Section: Biotechnology

Original Research Article

INTEGRATING SERUM LEPTIN AND REMOTE PULSE OXIMETRY FOR POSTPARTUM PHYSIOLOGICAL MONITORING AND RISK STRATIFICATION

Mahak Bhandari[1], Nawneet K. Kurrey[2], Michael Mathur[3], Kavita Madipalli[4]

[1]*Research Scholar, School of Engineering, Department of Biotechnology, Ajeenkya DY Patil University, Pune, India*
[2]*PhD Professor (Associate) at Ajeenkya D Y Patil University, Pune, India*
[3]*President & CEO, BL Healthcare, Inc., Massachusetts, USA*
[4]*PhD Food Technology Research Associate at Ajeenkya DY Patil University, Pune, India*

Received *: 02/10/2026*
Received in revised form *: 28/10/2026*
Accepted *: 11/11/2026*

Corresponding Author:
Dr. Mahak Bhandari,
Research Scholar, School of Engineering, Department of Biotechnology, Ajeenkya DY Patil University, Pune, India.
Email: mahakmitra.bhandari@adypu.edu.in

DOI: 10.70034/ijmedph.2026.4.340

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (4); 2257-2263

ABSTRACT

Background: The postpartum period can include dramatic hormonal, metabolic and cardiovascular remodeling events that go beyond the traditional postpartum check-up. These changes have to be followed both metabolically and physiologically. Serum leptin data can be remotely monitored to assess metabolic and/or adipose tissue adaptations, and peripheral oxygen saturation (SpO_2) and pulse rate data can be remotely monitored to assess cardiorespiratory status. This study evaluates the possibility of combining these measures into a common framework for postpartum surveillance. The present study is based on the primary survey conducted by the author for a period of 7 months and studies reported oxygen saturation patterns, symptoms reported in relation to the changes in maternal oxygen saturation, serum leptin test and postpartum related changes. This study outlines experiences of monitoring and highlights the degree of variation in this process and the importance of more regular observation and accurate data collection during the postpartum period. The study emphasizes the significance of data accuracy of the monitoring source, individual health characteristic and clinical interpretation when integrating data from other monitoring sources. However, there were no paired individual-level leptin or oximetry measurements available, so the proposed framework will need to be tested in a prospective manner. The study findings will help inform future research on the use of integrated remote monitoring to support postpartum health care.

Materials and Methods: A descriptive study based on aggregate survey data from 235 responses collected over seven months (April–October 2026), using frequency and percentage analysis.

Results: Reported SpO_2 levels below 95% accounted for 56.2% of responses, while fatigue (57.0%) and rapid heartbeat (33.6%) were commonly reported. Serum leptin testing was reported in 49.8% of responses.

Conclusion: Integrating serum leptin testing with remote pulse oximetry may support comprehensive postpartum monitoring. However, prospective studies with linked individual-level data are required to validate its clinical utility.

Keywords: Postpartum monitoring, serum leptin, pulse oximetry, remote healthcare monitoring, maternal health.

INTRODUCTION

The postpartum period is characterized by endocrine changes concerning fluid, blood pressure, energy metabolism, body composition, sleep and lactation. Continuity of observation is important as some health concerns may become apparent after routine follow-up. Digital monitoring may be an alternative to scheduled visits, when data registered by the device need to be measured and understood within a clinical pathway.[1,2]

Leptin is a fat-secreted hormone that plays a role in energy homeostasis and reproductive physiology. Maternal plasma leptin levels vary during pregnancy, delivery, after birth and during lactation and therefore need to be interpreted according to postpartum time and the clinical situation.[3,4] Leptin should not be used alone to make a diagnosis but should be used in conjunction with other measures of blood oxygenation.

The peripheral oxygen saturation level and the pulse rate are estimated by pulse oximetry. Remote reading is helpful for repeated reading but movement, peripheral perfusion, placement of the sensors, skin pigmentation, sensor performance and data transmission can all affect the readings. Some,[5,6] have warned against the use of remote pulse oximetry and some,[5–8] have reported that it may be inaccurate due to skin pigmentation. Unexpected readings can not be diagnosed automatically: repeat measurement and clinical evaluation is necessary.

The main aim of this work is to develop a clinically useful tool for integrating serial measurements of leptin with remote measures of SpO2 and pulse-rate during the postpartum period of recovery. It also outlines the existing survey results, specifies the data quality and clinical governance requirements and outlines at the participant level what information will be needed to establish whether leptin provides information in addition to existing clinical and anthropometric data. The proposed integration is a hypothesis and is not a rule that can be assumed to be true or predicted.

MATERIALS AND METHODS

Study design and data source: This manuscript is a conceptual synthesis of the information provided in the articles and a description of the primary data collected by the author in the survey. I can give you a summary of the survey overall, with some aggregate counts and percentages (available from 235 responses). The first observation was made on 2nd April 2026 and the last on 10th October 2026. For this analysis, no information at the individual level was available.

The manner in which the survey was conducted and the variables that were included in the survey.

Of those who replied, there were 235 case reports and 235 reports from healthcare professionals. The following variables were included: respondent role, time since delivery, source of observation, reported oxygen-saturation category, report of reduced oxygen-saturation readings (repeat record), symptoms reported, and report of serum leptin test and test status.Variables retained were respondent role, time since delivery, source of observation, reported level of oxygen-saturation category, repeat report of reduced level of oxygen-saturation, reported symptoms, reported status of serum leptin test and result of serum leptin test.

Statistical analysis: If a source summary did not specify a multiple-response item, 235 was a denominator (denominator = 100) for counts and percentages. For multiple response items percentages were calculated on the basis of all responses and therefore were not expected to sum to 100%. No inferential tests, confidence intervals, correlations or predictive model was done since there was no data on the respondents' level or on their linked leptin and oxometry observations.

Framework development proposal: The proposed framework was built by separating metabolic-endocrine measurements from cardiorespiratory observations, and identifying variables in their contextual environment that were required to interpret the measurements so as to understand how they were related. The framework also includes measurement provenance, quality flags, participant level linkage, clinical oversight and a prospective validation plan. These elements are not necessarily survey activities.

RESULTS

The respondents were also asked for a personal profile and timing after pregnancy.

Altogether, 90 (38.3%) of the responses were 'case-reported responses' (the remainder were from health care professionals). Most responses (70, 29.8%) were in the 3-6 month postpartum period. Observation sources were case reported, healthcare-professional observed, verified clinical or device control, and combined sources. Distribution given in [Table 1].

Table 1: Response profile, postpartum timing, and observation source (n = 235).

Characteristic	Category	n	%
Respondent role	Doctor-verified case data reported	55	23.4
	Healthcare professionals reported	62	26.4
	Other professionals reported	28	11.9
	Case reported	90	38.3
Time since delivery	0–6 weeks	56	23.8
	7–12 weeks	56	23.8
	3–6 months	70	29.8
	7–12 months	27	11.5
	More than 12 months	26	11.1
Observation source	Case reported	71	30.2
	Healthcare professionals reported	65	27.7
	Doctor-verified case data reported	39	16.6
	Combined sources	60	25.5

Table 1: Source: Primary survey data, 2026 (n = 235).

Reported oxygen saturation and repeat patterns

The reported SpO_2 categories were 95–100% in 87 responses (37.0%), 93–94% in 51 (21.7%), 90–92% in 37 (15.7%) and below 90% in 44 (18.7%). Ten responses (4.3%) were recorded as not measured and six (2.6%) as unknown [Table 2; Figure 1]. The three categories below 95% accounted for 132 responses (56.2%). This figure is a descriptive grouping of reported categories, not a confirmed prevalence estimate of hypoxaemia, because measurement conditions, device validation, repeat confirmation, and clinical adjudication were not established for each observation.

Table 2: Reported oxygen-saturation categories (n = 235).

Reported SpO_2 category	N	%
95–100%	87	37.0
93–94%	51	21.7
90–92%	37	15.7
Below 90%	44	18.7
Not measured	10	4.3
Unknown	6	2.6

Table 2: Source: Primary survey data, 2026 (n = 235).

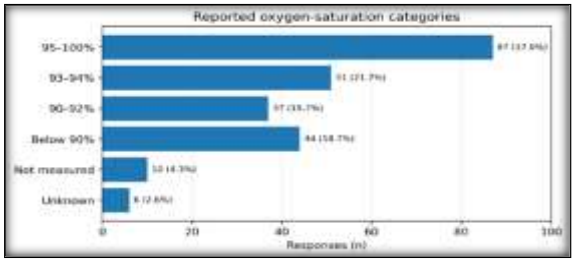

Figure 1: Distribution of reported oxygen-saturation categories. Values are counts and percentages of the 235 survey responses.

Reduced SpO_2 readings were reported as a single reading in 27 responses (11.5%), repeated on the same day in 49 (20.9%), and repeated across several days in 55 (23.4%). Eighty responses (34.0%) indicated no low readings, while 24 (10.2%) were unknown [Table 3 & Figure 2]. The survey summary does not establish whether repeated measurements were obtained using the same device or under standardized conditions.

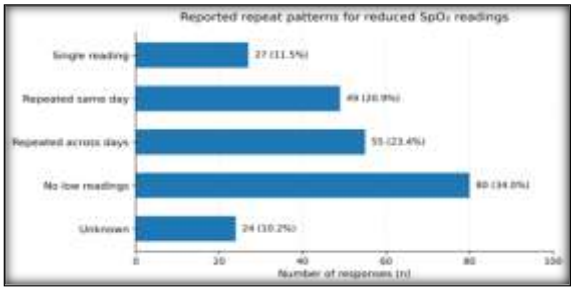

Figure 2: Reported repeat patterns for reduced SpO_2 readings. Bars show the number of responses; labels provide counts and percentages (n = 235).

Table 3: Reported repeat pattern for reduced SpO_2 readings (n = 235).

Repeat pattern	N	%
Single reading	27	11.5
Repeated same day	49	20.9
Repeated across days	55	23.4
No low readings	80	34.0
Unknown	24	10.2

Table 3: Source: Primary survey data, 2026 (n = 235).

Symptoms associated with reported readings: Fatigue was mentioned in 134 of the answers, or 57.0 percent. In 79 answers, or 33.6 percent, a fast heartbeat was reported. In 72 answers, which is 30.6 percent, breathlessness was reported. Thirty-three reported dizziness, or 14.0 percent. Headache was reported in 28 answers which's 11.9 percent. Forty-seven responses, twenty point zero percent, reported no symptoms. 24 answers which is 10.2 percent were not checked [Table 4] shows this. [Figure 3] These percentages are not independent of each other because people could choose more than one symptom.

Table 4: Symptoms associated with reported readings; multiple responses permitted (n = 235).

Symptom	N	% of responses
Fatigue	134	57.0
Rapid heartbeat	79	33.6
Breathlessness	72	30.6
Dizziness	33	14.0

Headache	28	11.9
No symptoms	47	20.0
Not assessed	24	10.2

Table 4: Source: Primary survey data, 2026 (n = 235).

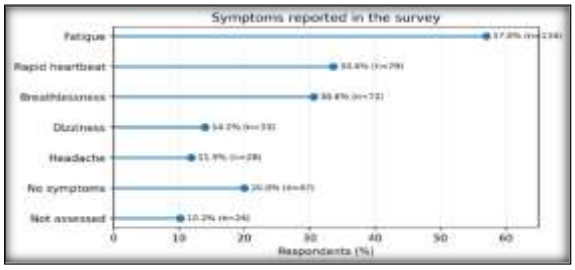

Figure 3: Percentage of respondents reporting each symptom. Multiple responses were permitted; percentages are not mutually exclusive.

Serum leptin testing status: Serum leptin testing was done in 117 people, which's 49.8 percent. Twenty nine point four percent, or sixty nine people, said testing was not done. 20.9 percent and 49 people were unsure. This is illustrated in Table 5. Figure 4 Further questions about the lab results revealed 70 were high, 16 were in the range, nine were below the normal range, 50 had unknown results, and 90 did not have the test done. These result categories add up to 235 responses. The 145 responses indicating the test was done do not match the 117 respondents indicating the test was done in the testing question. The difference is clearly illustrated. Needs to be checked with questionnaire data original before further analysis.

Table 5: Self-reported serum leptin testing and result status (n = 235).

Survey item/category	N	%
Testing status: Yes	117	49.8
Testing status: No	69	29.4
Testing status: Not sure	49	20.9
Result status: Elevated	70	29.8
Result status: Within laboratory range	16	6.8
Result status: Below laboratory range	9	3.8
Tested; result unknown	50	21.3
Not tested (result-status item)	90	38.3

Table 5: Source: Primary survey data, 2026 (n = 235).

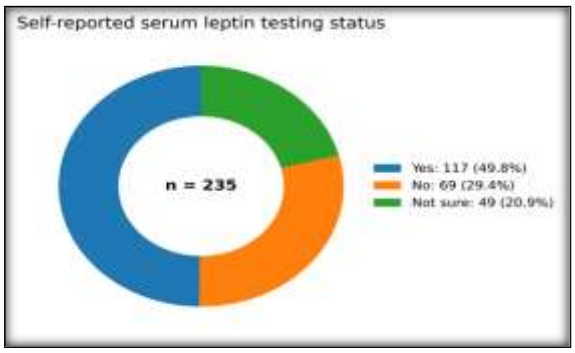

Figure 4: Self-reported serum leptin testing status. The chart depicts the testing-status item only; it does not combine the separate result-status categories.

Methodological issues such as adiposity, postpartum interval and lactation influence leptin values. In any longitudinal evaluation, laboratory assay procedures and sample handling should therefore be standardized.[3,4,9]

Change in weight after birth reported: Weight loss more than 5 kg was reported in 82 responses (34.9%) and weight gain more than 5 kg was reported in 77 responses (32.8%). Smaller changes and unmonitored weights were common [Table 6, Figure 5]. These summary categories contain anthropometric information but are not directly associated with individual Leptin or oximetry observations.

Table 6: Reported postpartum weight change (n = 235).

Weight-change category	N	%
Loss >5 kg	82	34.9
Loss 2–5 kg	24	10.2
Change <2 kg	17	7.2
Gain 2–5 kg	20	8.5
Gain >5 kg	77	32.8
Not monitored	15	6.4

Table 6: Source: Primary survey data, 2026 (n = 235).

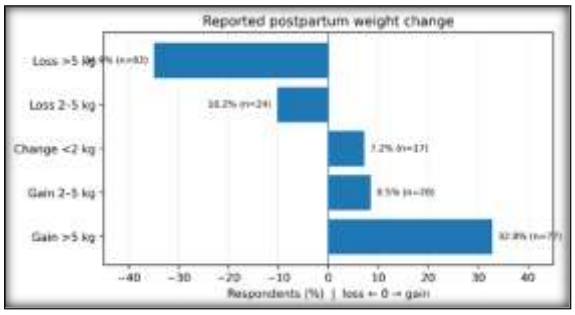

Figure 5: Reported postpartum weight change. Weight loss is plotted to the left and weight gain to the right; the category below 2 kg is shown separately as reported.

Proposed integrated monitoring framework: Remote oximetry and serum leptin are body systems. SpO_2 and pulse rate provide repeated checks of breathing and heart function, while serum leptin can provide a picture of metabolism and hormones. The plan should consider whether serum leptin and remote oximetry paths provide further information jointly; it should not assume serum leptin and SpO_2 are the same or that each change in serum leptin exactly matches a change in SpO_2. Reliability, user adherence, setting and integration into clinical care are points to be carefully reviewed for wearable and remote-monitoring devices.[10–12]

Programs that check blood pressure after delivery have been evaluated as a way to extend follow-up and care after delivery. Those studies provide background for the monitoring path that we propose but they do not confirm the exact mix of serum leptin and pulse oximetry that we are considering here.[12–14]

Table 7: Measurement domains and their proposed roles in the integrated framework.

Domain	Measure	Proposed method	Interpretive role
Metabolic/endocrine	Serum leptin	Standardized laboratory assay (e.g., validated ELISA)	Longitudinal adiposity/endocrine context; interpret with body composition, timing and lactation
Cardiorespiratory	SpO_2 and pulse rate	Compatible pulse oximeter with device and signal-quality metadata	Repeated oxygenation and pulse observations; confirm abnormal readings
Vascular	Blood pressure	Validated home blood-pressure monitor	Context for postpartum hypertensive risk and escalation
Anthropometric	Weight, height, BMI	Digital scale and measured height	Contextual covariates for leptin and postpartum weight trajectory
Clinical/laboratory	Haemoglobin; glucose status; optional thyroid tests	Clinical record and laboratory assays	Potential confounders and co-existing conditions
Case-reported	Symptoms, sleep, lactation, medication and activity	Structured questionnaire and scheduled check-ins	Clinical context, adherence and case-reported recovery

Table 7: Source: Authors' proposed integrated monitoring framework.

Table 8: Proposed schedule for prospective postpartum monitoring.

Time point	Proposed measurements	Purpose
Late pregnancy (36–40 weeks), where feasible	Baseline clinical history, anthropometry, leptin, blood pressure and device familiarization	Pre-delivery reference
24–48 hours postpartum	Clinical assessment, leptin, blood pressure, weight, symptoms, and supervised SpO_2/pulse measurement	Early postpartum reference and device onboarding
Postpartum days 3–7	Leptin where feasible; repeated remote SpO_2/pulse, blood pressure, and symptom review	Capture early physiological transition.
2 weeks	Remote physiological trends and symptom review; leptin if protocol permits	Early recovery trajectory
6 weeks	Clinical review, anthropometry, leptin and device summary	Postpartum follow-up
12 weeks	Repeat clinical and laboratory assessment where feasible	Persistence or resolution of trends

Table 8: Source: Authors' proposed postpartum monitoring schedule.



Figure 6: Fingertip pulse oximeter interface illustrating the device type considered in the proposed remote-monitoring framework.

The device photograph in [Figure 6] illustrates a fingertip pulse oximeter interface.

Proposed observation schedule

The schedule in [Table 8] is proposed for prospective evaluation and was not implemented as part of the current aggregate survey.

DISCUSSION

Data integration, quality control and validation data.

- Each participant should be given a code that identifies them in the study; names and other

direct details should not be in the data that is used for analysis.

- Each observation should have the code of the person, the time it was recorded, the day after giving birth, the device used, the type of measurement, the units, the result, where it came from and if it is of quality.
- Record information about the oximeter model, software version, where the sensor was placed, how the reading was taken, whether there was movement or blood flow, and whether the measurement was repeated.
- Separate raw observations from features derived from these such as average SpO2 for the nite, percent of readings below a certain number, summaries of the pulse rate and length of time the device was not used.
- For leptin tests document the type of test, the batch number, the calibration at the time of draw, the length of time before processing, the storage conditions, the number of freeze-thaw cycles, the units and the laboratory details.
- Leptin data and remote observations should only be linked by a person code and time period. Do not attempt to guess who the data belongs to by using numbers.
- Data quality issues not real measurements. Times when the device was not used when data was sent late when the signal was not good and when the device didn't work.
- Data collection and reuse should be controlled by rules on who can see it, how it's stored, logs of who has accessed it, how long it's kept and proof that people agreed to take part.

Future statistical analysis: A study that comes later should decide what the main result is, how into the future it looks and what should be done based on that before people start joining. Summary information should be chosen based on how the data's spread out. You might use Pearson or Spearman correlation to look at links if it makes sense; repeated measurements should be studied with models that take into account that the same person is involved. Possible factors to look at might include the time after giving birth body mass index or body shape how the baby was born how times the person has had a baby before if they are nursing, hemoglobin levels, blood pressure, medical history and how good the device was. The model should be tested separately for how it tells things apart how accurate it is and how useful it is in real life with tests that look at each person and the time they were studied. It needs to be tested on groups before it can be used in real medical settings. The number of people in the study should be explained in terms of the result or change expected in each person. How to test it, how to deal with missing data, the period of time for checking, and the result is clear. Don't start building a risk predicting model.

Clinical Safety: The system that checks the data should assist, not replace what doctors do. If the SpO2 reading is not normal, it should be rechecked. Doctors agree that the quality of the signal should be considered under a plan. If the reading is not normal, if there are signs that's a problem, or blood pressure is too high, a doctor should look at it, following the usual steps of care. The person should go to emergency services not rely on a computer if there is an emergency. Nor does this paper suggest a number or computer making treatment choices.

Study limitations

- The report shows numbers instead of details for each person; so the study can only look at basic counts and percentages.
- The 235 answers include information from people and from doctors and the sources of the data are different. The total of 235 should not be thought of as 235 people who had a baby.
- There was no data that links a person's leptin levels and SpO_2 readings; so we couldn't look at how they're related over time or make a combined risk score.
- For all the information reported, not all the details about the device how it was used how to check again and how to decide if something is correct were given.
- Some questions allowed than one answer so the percentage numbers don't cover all the options.
- The survey does not show if the system is accurate how well it works, if it causes changes or if it works in situations.
- The question about leptin test status and the separate result status don't. Need to be checked against the original data from the survey.

CONCLUSION

A way of using repeated leptin tests and remote checks of oxygen levels may work for research because the two types of tests look at parts of what happens after a baby is born. The survey gives some information on monitoring after giving birth. Does not have the linked data needed to show the idea works. The next step should be a study that follows people over time using the lab methods devices that are known to work results that matter for real life good ways to check data quality and clear ways to test the model. Until there is proof this idea should be seen as something that is being tested and should not be used on its own to make a diagnosis or decide on treatment.

REFERENCES

1. S. Goodday, E. Karlin, A. Brooks et al., "Better understanding of the metamorphosis of pregnancy (BUMP): protocol for a digital feasibility study in women from preconception to postpartum," npj Digital Medicine, vol. 5, Article 40, 2022. https://doi.org/10.1038/s41746-022-00579-9
2. S. Y. Tan, J. Sumner, Y. Wang, and A. W. Yip, "A systematic review of the impacts of remote healthcare monitoring interventions on safety, adherence, quality-of-life and cost-related outcomes," npj Digital Medicine, vol. 7, Article 192, 2024. https://doi.org/10.1038/s41746-024-01182-w
3. N. F. Butte, J. M. Hopkinson, and M. Nicolson, "Leptin in human reproduction: serum leptin levels in pregnant and lactating women," The Journal of Clinical Endocrinology &

Metabolism, vol. 82, no. 2, pp. 585–589, 1997. https://doi.org/10.1210/jcem.82.2.3731
4. M. Stefaniak, E. Dmoch–Gajzlerska, B. Mazurkiewicz et al., "Maternal serum and cord blood leptin concentrations at delivery," PLoS ONE, vol. 14, no. 11, Article e0224863, 2019. https://doi.org/10.1371/journal.pone.0224863
5. A. Alboksmaty, T. E. Beaney, S. Elkin et al., "Effectiveness and safety of pulse oximetry in remote patient monitoring of patients with COVID-19: a systematic review," The Lancet Digital Health, vol. 4, no. 4, 2022. https://doi.org/10.1016/S2589-7500(21)00276-4
6. R. Al-Halawani, P. H. Charlton, M. Qassem, and P. A. Kyriacou, "A review of the effect of skin pigmentation on pulse oximeter accuracy," Physiological Measurement, vol. 44, no. 5, Article 05TR01, 2023. https://doi.org/10.1088/1361-6579/acd51a
7. S. Singh, M. R. Bennett, C. Chen et al., "Impact of skin pigmentation on pulse oximetry blood oxygenation and wearable pulse rate accuracy: systematic review and meta-analysis," Journal of Medical Internet Research, vol. 26, Article e62769, 2024. https://doi.org/10.2196/62769
8. J. Levy, D. Álvarez, A. A. Rosenberg et al., "Digital oximetry biomarkers for assessing respiratory function: standards of measurement, physiological interpretation, and clinical use," npj Digital Medicine, vol. 4, Article 1, 2021. https://doi.org/10.1038/s41746-020-00373-5
9. Z. Ma, R. L. Gingerich, J. V. Santiago et al., "Radioimmunoassay of leptin in human plasma," Clinical Chemistry, vol. 42, no. 6, pp. 942–946, 1996. https://doi.org/10.1093/clinchem/42.6.942
10. G. S. Ginsburg, R. W. Picard, and S. Friend, "Key issues as wearable digital health technologies enter clinical care," New England Journal of Medicine, vol. 390, no. 12, pp. 1118–1127, 2024. https://doi.org/10.1056/nejmra2307160
11. M. Smuck, C. A. Odonkor, J. K. Wilt et al., "The emerging clinical role of wearables: factors for successful implementation in healthcare," npj Digital Medicine, vol. 4, Article 45, 2021. https://doi.org/10.1038/s41746-021-00418-3
12. A. Hauspurg, L. S. Lemon, B. A. Quinn et al., "A postpartum remote hypertension monitoring protocol implemented at the hospital level," Obstetrics & Gynecology, vol. 134, no. 4, pp. 685–691, 2019. https://doi.org/10.1097/AOG.0000000000003479
13. A. Hirshberg, Y. Zhu, A. Smith-McLallen, and S. K. Srinivas, "Association of a remote blood pressure monitoring program with postpartum adverse outcomes," Obstetrics & Gynecology, vol. 141, no. 6, pp. 1163–1170, 2023. https://doi.org/10.1097/AOG.0000000000005197
14. B. J. Arkerson, M. M. Finneran, S. R. Harris et al., "Remote monitoring compared with in-office surveillance of blood pressure in patients with pregnancy-related hypertension: a randomized controlled trial," Obstetrics & Gynecology, vol. 142, no. 4, pp. 855–861, 2023. https://doi.org/10.1097/AOG.0000000000005327
15. J. Matthews, I. Soltis, M. Villegas-Downs et al., "Cloud-Integrated Smart Nanomembrane Wearables for Remote Wireless Continuous Health Monitoring of Postpartum Women," Advanced Science, vol. 11, no. 13, Article 2307609, 2024. https://doi.org/10.1002/advs.202307609