

Self-monitoring of blood pressure and telemonitoring for hypertensive pregnant women: A literature review

Anggi Wilis Prihazty^{1,*} and Ernawati²

¹ Midwifery student, Midwifery Study Program, Faculty of Medicine, Universitas Airlangga, Surabaya, East Java, Indonesia.

² Maternal-Fetal Medicine Division, Obstetrics and Gynecology Department, Dr. Soetomo Academic General Hospital, Universitas Airlangga, Surabaya, East Java, Indonesia.

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Abstract

The hypertensive disorder in pregnancy has remained an important contributor to high rates of maternal and fetal morbidity and mortality. New approaches with self-monitoring of blood pressure and telemonitoring may become an option of care for pregnant women with hypertension in the future. Although further investigation is needed, the positive impacts have been recognized in several studies. This study aimed to synthesize and compare the current evidence related to acceptance, implementation, feasibility, outcomes, benefits, integration in clinical settings, and the finding of barriers for further planning. This study is a literature review using scientific articles related to the topic of self-monitoring of blood pressure and telemonitoring in pregnant women with hypertensive disorders. This study concluded that positive acceptance and the discovery of numerous benefits may be a consideration for the implementation of self-monitoring blood pressure and telemonitoring in hypertensive pregnant women. Further feasibility and safety trials remain to be conducted.

Keywords: Telemonitoring; Self-monitoring of blood pressure; Pregnancy hypertension; Preeclampsia

1. Introduction

Globally, approximately 14% of maternal deaths were caused by high blood pressure disorders during pregnancy. This problem has led to high rates of morbidity, severe long-term adverse effects, and fatal outcomes, such as maternal or infant death (1). The global increase of hypertensive disorders in pregnancy from 1990 until 2019 was recorded at 10.92%, with the number of cases increasing from 16.3 to 18.8 million (2).

To improve the detection and management of hypertension in the community, a new approach is needed (3). No longer relying on conventional blood pressure monitoring, the existence of health applications and devices is considered to offer a great prospect for more flexibility in monitoring blood pressure (3). Strong evidence has been suggested that blood pressure telemonitoring could contribute to the detection, screening, diagnosis, and enhanced management of hypertension in adults (4). Compliance with medication, more optimal and intensive treatment, reduced risk of cardiac complications, improved patient quality of life, and even minimized cost are potential positive effects of blood pressure telemonitoring (4).

These opportunities may be beneficial for pregnant women with hypertension as well. Blood pressure monitoring is the basis of maternal care during pregnancy until postpartum to help determine the diagnosis and management of various hypertensive disorders (5). Knowing that hypertension in pregnancy may develop and worsen, it requires vigilant observation to ensure that blood pressure is well controlled and there is no progression of preeclampsia (6).

* Corresponding author: Anggi Wilis Prihazty, E-mail: anggi.wilis.prihazty-2020@fk.unair.ac.id

Although there is limited evidence to prove the feasibility of home blood pressure monitoring for hypertensive pregnant women, the outcomes were similar to conventional monitoring (7). Adopting self-monitoring blood pressure during pregnancy may provide a major improvement in maternal care and in the next five to ten years, telemonitoring may be considered as a standard practice for the countries that readily implement it (8). Therefore, it is necessary to know its acceptability, safety, feasibility, practice in pregnant women, consideration of benefits and possible effects, integration in clinical settings, and limitations that could be considered for the next plan.

2. Material and methods

This is a literature review method that used scientific article references obtained from Google Scholar, Pubmed, and Science Direct. Several keywords were used to find relevant articles such as "pregnancy hypertension", "preeclampsia", "telemonitoring", "self-monitoring of blood pressure", and "home-based blood pressure". This literature review included articles that were published within the last five years, which was between 2019-2023. There were 13 articles that were considered relevant to the topic of telemonitoring and self-blood pressure monitoring in pregnant women with hypertensive disorders were reviewed and compared.

3. Results and discussion

The articles that were considered related to the topic are explained in the following table.

Table 1 The Description of The Article Obtained

No.	Author	Research Title	Method	Result
1	Kalafat et al., 2019	Pregnancy Outcomes Following Home Blood Pressure Monitoring in Gestational Hypertension	Cohort study	There were no differences in pregnancy and delivery outcomes (9). Significant differences in the total number of daily assessment unit visits, $p=0.009$; total duration per week of monitoring, $p<0.001$; the total number of attendance for antenatal visits, $p=0.020$; were found to be lower in the self-monitoring group (9).
2	Peeling et al., 2019	A Randomised Controlled Trial of Blood Pressure Self-Monitoring in The Management of Hypertensive Pregnancy. OPTIMUM-BP: A Feasibility Trial	Randomised Controlled Trial	Most respondents had a high adherence of 80% or greater until delivery, median blood pressure measurement was reported at 6.1 and 5.5 days per week in gestational hypertension and chronic hypertension patients (10). There were no differences in the blood pressure result, dose, and compliance with hypertension medication, maternal and perinatal outcomes, anxiety levels, and quality of life (10).
3	Bowen et al., 2021	Adherence With Blood Pressure Self-Monitoring in Women With Pregnancy Hypertension, and Comparisons To Clinic Readings: A Secondary Analysis of OPTIMUM-BP	Randomised Controlled Trial	The median percentage of daily blood pressure self-monitoring in gestational hypertensive women was 85% and 77% in chronic hypertensive women, and the measurement result showed no difference (11). There were no factors associated with adherence, but the older gestational age in the gestational hypertension group had higher adherence (11).
4	Xydopoulos et al., 2019	Home Blood-Pressure Monitoring in a Hypertensive Pregnant Population: Cost-Minimization Study	Cohort study	The duration of blood pressure monitoring was longer ($p=0.004$), started earlier ($p=0.001$), and daily assessment unit visits were found to be reduced ($p<0.001$) in the home blood pressure monitoring group (12). The average cost savings were £200.69 to £286.53 per week (12).

5	Chappell et al., 2022	Effect of Self-monitoring of Blood Pressure on Blood Pressure Control in Pregnant Individuals With Chronic or Gestational Hypertension: The BUMP 2 Randomized Clinical Trial	Randomized clinical trial	The systolic results, primary, secondary, and fatal outcomes for maternal and perinatal in the self-monitoring and standard care groups showed no difference (13). There was no difference in anxiety level, quality of life, adherence, and dosage of antihypertensive drugs, but the perception of illness score was higher among respondents who measured blood pressure independently (13).
6	Fletcher et al., 2021	Changes to Management of Hypertension in Pregnancy, and Attitudes to Self-Management: An Online Survey of Obstetricians, Before and Following The First Wave of The COVID-19 Pandemic	Cross-sectional study	Self-measurement of blood pressure at home was accepted by the majority of obstetricians (88% of the first session, and 96% of the second session) and may have contributed to decision-making in the clinic, but they also repeated blood pressure measurements in the clinic (14). Hypertension medication alterations were accepted by obstetricians (47%) based on the patient's interpretation of self-measurements (14).
7	Bekker et al., 2023	Home Telemonitoring Versus Hospital Care in Complicated Pregnancies in The Netherlands: a Randomised, Controlled Non-Inferiority Trial (HoTeL)	Randomized controlled, non-inferiority trial	According to the primary outcomes of both groups, the difference in risk was 10-3% lower for those enrolled in intervention, a total of five cases of adverse outcomes were not related to the study (15). The telemonitoring group had better scores on Patient Participation and Satisfaction Questionnaire (PPSQ) (-8-9), higher satisfaction (-0-35), greater scoring for care (0-68), and the average cost reduction was €2774 due to fewer hospital admissions (15).
8	Jongsma et al., 2020	User Experiences With and Recommendations for Mobile Health Technology for Hypertensive Disorders of Pregnancy: Mixed Methods Study	Mixed methods study	The majority of respondents (96%) were comfortable utilizing mHealth, and most respondents (83%) perceived the opportunity for decision-making on the interventions they needed (16). The expertise of professionals to continue clinical management based on interpreted data is essential (16).
9	Munyungula and Shakwane, 2021	Self-Monitoring of Blood Pressure For Preeclampsia Patients: Knowledge and Attitudes	Qualitative study	Patients' understanding of hypertension in pregnancy disease was limited, but self-monitoring of blood pressure was openly accepted (17). However, it was limited by the fear of using or reading the results incorrectly and the inability to afford a blood pressure machine (17).
10	Pealing et al., 2022	Perceptions and Experiences of Blood Pressure Self-Monitoring During Hypertensive Pregnancy: A Qualitative Analysis of Women's And Clinicians' Experiences in the OPTIMUM-BP Trial	Qualitative study	Both the mother and the doctor accepted self-monitoring of blood pressure, women felt more control, understood about blood pressure and symptoms, and had reassurance about the results (18). Strategies for integrating self-monitoring results into clinical care were varied, and the successful outcome was determined by the close relationship between the doctor and the patient (18).
11	Tran et al., 2023	Implementation of a Home Blood Pressure Monitoring Program For The Management of Hypertensive Disorders	Cohort study	The majority of women found self-monitoring of blood pressure easy to implement (98%) (19). For treatment decisions, 72% of physicians used the range of results, 21% used the mean, and 16% the blood pressure measurements in the last three

		of Pregnancy, an Observational Study in British Columbia, Canada		days, but 82% of doctors did not readjust medication based on home monitoring results (19).
12	Vandenberk et al., 2019	Relationship Between Adherence to Remote Monitoring and Patient Characteristics: Observational Study in Women With Pregnancy-Induced Hypertension	Observational study	Remote monitoring adherence had a median value of 89.4% and the level of adherence was found to be associated with the Patient Health Questionnaire-9 (PHQ-9) and Experiences in Close Relationships-Revised Scale (ECR-R) results (20). Negative traits were found in the moderate adherence group, the low adherence group was found to have perfectionist traits, and the differences were not found between the over and good adherence groups (20).
13	LanssensDorien et al., 2019	A Prenatal Remote Monitoring Program in Pregnancies Complicated with Gestational Hypertensive Disorders: What Are the Contributors to the Cost Savings?	Retrospective study	With remote monitoring, the overall total cost by national insurance was 35.17% lower, but the patient's self-cost was 7.07% higher (21). The differences in costs compared to conventional care from largest to the least were for those who delivered <34 weeks, >37 weeks, and between 34-37 weeks, with the largest cost savings were for neonatal care (21).

3.1. The Acceptance of Telemonitoring and Self-Monitoring of Blood Pressure

All of the previous studies have shown that self-monitoring of blood pressure and telemonitoring are well-accepted. Both patients and doctors positively accepted home blood pressure monitoring (18). The implementation was considered easy (19). The acceptance of self-monitoring of blood pressure among pregnant women with gestational or chronic hypertension was determined based on adherence to blood pressure measurement (10). The study results by Munyungula and Shakwane in 2021 (17) showed that respondents were more enthusiastic about blood pressure monitoring at home, rather than in the clinic. The existence of applications such as mHealth for remote monitoring was considered convenient and satisfying for patients (16).

3.2. Reality of Adherence and The Implementation

Overall, pregnant women reported having good self-monitoring adherence (10,11,20). They felt responsible for their pregnancy health, thus encouraging their adherence to monitor blood pressure, especially for women with medication (18). The gestational hypertension group measured blood pressure more often since it was a new experience for them, particularly in those who were diagnosed at more than 32 weeks gestation (11). Likewise, another research showed that the frequency of measurement was more frequent among women with symptoms of hypertension or preeclampsia, and for those who were worried about their condition (16). Conversely, for those with stable conditions, daily blood pressure measurement was found to be too burdensome (16).

Patient demographic status was not found to be associated with adherence (11,20). However, maternal psychological characteristics such as some negative traits were associated with moderate adherence, and perfectionist traits towards others were found for those with less adherence, while there was no difference between over and good adherence (20). Lack of adherence is a manifestation of the avoidance of something perceived as potentially threatening due to the fear of receiving negative information, as well as perfectionist traits which make them more difficult to approach because the intervention involved a personal relationship with a health professional, while the absence of differences between good and over-adherence indicated that over-adherence was not a concern but more of a normal sign of their nature and adaptation process before childbirth (20).

3.3. Feasibility of Self-Monitoring of Blood Pressure

From all the studies reviewed, it was found that the results of self-monitoring of blood pressure and in the clinic remained similar, but there was no evidence for its efficacy in controlling blood pressure. The results of the self-measurement of blood pressure in the Bowen *et al* study (11) showed low inaccuracy, the difference in results between measurements at home and the clinic was minimal. Similar to the results of the Pealing *et al* study (10) which found similarities in blood pressure results at home and the clinic. This could be a rationale for determining the threshold for self-interpretation of blood pressure, equated with interpretation in the clinic (10). The opposite results were obtained

in a study by Chappell *et al* (13) which stated that the cause of the lack of control effect of self-monitoring blood pressure was due to the finding that almost 25% of respondents' blood pressure results were normal at home but high at the clinic. Whereas the study of Bowen *et al* (11) only found a few respondents whose measurement results were higher on the monitor and explained the possibility of non-compliance with self-measurement requirements such as certain activities carried out previously and measurements performed before taking medication.

3.4. The Safety Based on Outcomes

None of the studies revealed any adverse outcomes due to the implementation of self-blood pressure monitoring and telemonitoring. Either daily telemonitoring or hospitalization of pregnant women with complications was found to be equally effective and the primary outcome was better in the telemonitoring group, but there was no difference in maternal and fetal secondary outcomes (15). Other studies similarly found no difference in adverse outcomes in infants or mothers (12,13). Non-different pregnancy and delivery outcomes were also described in the Kalafat *et al* study (9) including gestational age at delivery, delivery method, maternal care unit, birth weight, restricted fetal growth, admission to the Neonatal Intensive Care Unit (NICU), or adverse outcomes in both infants and mothers. It was found that the higher proportion of cesarean sections and other conditions in the group of pregnant women with chronic hypertension who performed self-monitoring blood pressure in the Pealing *et al* study (10) may be coincidental and not caused by self-monitoring blood pressure because there was no difference found in medication adherence data between the standard care and intervention groups. It was consistent with some adverse outcome findings in the Bekker *et al* study (15) which were mentioned to be not related to the study. However, large multi-center studies are required to ensure safety (9).

3.5. Benefits of Self-Monitoring of Blood Pressure and Telemonitoring

Numerous benefits have been stated in several studies conducted in this review. It was reported that women who implemented self-monitoring of blood pressure had a greater sense of control over their health (10,12,16). Telemonitoring and self-monitoring of blood pressure enhance maternal and fetal health because women will be more independent and empowered (15,17). The telemonitoring group had higher satisfaction with care (15). Most women felt more comfortable and assured about the result of home blood pressure monitoring than in the clinic (18). Women felt secure and relaxed due to the closely supervised by health professionals (16). However, the Pealing *et al* study (10) found that there were no differences in respondents' quality of life and anxiety scores, but the "problem score" was lower in the intervention group.

The implementation of self-monitoring blood pressure in gestational hypertension women showed significantly fewer antenatal visits per week or total compared to standard care (9). This would be especially beneficial for women who visited clinics once per week or every 24-48 hours (14). Despite the reduced visits to healthcare facilities, early detection would still be possible for prompt intervention (16). Self-monitoring could be more accurate and frequent to detect abnormalities earlier and receive immediate intervention (12,17). For example, masked hypertension or white-coat hypertension are more likely to be diagnosed, thus follow-up can be carried out since maternal and perinatal outcomes can be worse (12,14). They found mHealth usage and displayed blood test results very informative and helped them realize when they should seek health services (16). All of the respondents felt the benefits of home blood pressure measurement especially when they noticed symptoms of preeclampsia (16). There was an increased understanding of the symptoms and the fact that blood pressure showed surprising variability (18). They tried to take measurements for new situations and learned the impact of the results (18). However, the Chappell *et al* study (13) stated that the strategy of self-monitoring of blood pressure and telemonitoring compared to standard care in women with chronic or gestational hypertension did not provide significantly better control of clinic-based blood pressure.

3.6. Cost Impact of Self-Monitoring of Blood Pressure and Telemonitoring

All studies related to this section have shown the subsequent impact of implementing blood pressure self-monitoring and telemonitoring, which is cost-saving. The average cost saving with the telemonitoring strategy was 18% per patient, not because of the actual cost of telemonitoring itself, but due to the reduction of pregnant women's admissions (15). Likewise, the results of a study by Xydopoulos *et al* (12) showed the number of outpatient visits for blood pressure monitoring was reduced, resulting in lower costs for each patient per week, especially when the application was added. Furthermore, if this strategy is implemented for pregnant women with complications in the Netherlands, it could have an impact on the annual budget estimated at €56-€134 million per year (15).

The greatest cost savings with telemonitoring in hypertensive pregnant women were reported in neonatal care and it was found that the older the gestational age at delivery, the lower the cost of neonatal care obtained (21). Costs were reported to be reduced by more than 50% for 10 days older neonates in the group delivered <34 weeks with remote

monitoring because it was able to detect abnormal events resulting in immediate interventions to prevent deterioration, including postponing preterm labor by up to 10 days (21).

3.7. The Integration in Clinical Settings

The results of blood pressure self-monitoring were suggested to be considered by doctors for determination of management (18). Following the pandemic, more obstetricians have expressed positive perspectives towards the integration of patient self-monitoring of blood pressure into clinical care such as to facilitate blood pressure measurement outside the clinic and support management decisions (14). However, repeated measurements in the clinic remain the priority for treatment decisions (14). In a pandemic context, a study by Tran *et al* (19) stated that the results of blood pressure self-monitoring alone were able for hypertension management and most doctors used the range of blood pressure results at home for the determination. However, this was different from the results of the Chappell *et al* study (13) which revealed no difference in antihypertensive medication since doctors preferred to rely on blood pressure results in the clinic even though there was access to the patient's self-monitoring data.

The results of the patient's measured blood pressure encouraged a discussion related to blood pressure and the use of medication (18). If abnormal results or symptoms are observed, doctors should contact the patient (18). Patients felt satisfied if the health professional provided follow-up care (16). Establishing a close relationship between doctors and patients was the key to the successful integration of self-monitoring blood pressure (18).

3.8. Barriers and Limitations of Current Implementation

Several respondents felt some limitations to implementing it such as a lack of familiarity with using blood pressure machines, lack of confidence, the concern of inaccurate readings that would worsen their condition, and inability to purchase the device (17). Doctors were also concerned that women may misunderstand the 'normal' readings and neglect important symptoms (18). Another concern was the fear of elevated blood pressure results followed by negative responses from healthcare professionals due to poor medication adherence or incorrect diet (17).

4. Conclusion

Self-monitoring blood pressure measurement and telemonitoring were accepted and implemented well among hypertensive pregnant women. The numerous benefits reported without any studies showing adverse outcomes may be a consideration for its implementation. Self-monitoring results by pregnant women can be integrated into clinical care. However, more studies are required to ensure its feasibility and safety. Possible solutions to the barriers discovered should be discussed.

Compliance with ethical standards

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Disclosure of Conflict of interest

There is no conflict of interest to declare.

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