

## OBSTETRICS

# Randomized comparison of a reduced-visit prenatal care model enhanced with remote monitoring



Yvonne S. Butler Tobah, MD; Annie LeBlanc, PhD; Megan E. Branda, MS; Jonathan W. Inselman, BS; Megan A. Morris, PhD; Jennifer L. Ridgeway; Dawn M. Finnie; Regan Theiler, MD, PhD; Vanessa E. Torbenson, MD; Ellen M. Brodrick, APRN, CNM; Marnie Meylor de Mooij, MDes, MBA; Bobbie Gostout, MD; Abimbola Famuyide, MBBS, FRCOG

**BACKGROUND:** Standard prenatal care, consisting of 12–14 visits per pregnancy, is expensive and resource intensive, with limited evidence supporting the structure, rhythm, or components of care. Some studies suggest a reduced-frequency prenatal care model is as safe as the standard model of care for low-risk pregnant women, but evidence is limited. We developed and evaluated an innovative, technology-enhanced, reduced prenatal visit model (OB Nest).

**OBJECTIVE:** To evaluate the acceptability and effectiveness of OB Nest, a reduced-frequency prenatal care model enhanced with remote home monitoring devices and nursing support.

**STUDY DESIGN:** A single-center randomized controlled trial, composed of pregnant women, aged 18–36 years, recruited from an outpatient obstetric tertiary academic center in the Midwest United States. OB Nest care consisted of 8 onsite appointments with an obstetric provider; 6 virtual visits consisting of phone or online communication with an assigned nurse, supplemented with fetal Doppler and sphygmomanometer home monitoring devices; and access to an online community of pregnant women. Usual care consisted of 12 prescheduled prenatal clinic appointments with obstetric providers. Acceptability of OB Nest was measured by validated surveys of patient satisfaction with care at 36 weeks; perception of stress at 14, 24, and 36 weeks; and perceived quality of care at 36 weeks of gestation. Effectiveness was analyzed by comparing adherence to the American College of Obstetricians and Gynecologists recommended routine prenatal and ancillary services, maternal and fetal safety outcomes, and healthcare utilization.

**RESULTS:** Three hundred pregnant women at <13 weeks of gestation were recruited and randomized to OB Nest or usual care (150 in each arm)

using a minimization algorithm. Demographic characteristics were similar between groups. Compared to usual care, patients in OB Nest had higher satisfaction on a 100-point validated modified Littlefield and Adams Satisfaction scale (OB Nest = 93.9% vs usual care = 78.9%,  $P < .01$ ). Pregnancy-related stress, measured, on a 0–2 point Prenatal Maternal Stress validated scale, with higher scores indicating higher levels of stress, was lower among OB Nest participants at 14 weeks (OB Nest = 0.32 vs usual care = 0.41,  $P < .01$ ) and at 36 weeks of gestation (OB Nest = 0.34 vs usual care = 0.40,  $P < .03$ ). There was no statistical difference in perceived quality of care. Adherence to the provision of American College of Obstetricians and Gynecologists prenatal services was similar in both arms. Maternal and fetal clinical outcomes were similar between groups. Total reported nursing time was higher in OB Nest (OB Nest = 171.2 minutes vs usual care = 108.2 minutes, 95% confidence interval, 48.7–77.4).

**CONCLUSION:** OB Nest is an innovative, acceptable, and effective reduced-frequency prenatal care model. Compared to routine prenatal care, OB Nest resulted in higher patient satisfaction and lower prenatal stress, while reducing the number of appointments with clinicians and maintaining care standards for pregnant women. This program is a step toward evidence-driven prenatal care that improves patient satisfaction.

**Key words:** alternative prenatal care, connected prenatal care, innovative prenatal care, low-risk prenatal care, prenatal telemedicine, reduced prenatal visits, remote prenatal care, telehealth and pregnancy, telehealth obstetric care, virtual prenatal care

The traditional model of prenatal care in the United States is resource intensive and fraught with nationwide variation.<sup>1</sup> The American College of Obstetricians and Gynecologists (ACOG) recommends an individualized approach to the frequency of

prenatal care, yet suggests 12–14 visits during the course of a 40-week pregnancy.<sup>2</sup> Evidence in support of this frequency of care is largely based on expert opinion<sup>1,3,4</sup> and differs from the World Health Organization (WHO) recommendation of 8 scheduled visits for low-risk prenatal care.<sup>5</sup> In 1989, the U.S. Department of Health and Human Services Expert Panel on Prenatal Care acknowledged the lack of evidence-based prenatal care models and recommended an individualized flexible schedule based on the needs of the patient and her pregnancy risk.<sup>3,4</sup> Several studies have since validated this approach.<sup>6–10</sup> Villar's systematic review of antenatal care programs for low-risk

women concluded that a reduction in prenatal visits could be implemented without increasing adverse maternal or fetal outcomes,<sup>10</sup> while Partridge's retrospective study of a reduced prenatal care guideline resulted in a reduction to 9 prenatal visits, with no increase in perinatal complications.<sup>9</sup> More recently, a retrospective comparison of patients who received <10 prenatal visits to those with >10 visits found no difference in neonatal composite outcomes, including neonatal intensive care unit admission, low Apgar score, low umbilical pH, and neonatal demise.<sup>7</sup>

While studies support the safety of reducing the frequency of prenatal visits, evidence of acceptability to

**Cite this article as:** Yvonne S. Butler Tobah YS, LeBlanc A, Branda ME, et al. Randomized comparison of a reduced-visit prenatal care model enhanced with remote monitoring. *Am J Obstet Gynecol* 2019;221:638.e1-8.

0002-9378/\$36.00

© 2019 Elsevier Inc. All rights reserved.  
<https://doi.org/10.1016/j.ajog.2019.06.034>

 Click [Supplemental Materials](#) under article title in Contents at [ajog.org](#)

## AJOG at a Glance

## Why was this study conducted?

To evaluate the acceptability and effectiveness of a reduced-frequency prenatal care model with remote home monitoring devices and nursing support.

## Key findings

Pregnant women randomized to a reduced-frequency prenatal care model, enhanced with remote home monitoring and nursing support, had significantly higher satisfaction with care, had lower prenatal-related stress, and saved an average of 2.8 obstetric clinician appointments per patient compared to patients in the usual prenatal care model. Nursing time spent on coordinating care was higher in the alternative model of prenatal care.

## What does this add to what is known?

This randomized controlled trial reaffirms that reduced-frequency prenatal care models with remote monitoring are as effective as the standard 12–14 traditional visits model, and results in greater patient satisfaction and lower prenatal-related stress.

pregnant women is less clear. Some studies suggest uptake remains limited because of expectations of frequent routine care, lack of perceived support, and perception that large gaps between prenatal appointments are too long.<sup>11,12</sup> A recent review of contemporary prenatal care suggests that integrating mobile apps and telehealth options to modified prenatal visit programs may yield an equally satisfying experience as traditional care.<sup>13</sup> But such a novel approach has not been rigorously studied.

To address this need, we developed an alternative bundle of prenatal care—OB Nest—which included fewer on-site clinic appointments supplemented with virtual visits, home monitoring devices, and an online prenatal community.<sup>14,15</sup> We hypothesized that when compared to traditional prenatal care, OB Nest would optimize outcomes important to pregnant women while maintaining the provision of ACOG-recommended services. This study compares the acceptability and effectiveness of OB Nest to traditional prenatal care.

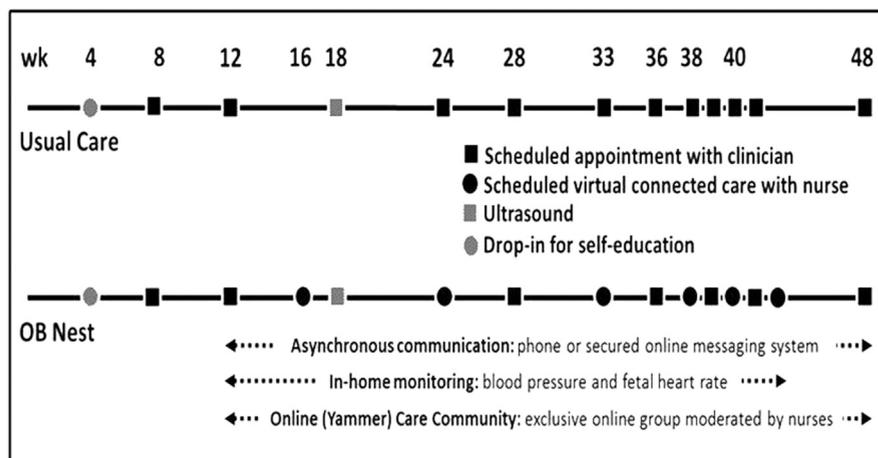
## Materials and Methods

In 2011, a collaboration between pregnant women, their obstetric care team, the Center for Innovation, and the Center for the Science of Health Care Delivery at Mayo Clinic was created for the purpose of redefining prenatal care for low-risk pregnant women.<sup>14,15</sup> Development and evaluation occurred from September 2011 through December 2011, and consisted of testing 19 different experiments aimed at modifying traditional prenatal care for low-risk pregnant women.<sup>14</sup> Final recommendations based on feasibility and potential impact on care were included in the OB Nest bundle.

Between March 2014 and January 2015, we conducted a single-center randomized controlled trial within the Outpatient Obstetric Division at Mayo Clinic, a tertiary care academic center in Rochester, Minnesota, serving approximately 2400 pregnant women annually. Enrollment criteria included English-speaking pregnant women between 18 and 36 years old, at <13 weeks of gestation, without a concurrent medical or obstetric complication, who had the ability to provide informed consent. Exclusion criteria included diagnoses of any chronic medical conditions, including hypertensive disorders, coagulopathies, diabetes, class 3 obesity, immunodeficiency conditions, genetic disorders, multi-fetal gestation, prior history or risk factors for preterm delivery, pulmonary disorders, unstable mental health conditions, or obstetrician judgment that determined the pregnancy was at high risk for complications. Full details of our study procedures and the original protocol are found in the [Appendix \(Supplement 1\)](#).

Participants in OB Nest were assigned to the following: (1) 8 scheduled clinic appointments with an obstetrician or a certified nurse midwife (CNM), depending on clinic schedule; (2) 6 virtual (phone or online) connected care visits with an OB Nest registered nurse (RN) consisting of home blood pressure and fetal heart rate evaluation,

**FIGURE 1**  
Usual care compared to OB Nest schedule of care

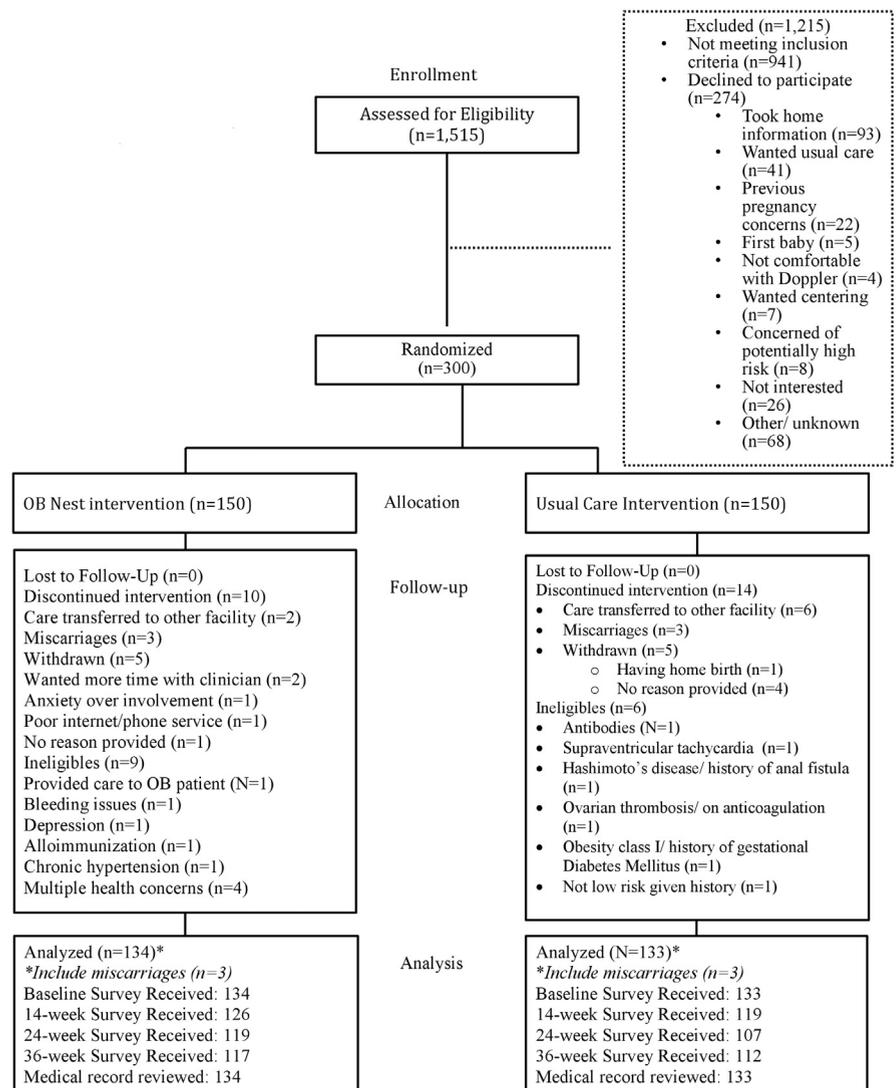


Butler Tobah et al. Randomized comparison of an enhanced reduced-visit prenatal care model. *Am J Obstet Gynecol* 2019.

gestational age—appropriate anticipatory guidance per ACOG recommendations; and additional nursing education, based on patient's individual needs; (3) home digital sphygmomanometer and handheld fetal Doppler; and (4) access to an online prenatal care community consisting of an institutional social network of OB Nest participants interested in seeking support and advice from their peers. An OB Nest nurse monitored online social network correspondence on a weekly basis to ensure information shared was accurate. OB Nest nurses trained OB Nest patients on measurement of fetal heart rate and maternal blood pressure. Written educational instructions, including normal reference ranges, were provided to OB Nest patients. Patients reported their home data electronically through online messaging via the institution's electronic medical record system or over the phone to the OB Nest nurse. Nursing staff collected data over the phone and recorded this information to patients' electronic medical records. Participants in the usual prenatal care model were scheduled for the traditional 12 clinic appointments with an obstetrician or a CNM per ACOG recommendations (Figure 1). Participants, nurses, or clinicians could at any point request further appointments or phone visits if deemed clinically necessary. All participants, regardless of assigned arm, received the recommended laboratory evaluations, ultrasound imaging, immunizations, patient education, and other ancillary services per ACOG recommendations. Participants who developed significant complications during the course of pregnancy were treated per recommendations of their clinician, irrespective of the assigned arm.

Women presenting for an initial prenatal appointment were screened and recruited by an obstetric nurse. After informed consent was obtained, participants were randomized to either OB Nest (intervention) or usual care (UC), using a dynamic allocation system, with an algorithm minimizing imbalances in a 1:1 ratio across the following factors: age (<35 vs ≥35), body mass index (≤30 vs >30), and

**FIGURE 2**  
OB Nest randomized controlled trial study algorithm



Butler Tobah et al. Randomized comparison of an enhanced reduced-visit prenatal care model. *Am J Obstet Gynecol* 2019.

parity (0 vs 1+). The allocation sequence was concealed from the study nurse who enrolled and assessed the eligibility of participants. Study team nurses and clinicians were aware of the assigned arms after randomization occurred. Team members analyzing quantitative data were blinded to which intervention arm mothers were assigned to. A physician confirmed pregnancy risk status at the subsequent visit, using study exclusion criteria (Supplement 1). Enrollees were not offered financial incentive for participation in the study.

We evaluated the acceptability and effectiveness of OB Nest. Acceptability was measured by comparing satisfaction with care, perception of stress, and perceived quality of care, using validated surveys. Satisfaction with care was measured at 36 weeks of gestation using a modified Littlefield and Adams 16-item self-reported validated Satisfaction subscale survey, evaluated on a 5-point Likert-type scale summed and converted to a 0- to 100-point scale.<sup>16</sup> Pregnancy-related stress was measured at 14, 24, and 36 weeks of gestation using a 9-item validated PreNatal

**TABLE 1**  
**OB Nest randomized controlled trial demographic characteristics of study participants**

Variable	OB Nest (n = 150)	Usual care (n = 150)	Pvalue
Maternal age, mean $\pm$ SD	29.5 $\pm$ 3.3	29.7 $\pm$ 3.6	.44
Maternal age $\geq$ 35, n (%)	13 (8.7)	12 (8.0)	.83
White race, n (%)	137 (91.3)	137 (91.3)	1.0
Body mass index, mean $\pm$ SD	25.3 $\pm$ 5.4	26.0 $\pm$ 6.7	.77
Body mass index $>$ 30, n (%)	22 (14.7)	22 (14.7)	1.0
Gravida of 1, n (%)	48 (32.0)	50 (33.3)	.28
Parity of 1, n (%)	90 (60.0)	89 (59.3)	.91
Past cesarean delivery, n (%)	9 (6.0)	16 (10.7)	.14
Married/marriage-like relationship, n (%)	146 (97.3)	146 (97.3)	.26
Education, n (%)			.60
High school graduate or less	4 (2.7)	7 (4.7)	
Some college or associate's degree	33 (22.0)	30 (20.0)	
Four-year college graduate	58 (38.7)	54 (36.0)	
Graduate/professional school degree	47 (31.3)	47 (31.3)	
Missing	8 (5.3)	12 (8.0)	
Private insurance, n (%)	135 (90.0)	129 (86.0)	.29
Annual household income, n (%)			.64
<\$40,000	18 (12.0)	14 (9.3)	
\$40,000 to \$79,999	42 (28.0)	44 (29.3)	
$\geq$ \$80,000	81 (54.0)	78 (52.0)	
Missing	9 (6.0)	14 (9.3)	

SD, standard deviation.

Butler Tobah et al. Randomized comparison of an enhanced reduced-visit prenatal care model. Am J Obstet Gynecol 2019.

Maternal Stress survey.<sup>17</sup> Scores were summed and averaged, with higher scores indicating higher levels of pregnancy-related stress. Perception of the quality of prenatal care received was measured at 36 weeks of gestation by a modified validated 30-item Prenatal Interpersonal Processes of Care scale, which assessed communication, decision making, and interpersonal style. Responses were converted to a 0- to 100-point scale for each sub-scale item, with higher scores indicating higher perceived quality of care.<sup>18</sup>

Effectiveness of the OB Nest intervention was evaluated by proxy measures including adherence to the ACOG-recommended routine prenatal laboratory services, ultrasound imaging, immunization, and patient education. We compared medical diagnoses,

complications, maternal delivery outcomes, and fetal clinical outcomes, including route of delivery, preterm deliveries, birthweight, and Apgar scores. We compared healthcare utilization by extracting unscheduled obstetric office visits, triage care, and emergency department visits from medical records. We measured connectivity to care by nursing time spent on interacting with patients, including coordinating care, communication (phone/online) with patients, and monitoring the online community website. Data was captured using Mayo Clinic's Workload Measurement and Reporting System.

The study was powered to detect differences in patient satisfaction, as satisfaction with care was considered the most important endpoint of pregnant patients and caregiver representatives

when creating the OB Nest bundle. Using a 2-sided alpha level of 0.05, it was estimated that a sample size of 270 (135/arm) would have 98% power to detect a difference of 7 points, based on a standard deviation of 14.4,<sup>16</sup> with 10% attrition. With that, the study team aimed to recruit 300 pregnant women (150/arm). Sample size calculations for other outcomes are found in the original protocol (Supplement 1).

A modified intention-to-treat was used to account for participants who were randomized but subsequently became ineligible, prior to the start of the intervention. Otherwise, all participants were analyzed in the arm they were originally assigned, regardless of whether they received the intervention assigned or crossed over to usual care (Figure 2). Missing responses were

**TABLE 2**  
**OB Nest randomized controlled trial measures of acceptability of prenatal care**

Outcomes <sup>a</sup>	OB Nest (n = 134)	Usual care (n = 133)	Mean difference (95% CI)	P value
Satisfaction with care, mean ± SD (0–100, 100 = highly satisfied)	93.90 ± 7.02	78.89 ± 6.58	15.01 (13.38–16.64)	<.01
Missing imputed, n	19	21		
Pregnancy-related stress, mean ± SD (0–2, 2 = highly stressed)				
14 weeks	0.32 ± 0.21	0.41 ± 0.23	-0.09 (-0.14 to -0.04)	<.01
Missing imputed, n	8	14		
24 weeks	0.31 ± 0.21	0.35 ± 0.21	-0.04 (-0.09 to 0.01)	.19
Missing imputed, n	15	26		
36 weeks	0.34 ± 0.23	0.40 ± 0.22	-0.06 (-0.11 to 0.01)	.03
Missing imputed, n	17	21		
Quality of care, mean ± SD (0–100, 100 = highly satisfied)				
Communication	83.56 ± 12.49	82.96 ± 12.25	0.6 (-2.37 to 3.57)	.69
Missing imputed, n	18	21		
Decision making, mean ± SD	80.44 ± 19.49	76.71 ± 19.22	3.73 (-0.91 to 8.37)	.12
Missing imputed, n	19	21		

CI, confidence interval; SD, standard deviation.

<sup>a</sup> Missing responses imputed to the mean for intention-to-treat analysis.

Butler Tobah et al. Randomized comparison of an enhanced reduced-visit prenatal care model. Am J Obstet Gynecol 2019.

imputed to the mean for the primary outcome. Outcomes were compared by arm using Fisher exact test statistic for categorical outcomes and *t* test for continuous outcomes. The analysis was generated using SAS software version 9.4 (SAS Institute Inc, Cary, NC). We adhered to CONSORT guidelines in the reporting of quantitative study findings.<sup>19</sup> This study was reviewed and approved by the Mayo Clinic Institutional Review Board (Reference #13-009513) and registered at [ClinicalTrials.gov](http://ClinicalTrials.gov) (Identifier: NCT02082275) on March 6, 2014.

## Results

From March 2014 through January 2015, 1515 women presenting for prenatal care were screened for eligibility and 300 patients at <13 weeks of gestation were recruited and randomized into OB Nest or usual care (150 per arm). The flow of participants and completeness of data were similar across arms (Figure 2). The average age was 29 years, the majority were white, and 97% were married (Table 1).

Compared to patients in usual care (UC), participants randomized to OB Nest (OBN) had higher satisfaction with care (OBN = 93.90 vs UC = 78.89; mean group difference [MD] 15.01, 95% confidence interval [CI], 13.38–16.64). Pregnancy-related stress was lower in OBN at 14 weeks of gestation (OBN = 0.32 vs UC = 0.41; MD = -0.09, 95% CI, -0.14 to -0.04) and at 36 weeks of gestation (OBN = 0.34 vs UC = 0.40; MD = -0.06, 95% CI, -0.11 to -0.01). Quality of care, specifically communication and decision making, were not significantly different across arms (Table 2).

The majority of patients in each arm received an influenza vaccine (OBN = 105 [80.2%] vs UC = 109 [83.8%], *P* = .44), a Tdap booster (OBN = 119 [90.8%] vs UC = 117 [90.0%], *P* = .82), mid-pregnancy education (OBN = 127 [96.6%] vs UC = 123 [94.6%], *P* = .35), screening for group B *Streptococcus* (OBN = 128 [97.7%] vs UC = 129 [99.2%], *P* = .32), and depression screening (OBN = 130 [99.2%] vs UC = 129 [99.2%], *P* = 1.0).

No differences in maternal or fetal complications were observed across arms, with the exception of the incidence of gestational diabetes, which was higher in OB Nest (OBN = 6 [4.5%] vs UC = 0 [0.0%], *P* < .01). No significant differences in the incidence of cesarean deliveries (OBN = 17 [12.7%] vs UC = 20 [14.9%], *P* < .56), preterm deliveries <37 weeks (OBN = 4 [3.0%] vs UC = 3 [2.3%], *P* < .71), birthweight <2500 grams (OBN = 1 [0.7%] vs UC = 2 [1.5%], *P* < .56), or Apgar scores <7 (OBN = 3 [2.2%] vs UC = 2 [1.5%], *P* < .66) were observed (Appendix: Supplement 2).

As planned, number of scheduled obstetric provider (obstetric physician or CNM) appointments was lower for pregnant women in OB Nest compared to usual care (OBN = 7.6 vs UC = 10.4, MD = -2.9, 95% CI, -3.4 to -2.3). While the number of clinic appointments with RNs was significantly lower for patients in OB Nest (OBN = 1.4 vs UC = 2.1, MD = -0.7, 95% CI, -0.88 to -0.46), the total reported minutes spent on these appointments per mother was

**TABLE 3**  
**OB Nest randomized controlled trial healthcare utilization and connectivity**

Outcomes	OB Nest (N = 134)	Usual care (N = 133)	Mean difference (95% CI)	Pvalue
On-site appointments, mean ± SD				
All	11.25 ± 3.64	14.69 ± 3.71	-3.44 (-4.32 to -2.56)	<.01
Clinicians	7.59 ± 1.99	10.44 ± 2.36	-2.85 (-3.37 to -2.33)	<.01
Physicians only	3.25 ± 2.79	3.11 ± 4.16	0.14 (-0.71 to 0.99)	.73
Midwives only	4.34 ± 2.50	7.34 ± 3.91	-3 (-3.79 to -2.21)	<.01
Nurses	1.44 ± 0.74	2.11 ± 0.97	-0.67 (-0.88 to -0.46)	<.01
Other (ultrasound/genetics)	2.22 ± 1.78	2.14 ± 1.47	0.08 (-0.31 to 0.47)	.68
Connectivity, mean ± SD, minutes per mother				
Overall	401.2 ± 137.3	167.1 ± 86.9	234.1 (206.6–261.6)	<.01
Care coordination tasks	146.4 ± 55.8	6.1 ± 12.4	140.3 (130.6–150.0)	<.01
Connected care appointments (online, phone)	171.2 ± 67.2	108.2 ± 51.7	63.0 (48.7–77.4)	<.01

CI, confidence interval; SD, standard deviation.

Butler Tobah et al. Randomized comparison of an enhanced reduced-visit prenatal care model. *Am J Obstet Gynecol* 2019.

significantly higher for OB Nest (OBN = 171.2 vs UC = 108.2, MD = 63.0, 95% CI, 48.7–77.4). The number of minutes RNs reported spending on coordination of care (ie, phone call, follow-up with participants) was also significantly higher in OB Nest (OBN = 146.4 minutes vs UC = 6.1 minutes, MD = 140.3, 95% CI, 130.6–150.0) (Table 3).

## Comment

### Principal findings

This study adds to the limited number of randomized controlled trials incorporating remote monitoring and telehealth tools for the redesign of prenatal care. We found that participants in OB Nest had significantly higher satisfaction with care and lower prenatal-related stress, compared to patients in the usual care model. Perceived quality of care was similar between groups. Nursing time spent on coordinating care was higher in OB Nest. There was no significant difference in the provision of ACOG-recommended ancillary prenatal services.

### Results

Pregnant women enrolled in OB Nest received approximately 50% of their prenatal care in the comfort of their home or other preferred nonclinical environment, yet reported greater

satisfaction with care received and lower pregnancy-related stress. This is unlike the results of prior studies, which successfully reduced the number of scheduled prenatal visits but reported lower patient satisfaction with the care received.<sup>6,12</sup> Interestingly, Woo et al's review of contemporary prenatal care recommends integrating telehealth options into modified prenatal care programs, to maintain patient satisfaction with care.<sup>13</sup> Notably, OB Nest inclusion of home monitoring devices for fetal heart rate and blood pressure, along with the addition of connected care virtual visits, accomplishes this goal.

OB Nest saved an average of 2.8 scheduled prenatal appointments per patient, but this savings was seen for midwives and not physicians. This reflects the standard practice of care at the study site, providing an opportunity to maximize the capacity of CNM-led low-risk prenatal care while obstetricians focus on higher-risk pregnancies. This is also consistent with the WHO recommendation for task shifting to optimize patient care with the appropriate provider.<sup>5</sup>

Although the number of on-site nursing appointments was lower for OB Nest, the duration of time spent on connected care by phone or online was

significantly higher compared to usual care. Nursing time spent coordinating care was also significantly higher for OB Nest. Given the novelty of the OB Nest approach, the longer duration of coordinating care was expected. However, the significantly longer duration of connected nursing care appointments was unexpected.

### Clinical implications

The standard frequency of prenatal care visits was created when technological advances in monitoring pregnancy were not readily available to patients.<sup>3</sup> Despite general consensus on its safety and efficacy, the reduced prenatal care model has not been widely adopted, largely because of its failure to address women's preferences.<sup>1,3,13</sup> Contemporary guidelines for best practices in prenatal care support the prioritization of a prescriptive approach to care. In 2016, the WHO issued contemporary recommendations for global antenatal care, including the provision of a patient-centered approach, and recommendation for 8 scheduled prenatal visits.<sup>5</sup> This is consistent with Woo et al's recommendation for an enhanced reduced-visit prenatal care model, consisting of 8 visits, supplemented with telehealth tools.

Our study design allowed for an analysis of both traditional (number of clinic appointments, adherence to standard care guidelines) and nontraditional (patient perspective, utility of home-based medical technology) aspects of prenatal care. However, we recognize that our findings mainly apply to the overall OB Nest bundle. The individual components of OB Nest were not designed to be analyzed separately. However, it is the totality of the prenatal care package recommended by ACOG that is thought to be an effective preventive strategy. The duration of time OB Nest nurses spent on virtual care was much longer than anticipated. Perhaps this may reflect the difference in approach to care between obstetric clinicians (doctor and CNM) and obstetric nursing care (RN), or it may be a reflection of patient desire for improved connectedness to care providers. Additional studies are required to further investigate this finding and its impact on cost of care.

Although our study was not powered to detect differences in obstetric complications, a higher number of gestational diabetes cases was noted in OB Nest when compared to usual care. However, this is likely of little significance, since the prevalence shown is consistent with what would be expected in a low-risk obstetric cohort. While this may be an artifact, it is important for future research to evaluate the safety of this model in diverse low-risk patient populations.

### Strengths and limitations

This study was strengthened by the use of a rigorous randomized trial design, with optimal allocation concealment, and high survey completion rates. The range of outcomes evaluated is currently not well represented in the obstetric literature. There were a number of limitations. Notably, pregnant women participating in the study were all receiving care at the same tertiary academic center and were mainly college-educated white women of high socioeconomic status, reflecting the demographics of the study

setting. Interestingly, a recent quality improvement initiative offers a glimpse into the demographics of expectant mothers who may opt for a reduced-visit prenatal model. Patients opting for the reduced-visit model were more likely to be partnered, multiparous, and not receiving government assistance.<sup>19</sup> Future research is needed to determine if this model of care is as effective in a more socio-demographically diverse population. Although team members analyzing the quantitative results were blinded to which intervention arm mothers were assigned, study nurses, clinicians, and pregnant women were aware of the assigned arm, which may have affected questionnaire responses. The study was adequately powered to detect statistical differences in patient-reported outcomes, but was underpowered to detect differences in adverse maternal and fetal safety outcomes (given their low prevalence) in a low-risk obstetric population. Larger, multicenter studies are needed to evaluate maternal and fetal outcomes and scalability in differing health systems.

### Conclusion

Current models of prenatal care for low-risk pregnant women require significant expenditure of patients' time and healthcare resources.<sup>2,12</sup> OB Nest offers a novel alternative to the traditional approach to care. By reducing the number of scheduled onsite appointments and supplementing care with remote monitoring, OB Nest yielded better outcomes important to low-risk pregnant women without impacting quality of care. This program is a significant step toward ensuring prenatal care is evidence-based, is of high quality, and impacts healthcare outcomes important to patients. ■

### Acknowledgments

We would like to thank the patients, staff, and providers who were engaged in the OB Nest project, especially the following individuals: OB Nest Clinical and Nursing Support, Mayo Clinic Rochester MN: Roger W. Harms, MD; Douglas Creedon, MD, PhD; Anne Baron, RN; Katie

Slifko, RN; Christine Domask, RN; Nancy Jo Knutson, RN; Susan M. Sobolewski, RN; Misty Baker, RN; Maureen Lemens, RN; OB Nest Quality and Administrative Support, Mayo Clinic, Rochester MN: Kate Nesbitt; Angela Sivly; Lenae M. Barkey; Rajeev Chaudhry, MBBS, MPH; Rachael Hodnev, MBA; Members of the Mayo Clinic Center for Innovation who worked with the clinical staff to design and pilot the OB Nest intervention components: Andrea Brown, MD; Daniel O'Neil; Matthew Gardner; Mekayla Beaver, MS; Rachel Hamilton.

We would also like to thank Joan Griffin, PhD, who assisted in the final revision of the manuscript.

All individuals acknowledged above report no conflict of interest and were not compensated.

### References

- Alexander GR, Kotelchuck M. Assessing the role and effectiveness of prenatal care: history, challenges, and directions for future research. *Public Health Rep* 2001;116(4):306–16.
- Kriebs JM. Guidelines for perinatal care, sixth edition: by the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists. *J Midwifery Womens Health* 2010;55(2):e37.
- Rosen MG, Merkatz IR, Hill JG. Caring for our future: a report by the expert panel on the content of prenatal care. *Obstet Gynecol* 1991;77:782–7.
- Gregory KD, Johnson CT, Johnson TR, Entman SS. The content of prenatal care. Update 2005. *Womens Health Issues* 2006;16(4):198–215.
- de Masi S, Bucagu M, Tunçalp O, et al. Integrated person-centered health care for all women during pregnancy: implementing World Health Organization recommendations on antenatal care for a positive pregnancy experience. *Glob Health Sci Pract* 2017;5(2):197–201.
- Binstock MA, Wolde-Tsadiq G. Alternative prenatal care. Impact of reduced visit frequency, focused visits and continuity of care. *J Reprod Med* 1995;40(7):507–12.
- Carter EB, Tuuli MG, Caughey AB, Odibo AO, Macones GA, Cahill AG. Number of prenatal visits and pregnancy outcomes in low-risk women. *J Perinatol* 2016;36(3):178–81.
- Dowswell T, Carroli G, Duley L, et al. Alternative versus standard packages of antenatal care for low-risk pregnancy. *Cochrane Database Syst Rev* 2010(10):CD000934.
- Partridge CA, Holman JR. Effects of a reduced-visit prenatal care clinical practice guideline. *J Am Board Fam Pract* 2005;18(6):555–60.
- Villar J, Carroli G, Khan-Neelofur D, Piaggio G, Gulmezoglu M. Patterns of routine antenatal care for low-risk pregnancy. *Cochrane Database Syst Rev* 2001(4):CD000934.
- Novick G. Women's experience of prenatal care: an integrative review. *J Midwifery Womens Health* 2009;54(3):226–37.

12. Sikorski J, Wilson J, Clement S, Das S, Smeeton N. A randomised controlled trial comparing two schedules of antenatal visits: the antenatal care project. *BMJ* 1996;312(7030):546–53.
13. Woo VG, Lundeen T, Matula S, Milstein A. Achieving higher-value obstetrical care. *Am J Obstet Gynecol* 2017;216:250.e251–250.e214.
14. de Mooij MJM, Hodny RL, O’Neil DA, et al. OB Nest: reimagining low-risk prenatal care. *Mayo Clin Proc* 2018;93:458–66.
15. Ridgeway JL, LeBlanc A, Branda M, et al. Implementation of a new prenatal care model to reduce office visits and increase connectivity and continuity of care: protocol for a mixed-methods study. *BMC Pregnancy Childbirth* 2015;15:323.
16. Littlefield VM, Adams BN. Patient participation in alternative perinatal care: impact on satisfaction and health locus of control. *Res Nurs Health* 1987;10(3):139–48.
17. Lobel M, Cannella DL, Graham JE, DeVincent C, Schneider J, Meyer BA. Pregnancy-specific stress, prenatal health behaviors, and birth outcomes. *Health Psychol* 2008;27(5):604–15.
18. Wong ST, Korenbrot CC, Stewart AL. Consumer assessment of the quality of interpersonal processes of prenatal care among ethnically diverse low-income women: development of a new measure. *Womens Health Issues* 2004;14(4):118–29.
19. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Obstet Gynecol* 2010;115(5):1063–70.

---

### Author and article information

From the Division of Obstetrics, Department of Obstetrics and Gynecology Mayo Clinic, Rochester, MN (Drs Butler Tobah, Theiler, Torbenson, Gostout, and Famuyide, and Ms Brodrick); Mayo Clinic Health Sciences Research,

Rochester, MN (Ms Branda, Mr Inselman, Dr Morris); Mayo Clinic Center for Innovation, Rochester, MN (Ms Meylor de Mooij); Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery at Mayo Clinic, Rochester, MN (Ms Ridgeway, Ms Finnie); Knowledge and Evaluation Research Unit at Mayo Clinic, Rochester, MN (Dr LeBlanc); and the Department of Family and Emergency, Laval University, Quebec, Canada (Dr LeBlanc).

Received Dec. 1, 2018; revised June 5, 2019; accepted June 13, 2019.

The authors report no conflict of interest.

This study was funded by the Obstetrics Division at Mayo Clinic with support from the Mayo Clinic Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery. Clinical Trial Registration: [ClinicalTrials.gov](https://clinicaltrials.gov) NCT02082275; date of registration: March 6, 2014; date of initial participant enrollment: March 11, 2014.

The abstract (oral) was presented at the American College of Obstetrics and Gynecology Annual Clinical and Scientific Meeting in Washington, DC on May 16, 2016.

Corresponding author: Yvonne S. Butler Tobah, MD. [ButlerTobah.Yvonne@mayo.edu](mailto:ButlerTobah.Yvonne@mayo.edu)