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Integrating IoT-Based Maternal Monitoring, Gestational Age Tracking and Antenatal Care: A Systematic Review and a Proposed Digital Health Model

Indah[1]*
Harmika[2]
Fitri Kurniawati[3]
*Bachelor of Midwifery Study Program, Pelita Ibu University, Kendari, Indonesia
Corresponding mail id : indahgazalba@gmail.com

Abstract
Most maternal deaths occur in low- and lower-middle-income countries, and many of the complications behind them develop in the weeks between antenatal contacts. In Indonesia, 86.7% of pregnant women had a first-trimester contact in 2023, but only 17.6% reached the six-contact national standard. Wearable sensors and Internet of Things (IoT) devices can measure maternal and fetal parameters at home, yet it is unclear whether they are designed around gestational age and connected to the midwives who provide antenatal care. This systematic review, reported according to PRISMA 2020, searched PubMed/MEDLINE on 22 November 2026 with three search strings covering wearable, IoT and remote monitoring in pregnancy, gestational-age-based digital tracking, and digital antenatal care tools in low- and middle-income countries. Of 192 records screened, 136 met the eligibility criteria, and two more were found through citation tracking, giving 138 studies (111 primary studies and 27 reviews). Remote blood pressure monitoring (40 studies) and fetal monitoring (38) were the largest groups, followed by multiparameter wearables (27), digital antenatal care tools (24) and glucose monitoring (9). High-income countries produced 78 studies and low- and middle-income countries 29, of which only one came from Indonesia. Sensor studies reported good technical performance, such as a sensitivity of 90% for an IoT fetal movement device, and remote blood pressure programmes reduced antenatal visits and admissions without increasing adverse outcomes. Effects on maternal and neonatal outcomes were inconsistent across meta-analyses. None of the 114 sensor-based studies described gestational age as a system function, whereas 13 of the 24 digital antenatal care tools did, and clinician linkage was common in blood pressure and glucose programmes but rare in fetal and multiparameter wearables. Sensing, gestational-age logic and antenatal care workflows have therefore developed in separate streams. The review proposes a five-layer Integrated Gestational-Age-Based Maternal Monitoring and Antenatal Care (IGAM-ANC) model, with an evaluation framework and five propositions, for development and testing with midwives in Indonesian primary care.

Keyword: *Internet of Things, wearable sensors, remote monitoring, gestational age, antenatal care, maternal health, midwifery, digital health, systematic review*

I. INTRODUCTION

Progress in maternal survival has slowed. According to the World Health Organization, about 260,000 women died during or after pregnancy and childbirth in 2023, and about 92% of these deaths occurred in low- and lower-middle-income countries, most of them from preventable causes [1]. Many of the complications that lead to these deaths, such as hypertensive disorders, develop gradually during pregnancy and can be detected if the right measurements are taken at the right time. Antenatal care (ANC) is the main way health systems do this. In 2016 the WHO raised its recommended number of antenatal contacts from four to eight, with the first contact within 12 weeks of gestation and later contacts at 20, 26, 30, 34, 36, 38 and 40 weeks [2], [3]. The WHO stated that the eight-contact model could reduce perinatal deaths by up to eight per 1,000 births compared with a four-visit model [3].

The benefit of this schedule depends on women completing it. A meta-analysis of 145 studies from 89 low- and middle-income countries estimated pooled coverage of at least one antenatal visit at 85.0%, but only 50.8% for four visits and 48.9% for postnatal care [4]. Indonesia shows the same drop. The 2023 Indonesian Health Survey found that 86.7%

of pregnant women had a pure first-trimester contact (K1), 68.1% had four contacts (K4) and only 17.6% completed the six contacts required by national policy (K6) [5]. Fig-1 places the two patterns side by side. For most women the problem is not the first contact but what happens afterwards.

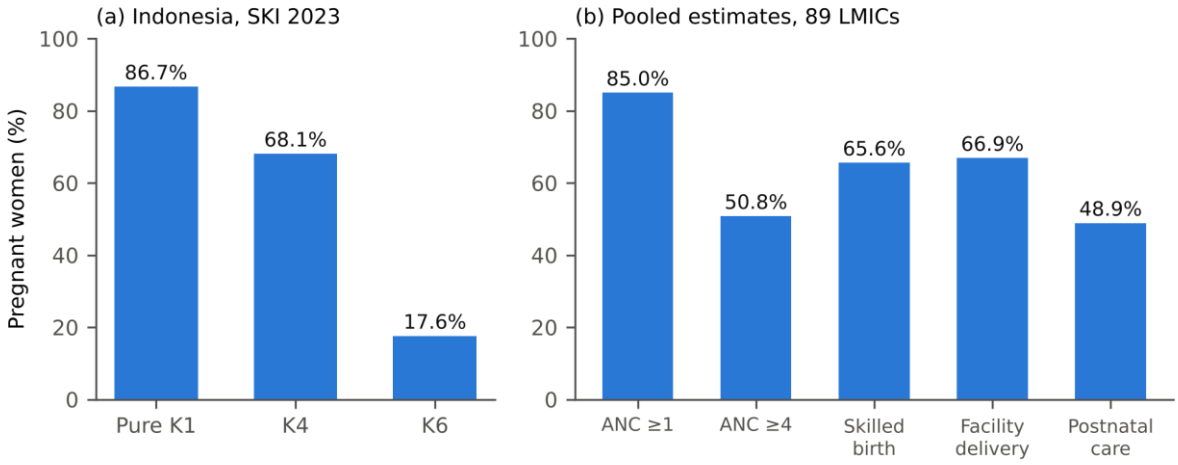


Fig-1: Continuity Gap in Antenatal Care: (a) Indonesia, 2023; (b) Pooled Estimates from Low- and Middle-Income Countries

The structure of the WHO schedule explains why gaps matter. Even when all eight contacts are kept, a woman goes eight weeks between the first and second contact and six weeks between the second and third (Fig-2). These intervals are long enough for blood pressure to rise, for fetal movements to change or for nutritional and psychological problems to worsen unnoticed. In Southeast Sulawesi, for example, maternal stress was associated with an 11-fold higher risk of preterm labour [6], and chronic energy deficiency among pregnant women in a coastal health centre was linked to gravidity and to education, income and local culture [7]. Each of these conditions changes over weeks, not at the moment of a clinic visit.

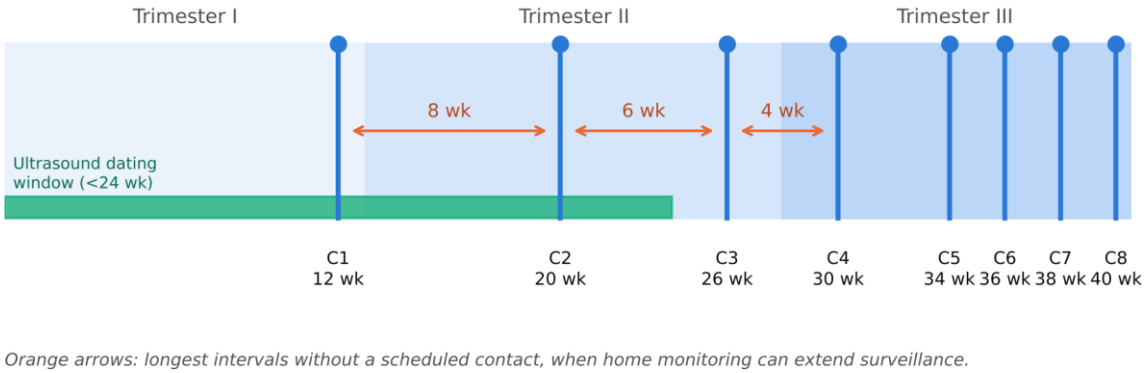


Fig-2: WHO Eight-Contact Antenatal Schedule and the Intervals between Scheduled Contacts

Engineering research offers a way to watch over these intervals. Wearable sensors can record maternal heart rate, blood pressure, activity, sleep and stress, and fetal heart rate and movements [8], [9]. An IoT-enabled wearable that combined accelerometer and gyroscope sensors with machine learning detected fetal movements in 35 pregnant women with a sensitivity of 90.00% and an F1-score of 88.56%, transmitted data with an average latency of 423.6 ms and ran for up to 48 hours on one charge [10]. Reviews of home monitoring, however, report problems with user compliance, data reliability and data security [11], and remote fetal monitoring has produced mixed effects on clinical outcomes [12], [13].

Two further problems are less often discussed. The first is that a measurement means different things at different stages of pregnancy. Blood pressure, heart rate and fetal activity follow trimester-specific patterns [14], [15], and the content of each antenatal contact depends on gestational age [2]. A device that does not know the gestational age cannot decide which parameters to monitor, which thresholds to apply or which contact is due. The second is that data are useful only if a health worker can see and act on them. Indonesian research has already shown that new digital services fail when users cannot operate them and when health information systems lack monitoring, evaluation and supervision [16], [17], while community programmes that track pregnant women and keep village midwives on call have achieved complete facility-based delivery in some districts [18]. The question is whether IoT monitoring can be built into such an antenatal pathway rather than added beside it.

This review addresses that question through three research questions. RQ1 asks which IoT, wearable and remote monitoring technologies have been studied in antenatal care and how they have been evaluated. RQ2 asks to what extent these technologies use gestational age as a system function and transmit data to clinicians within the antenatal pathway. RQ3 asks how the evidence can be combined into a model for developing and evaluating an integrated gestational-age-based monitoring system in Indonesian primary care. The paper contributes a classification of 138 studies by technology, evaluation level, gestational-age linkage and clinician linkage; a five-layer model; an evaluation framework; and five testable propositions.

Conceptual Foundations

The analysis rests on three working definitions. IoT-based maternal monitoring refers to sensors worn or used by the pregnant woman that send data automatically, through a phone or a gateway, to a server where they can be processed and viewed. Gestational age tracking means that the system holds a validated estimate of gestational age, ideally from early ultrasound, and uses it to decide schedules, parameters and thresholds; it does not mean that the device estimates gestational age itself. ANC integration means that monitoring data reach the midwife or doctor responsible for the woman, are stored with her antenatal record and lead to defined actions. A system that meets all three conditions can extend the antenatal contact into the time between contacts, while a system that meets only the first produces data without a clear owner.

II. LITERATURE REVIEW

The background literature falls into four streams: wearable and IoT sensing, remote blood pressure and glucose monitoring, digital tools for antenatal care in low- and middle-income countries, and implementation and user experience. These streams are reviewed below and then synthesised into the gap that motivates the study.

a) Wearable and IoT Sensing in Pregnancy

Alim and Imtiaz reviewed wearable sensors for maternal health and found that most had been tested in controlled environments rather than in free-living conditions [8]. Liu and colleagues described how wearable sensors, data processing and artificial intelligence are being combined for pregnancy monitoring, and noted that threshold-based and AI-based algorithms are both in use [9]. Long-term IoT monitoring with commercial smartwatches has proven feasible: a Finnish system collected photoplethysmography, activity and sleep data over nine months [19], and valid activity data were available for about 75% of possible days during pregnancy [20]. Engineering studies have built fetal electrocardiography systems with high detection accuracy [21], [22], compact pressure-strain patches that separate fetal from maternal movement with more than 90% accuracy [23], and edge-computing models that run fetal movement detection on small devices for about 25 hours per charge [24].

b) Remote Blood Pressure and Glucose Monitoring

Blood pressure is the most mature application. A meta-analysis of 18 studies with 28,094 patients found that antenatal remote blood pressure monitoring reduced outpatient visits and admissions without increasing adverse maternal or fetal outcomes [25]. The BUMP trials in the United Kingdom showed that self-monitoring alone did not lead to earlier clinic detection of hypertension or better blood pressure control [26], [27], whereas the SAFE@home digital platform in the Netherlands, which linked self-monitoring to a clinical team, was associated with fewer composite adverse outcomes and less severe hypertension [28]. Remote glucose monitoring for gestational diabetes did not improve glycaemic control or maternal-fetal outcomes in a meta-analysis of 11 trials [29], although sharing continuous glucose data with clinicians was associated with lower HbA1c in women with type 1 diabetes [30].

c) Digital Tools for Antenatal Care in Low- and Middle-Income Countries

In low- and middle-income countries, digital antenatal care has relied on mobile messaging and decision support rather than sensors. Short message reminders increased optimal antenatal care, skilled birth attendance and postnatal care in a meta-analysis of 26 studies [31], and mHealth interventions increased four-visit antenatal care in a synthesis of nine trials [32]. A digital health registry with clinical decision support improved guideline adherence for anaemia screening and management in Palestinian primary care [33], and a Cochrane review found that digital tracking combined with provider decision support could improve some antenatal and postnatal outcomes [34]. A scoping review of digital health for effective antenatal coverage found that most studies dealt with education and behaviour change, and few assessed the quality of care [35].

d) Implementation and User Experience

Women are generally willing to use monitoring devices. In a survey of 507 pregnant women, 91% accepted wearable ECG monitoring outside the hospital [36]. Yet only 5.9% of 493 women in a German survey saw self-monitoring as an alternative to consulting a physician [37], and women were more likely to use devices if they knew clinicians were watching the data [38]. Adherence falls when reminders and feedback are weak: in Ghana, mean daily adherence to home blood pressure monitoring was 73.7%, with wide variation [39]. Provider readiness and system fit also matter. Only 38%

of Dutch obstetric centres offered home monitoring or telemonitoring in 2018 [40], and in a United States programme a quarter of eligible pregnancies never received an offer from their provider [41].

e) Synthesis and Research Gap

The review of these streams leaves three gaps. The first is an integration gap: sensor research, remote monitoring programmes and digital antenatal care tools have grown as separate streams with different aims, users and outcome measures. The second is a gestational-age gap: few sensor systems use gestational age to decide what to measure, when to remind and which thresholds to apply. The third is a context gap: evidence on IoT monitoring comes mainly from high-income countries, while low- and middle-income countries have tested mostly text messaging and decision support. No review has yet classified the evidence on all three dimensions together, and no model has been proposed that links them for midwife-led antenatal care in Indonesia.

III. METHODOLOGY

The study was a systematic review with a narrative and descriptive synthesis, followed by model development. It is reported according to the PRISMA 2020 statement [42]. The protocol was not registered.

a) Eligibility Criteria

Eligibility criteria are listed in Table-1. Studies were included if they involved pregnant women or antenatal care providers, examined IoT, wearable, remote or home monitoring devices or digital antenatal care tools with tracking or monitoring functions, and reported technical performance, feasibility, usability, acceptability, clinical, service or economic outcomes. Primary studies of any design and systematic, scoping or narrative reviews were eligible.

Table-1: Eligibility Criteria of the Review

Criterion	Inclusion	Exclusion
Population	Pregnant women in the antenatal period; antenatal care providers (midwives, nurses, doctors, community health workers)	Studies limited to labour, delivery or the postpartum period
Technology	IoT, wearable, remote or home monitoring devices; digital antenatal care tools with tracking, reminder or decision-support functions	Educational apps without monitoring or tracking; diagnostic sleep studies; non-pregnancy devices
Outcomes	Technical performance, feasibility, usability, acceptability, adherence, clinical, service or economic outcomes	No outcome related to monitoring or antenatal care
Study type	Primary studies of any design; systematic, scoping and narrative reviews	Protocols, letters, case reports, errata, preprints
Time and language	January 2016 to November 2026; English	Other languages

b) Information Sources and Search Strategy

PubMed/MEDLINE was searched on 22 November 2026 through its programming interface for records published from January 2016 to November 2026. Three strings were used. S1 combined IoT, wearable, remote monitoring, telemonitoring and home monitoring terms in the title or abstract with pregnancy, antenatal, prenatal, maternal or fetal terms and with monitoring in the title. S2 combined gestational age with smartphone, mobile application, app or digital terms, antenatal or prenatal care, and tracking, reminder or scheduling terms. S3 combined mHealth, digital health or decision support terms with antenatal or prenatal care in the title and with Indonesia, Asia, Africa or low- and middle-income country terms. Two further records were identified by tracking citations in the preliminary evidence assembled before the search.

c) Selection and Data Extraction

Records were deduplicated by PubMed identifier and screened by title and abstract against the criteria. For each included study the following items were charted: country, design, technology category, evaluation level, gestational-age linkage and clinician linkage. Technologies were grouped into five categories: multiparameter wearable or IoT maternal monitoring, remote blood pressure monitoring, fetal monitoring, remote glucose or metabolic monitoring, and digital antenatal care tools. Evaluation level was coded as technical performance, feasibility and acceptability, clinical or service outcomes, economic evaluation, or review. Gestational-age linkage was coded as present when the system used gestational age to schedule contacts, select parameters, set thresholds or time messages. Clinician linkage was coded as present when data were transmitted to or reviewed by a clinical team as part of care. Countries were grouped by World Bank income level. Screening and charting were done by one reviewer, and formal risk of bias assessment was not performed because of the heterogeneity of designs.

d) Synthesis and Model Development

Results were summarised as counts and cross-tabulations and as a narrative synthesis by technology. Gaps identified in the synthesis were then mapped to system requirements, which were organised into a layered model and an evaluation framework.

IV. RESULTS AND DISCUSSION

a) Study Selection and Characteristics

The search returned 192 records (S1 160, S2 8, S3 24) with no duplicates. After screening, 56 records were excluded: 15 because the concept was not relevant, 14 because they concerned only labour or the postpartum period, 13 protocols, 12 letters, case reports, errata, preprints or records that could not be retrieved, and two non-English papers. With two records from citation tracking, 138 studies were included, of which 111 were primary studies and 27 were reviews (Fig-3).

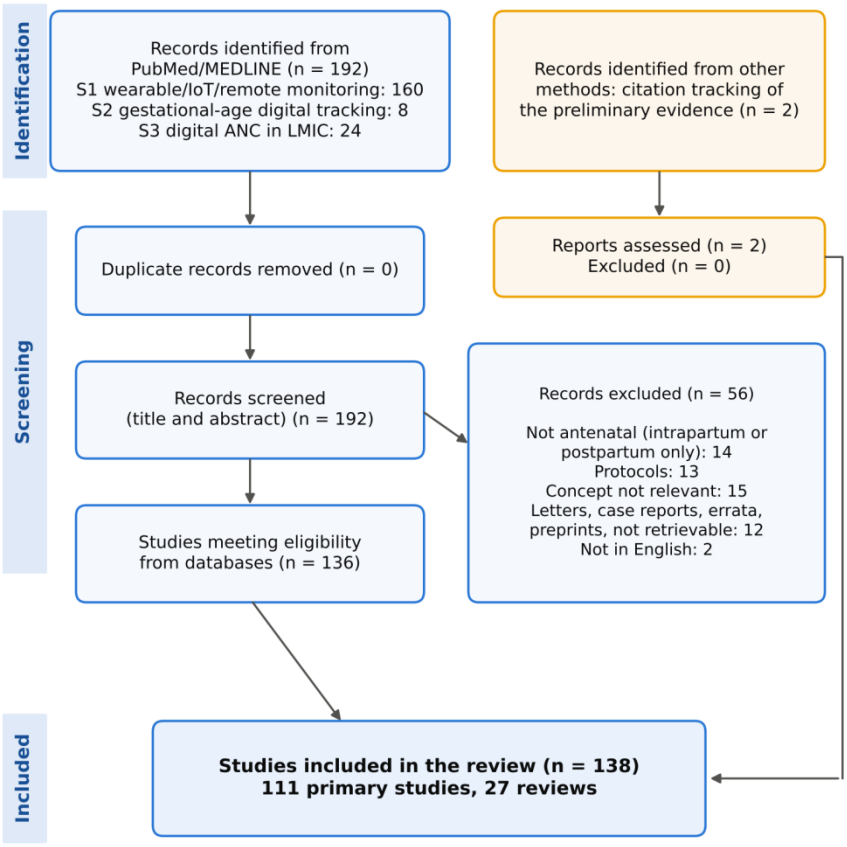


Fig-3: PRISMA 2020 Flow Diagram of Study Selection

Publication increased over the period: 64 of the 138 studies (46.4%) appeared from 2024 to 2026 (Fig-4a). High-income countries contributed 78 studies, low- and middle-income countries 29, multi-country reviews 27, and four studies did not state a setting. The United States (28 studies), the United Kingdom (14) and Belgium (8) were the most frequent settings, and only one study came from Indonesia [43]. Sensor-based categories were concentrated in high-income countries, while digital antenatal care tools were concentrated in low- and middle-income countries (Fig-4b). Table-2 summarises the characteristics by technology.

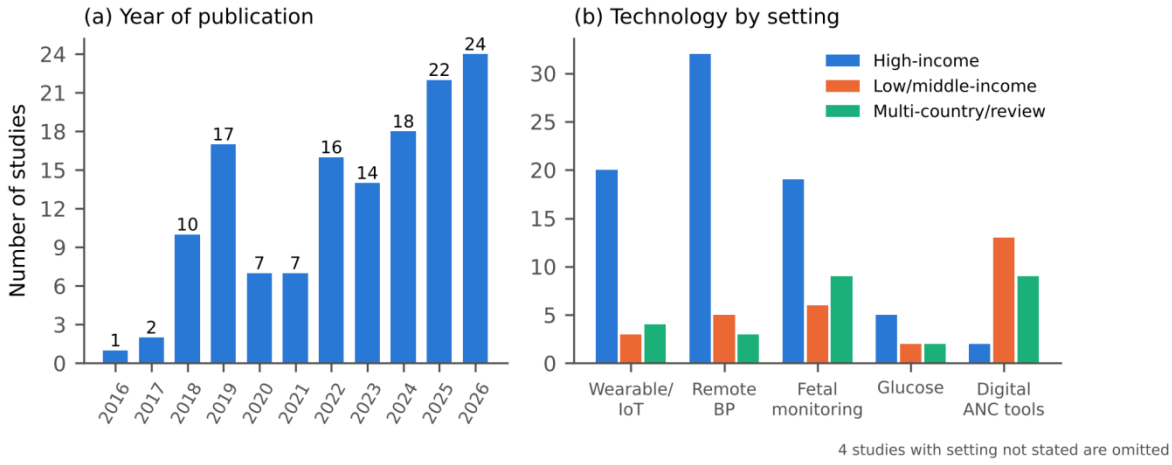


Fig-4: Included Studies by (a) Year of Publication and (b) Technology Category and Setting

Table-2: Characteristics of Included Studies by Technology Category (n = 138)

Technology category	n	HIC / LMIC / other	Evaluation T / F / C / E / R	GA-linked	Clinician-linked
Multiparameter wearable/IoT	27	20 / 3 / 4	7 / 15 / 1 / 0 / 4	0 (0%)	7 (26%)
Remote blood pressure	40	32 / 5 / 3	4 / 19 / 9 / 5 / 3	0 (0%)	31 (78%)
Fetal monitoring	38	19 / 6 / 13	16 / 10 / 3 / 0 / 9	0 (0%)	10 (26%)
Glucose/metabolic	9	5 / 2 / 2	1 / 3 / 3 / 0 / 2	0 (0%)	7 (78%)
Digital ANC tools	24	2 / 13 / 9	0 / 9 / 6 / 0 / 9	13 (54%)	13 (54%)
Total	**138**	**78 / 29 / 31**	**28 / 56 / 22 / 5 / 27**	**13 (9%)**	**68 (49%)**

b) Technical Performance of Sensors

Technical studies reported encouraging accuracy, but almost always against laboratory or hospital references in small samples. Fetal movement detection with IoT wearables reached a sensitivity of about 90% in 35 women [10], [24], and fetal ECG extraction reached sensitivity above 99% in recorded datasets [21]. A wireless home fetal and maternal heart rate system correlated closely with cardiotocography in 147 women (r = 0.92) [44], and a wearable fetal ECG monitor had a lower confusion rate than Doppler in a hospital comparison [45]. A mobile cardiotocography device produced readable recordings in 99.8% of 1,278 home sessions from 101 low-risk women [46]. Blood pressure devices showed mean differences of 1.7 mmHg systolic and 1.5 mmHg diastolic against staff measurements [47], but a smartphone camera-based blood pressure app produced systematic differences of several mmHg in the second and third trimesters [48]. One AI-based maternal care framework achieved more than 99.8% classification accuracy, but only on synthetic data, and the authors stated that this did not establish clinical validity [49]. Across the technical studies, validation in community settings, in low-resource networks and across gestational ages was rare.

c) Clinical and Service Effects

Evidence on clinical effects was strongest for blood pressure programmes and weakest for fetal and multiparameter wearables. Remote blood pressure monitoring reduced visits and admissions [25] and was cost-effective in some Belgian analyses [50], although a later Belgian cost-effectiveness study found that both remote and self-monitoring exceeded accepted willingness-to-pay thresholds [51]. For fetal monitoring, two meta-analyses found fewer cases of neonatal asphyxia with remote monitoring [12], [52], but most trials in one of them came from China, and a 2026 meta-analysis of eight trials found no difference in low Apgar scores or caesarean delivery [13]. A review of 40 trials of remote antenatal monitoring identified 1,004 verbatim outcomes grouped into 361 unique outcomes, which makes pooling difficult [53]. In low- and middle-income settings, voice messages increased eight-contact attendance in Lagos [54], whereas text reminders in Samoa were followed by fewer visits, partly because women registered late in pregnancy [55]. In Indonesia, a digital-spiritual assistance model increased haemoglobin by 0.7 g/dL and improved antenatal care compliance [43].

Table-3: Key Evidence on Technical, Clinical and Implementation Outcomes

Technology	Key evidence	Implication for an integrated system
Fetal movement and fECG wearables	IoT accelerometer-gyroscope device: sensitivity 90.00%, F1 88.56%, latency 423.6 ms, 48 h battery in 35 women [10]; fECG extraction sensitivity 99.62% [21]	Accuracy shown in small samples; validation at home and across gestational ages still needed
Home fetal heart rate monitoring	Correlation with CTG r = 0.92 in 147 women [44]; meta-analyses show fewer neonatal asphyxia cases [12], [52] but no difference in low Apgar or caesarean rates in eight trials [13]	Clinical benefit uncertain; should be linked to clinician review rather than used alone
Remote blood pressure	Fewer visits and admissions with no increase in adverse outcomes, 18 studies [25]; self-monitoring alone did not speed detection [26]; team-linked platform reduced severe hypertension [28]	Value depends on routing readings to a clinical team with response rules
Connectivity	Automatically synchronised cuffs produced 2.13 times more daily measurements [56]	Automatic transmission should be the default design
Digital ANC tools (LMIC)	SMS reminders improved optimal ANC (RR 1.34) [31]; tracking with decision support improved some outcomes [34]; text reminders failed where women registered late [55]	Schedules and reminders work best when anchored to an accurate gestational age from early pregnancy
User and access factors	Low smartphone ownership among phone owners in Ethiopia (37.6%) [57]; poor interpretation of BP values without colour coding [58]	Offline operation, simple displays and cadre support are needed in low-resource settings

d) Gestational-Age Linkage and Clinician Linkage

Fig-5 shows the central finding of the review. None of the 114 sensor-based studies described gestational age as a function of the system, that is, as an input that set schedules, parameters, thresholds or messages. Many reported gestational age only as a participant characteristic or analysed results by trimester [14], [15]. Fixed alert ranges were the norm, and one AI framework was designed explicitly because fixed ranges had caused alert fatigue among clinicians, although it was tested only on synthetic data [49]. In contrast, 13 of the 24 digital antenatal care tools were explicitly organised around gestational age, for example through pregnancy-stage text messages [59], contact reminders [31] or prenatal management systems built on the WHO Digital Adaptation Kit for antenatal care, which converts WHO recommendations into machine-readable formats [60]. Clinician linkage followed a different pattern. It was present in 78% of blood pressure studies and 78% of glucose studies, where data were sent to a clinical team, but in only 26% of fetal monitoring and multiparameter wearable studies, most of which ended at the device or the woman's phone. Only five studies, all of them digital antenatal care tools, had both forms of linkage.

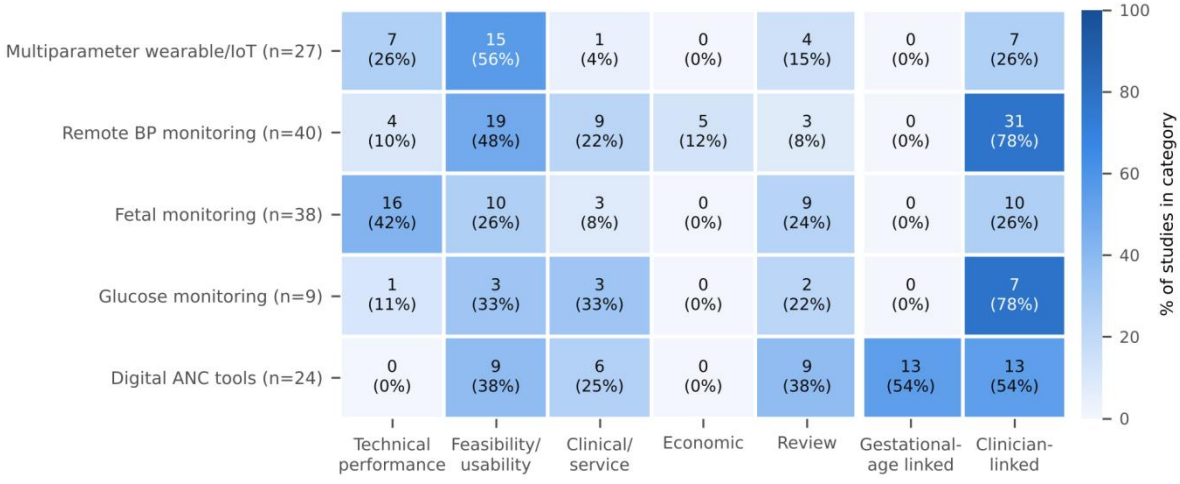


Fig-5: Evaluation Level, Gestational-Age Linkage and Clinician Linkage by Technology Category

The two forms of linkage are therefore located in different technologies. Sensors know what is happening but not when in pregnancy it is happening, and messaging tools know when but not what. This separation helps explain why some programmes fail to improve outcomes. In the BUMP trials, women measured their own blood pressure but the readings did not change when hypertension was detected in clinic [26], whereas programmes that routed readings to a team with

defined responses reported fewer adverse outcomes [28]. Connectivity also affects engagement: blood pressure cuffs that synchronised automatically to a monitoring platform produced 2.13 times more measurements per day than cuffs that did not [56].

e) Implementation Barriers and Facilitators

Implementation evidence pointed to four groups of factors. User factors included adherence, anxiety and numeracy. Adherence to remote monitoring in Belgium varied with anxiety, depression and attachment style [61], high digital engagement was associated with psychological distress in one cross-sectional study [62], and in Ghana only 36.3% of women monitoring their blood pressure at home correctly identified the cut-off for elevated systolic pressure, although colour-coded displays improved interpretation [58]. Provider factors included workload, trust in device accuracy and clarity about responsibility for data [63], [64]. System factors included device supply, integration with records and data security [11], [65]. Access factors were most important in low-resource settings: in northwest Ethiopia, 76.7% of mothers owned a mobile phone but only 37.6% of owners had a smartphone [57], and adoption of a point-of-care decision support device by Ghanaian midwives was low to moderate and depended on recognition and supervision [66]. Women in Tanzania welcomed digital tools but asked that they be introduced alongside improvements in the quality of antenatal care [67].

f) The Proposed IGAM-ANC Model

Fig-6 presents the Integrated Gestational-Age-Based Maternal Monitoring and Antenatal Care (IGAM-ANC) model derived from these findings. The sensing layer (L1) contains devices whose accuracy has been shown in pregnancy, such as validated blood pressure cuffs [47], [68], and newer sensors, such as fetal movement wearables, only when they have been validated against a reference [10]. The edge and connectivity layer (L2) processes signals on the device, flags poor-quality readings and buffers data when the network is unavailable, following designs that reduce transmission needs [22], [24]. The gestational-age engine (L3) holds the dating estimate, calculates gestational age in weeks and days, maps the woman to the WHO and national contact schedule [2] and selects the parameters, thresholds, reminders and education content that apply at each stage. The ANC integration layer (L4) places home data in the Puskesmas record, generates tiered alerts with a midwife in the loop, prepares the next contact and assigns cadres to follow up missed readings, building on community tracking that has already worked in Southeast Sulawesi [18]. The evaluation layer (L5) specifies what must be measured before the model can be called effective.

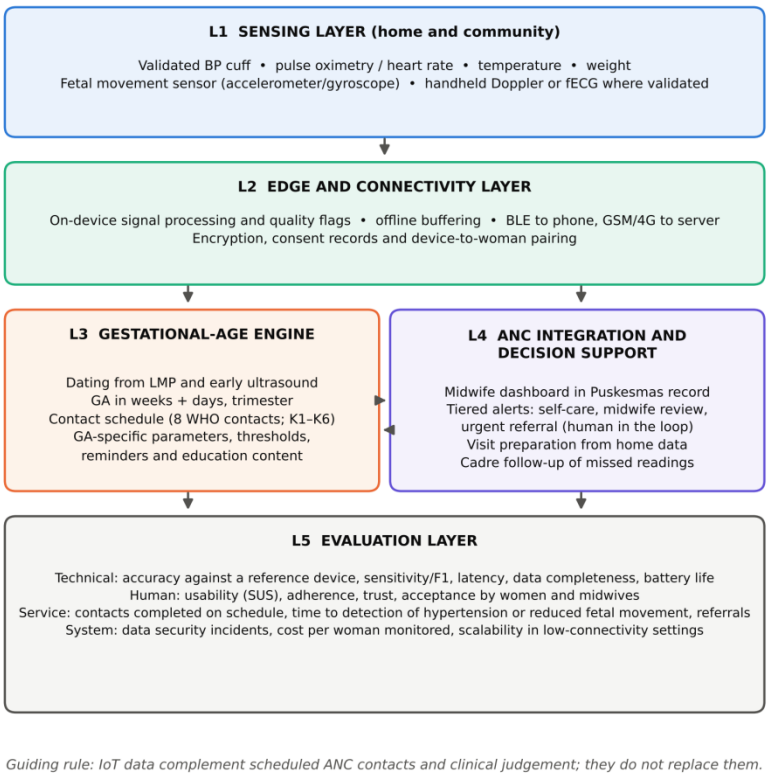


Fig-6: The Integrated Gestational-Age-Based Maternal Monitoring and Antenatal Care (IGAM-ANC) Model

Table-4 links each gap identified in the review to the layer of the model that addresses it and to the metric by which it should be evaluated. The table is intended as a design checklist for engineering and midwifery teams working together.

Table-4: From Review Gap to Model Requirement and Evaluation Metric

Gap identified	Model layer	Evaluation metric	Proposition
Sensors validated mainly in laboratories	L1 Sensing	Bias and limits of agreement against reference devices at home	P4
Data loss and poor connectivity	L2 Edge and connectivity	Data completeness, latency, battery life, offline recovery	P5
No gestational-age logic in sensor systems	L3 Gestational-age engine	Alert accuracy by trimester; schedule adherence	P1, P3
Data not reaching midwives	L4 ANC integration	Time from abnormal reading to midwife action; referrals	P2
Heterogeneous outcomes across trials	L5 Evaluation	Core outcome set: K6 completion, early detection, usability, trust, cost	P1-P5

g) Propositions for Empirical Research

Five propositions follow from the model. P1: Monitoring systems that use gestational age to select parameters, thresholds and reminders will produce fewer false alerts and higher adherence than systems with fixed settings. P2: Systems that transmit data automatically to a midwife with defined response rules will detect hypertension and reduced fetal movement earlier than self-monitoring alone, consistent with the contrast between self-monitoring and team-linked programmes [26], [28]. P3: Linking home monitoring to the contact schedule will increase the proportion of women who complete six contacts, because each contact is anticipated and missed readings trigger follow-up. P4: The effects in P1 to P3 will depend on device accuracy in community conditions, so that unvalidated sensors will reduce trust and use [48], [69]. P5: Smartphone ownership, connectivity, numeracy and workload will moderate every link, so that the same system will perform worse in rural and low-resource areas unless it supports offline operation and cadre assistance [57], [58].

h) Implications for Practice and Policy

For engineering teams, the review suggests designing around the antenatal pathway rather than around a single sensor: device output should carry a time stamp, gestational age and quality flag, and the system should be tested in homes and with the networks women actually use. For midwifery services, monitoring should be introduced with explicit responsibility for reviewing data, clear thresholds and protected time, since lack of clarity about action was a major concern among providers [63]. For policymakers in Indonesia, any IoT monitoring should connect to the national primary care information system rather than create parallel records, and should be evaluated on whether it increases K6 completion and early detection, not only on whether it works technically. Health information systems at Puskesmas level also need monitoring, evaluation and supervision capacity before new data streams are added [17].

i) Limitations

The review has limitations. Only PubMed/MEDLINE was searched, so engineering studies indexed only in IEEE Xplore, Scopus or Web of Science, and Indonesian studies in national databases, are likely to be under-represented. Screening and charting were done by one reviewer from titles and abstracts, and codes for gestational-age and clinician linkage depended on what abstracts reported, which may underestimate linkage in some systems. No risk of bias assessment was performed. The IGAM-ANC model is a proposal derived from the review and has not yet been built or tested.

V. CONCLUSIONS

IoT and wearable technologies for pregnancy have advanced quickly, and many sensors now measure maternal and fetal parameters with good technical accuracy. Remote blood pressure monitoring is the most mature application, while evidence for fetal and multiparameter wearables is still mostly technical and from high-income countries. The review found that gestational-age logic lives mainly in messaging tools, clinician linkage mainly in blood pressure and glucose programmes, and very few systems combine both with sensing. This separation is the main barrier to using IoT to keep women in continuous antenatal care. The IGAM-ANC model sets out how sensing, gestational-age tracking and midwife-led antenatal care can be joined, and how such a system should be evaluated. Its next step is development and testing with midwives and pregnant women in Indonesian primary care, where most women start antenatal care but few complete it.

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