

Use of a wireless monitoring device to perform nonstress tests from home: the patient perspective



OBJECTIVE: Antenatal fetal surveillance is performed in high-risk pregnancies to reduce the risk of stillbirth.¹ Surveillance recommendations require numerous in-clinic appointments for nonstress tests (NSTs).¹ NST attendance is limited by transportation, childcare, and work demands.²

INVU by Nuvo is an United States Food and Drug Administration–cleared, remote, self-administered maternal-fetal monitoring approach. In a prospective cohort study, 93.9% of NSTs performed remotely using INVU were clinically acceptable, and >88% were completed without in-clinic evaluation.³ In this study, we explored patient acceptability of remote fetal monitoring using quantitative and qualitative approaches to help clinicians and users understand the experience, while providing actionable insights for optimization.

STUDY DESIGN: This prospective mixed-methods study encompassed survey and qualitative portions. Patients were enrolled in 1 of 2 prospective cohorts that studied the use of INVU to remotely perform clinically indicated NSTs in high-risk pregnancies from October 2020 to March 2023. A device description and the inclusion and exclusion criteria for these cohorts are described in the Supplemental File, and the clinical data have been reported elsewhere.³ These studies were approved by the [University of Pennsylvania] Institutional Review Board.

Survey study: Cohort patients who attempted ≥ 1 remote NST were eligible for the weekly survey, which included a modified version of the validated Acceptability of Intervention Measure (AIM) (4-item Likert-scale measure) and open-ended questions regarding patient experience.⁴ Descriptive statistics were used, and analyses were performed using Stata, version 15.0 (StataCorp LL, College Station, TX).

Qualitative study: Beginning May 2022, after 2 attempted remote sessions, cohort patients were invited to participate in a semi-structured qualitative interview until thematic saturation was achieved. A Consolidated Framework for Implementation Research influenced interview guide⁵ elicited information on (1) experiences with in-clinic and remote monitoring, (2) barriers to or facilitators of remote monitoring, and (3) suggestions for improvement. For the analysis, an integrated approach was used in NVivo12 with excellent intercoder reliability (the Supplemental File contains detailed information on the qualitative methods).

RESULTS: A total of 56 patients enrolled in the 2 cohort studies (Table 1). Of those, 40 patients (71.4%) completed

105 surveys (median, 2; interquartile range [IQR], 1–4 surveys/person) with a median acceptability of 15 of a possible 20 (IQR, 14–16).

When asked to provide feedback about remote monitoring, the most frequently cited issue related to belt connectivity (19/105; 18.1%) or belt fit or comfort (16/105; 15.2%). Patients reported several benefits of remote monitoring, including avoiding in-clinic interactions (53/89; 59.6%), ease and speed of INVU (13/89; 14.6%), avoiding traffic or parking issues ($n=6$), and decreased costs ($n=2$). For recommendations for improvement, many reported none (41/89; 46.1%) and others relayed recommendations for improved belt fit or comfort (33/89; 37.1%).

Qualitative: Twelve patients participated in qualitative interviews. Sample interview questions with representative quotes are shown in Table 2.

Previous experiences with in-clinic monitoring: Few participants expressed positive experiences with in-clinic sessions, including a sense of ease or comfort. However, the majority spoke about coordinating childcare and frustrations surrounding travel time, public transportation, work scheduling, and parking with each factor perceived as being financially impactful.

Patient experiences with remote monitoring: The majority reported excitement for at-home monitoring, stating a belief that it would be convenient and less costly. Participants reported feeling relieved of the logistics and expenses of in-clinic monitoring. Concerns with remote monitoring were primarily hypothetical what-ifs. Yet, when probed, the majority reported reassurance about receiving similar monitoring as received in-clinic.

Participants conducted home monitoring in bed or a reclining chair. Generally, at-home sessions lasted for less than 1 hour. Participants also reported that while performing remote monitoring, some worked, whereas others watched TV. Participants reported that household members were either neutral about remote monitoring or provided enthusiastic support. One stated that remote monitoring allowed her spouse to participate, contrasting this with childcare logistics and COVID-19 restrictions.

Barriers and facilitators: Some participants mentioned the need for increased set-up support. One mentioned difficulty with staying still during the experience. For facilitators, in addition to the decreased need for childcare, transportation, and cost, several stated they appreciated clinician communication through the application.

Suggestions for future implementation: A few participants did not have suggestions for improvement, feeling that the

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TABLE 1
Demographic characteristics of participants for each study component, namely the (1) quantitative study and (2) qualitative study

Characteristics		Quantitative study n=56 n (%)	Qualitative study n=12 n (%)
BMI at enrollment (kg/m ²) ^a		35.8 (±6.8)	33.9 (±7.5)
Age (y) ^a		34.6 (±5.7)	36.5 (±4.6)
Race ^b	Black	27 (48.2)	3 (25.0)
	White	21 (37.5)	7 (58.3)
	Asian	4 (7.1)	1 (8.3)
	Other or unknown	4 (7.1)	1 (8.3)
Ethnicity	Hispanic or Latinx	8 (14.3)	2 (16.7)
Parity	Nulliparous	22 (39.3)	6 (50.0)
Insurance status	Medicaid	22 (39.3)	2 (16.7)
	Private insurance	30 (53.6)	10 (83.3)
	Unknown	2 (3.6)	0 (0)
Gestational age at enrollment ^a		34.1 (±1.1)	33.4 (±1.8)
Cohort	No. 1 (Oct. 2020—June 2022)	34 (60.7)	6 (50.0)
	No. 2 (Nov. 2022—April 2023)	22 (39.3)	6 (50.0)

^a The data are presented as mean (±standard deviation); ^b Patients could select more than 1 race.
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TABLE 2
Summary of interview questions in terms of the Consolidated Framework for Implementation Research (CFIR) constructs and representative quotes

Domain	CFIR construct	Interview question(s)	Representative quotes
Experience with in-clinic monitoring	Innovation	Have you ever had a fetal monitoring session in person? If so, what was that experience like for you? What issues did you have coming in for in-person monitoring?	“... My main issue was childcare due to the fact that I work from home. So my youngest doesn't attend any type of schooling... So I couldn't bring her. That... really hurts because I was trying to find people to watch her.”
Experience with remote monitoring	Innovation	When you were approached about at-home fetal monitoring, what did you think? Did anything worry you?	“I was very excited about it because I didn't want to have to leave the work site or be late to work.”
	Innovation	Tell me about your first at-home fetal monitoring session. Did you have to trouble shoot to get the monitoring session to work?	“In terms of putting the belt on, getting everything set up, and then like cleaning everything off after, it was probably about like 35, 40 minutes, but the actual monitoring session was around 20.”
	Inner setting	Where did you do the monitoring? What position were you in? How did that feel for you? What did you do while doing at-home monitoring?	“Sometimes I might do some work, emails, and other times if I wanted to really, fully utilize that, I binge watch something on Netflix to be honest.”
	Inner setting	How did you feel about the communication with a doctor or nurse during the session? At the end of the session?	“I felt very confident given the level of communication that was being done through the app during the monitoring.”

(continued)

TABLE 2

Summary of interview questions in terms of the Consolidated Framework for Implementation Research (CFIR) constructs and representative quotes (continued)

Domain	CFIR construct	Interview question(s)	Representative quotes
	Individuals	How did others in your household feel about you doing at-home monitoring?	"It was good to be able to see that . . . his heart rate was great, and also to share that experience with my husband."
Barriers or facilitators	Inner setting	If you've had in-person monitoring, how does at-home monitoring compare for you? Is there anything better about at-home monitoring than in-person? Anything worse? Do you feel like at-home monitoring impacted how much time or money you would need to spend on monitoring, such as on transportation or childcare?	"I think the only real thing in terms of having this be the ultimate experience would just be the belt could get to a point where you didn't have to be completely still and feel like you couldn't move at all, for fear of some connection issue and having to restart."
Recommendations for improvement	Implementation process	What would you change about at-home monitoring to improve the experience? Are there additional resources that would have been helpful to you?	"I would change how comfortable it is. How it sits. It looks like it was only designed to fit a certain type of body type. So, I just wish it was a little more comfortable to certain body types. Like for me to get accurate signal, it has to be super tight."
	Implementation process	What issues would you see with expanding this type of monitoring to more or all patients?	"I think integrity of hardware and such that might be an issue of people that have a lot of kids at-home, kids get curious, kids like to play with things. So keeping it safe from other sources."

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experience was straightforward. One brought up fit, expressing body type inclusivity concerns. Other participants felt that remote monitoring may still require additional planning if the home environment includes children.

DISCUSSION: This study demonstrated patient acceptability of remote fetal monitoring using INVU with the use of quantitative and qualitative data to describe concrete barriers and suggestions for improvement. This innovation approach centered the patient, a novel step in academia-industry collaboration, and led to device modifications to improve comfort and signal reliability. These improvements have the potential to maximize the success of our ongoing randomized clinical trial, the Remote Pregnancy Monitoring to Improve Access (REACTIVE) study (<https://clinicaltrials.gov/study/NCT05847790>), which compares in-clinic and remote monitoring in terms of NST completion and clinical outcomes, focusing on racial and ethnic disparities. ■

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