Cellular-Enabled Remote Patient Monitoring for Pregnancies Complicated by Hypertension

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INTRODUCTION Unmanaged hypertension in pregnancy is the second most common cause of direct maternal death and disproportionately affects women in rural areas. While telehealth technologies have worked to reduce barriers to healthcare, lack of internet access has created new challenges. Cellular-enabled remote patient monitoring devices provide an alternative option for those without access to internet.

OBJECTIVE This study aimed to assess maternal and neonatal clinical outcomes and patient acceptability of an integrated model of cellular-enabled remote patient monitoring devices for blood pressure supported by a 24/7 nurse call center.

METHODS In a mixed-methods study, 20 women with hypertension during pregnancy were given a cellular-enabled BodyTrace blood pressure cuff. Participants' blood pressures were continuously monitored by a nurse call center. Participants completed a baseline survey, post-survey, and semi-structured interview after 8 weeks of device use.

RESULTS Participants reported a significant decrease in perceived stress after device use ($P = .0004$), high satisfaction with device usability (mean = 78.38, SD = 13.68), and high intention to continue device use (mean = 9.05, SD = 1.96). Relatively low hospitalization and emergency department rates was observed (mean = 0.35, SD = 0.59; mean = 0.75, SD = 0.91). Participant-perceived benefits of device use included convenience, perceived better care owing to increased monitoring, and patient empowerment. Perceived disadvantages included higher blood pressure readings compared to clinical readings and excessive calls from call center.

CONCLUSION Remote patient monitoring for women whose pregnancies are complicated by hypertension can reduce barriers and improve health outcomes for women living in rural and low-health-resource areas.

KEYWORDS Remote patient monitoring; Cellular-enabled remote patient monitoring device; Hypertension; Pregnancy; Pregnant women

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Introduction

Hypertension in pregnancy is associated with adverse maternal and neonatal health outcomes. In the United States, rates of hypertensive disorders in pregnancy more than doubled from 2007 to 2019[1] and complications due to poorly managed hypertension are the second most common cause of direct maternal death.[2] Uncontrolled hypertension during pregnancy is associated with increased risk of complications such as preeclampsia, fetal growth restriction, low birthweight, and preterm delivery.[1–3] This disproportionately affects minority women and women living in rural areas.[4,5]

According to the American College of Obstetrics and Gynecology, hypertension in pregnancy is diagnosed by the occurrence of at least 2 systolic blood pressure (BP) readings of 140 mm Hg or greater and/or diastolic BP readings of 90 mm Hg or greater when taken at least 4 hours apart at rest.[6] Early diagnosis of hypertensive-related conditions in pregnancy works to reduce hospitalizations and improves maternal and neonatal health outcomes. Management of chronic health conditions can be challenging for those living in low-resource and rural areas. Rural populations are more likely to experience significant healthcare barriers related to travel time, cost, time away from work, and lack of reliable transportation.[7] These challenges contribute to health disparities among rural and socioeconomically disadvantaged populations.[7]

Pregnant women with hypertension require closer monitoring and more frequent prenatal visits compared with normotensive pregnant women.[3] The emergence of telehealth technologies has worked to reduce such barriers; however, many areas still lack access to broadband internet. In 2019 it was reported that 8% of people in the United States were without internet access in the home.[8] Individuals living in rural areas are nearly 2 times more likely to lack internet access than their urban counterparts.[7,8] Remote patient monitoring (RPM) using cellular-enabled devices offers an alternative to frequent clinic visits for management of hypertension in pregnancy. Cellular-enabled devices use cell towers to automatically transmit BP readings to a

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KEY FINDINGS

- The use of cellular-enabled RPM devices supported by a 24/7 nurse call center is a valuable tool for managing hypertension in pregnant women. Most participants felt they received better care due to the automatic uploading of their blood pressure readings and knowing a healthcare professional was monitoring their readings 24/7.
- Participants also expressed high satisfaction with ease of use and convenience of the RPM device and reported it helped reduce stress and fostered a sense of empowerment in regard to improving their own health outcomes. In addition, participants who used the cellular-enabled remote patient monitoring device showed relatively low hospitalization rates.
- RPM has overall received positive feedback from participants, allows for closer monitoring of hypertensive disorders in pregnancy, and has the potential to reduce visits to the emergency room and hospitalizations due to complications of hypertension in pregnancy.

physician portal, eliminating the need for internet or smartphones and allowing the healthcare team to monitor BP readings between clinic visits. This provides physicians with the ability to manage hypertension more accurately in pregnancy while reducing health barriers for those living in rural areas, leading to better health outcomes for mothers and their newborns.

This study is a follow-up to a pilot study previously conducted by the authors, which found that participants who used the RPM BP device reported high satisfaction with the device. Some reported advantages to using the device included increased monitoring by health professionals, patient empowerment, decreased number of clinic visits, and ease of using the device. In this follow-up study, we aimed to assess maternal and neonatal clinical outcomes associated with use of the RPM BP device in an integrated care model. Patient acceptability of the device was part of the evaluation, as the device requires minimal intervention from the user, with BP data automatically uploaded to a physician portal using cellular-based technology.

This study aimed to assess maternal and neonatal clinical outcomes as well as patient acceptability of an integrated model of cellular-enabled RPM devices for BP supported by a 24/7 nurse call center.

Methods

Study design

This was a mixed-methods study using a pre-post survey design and semi-structured qualitative interview to assess the feasibility and acceptability of an integrated model of cellular-enabled RPM devices for BP supported by a 24/7 Nurse Call Center (NCC). Maternal clinical outcomes were retrospectively assessed using patients' EPIC charts. Thirty pregnant women with hypertension were invited to participate in the study. Participants were provided with a BodyTrace™ (BodyTrace, Inc, New York, NY) kit that included a BP cuff and weight scale for home use in accordance with their healthcare providers' recommendation. The BodyTrace BP cuff is equipped with cellular transmission capabilities allowing for BP readings to be automatically uploaded to a physician portal. As the devices do not need Wi-Fi or Bluetooth, they eliminate the need for a smartphone and create a greater level of ease and access for those in underserved or rural areas. The device uses standard cell phone technology and cell towers to automatically transmit the data to a physician portal. For individuals living in areas without cell coverage, the device stores any BP readings taken and will automatically upload those readings once cellular coverage is reestablished. BP parameters were set according to the University of Arkansas for Medical Sciences (UAMS) High Risk Pregnancy Program guidelines and were closely monitored by registered nurses in the NCC, which is staffed 24 hours a day, 7 days a week. If a participant's BP readings were outside of the set range of 140/90, NCC staff would contact the participant to triage and provide further instructions as needed. Participants were asked to complete a baseline survey, use the BodyTrace BP RPM device for 8 weeks, and then complete an exit survey and semi-structured interview. The study was approved by the UAMS Institutional Review Board (#261908).

Participants

Participants included women aged $\geq$18 years whose pregnancies were complicated by hypertension and who received their prenatal care at the UAMS Women's Health Clinic. Participants must have had elevated BP meeting the criteria of systolic $\geq$140 and/or diastolic $\geq$90 for at least 1 reading.

Thirty women who met the eligibility criteria were consented to participate; however, 10 were lost to follow-up, resulting in a total of 20 participants included in the data analysis. Participants received a $25 gift card after completion of each survey and the semi-structured interview as compensation for participation.

Data collection

Quantitative data

A trained research associate obtained informed consent verbally. Participants completed a web-based, self-administered survey at baseline consisting of 4 sections: (1) demographic characteristics, (2) perceived stress, (3) anxiety, and (4) perceived benefits. After using the BodyTrace BP RPM device for 8 weeks, participants were asked to complete a post-survey consisting of 5 sections: (1) perceived stress, (2) anxiety, (3) perceived benefits, (4) system usability, and (5) behavioral intention. Surveys took approximately 10–15 minutes to complete. Maternal and neonatal outcomes including preeclampsia, fetal growth restriction, preterm delivery, lower birthweight, BP medication, gestational age at consent,

Table 1 Patients' characteristics (N = 20)

Characteristic	n (%)	Total n responded
Race		20
Black or African-American	12 (60.00%)	
White	7 (35.00%)	
Other	1	
Hispanic		16
No	15 (93.75%)	
Yes	1 (6.25%)	
Marital status		20
Married	7 (35.00%)	
Divorced, separated, or widowed	1 (5.00%)	
Single	12 (60.00%)	
Highest education		20
9th–12th grade	2 (10.00%)	
High school graduate or GED	6 (30.00%)	
Some college or technical school	9 (45.00%)	
College graduate or higher	3 (15.00%)	
Annual household income		20
<$15,000	6 (30.00%)	
$15,000 to <$20,000	3 (15.00%)	
$20,000 to <$25,000	3 (15.00%)	
$25,000 to <$35,000	1 (5.00%)	
$35,000 to <$50,000	4 (20.00%)	
$50,000 to <$75,000	2 (10.00%)	
≥$75,000	1 (5.00%)	
Employment		20
Full-time	12 (60.00%)	
Part-time	2 (10.00%)	
Unemployed	6 (30.00%)	
Number of children aged <18 years		20
0	7 (35.00%)	
1	5 (25.00%)	
2	3 (15.00%)	
3	3 (15.00%)	
4	1 (5.00%)	
5 or more	1 (5.00%)	
First pregnancy		20
No	13 (65.00%)	
Yes	7 (35.00%)	
Last baby delivered		12
Preterm	4 (33.33%)	
Term	7 (58.33%)	
Post-term	1 (8.33%)	
Last baby birthweight range		12
1–2 pounds	1 (8.33%)	
3–4 pounds	1 (8.33%)	
5 pounds–<6 pounds	3 (25.00%)	
6 pounds or more	7 (58.33%)	
First pregnancy with blood pressure issues or preeclampsia		13
No	9 (69.23%)	
Yes	4 (30.77%)	
Feel about using technology		20
Using technology does not scare me at all	17 (85.00%)	
Using technology makes me feel uneasy	3 (15.00%)	

number of emergency department visits, number of hospitalizations, number of calls to the 24/7 high-risk pregnancy call center, and number of times the device was used were collected retrospectively from patient charts in EPIC.

Table 2 Models comparing pre and post scales

Measures	Pre-survey Mean	Pre-survey SD	Post-survey Mean	Post-survey SD	*P* value[†]
Perceived stress	7.2	2.71	5.00	3.32	.0004
Anxiety	9.4	4.19	8.40	3.95	.1208
Perceived benefits	22.55	4.59	22.10	3.96	.4625
System usability	–	–	78.38	13.68	–
Behavioral intention	–	–	9.05	1.96	–

[†]*P* values calculated using paired *t* test and Wilcoxon signed rank test.

Qualitative data

Participants were interviewed over the phone using a semi-structured interview guide at the conclusion of the study. Interviews lasted on average 5–10 minutes. All interviews were audio-recorded and transcribed verbatim.

Measurements

Perceived stress

Perceived stress was assessed using Cohen's Short Form Perceived Stress Scale (PSS-4)—a brief, 4-item self-report instrument using a 5-point Likert scale.[9]

Anxiety

The Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety Short Form, a 4-item, validated self-report instrument that uses a 5-point Likert scale, was used to measure anxiety.[10] Higher sum composite scores correlate to higher levels of perceived anxiety.[10]

Perceived benefits

Perceived benefits associated with device use were assessed using an adapted instrument from previous research on mobile health devices, which included 5 Likert-scale questions.[11]

System Usability and Satisfaction

System usability and satisfaction was assessed using a 10-item validated instrument to assess participant satisfaction with the usability of the device.[12]

Behavioral intention

Behavioral intention was assessed using 2 questions: "If the opportunity presented itself again, I would use the system to monitor my health from home" and "I would recommend the system to other women eligible to monitor their health from their home." The 2 questions used a 5-point Likert scale.

Data analysis

Quantitative data

Descriptive statistics of participants' demographic characteristics are reported in Table 1. The paired *t* test and Wilcoxon signed rank test were used to compare the study measures of participants before and after use of the BodyTrace device and

are reported in Table 2 with each scale pre- and postintervention mean and standard deviation. Descriptive statistics of maternal outcomes for users and partial users are reported in Table 3 and Table 4, respectively. Partial users were defined as individuals who used the RPM BP device at least 1 time but did not use the device for the full 8 weeks and did not complete the post-survey.

Qualitative data

Two researchers analyzed the qualitative data using MAXQDA Plus 20 software (VERBI Software, Berlin, Germany). First, all interview transcripts were read by the coders to familiarize themselves with the data. The codebook was then developed in an iterative process of discussion and refinement. Coders used constant comparative analysis to search line by line for patterns, codes, and themes. As new codes and themes emerged, the coders reviewed previous interviews to ensure consistency. After all transcripts were coded, the data analysis team identified major themes and exemplary quotations.

Results

Characteristics of the sample

Sociodemographic characteristics of the 20 participants are reported in Table 1. The majority of the participants were Black or African American (60.00%), non-Hispanic (93.75%), single (60.00%); had at least some college or technical school education (60.00%); and were fully employed (60.00%). The distribution of annual household income varied, with the majority falling below $25,000 (60.00%), followed by $25,000–$75,000 (35.00%). Most participants had 1 or more children aged under 18 years (65.00%) and reported that this was not their first pregnancy (65.00%). Among the participants, 58.33% had their last baby delivered at term, with 33.33% being preterm and 8.33% post-term. The birthweight of last baby ranged from 1–2 pounds (8.33%) to 6 pounds or more (58.33%). Most participants reported that this was not their first pregnancy with BP issues or preeclampsia (69.23%). Regarding technology usage, 85.00% of participants expressed no fear of using technology, while 15.00% felt uneasy about it.

Quantitative results

The means and standard deviations for pre- and post-survey scales are presented in Table 2. Paired t tests or Wilcoxon signed rank tests were used to examine the significance of the differences between the pre-survey and post-survey scores as appropriate. There was a significant decrease in participants' perceived stress levels after using the device ($P = .0004$). However, no statistically significant differences were observed in anxiety score ($P = .1208$) or perceived benefits of using the device ($P = .4625$) between the pre-survey and post-survey. After 8 weeks of device usage, participants reported a positive perception of the device's usability, with a mean score of 78.38 (SD = 13.68), and expressed a high intention to continue using the device, with a mean score of 9.05 (SD = 1.96). These findings underscore the device's effectiveness in managing stress and emphasize the participants' favorable perceptions and willingness to use the device.

Table 3 displays descriptive data of maternal outcomes for users. Some outcomes were unavailable owing to delivery outside of UAMS. The majority of users had preeclampsia (55.56%) and used BP medication (77.78%). Most users did not have fetal growth restriction (83.33%), did not deliver preterm (55.56%), and did not have low birthweight (77.78%). The means and standard deviations for gestation age at time of consent, the frequency of device usage, the number of times participants visited the emergency department, the number of hospitalizations, and the number of calls made to the 24/7 High Risk Pregnancy Program Call Center at UAMS are also reported. Among the 20 participants, an average of 0.75 (SD = 0.91) visits to the emergency department were reported. Similarly, relatively low hospitalization rates among the participants were observed, with an average of 0.35 times (SD = 0.59). The average number of calls made to the 24/7 High Risk Pregnancy Program Call Center at UAMS was 2.75 (SD = 2.34). Moreover, participants

Table 3 Maternal outcomes for users

Measures	N	n (%)	Mean (SD)
Preeclampsia	18		–
No		8 (44.44%)	
Yes		10 (55.56%)	
Fetal growth restriction	18		–
No		15 (83.33%)	
Yes		3 (16.67%)	
Preterm delivery	18		–
<34 weeks		2 (11.11%)	
<37 weeks		6 (33.33%)	
No		10 (55.56%)	
Low birthweight (<2500 g)	18		–
No		14 (77.78%)	
Yes		4 (22.22%)	
Very low birthweight (<1500 g)	18		–
No		17 (94.44%)	
Yes		1 (5.56%)	
Blood pressure medication	18		–
Labetalol		1 (5.56%)	
Amlodipine		9 (50.00%)	
Nifedipine		4 (22.22%)	
No		4 (22.22%)	
Gestational age (weeks) at consent	20	–	18.73 (4.38)
Number of emergency department visits	20	–	0.75 (0.91)
Number of times hospitalized	20	–	0.35 (0.59)
Number of times call the 24/7 High Risk Pregnancy Program Call Center at UAMS	20	–	2.75 (2.34)
Number of times used device	20	–	35.55 (36.82)

UAMS = University of Arkansas for Medical Sciences.

reported a mean device usage of 35.55 times (SD = 36.82), reflecting a substantial utilization of the device throughout the study period.

Table 4 displays maternal outcomes for partial users. Some maternal outcomes were unavailable owing to delivery at another hospital or loss of pregnancy. The majority of partial users did not have preeclampsia (80.00%), did not have fetal growth restriction (60.00%) but did deliver preterm (60.00%), had low birthweight (60.00%), and were on BP medication (60.00%). The mean gestational age of consent for partial users was 19.91 weeks (SD = 4.57).

Qualitative results

Advantages

Participants described the advantages of using the RPM BP device, including (1) easy/convenient to use, (2) perceived better care, (3) increased monitoring of BP, (4) call center support, and (5) participant empowerment.

Easy/convenient: Many participants stated that the device was easy to use and that the automatic upload of their BP readings was convenient. One participant stated, "*I really liked it…I didn't have to really write down anything. The record just goes straight to the office. That's the best part.*" Another patient stated, "*It was an easy system to use. It's digital. And it would just pop up right then and there. If it's too high or too low, you get a call from the hospital. So, I liked it, I really did. I enjoyed it.*"

Perceived better care: Many participants perceived that they received better care while using the device, as their BP readings were closely monitored by the nurses in the call center as well as their medical team. One participant stated, "*I felt quite closely monitored, me being at risk to have preeclampsia. I felt I was being monitored closely and felt more cared for.*" Another patient reflected on the benefit of having someone manage her BP, saying, "*I can ignore stuff, but if someone reminds me that it's something that I don't need to ignore then I won't.*" One patient felt the device improved her care because she did not have to self-determine if her BP readings were too high, stating, "*I think it was better care because as soon as it was high or anything was out of whack with it, you guys had a nurse immediately called me to make sure I was OK or I could go straight into triage and that was very helpful….You know, some people don't know quite if it's OK or not OK. So, to have that nurse with that feedback and that reassurance of having someone that does care, call you and comfort you, that is great to have.*"

Increased monitoring of BP: Many participants felt that using the device made them feel safe and well cared for by their medical team owing to the increased amount of monitoring of their BP. One participant stated, "*It made me feel good that somebody was really keeping an eye on [my blood pressure]*" while another said, "*You always had someone there, so it made me feel safe no matter what I was doing or where I was at.*"

Call center: Most participants appreciated the support from the 24/7 nurse call center, which would call participants after a high BP reading. One participant stated it enhanced her care: "*I really appreciated the call center being there 24/7, calling me, checking up on me and making sure that I had their number to let them know if I had any issues or if I had any questions and it was available 24/7 to me.*" Another reflected on the speed with which the call center responded to high readings, saying, "*They were very swift…their timeliness was impressive, actually.*" Another participant reflected, "*Everyone was respectful and caring. You don't get that a lot of places.*"

Participant empowerment: Participants reported that one advantage to using the device was being able to better care for themselves and their health. One participant stated, "*Because I was able to monitor it myself, I could kind of pinpoint what I needed to eat and what I didn't need to eat for that day. So that takes a lot of stress off too.*" Another participant said, "*It helped me monitor and keep a close eye on my blood pressure and monitor my blood pressure numbers,*" while another said, "*It helped me to monitor my numbers to make sure that everything was*

Table 4 Maternal outcomes for partial users

Measures	N	n (%)	Mean (SD)
Preeclampsia	5		–
No		4 (80.00%)	
Yes		1 (20.00%)	
Fetal growth restriction	5		–
No		3 (60.00%)	
Yes		2 (40.00%)	
Preterm delivery	5		–
<34 weeks		2 (40.00%)	
<37 weeks		1 (20.00%)	
No		2 (40.00%)	
Low birthweight (<2500 g)	5		–
No		2 (40.00%)	
Yes		3 (60.00%)	
Very low birthweight (<1500 g)	5		–
No		4 (80.00%)	
Yes		1 (20.00%)	
Blood pressure medication	5		–
Labetalol	5	1 (20.00%)	
Amlodipine		2 (40.00%)	
Nifedipine		0 (0.00%)	
No		2 (40.00%)	
Gestational age (weeks) at consent	8	–	19.91 (4.57)
Number of emergency department visits	8	–	0.25 (0.46)
Number of times hospitalized	8	–	0.13 (0.35)
Number of times call the 24/7 High Risk Pregnancy Program Call Center at UAMS	8	–	0.88 (0.99)
Number of times used device	8	–	17.00 (13.97)

UAMS = University of Arkansas for Medical Sciences.

OK and it was helping me to kind of keep a gauge on my blood pressure."

Disadvantages

While most participants reported no issues with using the device, a few reported issues with the call center protocol or perceiving that the device gave higher BP readings when compared to clinical BP monitors.

Issues with protocol: A few participants reported disliking the protocol, stating that they received too many phone calls from the call center following high BP readings. One participant said, *"People would call to make sure that I'm OK and then I would take it again and it would be higher because I felt like they were going to call me again."* Another patient reported, *"They would call me all the time…sometimes, I wouldn't answer the phone."*

Inaccurate readings: Some participants reported feeling like their BP readings were inaccurate. One participant reported a negative effect on their anxiety, stating *"If the machine was accurate, then I would feel more comfortable taking readings, but I stopped using it because it wasn't accurate."* Another patient said, *"It was misreading my blood pressure. It was reading a lot higher than what it really was, and then it signaled me to go to the emergency room. And so, when I went to the emergency room, my blood pressure was perfectly fine, but the monitor was still reading that it was high."*

Discussion

This follow-up study focused on feasibility and satisfaction of an integrated care model that uses cellular-enabled RPM devices with a 24/7 NCC to monitor BP in pregnancies complicated with hypertension. Using a pre-post survey design, patients' satisfaction with the device, their perceived stress, anxiety, intentions to continue using the device, and perceived benefits associated with using the device were assessed. A semi-structured interview was used to examine other perceived advantages and disadvantages of using a cellularly enabled RPM device. Our parent study demonstrated a high level of patient satisfaction with using an RPM device to monitor BP in hypertensive pregnant women.[13] In addition, the current study retrospectively looked at clinical outcomes for patients using a cellularly enabled RPM device to manage hypertension during pregnancy and found 55.56% were diagnosed with preeclampsia, 16.67% had fetal growth restriction, 22.22% measured low birthweight, and 44.44% delivered preterm. Of the 20 respondents, 14 (77.78%) were given BP medication during pregnancy. These findings highlight the potential benefits of using the device in improving maternal outcomes.

To our knowledge, we are the first to assess the use of cellular-enabled RPM BP devices for management of hypertension during pregnancy in the current study as well as in the parent study.[13] Previous studies on postpartum women found a potential reduction in clinical healthcare cost associated with using Bluetooth RPM to monitor BP related to postpartum hypertension.[14–16] Another study in postpartum women had fewer readmissions related to hypertension than their counterparts who did not use a RPM device.[16] Payakachat and colleagues[15] demonstrated high positive feedback regarding the use of Bluetooth BP RPM in postpartum women, mostly due to the reduction of required travel for clinic visits, real-time monitoring of their BP by health professionals, and increased participant empowerment to manage their own health. This aligns with results from the current study, with participants again emphasizing ease of device use, improved management of their BP, and increased perceived ability to manage their own hypertension.

However, one disadvantage to devices utilizing Bluetooth is the required access to broadband services. In 2019 it was reported that 8% of people in the United States were without internet access[8] and individuals living in rural areas are nearly 2 times more likely to lack access to internet services.[7,8] Cellular-enabled RPM devices, such as used in this study, do not require internet access or a smartphone. The ability to monitor hypertension without requiring access to internet or smartphone services further reduces barriers for rural and low-health-resource populations, increasing their ability to obtain healthcare services, reducing travel needs for outpatient visits, and decreasing emergency department usage for complications due to undermanaged chronic conditions. Reducing such burdens on hospitals and patients has the potential to lower healthcare-related costs and improve health outcomes for individuals living in rural areas. A recent study at the University of Mississippi Medical Center showed that hypertension RPM in a low-income rural population was associated with a significant reduction in BP.[17] RPM has been shown to be cost effective for management of hypertension and works to achieve a prolonged decrease in health-related costs.[18] Participants using telemedicine indicated use addressed barriers such as transportation issues and lack of timely diagnoses within low-income populations.[19] The effectiveness of RPM for BP management in low socioeconomic areas indicates that RPM is accepted within the population and is a feasible solution for the management of chronic diseases. The current study further highlights the positive perception and acceptance of using cellularly enabled RPM and its impact in reducing barriers to healthcare access.

Despite the many advantages to using cellular-enabled RPM BP devices, participants reported some issues with the device and protocol. Some participants expressed concern that the BP readings from the device were inaccurate. While some variability in remote BP devices is expected,[20] patient concern about inaccurate readings was presented in both the parent study[13] and the current study. This is likely owing to the fact that cellular-enabled devices are a relatively new technology with room for improvement. Some participants additionally reported disliking the protocol, stating that they received too many phone calls from the 24/7 call center in response to high readings. This provides an additional area for improvement for future studies.

Owing to the low number of studies assessing RPM BP use during pregnancy, there is little data available regarding the impact of RPM BP management during pregnancy on

maternal health outcomes. A study that assessed the impact of RPM BP on postpartum women found that use of an RPM BP device had no effect on hospital readmissions for hypertension or initiation of antihypertensive medications after pregnancy.[21] A study in Belgium that assessed healthcare utilization among pregnant women with hypertension found that participants using an RPM BP device had lower prenatal hospital admissions and lower rates of preeclampsia when compared to those not using a RPM BP device.[22] The study found no difference in mode of delivery between the groups or neonatal outcomes, but rates of Neonatal Intensive Care admissions among the RPM group were lower.[22] While the small sample size of the current study eliminates the possibility of comparison between users and partial users, emergency room visits, hospitalizations, and calls to the 24/7 UAMS High-Risk Pregnancy Call Center were low for the user group. Low birthweight and fetal growth restriction in the user group were also low; however, more than half of users developed preeclampsia. Future research on the effect of BP RPM use during pregnancy on maternal and neonatal outcomes is needed.

There were limitations to the current study. The sample size of 20 is small; however, the information found is valuable for future studies regarding cellular-enabled RPM BP devices for management of hypertension during pregnancy, as large clinical trials in a wider patient population are needed. In addition, the main study outcomes were self-reported, indicating the possibility of social desirability bias to impact both quantitative and qualitative data.

Conclusion

The use of cellular-enabled RPM devices supported by a 24/7 NCC is a valuable tool for managing hypertension in pregnant women. Most participants felt they received better care owing to the automatic uploading of their BP readings and knowing a healthcare professional was monitoring their readings 24/7. Participants also expressed high satisfaction with ease of use and convenience of the RPM device and reported that it helped reduce stress and fostered a sense of empowerment in regard to improving their own health outcomes. Data also shows relatively low hospitalization rates among users. Some participants reported instances of higher BP readings by the device when compared to clinical readings, prompting unnecessary calls from the call center, which was reported as a disadvantage of using the device. However, RPM has overall received positive feedback from participants, allows for closer monitoring of hypertensive disorders in pregnancy, and has the potential to reduce visits to the emergency room and hospitalizations owing to complications of hypertension in pregnancy. Because of this, RPM of women whose pregnancies are complicated by hypertension should be considered to reduce barriers and improve health outcomes for women living in rural and low-health-resource areas.

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Disclosures

The authors have no conflicts to disclose.

Authorship

Informed consent was obtained from all participants. The study was approved by the UAMS Institutional Review Board (#261908) and adhered to ethical guildlines. All authors attest they meet the current ICMJE criteria for authorship.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.cvdhj.2024.03.001.

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