

The femtech revolution—A new approach to pregnancy management: Digital transformation of maternity care—The hybrid e-health perinatal clinic addressing the unmet needs of low- and middle-income countries

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Abstract

Prenatal care and infant mortality rates are crucial indicators of healthcare quality. However, millions of women in low-income countries lack access to adequate care. Factors such as high-risk pregnancies and unmanaged diet increase the risk of developing complications during pregnancy, highlighting the need for continuous monitoring of maternal health. The increasing burden of non-communicable diseases represents a significant threat to fragile health systems. The lack of access to appropriate prenatal care and poor maternal and newborn health outcomes are major concerns in low- and middle-income countries (LMICs). It emphasizes the need for innovative, integrative approaches to healthcare delivery, especially in pregnant women. The health services need to be reorganized holistically and effectively, focusing on factors that directly impact maternal, neonatal, and infant mortality, resulting in improved access to maternity services and survival of “at-risk” mothers and their offspring in many LMICs. Based on the FIGO (the International Federation of Gynecology & Obstetrics) recommendations of extending preconception care to the postpartum stage, the authors of this review have developed a new model of care—PregCare—based on the triple-intervention-based holistic and multidisciplinary maternal and fetal medicine model for low-risk pregnancies. This model will help transform the traditional model's high visitation frequency into a safe and reduced office visit, while increasing virtual connections, point of care and self-care with doctors, nurses, and community-based providers of self-care. This shall be based on a sophisticated central PregCare call center powered by innovative technologies combined with experienced personnel in perinatal management (doctors and nurses/midwives).

KEYWORDS

digital health, femtech, low- and middle-income countries, new technologies, point of care, pregnancy management

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1 | INTRODUCTION

The World Health Organization (WHO) recognizes prenatal care and infant mortality rate as important measures of healthcare quality. However, over 44 million women in low-income countries lack access to these vital services. Various factors, including advanced maternal age and inadequate diet management, contribute to an elevated risk of developing hypertension and diabetes during pregnancy. Moreover, pregnant women with pre-existing chronic conditions require ongoing health monitoring throughout pregnancy to ensure optimal outcomes.¹

In recent years, increasing advances have been directed towards new forms of health technology for personal use, also known as personal health tracking technologies (PHTTs). PHTTs—from “smart-watches” to “Fitbits”—play an increasingly vital role in self-care and healthcare practices.² Nonetheless, insufficient attention has been drawn to the fact that many PHTTs are marketed explicitly at women; these are known as “femtech”.²

Femtech was coined by Ida Tin, a Danish entrepreneur who founded Clue, a period- and fertility-tracking app, in 2016. As an industry, femtech broadly encompasses any digital or standard health devices aimed at women's health, including wearables, Internet-connected medical tools, mobile apps, hygiene products, and others.^{3,4}

Several new software and digital tools have emerged from the public and private sectors to address women's reproductive health needs. These technologies range from the menstrual cycle-tracking apps, vital sign-monitoring tools, and screening for cervical cancer to medical devices for pelvic floor strengthening.⁵

Despite the notable growth of telemedicine in recent years, primarily aimed at improving access to specialized healthcare services for individuals residing in rural or remote areas, its application in prenatal care has been limited. Before the onset of the COVID-19 pandemic, telemedicine was rarely employed in obstetrics as a routine practice. However, after the declaration of a state of emergency in response to COVID-19, the American College of Obstetricians and Gynecologists (ACOG) recommended the incorporation of telehealth appointments as a means to mitigate the transmission of infections during clinic visits and interactions with healthcare providers. This shift in approach was implemented to ensure the safety of both patients and healthcare personnel.¹

Therefore, we, the authors, put forth a groundbreaking proposal for the global delivery of “e-hybrid” prenatal care. The current prenatal care system fails to address patients' needs, necessitating a new, effective approach. To address this gap, we first highlight the shortcomings of existing prenatal care services in aligning with the diverse needs of patients. Subsequently, we introduce a comprehensive conceptual model that considers the medical and support requirements of pregnant individuals. By customizing prenatal care models based on this framework, we can minimize the overuse of unnecessary services while enhancing access to crucial non-medical support. However, the successful implementation of e-hybrid prenatal care hinges upon overcoming certain challenges we identify. These challenges must be adequately addressed to revolutionize the provision of prenatal care globally.

2 | MATERNAL HEALTH CHALLENGES IN LMICs

Inadequate utilization of maternal and newborn health services remains a challenge in LMICs. Disparities in accessing recommended care packages are prevalent, with low percentages of women receiving the full range of services.⁶ For instance, in sub-Saharan Africa, only 14% of women received the recommended package of services, which includes at least one antenatal care (ANC) visit, with a recommended number of four or more ANC visits, delivery with a skilled birth attendant, postnatal care (PNC) within 24 h, and family planning counseling within 1 year of giving birth.⁷ In Ghana, although 86.1% of women received ANC visits,⁴ and 75.6% gave birth at a health facility, the rates significantly dropped to 25.4% for PNC within 48 h, and only 8.0% completed the continuum of care.⁸ This pattern of declining utilization of the service along the continuum of care during pregnancy, childbirth, and the postnatal period was also observed in South Asia, where only one-quarter of women received all the required services.^{7,9}

In 2015, India accounted for a significant proportion of global maternal deaths, with disparities observed between states.¹⁰ Northern states, such as Assam, Uttar Pradesh, and Rajasthan, had higher maternal mortality ratios than southern states, such as Kerala and Tamil Nadu. These disparities reflect the country's inequity in healthcare utilization, particularly ANC and skilled birth attendance. Rural and economically disadvantaged mothers are particularly affected.¹⁰

These inequities are influenced by various determinants, including structural and intermediary factors, and affect specific groups such as low-income, socially marginalized, and less educated women.¹⁰ Therefore, addressing these determinants is essential to reduce maternal health inequities in India.

LMICs face barriers, such as declining service utilization along the continuum of care, limited access to healthcare facilities, and inequities in healthcare utilization, particularly among rural and economically disadvantaged populations. Addressing these determinants and improving access to prenatal care is crucial.¹¹ Innovative approaches, such as self-care interventions and virtual prenatal visits with remote monitoring, can help overcome barriers and improve patient satisfaction.^{12,13} Healthcare practitioners should prioritize addressing common co-morbidities, nutritional issues, and lifestyle factors in their settings, in line with FIGO (the International Federation of Gynecology & Obstetrics) preconception recommendations, to enhance maternal and fetal health outcomes.¹⁴

3 | UTILIZATION OF ANTENATAL CARE AND RECOMMENDED GUIDELINES FOR IMPROVED MATERNAL HEALTH OUTCOMES

While progress has been made in increasing the proportion of women attending the recommended number of ANC visits, many still lack access to comprehensive maternal care, leading to adverse outcomes for mothers and newborns. Understanding the

factors influencing ANC attendance is crucial for targeted policy interventions.¹⁵

The FIGO Pregnancy, Non-Communicable Diseases Committee and the FIGO Committee for Reproductive Medicine, Endocrinology, and Infertility emphasize the importance of providing systematic advice and support for women's nutrition and weight management during the preconception period. This recommendation aims to improve maternal health outcomes.^{14,16}

Although prenatal care is essential, the evidence on the association between visit frequency and outcomes is limited. WHO recommends a minimum of eight contacts with healthcare providers during pregnancy, with specific contact requirements for each trimester. However, the number of visits does not necessarily correlate with improved outcomes.¹⁷

Traditional guidelines, such as those from the ACOG, prescribe a specific schedule of prenatal visits.¹⁸ However, research suggests that increased visits may not be necessary for most low-risk pregnancies, and the effectiveness of prenatal care should focus on the content rather than solely the frequency of visits.¹⁹

Continuity of care, consideration of patient satisfaction and health outcomes, and new models of care are needed to improve access to prenatal care. These models should address the burden of clinic visits while ensuring adequate care and risk assessment.^{20,21} By adopting innovative approaches, we can enhance the effectiveness of prenatal care and promote positive pregnancy experiences.²²

4 | ADVANCES IN DIGITAL TECHNOLOGIES IN PREGNANCY MANAGEMENT

Digital technologies have revolutionized healthcare delivery, expanded treatment options, and improved precision in targeting specific conditions and patient types. In the realm of maternal health, there is a growing recognition of the need for a comprehensive approach encompassing prenatal care, long-term health care, and integration with existing health programs and services.²³ Maternal health services should no longer be confined to separate silos but should synergize with the agendas of non-communicable diseases (NCDs) to address contemporary challenges and disease patterns. This broader perspective is crucial for improving the well-being of both mothers and offspring globally.²⁴

Femtech, which refers to technology-based products and services designed specifically for women's health, can greatly benefit from a partnership research and development model. This model emphasizes joint decision-making, trust, and mutual understanding between institutions in high-income countries (HICs) and LMICs.²⁵⁻²⁷ Collaborative initiatives, such as WHO's African Partnerships for Patient Safety (APPS), promote human interaction through site visits, joint training, bi-directional learning, and the co-development of innovations, strengthening the role of organizations such as FIGO.²⁸ By working together, femtech companies and local

health institutions can bridge the accessibility gap in quality health care for women, especially in resource-limited communities.

Femtech holds immense potential in addressing the pressing healthcare needs of women in LMICs through developing innovative solutions tailored to these women's unique contexts, which can contribute to improving health outcomes and strengthening healthcare systems sustainably. Mobile apps, telemedicine platforms, wearable devices, and other femtech solutions can enhance access to healthcare services, raise awareness about health issues, and facilitate self-management of health conditions for women in LMICs.²⁹

5 | ACCELERATING TOWARDS TELEHEALTH SOLUTIONS IN THE COVID-19 ERA

The COVID-19 pandemic has accelerated the adoption of telehealth, transforming patient-practitioner relationships and bringing about long-overdue changes to the healthcare system. While there have been challenges in adjusting to new technology and workflows, hybrid health care combining in-person care and telehealth offers convenience, proactive treatment, and time efficiency. The digital transformation of health care is here to stay, as it provides better care at lower costs.³⁰ Traditionally, the use of telemedicine has been increasing worldwide in the last two decades.²³ For example, it was often applied in cardiac patients to transmit electrocardiography tracings from home to specialized centers for interpretation.³¹ However, the newly-available portable, lightweight, non-invasive devices for fetal heart rate and uterine contraction monitoring have made telemedicine an attractive alternative for antenatal surveillance.³²

Telehealth has been implemented in LMICs with varying success. For example, telemedicine has improved healthcare access in rural India and accurately treated conditions such as respiratory illnesses, diabetes, and hypertension.³³ In Mexico, the "Programa de Telesalud" provides teleconsultations and monitoring for chronic diseases in remote areas.³⁴ Similarly, telehealth consultations have reduced unnecessary referrals for patients in rural communities in Brazil.³⁵ These examples highlight how telehealth can enhance healthcare access and engagement in LMICs, similar to HICs such as the United States. Therefore, keeping the focus on telemedicine, our vision towards developing a new innovative approach was commenced to improve health services provided to pregnant women with appropriate support systems and services that are safe for high-risk pregnancy surveillance.

6 | THE NEED FOR DEVELOPING A NEW MODEL OF CARE

Developing a new model of care, PregCare, is essential to enhance maternal and fetal health outcomes throughout pregnancy and postpartum. Following FIGO recommendations, preconception care can

include risk assessment for conditions such as gestational diabetes and obesity, while extending care to the postpartum stage allows for integrated support.¹⁴ Appropriate screening for medical conditions during pregnancy improves outcomes and promotes the prevention of intergenerational NCDs.³⁶

During COVID-19, telehealth has reduced in-person visits, resulting in time and cost savings and increased satisfaction. Advanced healthcare solutions, such as the CareMother Fetosense remote monitoring device, have shown acceptability and usability, reducing the need for repeated visits. Telemedicine interventions, including virtual visits and remote monitoring, have effectively assessed fetal well-being, monitored weight gain, and facilitated consultations, with high provider satisfaction reported. Hence, hybrid prenatal care, combining in-person and virtual components, has shown higher utilization of services, increased patient satisfaction, reduced stress, and lower healthcare costs. PregCare embraces a holistic and multidisciplinary approach to optimize maternal and fetal medicine in pregnancies.^{1,37}

7 | HYBRID HEALTH PERINATAL MODEL CONCEPT

We present a groundbreaking approach to modern pregnancy management—a holistic and multidisciplinary model that leverages new technologies and focuses on point-of-care and digitalized solutions. Our approach recognizes the importance of delivering comprehensive services, beginning with a thorough patient evaluation, including medical and pregnancy history, demographics, biochemical and biophysical markers, sonography, and chemical blood tests. Incorporating the latest advancements in maternal-fetal medicine can predict, prevent, monitor, and manage pregnancy complications more effectively.

One of the key benefits of this approach is its ability to personalize medical care and allocate resources strategically. By utilizing the newest technologies, we can tailor medical attention to those who require it most, allowing others to have less intensive medical involvement. In addition, our approach aligns seamlessly with the modern era of social media, computerized algorithms derived from extensive databases, and the integration of diverse sources of information and expertise to develop evidence-based medical treatment plans.

We propose a revised schedule consisting of eight office or clinic visits to streamline the process, including six visits during pregnancy, from the early first trimester to delivery, and two visits encompassing the preconception and postpartum periods. By reducing the number of prenatal visits from the traditional 14, a figure lacking sufficient evidence-based literature, especially for low-risk pregnancies, we aim to optimize resource allocation and prioritize quality care.

Simultaneously, as the trend towards hospitalization of birth and obstetrical practices continues to evolve, our approach embraces innovative technologies that enable safe maternal and fetal follow-up within the comfort of a home or a point-of-care setting. By leveraging these cutting-edge tools, we ensure the well-being of both

the mother and infant while expanding access to remote locations that lack immediate medical facilities. Notably, our approach initiates with telemedicine services. It represents a unique contribution to the scientific literature. It offers a novel and innovative model to enhance maternal health outcomes and address the unmet needs of improving pregnancy outcomes in LMICs.

The PregCare model is based on the new, triple-intervention-based holistic and multidisciplinary maternal and fetal medicine model described above and in [Figure 1](#).

We followed the criteria suggested by the two WHO models and country guidelines to analyze the timely ANC visits ([Table 1](#)).³⁸

8 | IMPLEMENTATION OF THE HYBRID E-HEALTH PERINATAL MODEL

We propose a new model of care—PregCare—for low-risk pregnancies that reduce office visits while increasing virtual connections with doctors, nurses, and other providers, including self-care and a very sophisticated model of care for high-risk pregnancies supported by the newest technologies aimed at home-based, self-care, and point of care service.

We recognize that the traditional model of prenatal care fails to fully embrace the methodological and technological advances in pregnancy monitoring and communications. It operated under the assumption that face-to-face visits are the sole means of contact between expectant mothers and their care team, disregarding the demands of women's busy lives. In addition, this model often inadvertently medicalizes the pregnancy experience, potentially creating an undue reliance on frequent office visits for a sense of security in pregnancy outcomes.

With the development of PregCare, our team hypothesized that empowering low-risk and high-risk pregnant women to take a more active role in their parental care would shift the healthcare delivery paradigm from a sickness-oriented model to one focused on wellness. As a result, we propose a significant reduction of face-to-face visits by 50%, resulting in approximately 6–8 clinic and hospital visits throughout the pregnancy journey.

The service will be based on a sophisticated central PregCare call center powered by experienced personnel in perinatal management, including doctors, nurses, and front-line healthcare providers. PregCare can be implemented under various healthcare frameworks, including health maintenance organizations, Ministry of Health programs, hospitals, community services, or privately by insurance companies. The structure is outlined in [Figure 2](#). At the core of our vision is the recognition of the crucial role played by our innovative approach in empowering pregnant women to engage actively in prenatal and postnatal care activities. By embracing our approach, we aim to enhance maternal health outcomes while minimizing the necessity for frequent visits to healthcare facilities.

We aim to shift the traditional paradigm by providing women with the tools and support they need to take an active role in their care. Empowering women to participate in their prenatal and postnatal care leads to improved maternal health outcomes. In addition,

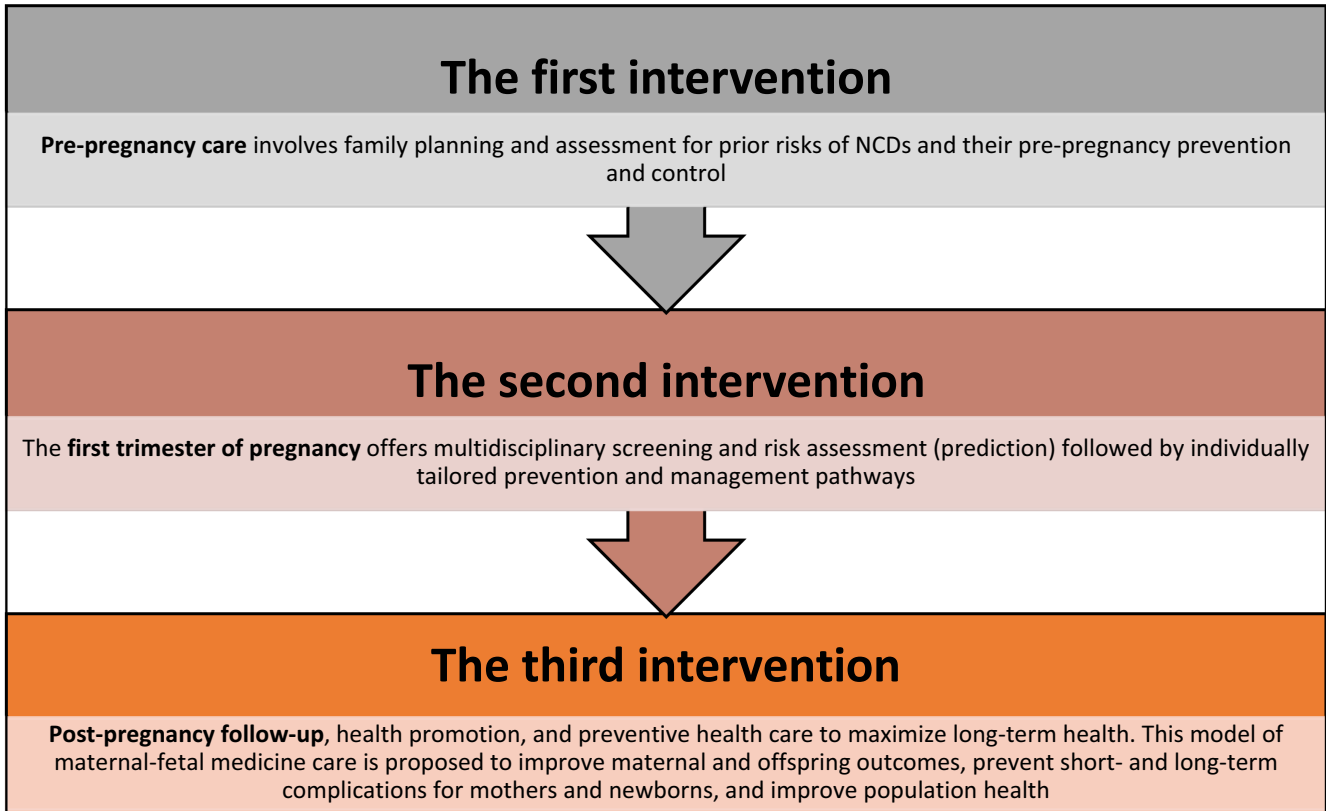


FIGURE 1 A new, triple-intervention-based holistic and multidisciplinary maternal-fetal medicine model.³⁶ NCD, non-communicable disease.

TABLE 1 Two WHO models criteria for ANC visits.³⁸

WHO FANC model	2016 WHO ANC model
First trimester	
Visit 1: 8–12 weeks	Contact 1: up to 12 weeks
Second trimester	
Visit 2: 24–26 weeks	Contact 2: 20 weeks Contact 3: 26 weeks
Third trimester	
Visit 3: 32 weeks	Contact 4: 30 weeks Contact 5: 34 weeks
Visit 4: 36–38 weeks	Contact 6: 36 weeks Contact 7: 38 weeks Contact 8: 40 weeks
Return for delivery at 41 weeks if not given birth	

Abbreviation: ANC, antenatal care.

by reducing the reliance on in-person visits to medical settings, we alleviate the burden placed on pregnant women, enabling them to better manage their busy lives.

By emphasizing the importance of our approach, we aim to highlight its positive impact on maternal health. Our vision centers around empowering women and ensuring they have the resources and opportunities to participate in their care journey actively. Through this approach, we strive to improve maternal health outcomes and promote the well-being of mothers and their infants.

9 | CONCLUSION

Antenatal care is crucial in promoting the health and well-being of mothers and their children. Adequate and comprehensive maternal health care during the antenatal period has been proven to improve birth outcomes significantly. However, healthcare systems worldwide face challenges in establishing and maintaining integrated policies and delivering a comprehensive range of essential primary care services during pregnancy, leading to an increased risk of adverse maternal and fetal outcomes. To address this issue, it is imperative to strengthen research efforts to develop and test models that enhance the responsiveness of health systems and to the specific health needs of the communities.

The proposed PregCare model represents a significant advancement in maternal health care, particularly for high-risk pregnancies. Leveraging the latest technologies, this model offers a sophisticated approach to care, focusing on providing services at home and in point-of-care settings. By implementing a triple-intervention-based holistic and multidisciplinary approach in maternal and fetal medicine, the PregCare model aims to improve communication between patients and providers, fostering mutual trust and reducing the burden associated with regular clinic visits. This hybrid model streamlines care delivery and enable providers to gather critical information that can inform long-term complications in at-risk mothers. Consequently, it has the potential to expedite pregnancy care and provide comprehensive, individualized attention, resulting in healthier outcomes for both mothers and their children.

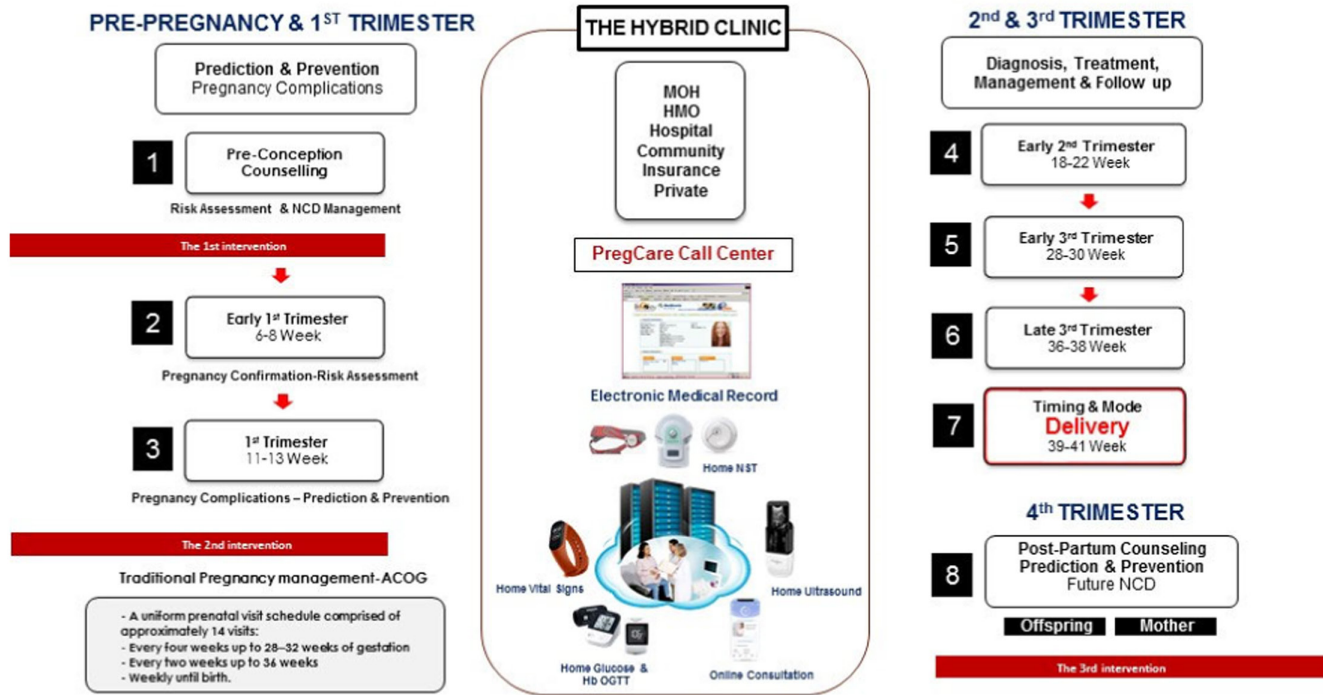


FIGURE 2 The hybrid perinatal clinic; a new approach to pregnancy management. From office to point-of-care/home—all you can do in eight steps. ACOG, American College of Obstetricians and Gynecologists; Hb, hemoglobin; HMO, Health Maintenance Organization; Home NST, home non stress test; MOH, Ministry of Health; NCD, non-communicable disease; OGTT, oral glucose tolerance test.

The PregCare model embraces intersectionality and addresses key principles, such as diversity, equity, social inclusivity, and fostering a sense of patient belonging for all. Integrating these principles into the model promotes a patient-centered approach that values each individual's unique needs and experiences. Ultimately, the PregCare model strives to transform maternal health care by providing comprehensive, quality care while empowering women and improving maternal and fetal health outcomes.

10 | IMPORTANT POINTS TO REMEMBER

1. Prenatal care is a critical preventive health service used in HICs worldwide. However, addressing the barriers to communication and using advanced tools to improve pregnancy outcomes and the long-term health of the offspring are needed.
2. FIGO recommends extending preconception care to the postpartum stage to increase the window of opportunity and access to women with nutritional needs, thus providing an integrated continuum of care.
3. Our proposed new model, PregCare, for pregnancy management supported by the latest technologies, aims to provide services at home and point-of-care service with reduced office visits while increasing virtual communications and self-care.
4. Generally, the traditional model of prenatal care assumes a rhythm of care dependent on face-to-face visits that precedes an appreciation for women's busy lives. Furthermore, several studies reported that the telemedicine support system is equally

effective compared to ambulatory hospital management in preventing adverse events in high-risk women.

5. Therefore, it is believed that face-to-face visits will be reduced by 50% to some 6–8 clinic and hospital visits with our model to improve maternal health outcomes with reduced visits burden, allowing maternal and fetal follow-up safely at the home or point-of-care setting. This service will be based on a sophisticated central PregCare call center powered by experienced personnel in perinatal management.

AUTHOR CONTRIBUTIONS

All authors contributed to conceptualization, writing original draft, review and editing, and final approval for publication.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data-sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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