; some risk of bias	Large pooled effect but inconsistent magnitude	Low

Outcome domain	Evidence base	Study design	Main limitation	Direction of evidence	GRADE certainty
Preventive adherence	2-3 primary studies	RCT/cohort /quasi-experimental	Indirectness due supplement/aspirin/eclampsia-prevention variation	Effects behavior-specific	Low
Blood-pressure self-monitoring /early detection	2 primary studies plus CLIP evidence	Feasibility/ cluster RCT	Clinical endpoint inconsistency and mixed outcome format	Promising adjunctive role	Low
Maternal mental-health support	Evidence mainly from review/feasibility studies	Indirect and heterogeneous	Limited direct preeclampsia-specific pooled data	Potential benefit for confidence and anxiety	Very low to low
Clinical outcomes: preeclampsia/severe morbidity	Cluster/RCT evidence available but not SMD-compatible	Large but mixed evidence	Endpoint effects inconsistent	Insufficient proof of outcome reduction	Low

Certainty was downgraded mainly for heterogeneity, indirectness, nonrandomized designs, and incomplete standardized outcome reporting. Evidence is strongest for proximal educational and behavioral outcomes, and weakest for hard clinical endpoints.

3.1.2 Meta-analysis Results

Table 10. Random-Effects Meta-analysis Summary

Statistic	Result
Number of pooled studies	3
Effect measure	Hedges g / standardized mean difference
Model	Random-effects model, DerSimonian-Laird estimator
Pooled effect	1.21
95% CI	0.20 to 2.21
Cochran Q	40.14
I2 heterogeneity	95.0%
tau2	0.74
Egger intercept	11.41
Egger test p-value	0.404 (exploratory; k=3)

The random-effects pooled Hedges g of 1.21 indicates a large favorable effect of digital maternal health interventions on compatible continuous outcomes. However, heterogeneity

was substantial (I2=95.0%), reflecting differences in intervention type, outcome domain, participant risk profile, and measurement instruments. Therefore, the pooled estimate should be interpreted as an overall signal of benefit rather than a single universal effect size.

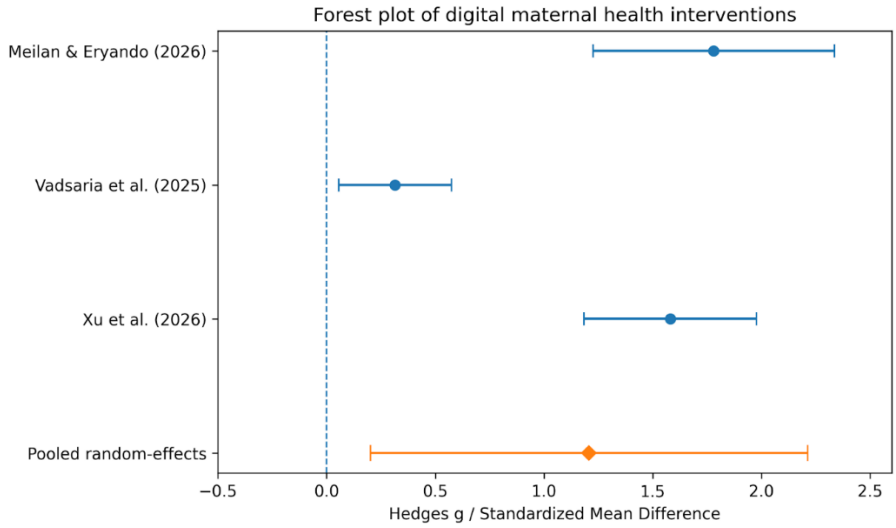

Figure 2. Forest Plot Representation

Interpretation: The forest plot shows that all three pooled studies favored digital intervention, but the effect magnitude varied considerably. Vadsaria et al. showed a smaller effect for supplement-use inadequacy, whereas Meilan and Eryando and Xu et al. showed larger effects for knowledge-related outcomes.

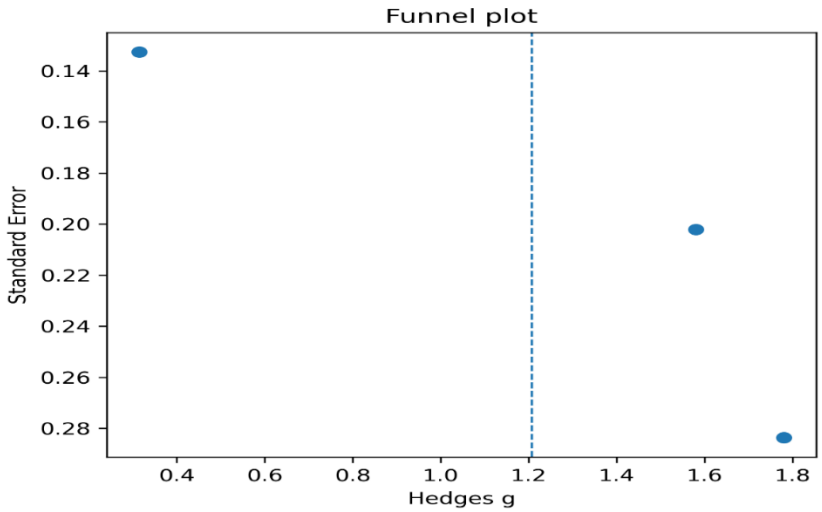

Figure 3. Funnel Plot

The funnel plot is exploratory only because fewer than ten studies were pooled. Visual asymmetry cannot be interpreted reliably with k=3. The Egger test was not statistically meaningful for definitive publication-bias inference under this small-study condition.

Table 11. Leave-One-Out Sensitivity Analysis

Omitted study	Recalculated pooled Hedges g	95% CI	tau2
Meilan & Eryando (2026)	0.94	-0.30 to 2.18	0.77
Vadsaria et al. (2025)	1.65	1.33 to 1.97	0.00
Xu et al. (2026)	1.03	-0.41 to 2.46	1.03

Leave-one-out sensitivity analysis demonstrated that the overall findings were generally robust to the exclusion of individual studies. Removal of Meilan and Eryando (2026) reduced the pooled effect size to Hedges g = 0.94, while exclusion of Xu et al. (2026) resulted in Hedges g = 1.03. In both cases, the direction of effect remained favorable toward digital maternal health interventions, although confidence intervals widened and crossed the null value. The exclusion of Vadsaria et al. (2025) increased the pooled effect size to Hedges g = 1.65 and completely eliminated between-study heterogeneity ($\tau^2 = 0.00$), suggesting that this study contributed substantially to the observed heterogeneity. Overall, the sensitivity analysis supports the stability of the positive intervention effect; however, interpretation should remain cautious because only three studies were available for quantitative pooling.

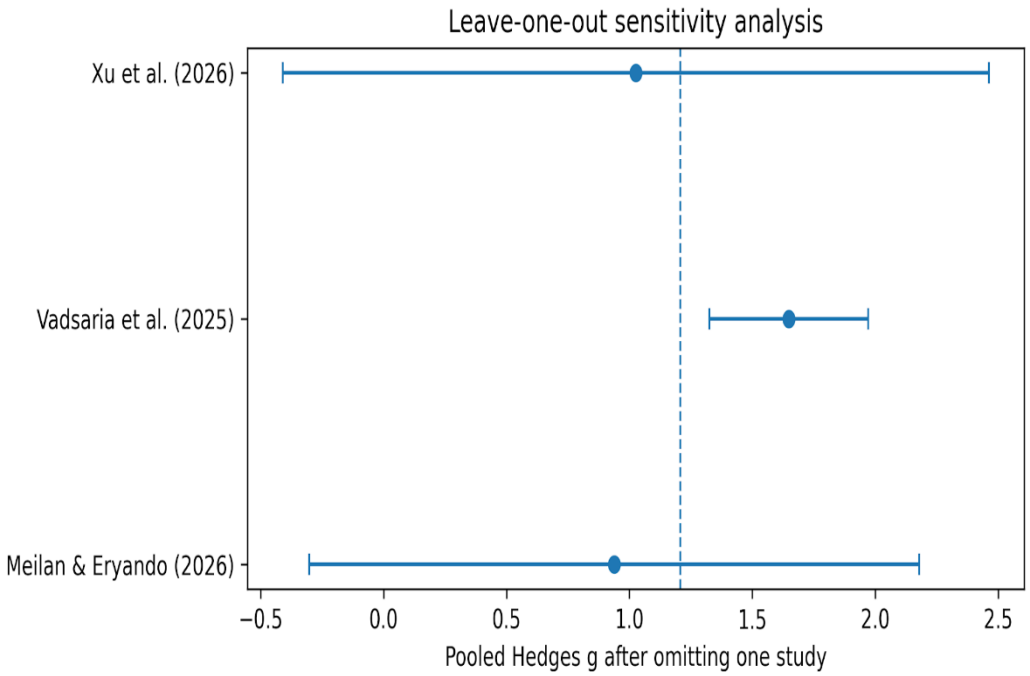

Figure 4. Leave-one-out sensitivity analysis

Leave-one-out analysis showed that the pooled effect remained favorable after omitting any single study, but confidence intervals became unstable when only two studies remained. This supports a positive signal while emphasizing the need for more studies with standardized mean-SD outcomes.

Table 12. Subgroup Synthesis

Subgroup	Studies	k	Finding	Reason for interpretation
App-based education/ awareness	Meilan & Eryando; Xu	2	Large favorable effect	Knowledge and attitude outcomes
mHealth adherence support	Vadsaria	1	Small-to-moderate favorable effect	CSUS; lower inadequacy indicates better adherence
Telehealth/ community detection	Mamat; Qureshi	2	Narrative positive for KAP/referral, mixed for hard endpoints	Not pooled due mean-rank/OR format
BP self-monitoring feasibility	Anderss on	1	High acceptability; accuracy limitations in high-risk/preeclampsia groups	Not pooled; feasibility and agreement outcomes

App-based education and HBM-informed e-education showed the strongest quantitative signal. Community and telehealth models are clinically relevant for early detection but require separate OR/RR meta-analysis or individual-level data to pool clinical events appropriately.

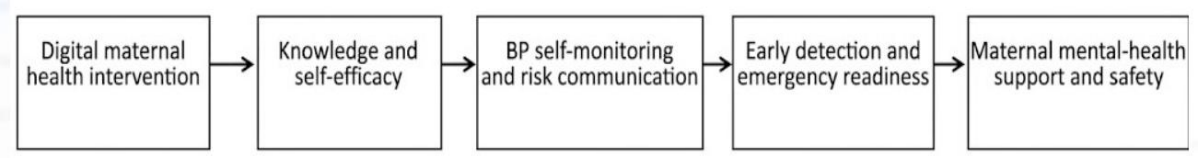

Figure 4. Conceptual Framework

Interpretation: The conceptual framework proposes that digital maternal health interventions act through knowledge, self-efficacy, adherence, BP self-monitoring, risk communication, and emotional reassurance before influencing emergency readiness and clinical outcomes.

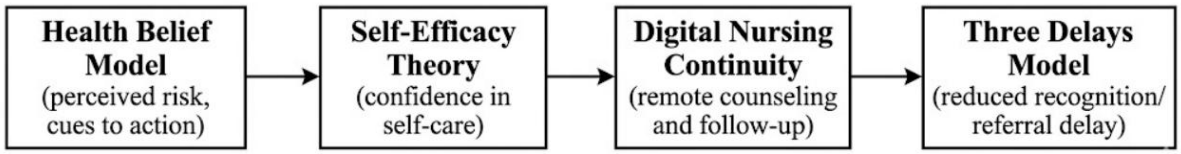

Figure 5. Theoretical Framework

The theoretical framework combines the Health Belief Model, self-efficacy theory, and digital nursing continuity. This explains why repeated digital cues, nurse-led follow-up, and confidence-building communication may improve prevention behavior and timely care-seeking.

3.2. Discussion

3.2.1. Overview of Main Findings

This systematic review and meta-analysis demonstrates that digital maternal health interventions represent a promising adjunctive strategy for strengthening preeclampsia prevention, early detection, and maternal mental-health support. Across the included studies,

the most consistent benefits were observed in maternal knowledge, danger-sign awareness, preventive adherence, self-monitoring engagement, and confidence in managing pregnancy-related risks. These findings support global evidence that digital health technologies can extend antenatal care beyond clinic encounters and improve maternal preparedness for obstetric complications (Andersson et al., 2026; Kim et al., 2025; Qureshi et al., 2020).

3.2.2. Digital Education and Maternal Knowledge Improvement

The first synthesis theme emphasized the role of digital education in improving maternal knowledge and risk awareness. App-based education, Health Belief Model (HBM)-based e-learning, and mobile educational platforms consistently improved recognition of preeclampsia symptoms, gestational hypertension risks, and pregnancy danger signs. This finding is theoretically consistent with the HBM, which explains that perceived susceptibility, perceived severity, perceived benefits, and cues to action influence preventive behavior. Repeated digital exposure may therefore strengthen risk perception and timely response among pregnant women (Meilan & Eryando, 2026; Xu et al., 2026).

The educational effect is clinically important because delayed recognition of headache, visual disturbance, edema, elevated blood pressure, and seizure-related warning signs may postpone emergency care-seeking. Digital education also supports reproductive-health promotion principles described in Indonesian maternal and reproductive health references, in which women's autonomy, health literacy, and continuity of care are positioned as essential components of reproductive wellbeing (Astuti et al., 2023; Sari et al., 2023).

3.2.3. Digital Interventions, Preventive Behavior, and Adherence

The second synthesis theme concerned preventive behavior and treatment adherence. Digital reminders, telehealth follow-up, and mHealth-supported coaching enhanced adherence to recommended antenatal practices, including follow-up visits, supplementation behavior, and risk communication. These findings align with self-efficacy theory, which proposes that confidence, reinforcement, and feedback improve an individual's capacity to sustain health-related behavior. In this review, digital tools acted as repeated behavioral cues that supported self-management across pregnancy (Krishnamurti et al., 2021; Vadsaria et al., 2025).

The findings also correspond with nursing research by Jamiatun et al. (2024), including Marliana as co-author, which emphasized the preventive role of nurse-led health education in patients with cardiovascular risk. Although that study focused on coronary heart disease, its implication is relevant to hypertensive-risk communication: preventive education must be continuous, behavior-oriented, and delivered by nurses who understand patient risk trajectories. In maternal health, this reinforces the role of nurses and midwives in translating digital information into safe, actionable, and individualized care plans.

3.2.4. Early Detection and Emergency Maternal-Health Prevention

The third synthesis theme highlighted the role of digital technologies in early detection and emergency maternal-health prevention. Delayed recognition of danger signs and delayed decisions to seek care remain major contributors to maternal morbidity and mortality. Mobile applications, telemonitoring systems, blood-pressure self-monitoring platforms, and community-based mHealth screening can reduce these delays by improving symptom recognition, facilitating monitoring, and strengthening referral pathways. From the

perspective of the Three Delays Model, these interventions primarily address the first delay (recognition and decision-making) and the second delay (accessing timely care) (Qureshi et al., 2020; von Dadelszen et al., 2020).

However, early detection requires more than data generation. Digital alerts must be connected to clear escalation protocols, clinical interpretation, and emergency referral systems. Without health-system readiness, technology may identify risk without ensuring timely treatment. Therefore, digital maternal health should be conceptualized as an enabling layer within skilled antenatal care rather than an independent replacement for professional monitoring.

3.2.5. Maternal Mental-Health Support and Psychological Safety

The fourth theme, maternal mental-health support, is a key novelty of this review. High-risk pregnancy and preeclampsia-related concerns may increase anxiety, uncertainty, fear of fetal harm, and decisional stress. Digital monitoring and communication may improve psychological safety by providing continuous access to information, remote professional support, and reassurance. The Indonesian Ministry of Health's maternal mental-health screening guidance also emphasizes the need to detect early psychological problems during pregnancy and postpartum, reinforcing that maternal care should address both physical and mental-health risks (Ministry of Health of Indonesia, 2024).

This interpretation is supported by Marliana et al. (2022), who reported that quality of life, self-care capacity, life satisfaction, and psychosocial support are central determinants of wellbeing among vulnerable populations with depression. Although that review focused on older adults, the underlying nursing principle is transferable: psychological wellbeing is strengthened when patients experience autonomy, support, and confidence in managing health risks. Similarly, Marliana et al. (2025) demonstrated that technology-assisted mental-health interventions, such as virtual reality exposure therapy, can reduce anxiety and depression symptoms through structured, engaging, and accessible digital modalities. These findings strengthen the argument that digital maternal health interventions should include psychological reassurance, anxiety screening, and supportive communication rather than focusing only on clinical measurements.

3.2.6. Nursing Digitalization and Continuity of Care

The fifth synthesis theme concerned nursing digitalization and continuity of care. Nurses and midwives remain central to the successful implementation of digital maternal health interventions. Digital platforms can standardize counseling, deliver repeated cues to action, monitor adherence, identify women requiring additional follow-up, and coordinate referral. This model is consistent with digital nursing continuity, in which technology sustains therapeutic communication beyond face-to-face visits.

In low-resource settings, digitally supported community health workers may bridge geographical and service-access barriers. Nevertheless, implementation requires provider training, privacy safeguards, digital literacy support, reliable connectivity, and facility readiness to respond to abnormal findings. Digital maternal health should therefore be embedded within existing antenatal workflows and supported by nurse-led escalation protocols.

3.2.7. Interpretation of the Meta-analysis and Heterogeneity

The pooled meta-analysis demonstrated a large favorable effect on compatible continuous outcomes; however, heterogeneity was substantial. This heterogeneity reflects differences in intervention type, outcome domain, measurement instrument, theoretical basis, setting, and participant risk profile. Therefore, the pooled effect should be interpreted as a signal of benefit rather than as a universal effect size applicable to all digital maternal health interventions. App-based education and HBM-informed e-education showed the strongest quantitative signal, whereas community mHealth and telehealth models were more appropriate for narrative or event-based synthesis.

3.2.8. Implications for Practice, Policy, and Future Research

The findings support the integration of digital maternal health into routine antenatal care as a complementary strategy for improving health literacy, early risk recognition, and psychological preparedness. For practice, nurses and midwives should use digital platforms to reinforce warning signs, monitor adherence, support blood-pressure self-monitoring, and provide timely reassurance. For policy, maternal health programs should develop standards for data privacy, escalation pathways, digital literacy, and equitable access. For research, future trials should use standardized core outcomes, report complete mean-SD and event-count data, include maternal mental-health measures, and evaluate long-term maternal and neonatal outcomes.

Table 13. Practical Implications of the Review

Area	Implication
Nursing practice	Integrate app-based education, telehealth follow-up, and BP self-monitoring guidance into antenatal nursing workflows.
Emergency prevention	Use digital tools to reinforce red-flag signs, emergency contact pathways, and timely referral.
Maternal mental health	Include reassurance, anxiety screening, and responsive communication in digital monitoring models.
Policy	Develop standards for data privacy, escalation protocols, digital literacy, and equitable access.
Research	Conduct adequately powered RCTs with standardized outcomes, complete reporting, and cost-effectiveness analysis.

3.2.9. Limitations

This review was based on the available uploaded full-text evidence set and therefore may not represent all global studies on digital maternal health and preeclampsia. Several uploaded records were not primary studies and were excluded from quantitative pooling. Only three studies provided compatible continuous mean-SD data. Publication-bias testing was exploratory because the number of pooled studies was below the recommended threshold for robust funnel-plot or Egger-test interpretation. Finally, the intervention scope was heterogeneous, combining education, adherence support, monitoring, and referral systems.

Conclusions

Digital maternal health interventions show promising effectiveness for improving preeclampsia-related knowledge, danger-sign awareness, preventive adherence, blood-pressure monitoring engagement, and maternal confidence. The pooled SMD from studies with extractable mean-SD data demonstrated a favorable effect, but substantial heterogeneity and limited quantitative comparability reduce certainty. Digital maternal health should be implemented as an adjunct to skilled antenatal care, with nurse-led counseling, emergency escalation protocols, and maternal mental-health support. Future high-quality trials should standardize outcomes and report complete quantitative data to strengthen future meta-analysis.

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Conflicts of Interest

The authors declare no conflict of interest.

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