Telemedicine and remote monitoring advancements for obstetric antenatal care

Jack Le Vance

Leo Gurney

R Katie Morris

Victoria Hodgetts Morton

Abstract

In recent years, the proportion of pregnant women now classifying as high-risk has increased. This is primarily due to guideline changes, implementation of national initiatives and an ageing maternal population. The requirement for serial antenatal maternal-fetal monitoring has therefore increased, placing a significant strain on outpatient obstetric services to cope with the increased demand. Advancements in digital medical innovation, combined with improvements in technological infrastructure has led to increasing development of methods for telemedicine and remote monitoring in both research and clinical settings of antenatal care. The recent pandemic has had also a substantial influence on technology development, as obstetric outpatient services were required to consider alternative solutions to the provision of antenatal care. This spotlight article presents the latest research in telemedicine and remote monitoring for obstetric antenatal care.

Keywords Asynchronous; cardiotocography; remote monitoring; synchronous; telemedicine; telemonitoring; ultrasound

Jack Le Vance ***MBChB*** *Clinical Research Fellow in Maternal Fetal Medicine and Speciality Registrar in Obstetrics and Gynaecology, Department of Applied Health Sciences, School of Health Sciences, College of Medicine and Health, University of Birmingham and Fetal Medicine Department, Birmingham Women's and Children's NHS Foundation Trust, Birmingham, UK. Conflicts of interest: none declared.*

Leo Gurney ***MBBS BMedSci MD MRCOG*** *Clinical Lead for Fetal Medicine and Consultant in Maternal Fetal Medicine, Fetal Medicine Department, Birmingham Women's and Children's NHS Foundation Trust, Birmingham, UK. Conflicts of interest: none declared.*

R Katie Morris ***MBChB PhD MRCOG*** *Professor of Obstetrics and Maternal Fetal Medicine and Honorary Consultant in Maternal Fetal Medicine, Department of Applied Health Sciences, School of Health Sciences, College of Medicine and Health, University of Birmingham and Fetal Medicine Department, Birmingham Women's and Children's NHS Foundation Trust, Birmingham, UK. Conflicts of interest: none declared.*

Victoria Hodgetts Morton ***BMBS PhD MRCOG*** *Associate Professor of Obstetrics and Honorary Consultant in Obstetrics, Department of Applied Health Sciences, School of Health Sciences, College of Medicine and Health, University of Birmingham and Fetal Medicine Department, Birmingham Women's and Children's NHS Foundation Trust, Birmingham, UK. Conflicts of interest: none declared.*

Introduction

Antenatal care is defined by the care delivered to patients prepartum during pregnancy to ensure optimal health for both the mother and fetus. All women will receive regular observations such as blood pressure monitoring across several timepoints of their antenatal care. In many cases, women with predisposing complications or those which arise during pregnancy require an increased frequency of maternal-fetal monitoring. These women are classified as high-risk, due to increased risk of adverse perinatal outcomes associated with their respective complications. Monitoring typically ranges from increasing blood pressure surveillance, to more sophisticated assessments of fetal wellbeing, such as cardiotocography and ultrasound. Modifications to national guidelines and implementation of national initiatives, combined with an ageing maternal population have led to a substantial rise in the number of high-risk pregnant women. This has placed significant strain on outpatient obstetric services, which at times can struggle to meet the increased demand for serial maternal-fetal monitoring. Furthermore, regular monitoring can place a monetary, psychological and emotional strain for both the patient and family. Therefore, discovering pathways to address such concerns is paramount to enhancing the quality of obstetric care within the United Kingdom.

Advancements in digital medical innovation, combined with improvements in technological infrastructure has led to increasing development of methods for telemedicine and remote monitoring in both research and clinical settings of antenatal care. The recent pandemic has had a substantial influence on technology development, as obstetric outpatient services were required to consider alternative solutions to the provision of antenatal care. This spotlight article presents the latest research in telemedicine and remote monitoring for obstetric antenatal care.

Differentiation between telemedicine and remote monitoring

Telemedicine and remote monitoring go hand-in-hand in many clinical circumstances; however, each have distinct characteristics which define each model separately. Telemedicine involves exchanging clinical information via telecommunication networks from one site to another. Transmission can be either synchronous (real-time) or asynchronous (distribution of medical data with delayed interpretation) communication. Remote monitoring utilises technological devices, frequently wearable or portable, which can act as a supplement or adjunct for typical maternal-fetal examinations conducted within the outpatient setting. Devices can have inbuilt infrastructure to utilise concurrent telemedicine transmission or be used in combination with a telemedicine consultation between the patient and clinician; or can be used in isolation.

Telemedicine

Telemedicine has been used in several aspects within obstetrics. A recent scoping review by Tormen et al. in 2024 examined 66 telemedicine studies. Nearly 50% of included studies incorporated telemedicine via virtual consultation for the management of gestational diabetes and maternal weight gain. Patient satisfaction was frequently high within reporting studies with

Please cite this article as: Le Vance J et al., Telemedicine and remote monitoring advancements for obstetric antenatal care, Obstetrics, Gynaecology and Reproductive Medicine, https://doi.org/10.1016/j.ogrm.2025.06.004

minimal difference in neonatal outcomes in telemedicine versus routine clinical appointments. Specifically, the use of teleultrasound has also been explored for antenatal care. In a recent review in 2024: Kariman et al. highlighted that for fetal teleultrasound services, both synchronous and asynchronous ultrasound transmission (11 studies) were feasible to conduct with concurrent high clinician and patient acceptability. Image quality was generally good. However, adequate technological infrastructure, including bandwidth and framerate requirements are important considerations to ensure adequate transmission of high-quality images. Vitally, the integration of teleultrasound services fostered an improvement in availability of care, particularly for rural areas which would otherwise have limited direct access to specialist input.

The integration of telemedicine consultations within antenatal care models has also been proposed by several authors. In most cases, in-person visits are scheduled for key timepoints, such as the booking appointment, at 28 weeks and at 36 weeks gestation, with virtual consultations replacing several other antenatal appointment timepoints. Low risk models have been proposed by Peahl et al., Palmer et al. and Fryer et al. (Figure 1). Slight variations in the frequency of virtual consultations have been proposed, with Peahl et al. incorporating four telemedicine visits with four in-person visits, whereas Palmer et al. utilised six virtual visits with only three in-person consultation. Palmer et al. additionally constructed a high-risk pregnancy model integrating five telehealth visits with five in-person consultations (Figure 2). Initially these models were developed to adequately cope with the pressures of the recent pandemic, however, due to the success following implementation, the models have continued at their respective institutions.

Remote monitoring

The integration of wearable or portable devices which can potentially replace interventions conducted within the outpatient consultation have been explored. Frequently these devices are used in conjunction with a telehealth appointment.

Blood pressure monitoring

There has been a recent emergence of literature on the feasibility and utility of remote blood pressure monitoring within obstetrics. A feasibility study and secondary analysis of the OPTIMUN-BP trial which comprised of women with gestational hypertension or pre-eclampsia demonstrated good adherence for home

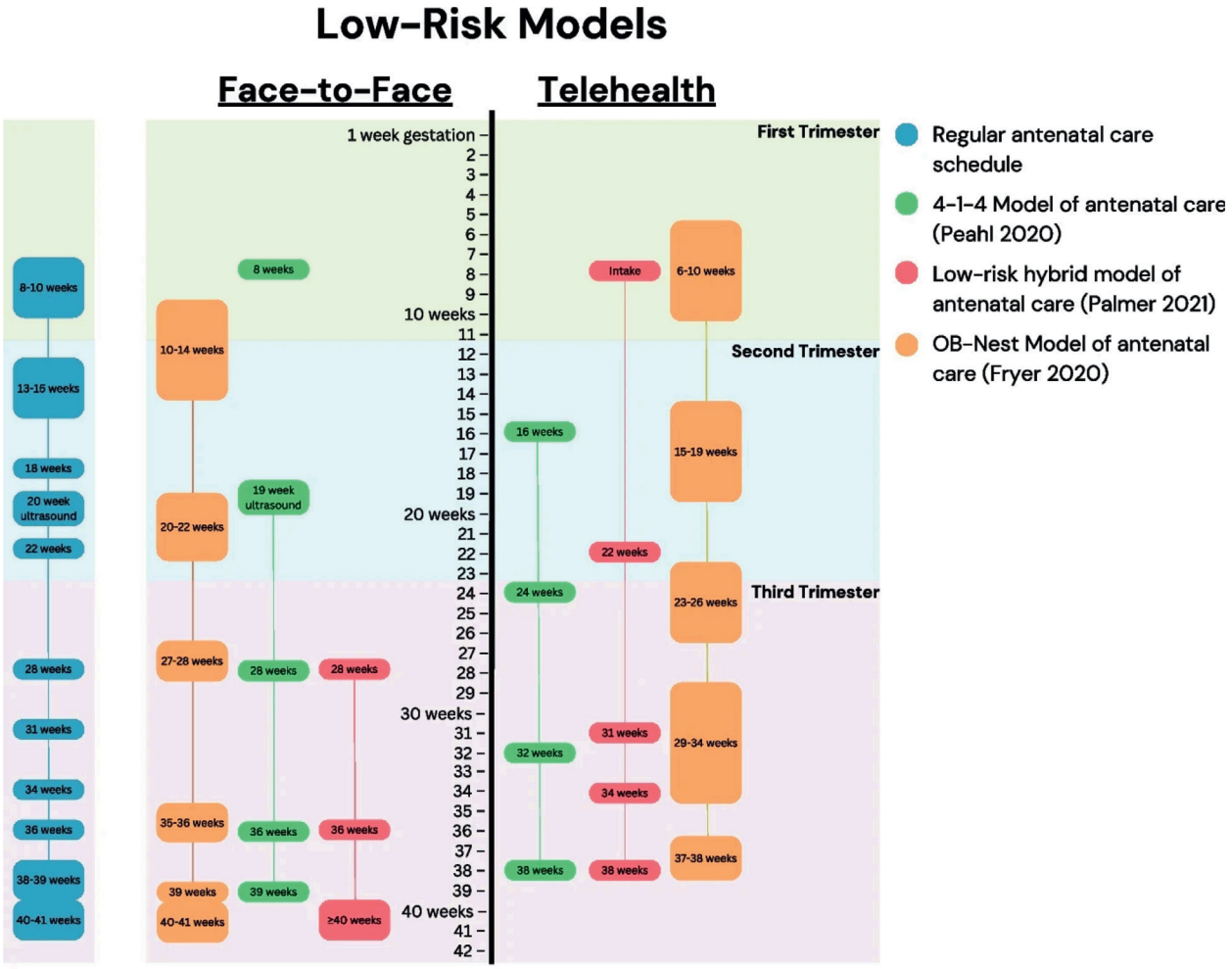

Figure 1 Schedule of face-to-face and telehealth visits for three antenatal telehealth models for low-risk pregnancies (Peahl et al., in green; Palmer et al., in red; Fryer et al., in orange), compared with the standard antenatal care schedule (in blue). Reproduced under the Creative Commons Attribution 4.0 International License from Atkinson J, Hastie R, Walker S, Lindquist A, Tong S. Telehealth in antenatal care: recent insights and advances. *BMC Med*. 2023;21(1):332.

Please cite this article as: Le Vance J et al., Telemedicine and remote monitoring advancements for obstetric antenatal care, Obstetrics, Gynaecology and Reproductive Medicine, https://doi.org/10.1016/j.ogrm.2025.06.004

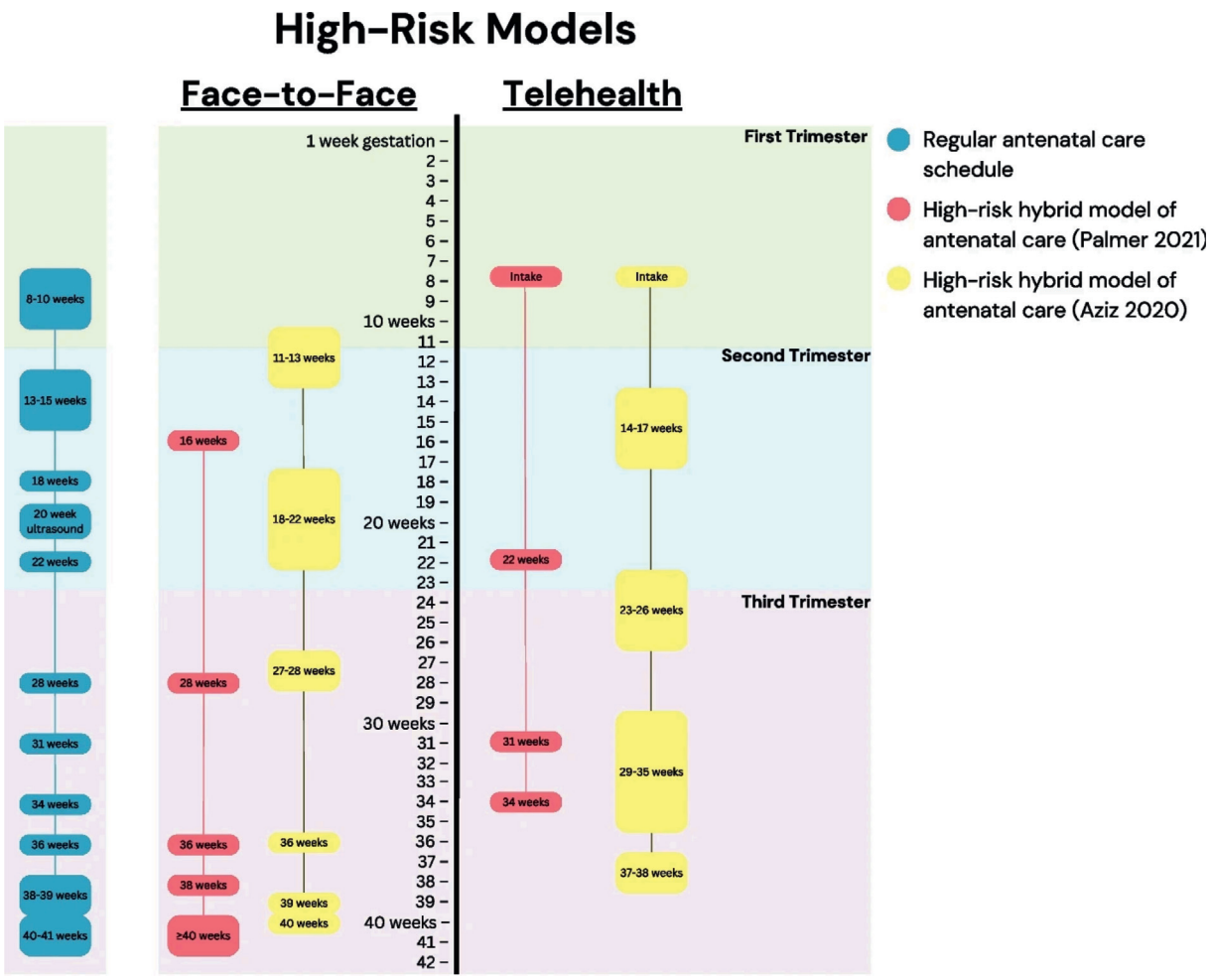

Figure 2 Schedule of face-to-face and telehealth visits for two antenatal telehealth models for high-risk pregnancies (Palmer et al., in red; Aziz et al., in yellow), compared with the standard antenatal care schedule (in blue). Reproduced under the Creative Commons Attribution 4.0 International License from Atkinson J, Hastie R, Walker S, Lindquist A, Tong S. Telehealth in antenatal care: recent insights and advances. *BMC Med*. 2023;21(1):332.

monitoring with minimal variation between home and clinic readings. The BUMP-2 trial by Chappell et al. comprised of 850 women with chronic or gestational hypertension exhibited similar blood pressure readings recorded remotely (with telemedicine review) compared to clinic readings. A recent systemic review by Rajkumar et al. in 2024 evaluated the effectiveness of remote blood pressure monitoring on clinical outcomes. Eighteen studies including 28,094 patients demonstrated that remote blood pressure monitoring reduced the frequency of antenatal outpatient visits and hospital admissions, whilst demonstrating no significant difference in adverse maternal-fetal outcomes, gestational age at delivery and rate of caesarean section. Important to note, included studies used portable blood pressure devices which did not have inbuilt transmission capabilities. The emergence of wearable blood pressure devices, such as smart watches, with inbuilt transmission of data may have potential to be highly acceptable and feasible for pregnant patients, whilst enabling clinicians to review readings in real-time. Further studies are necessitated to evaluate such devices; however, remote blood pressure monitoring has demonstrated to be highly feasible for the obstetric population.

Fetal heart rate monitoring

Remote monitoring of the fetal heart rate via a handheld Doppler or using sophisticated cardiotocography has been recently evaluated. Porter et al. explored the utility of the HeraBEAT device, a handheld fetal Doppler used by women to locate the fetal heartbeat, combined with real-time telemedicine consultation. Data from this device was noted to be comparable to in-clinic recordings. However, clinical applicability of this device is limited, as many women classified as high-risk would require sophisticated monitoring of the fetal heart rate using cardiotocography, rather than a novel Doppler device. In 2023, the HoTeL trial was the first randomised trial, conducted in the Netherlands, aimed at evaluating daily home cardiotocography monitoring versus hospital admission in 201 high-risk women. Results of the study demonstrated that home cardiotocography was non-inferior with respect to maternal-fetal outcomes versus hospital admission. Further feasibility studies by Mhanjna et al. and Suemitsu et al. have demonstrated good feasibility, high acceptability and adequate management of patient safety in women utilising home cardiotocography monitoring. Additionally, a recent systematic review in 2023 by Li et al. analysing nine

Please cite this article as: Le Vance J et al., Telemedicine and remote monitoring advancements for obstetric antenatal care, Obstetrics, Gynaecology and Reproductive Medicine, https://doi.org/10.1016/j.ogrm.2025.06.004

studies comparing remote cardiotocography versus routine care demonstrated no significant differences in rate of caesarean section, induction of labour, instrumental delivery, gestational age of delivery and rate of preterm birth. However, it should be noted that this review includes studies with significant methodological heterogeneity. Importantly, care pathways for high-risk women, will vary between countries. It is therefore pertinent to assess the capabilities and utility of cardiotocography within local units, particularly assessing feasibility within women of ethnic monitories, which were frequently underassessed within current published literature.

Remote ultrasound

Prior literature has demonstrated the educational and clinical utility of point-of-care ultrasound, with concurrent tele-supervision for under resourced settings. However, in recent years, studies have explored the feasibility of remote ultrasound whereby women perform their own monitoring with the data being tele-transmitted for clinical review. Hadar et al. assess the feasibility and acceptability of remote ultrasound via asynchronous assessment within 100 women using the Pulsenmore device (Figure 3). A device whereby women connect their phone into an ultrasound transducer to perform a self-scan of their pregnant abdomen via a series of sweeping motions. Results demonstrated a high detection rate for fetal heart rate activity (95.3%), fetal movements (88.3%) and assessment of amniotic fluid (92.2%). Acceptability was high among women citing high user satisfaction and confidence. Nir et al. also demonstrated similar positive outcomes using the same device within 10 patients. However, Pontontes et al. reported lower identification rates in 46 women, at only 52.2% for the fetal heart rate and amniotic fluid volume, whilst only 17.9% for fetal profile. The use of patient-operated ultrasound additionally has also demonstrated effectiveness for anxiety management in women with a history of recurrent pregnancy loss, as recently demonstrated in a 50-patient trial by Mor et al. Presently, patient-operated devices only provide limited assessment of fetal wellbeing and therefore cannot replace what is already conducted within the outpatient obstetric setting. Incorporation of biometry measurement or Doppler assessment via artificial intelligence may have grounds for a very impactful device. Technological advancements are warranted, but initial data is promising for this aspect of remote monitoring.

Figure 3 The Pulsenmore ultrasound device produced by GE Healthcare. Reproduced with permission from GE Healthcare.

Clinical safety

It is vitally important to consider safety outcomes when exploring and considering the usage of telemedicine and remote monitoring devices. In addition to the above-mentioned clinical outcome data, Güneş Öztürk et al. conducted a larger meta-analysis of over 230,000 women comparing obstetric telehealth interventions, including a variety of telemedicine and remote monitoring device with conventional care. Rates of hypertensive disorders in pregnancy, fetal growth restriction, preterm birth, caesarean section, postpartum haemorrhage and several neonatal complications were no different between groups. Similar findings were revealed in a large retrospective analysis of 22,323 pregnancies by Palmer et al. Interestingly, women in the telehealth groups were significantly more likely to have better glycaemic control, as reported by Xie et al.; a meta-analysis of 5108 women with gestational diabetes (real-time and remote monitoring).

Assessment of telemedicine and remote monitoring interventions of perinatal death has been infrequently reported due to the rare occurrence and substantial sample size required to be powered to assess this outcome. Palmer et al. saw no increased rates of stillbirth in their retrospective analysis; however, incidence rates were low in either group (11 (1%) in the telehealth group versus 105 (1%) in the routine care group).

Cost evaluation

Cost-effectiveness is an important consideration when implementing telemedicine services. Within teleultrasound services, initial startup costs for adequate technological infrastructure are high, however, frequently the cost of an individual consultation is less than standard care; reported to be up to nine times less by Cuneo et al. Frequently initial start-up costs can be accrued by monthly non-fixed savings, enabling services to be cost neutral

Please cite this article as: Le Vance J et al., Telemedicine and remote monitoring advancements for obstetric antenatal care, Obstetrics, Gynaecology and Reproductive Medicine, https://doi.org/10.1016/j.ogrm.2025.06.004

within 12–14 months, as reported by Chan et al. which explored the use of teleultrasound services. Van den Heuvel et al. conducted a cost analysis of their digital health platform, combined with remote monitoring for women with an increased risk of pre-eclampsia. The telehealth intervention was associated with a 19.7% average saving versus conventional care. Furthermore, the abovementioned HoTeL trial demonstrated significant cost savings with remote blood pressure and cardiotocography monitoring versus hospital inpatient admission, noting a mean cost saving of $8066 USD per participant. Cost savings are echoed within many published telemedicine studies and demonstrate the economic benefit for telemedicine/remote monitoring care models.

Patient experience

Telemedicine studies commonly included brief qualitative assessments of patients alongside analysis of clinical outcomes, frequently demonstrating high patient satisfaction and acceptability for the respective intervention. A recent systematic review by Ghimire et al. of over 15,000 pregnant women demonstrated that a hybrid antenatal care model including both virtual and in-person consultations were acceptable to both low-risk and high-risk women. Women preferred virtual consultations to telephone, whilst patient preferred communicating in their own language. Common barriers highlighted to successful implementation were poor technological infrastructure, privacy concerns, quality of care, language challenges and patients with technological illiteracy. Increased access to care, reduction in travel time, cost-benefit and increased confidence were common enablers to implementation cited by patients. Such facilitators and barriers have been commonly echoed through additional qualitative literature by Alkawaldeh et al. and Konnyu et al.

Managing anxiety is a vital consideration when implementing telemedicine and remote monitoring devices into obstetric care. Jongsma et al. reported some women felt anxious whilst awaiting the results of their home monitoring devices, however, responses were variable (cohort of 52 women). A thematic analysis of 507 women by Aydin et al. demonstrated that women felt more anxious with reduced face-to-face consultations, whilst delineating that telemedicine care was less personal. Ghimire et al. additionally noted that anxiety was one of the largest barriers to successful telehealth implementation. However, clinician continuity of care was demonstrated as an avenue to reduce patient anxiety and concerns surrounding self-monitoring; collated from 25 semi-structured interviews by Nguyen et al. Several studies cited a reduction in patient anxiety. Frequently lessening of anxiety was in relation to a reduced need to take time off work, minimising travel to hospital and less requirements to arrange childcare; reported by Mehl et al. These factors commonly associated with face-to-face outpatient visitations.

Generally, telemedicine and remote monitoring has been cited to increase access to care. Particularly for rural and remote areas whereby services would routinely not receive regular specialist care. However, reduced access to care frequently coincides with disparities in socioeconomic and educational status of patients. A study by Hinton et al. revealed that digital poverty, digital illiteracy, language background and sociocultural factors are visible barriers to equitable access to telemedicine care. It is vital for clinicians to therefore consider strategies to ensure inclusivity of disadvantages patients when implementing digital care models which do not widen the equity gap.

Provider experience

Telemedicine and remote monitoring implementation are generally favourable to providers, commonly demonstrating high acceptability, satisfaction and increased clinician confidence. Ghimire et al. noted healthcare professionals frequently felt that virtual appointments provided equivocal care versus in-person consultations, with improved efficiency. Flexibility of virtual care, whilst enabling clinicians to dedicate in-person clinic time to the most high-risk women were positive contributors to implementation as noted in a systematic review of 674 healthcare professionals by Konnyu et al. However, Hofmann et al. highlighted that substandard technological infrastructure, including poor image quality and lack of equipment were common attributors to low clinician satisfaction. Furthermore, Konnyu et al. stipulated that virtual care may compromise antenatal care by minimising the capacity of clinicians to adequately tackle the psychosocial needs to the patient. Therefore, it is imperative to ensure clinicians find a balanced medium between the joint usage of in-person and virtual/remote monitoring care.

Conclusion

Telemedicine and remote monitoring development for obstetric care has flourished over recent years, demonstrating positive outcomes for a variety of clinical metrics. As these interventions become increasingly more common, it is vital for clinicians to understand how best they can be translated into the obstetric context, primarily in a safe and patient-centred manner. It is vital to consider alternative avenues to provide outpatient care as the obstetric population become inherently more high-risk and the demand for serial monitoring surges. Telemedicine and remote monitoring may be a solution; however, further high evidenced literature is required prior to routine implementation. Initial evaluation demonstrates that telemedicine and remote monitoring may be feasible, acceptability and a cost-effective antenatal care model, without compromising on patient safety. ◆

FURTHER READING

Atkinson J, Hastie R, Walker S, et al. Telehealth in antenatal care: recent insights and advances. *BMC Med* 2023; **21:** 332.

Bekker MN, Koster MPH, Keusters WR, et al. Home telemonitoring versus hospital care in complicated pregnancies in The Netherlands: a randomised, controlled non-inferiority trial (HoTeL). *Lancet Digit Health* 2023; **5:** e116–24.

Chappell LC, Tucker KL, Galal U, et al. Effect of self-monitoring of blood pressure on blood pressure control in pregnant individuals with chronic or gestational hypertension: the BUMP 2 Randomized Clinical Trial. *JAMA* 2022; **327:** 1666–78.

Hadar E, Wolff L, Tenenbaum-Gavish K, et al. Mobile self-operated home ultrasound system for remote fetal assessment during pregnancy. *Telemed J E Health* 2022; **28:** 93–101.

Palmer KR, Tanner M, Davies-Tuck M, et al. Widespread implementation of a low-cost telehealth service in the delivery of antenatal care during the COVID-19 pandemic: an interrupted time-series analysis. *Lancet* 2021; **398:** 41–52.

Please cite this article as: Le Vance J et al., Telemedicine and remote monitoring advancements for obstetric antenatal care, Obstetrics, Gynaecology and Reproductive Medicine, https://doi.org/10.1016/j.ogrm.2025.06.004