English

# E-gestante obstetric monitoring system implemented at the maputo central hospital (HCM), mozambique


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Date of Receipt: October 12, 2025 | Approval Date: May 22, 2026



## Abstract

**Introduction**:Adequate obstetric care is an essential factor in promoting women's health during pregnancy. In Mozambique, the quality of obstetric care is compromised by the predominance of manual processes, poor communication among professionals, lack of integrated digital systems, administrative overload, and deficiencies in care delivery. **Objective**:In this context, the present study aimed to develop a digital system for obstetric follow-up in the context of the Central Hospital of Maputo (HCM). **Methodology:** The methodology is applied in nature, structured in four main stages: requirements gathering, agile system development, simulation in the HCM context, and statistical analysis of empirical data. The system integrates functionalities such as digital clinical records, automated appointment scheduling, risk alerts, and a confidential reporting module for obstetric violence. **Results:**The results demonstrated strong acceptance, with 75% of participants considering the system important for improving care. It was also identified that 72.2% of pregnant women reported limited follow-up during childbirth, confirming the urgency of technological solutions that promote transparency. **Conclusion:** It is concluded that the e-Gestante system is a viable and promising technological solution to strengthen the quality of obstetric care, reduce clinical risks, and foster more efficient and respectful care for women's health.



**Key-words:** Information system, maternal health, health digitization, obstetric violence.



## Resumen

Sistema de acompañamiento obstétrico e-gestante implementado en el hospital central de maputo (HCM), mozambique

**Introducción**:Una atención obstétrica adecuada es fundamental para promover la salud de la mujer durante el embarazo. En Mozambique, la calidad de la atención obstétrica está comprometida por el predominio de procesos manuales, la deficiente comunicación entre los profesionales, la ausencia de sistemas digitales integrados, la sobrecarga administrativa y las deficiencias en la atención. **Objetivo:** En este contexto, el objetivo fue desarrollar un sistema digital de atención obstétrica en el Hospital Central de Maputo (HCM) en Mozambique.**Metodología:** La metodología del estudio es de carácter aplicado y se estructura en cuatro etapas principales: recopilación de requisitos, desarrollo ágil del sistema, simulación en el contexto del HCM y análisis estadístico de datos empíricos. El sistema integra funcionalidades como registros clínicos digitales, programación automatizada de citas, alertas de riesgo y un módulo de informes confidenciales**. Resultados**:Los resultados demostraron la aceptación del sistema, ya que el 75 % de las participantes lo consideraron importante para mejorar la atención. Se identificó que el 72,2 % de las mujeres embarazadas reportaron una atención limitada durante el parto, lo que confirma la urgencia de soluciones tecnológicas que promuevan la transparencia. **Conclusión:** Se concluye que el sistema e-Gestante se presenta como una solución tecnológica viable y prometedora para fortalecer la calidad de la atención obstétrica, reducir los riesgos clínicos y promover una atención más eficiente y respetuosa de la salud de la mujer.



**Palabras clave:** Sistema de información; salud materna; violencia obstétrica; digitalización en salud.



## Resumo

Sistema de acompanhamento obstétrico e-gestante implementado no hospital central de maputo (HCM), moçambique

**Introdução**:O acompanhamento obstétrico adequado constitui um fator essencial para a promoção da saúde da mulher durante a gestação. Em Moçambique, a qualidade do acompanhamento obstétrico é comprometida pela predominância de processos manuais, comunicação deficiente entre profissionais, a ausência de sistemas digitais integrados, sobrecarga administrativa e falhas no cuidado. **Objetivo**:Perante este contexto, objetivou-se desenvolver um sistema digital de acompanhamento obstétrico no contexto do Hospital Central de Maputo (HCM) em Moçambique. **Metodologia:** A metodologia do estudo é de natureza aplicada, estruturada em quatro etapas principais: levantamento de requisitos, desenvolvimento ágil do sistema, simulação no contexto do HCM e análise estatística dos dados empíricos. O sistema integra funcionalidades como registo clínico digital, agendamento automatizado de consultas, alertas de risco e um módulo confidencial para denúncias.**Resultados**:Os resultados demonstraram aceitação do sistema, com 75% dos participantes a considerarem-no importante para a melhoria dos cuidados. Identificou- se que 72,2% das gestantes reportaram acompanhamento limitado durante o parto, confirmando a urgência de soluções tecnológicas que promovam a transparência.**Conclusão:** Conclui-se que o sistema e-Gestante apresenta-se como uma solução tecnológica viável e promissora para fortalecer a qualidade do cuidado obstétrico, reduzir riscos clínicos e promover um atendimento mais eficiente e respeitoso à saúde da mulher.

**Palabras-chave:** Sistema de informação; saúde materna; violência obstétrica; digitalização em saúde

## INTRODUCTION

Maternal health remains a major public health concern in developing countries, particularly in the African context, where factors such as limited access to obstetric care, a shortage of qualified professionals, and deficiencies in health infrastructure exacerbate the risks faced by pregnant women[1]. Several studies (Ngwenya & Nhancale, 2019; Kabiru & Agwanda, 2020) highlight the need for technological solutions tailored to the local context to improve care traceability, appointment scheduling, monitoring of health indicators, and communication between pregnant women and healthcare professionals. The use of health information systems, in addition to facilitating the management of clinical data, can offer additional features such as automated reminders, virtual assistance for addressing queries, and personalized educational guidance.

In Mozambique, although progress has been recorded in recent years, maternal mortality rates remain high. According to the Mozambican Ministry of Health[2], one of the major challenges facing the national health system lies in its capacity to provide continuous and effective care to pregnant women, particularly during the prenatal, delivery, and postpartum periods. The absence of computerized systems for recording and monitoring consultations, examinations, and warning signs represents a gap that compromises the quality of care provided. Within the SADC region, countries such as Zambia (SmartCare), South Africa (MomConnect), and others using DHIS2 demonstrate the potential of digital systems for maternal and child health [3,4]. In Mozambique, the primary system in use is SIS-MA; while efficient for collecting aggregated data, it does not facilitate continuous, individualized monitoring of pregnant women[5]. Furthermore, obstetric violence, often silent and institutionalized, remains a challenge in the country, negatively impacting the quality of obstetric care and women's rights (1). The lack of secure channels for reporting incidents perpetuates impunity and discourages victims from coming forward [6,7]. A heavy reliance on manual paper-based records, which are prone to loss and error, hinders the continuity of care and clinical decision-making.

The development of the e-Gestante system is significant because it fills a gap by offering continuous and individualized monitoring, it improves clinical management through the digitization and organization of records, it strengthens the humanization of care by creating a channel for direct communication and for reporting abusive practices, and it contributes to public policy by aligning with regional efforts to digitize maternal healthcare. Thus, this work develops an e-Gestante system as a technological solution tailored to the context of the Maputo Central Hospital, the largest hospital in Mozambique. This work constitutes an important tool, as, despite global advancements in reducing maternal mortality, Mozambique continues to face serious challenges in providing quality obstetric care [5].

As a national referral center, Maputo Central Hospital mirrors these difficulties, which include structural limitations, a shortage of trained human resources, and inefficiencies in service organization. These conditions directly compromise the well-being of pregnant women and newborns. Prominent among the most critical issues is the poor quality of obstetric care, manifested by delays in service delivery, a lack of adequate follow-up for consultations, and weaknesses in the early identification of clinical risks[5]. Also, the absence of secure channels for reporting grievances perpetuates impunity and discourages victims from reporting abuses [6,7]. Another significant challenge is the heavy reliance on manual paper-based records, which are prone to loss, delays in information transmission, and data entry errors. Such limitations hinder the continuity of care and compromise clinical decision-making.

The lack of integration among services also undermines the monitoring of pregnant women throughout the pregnancy-puerperium cycle, particularly when they transition between different health facilities. The absence of alert and monitoring systems reduces the capacity for the early detection of complications, increasing the risk of maternal and neonatal mortality.

Thus, the absence of digital solutions designed specifically for individualized obstetric care constitutes a technological gap that limits administrative efficiency, undermines the humanization of care, and compromises the protection of pregnant women's rights. Based on this scenario, it has become urgent to rethink the model of obstetric care, incorporating digital tools that respond in an integrated manner to the clinical and social needs of pregnant women.

In this context, the study's main question is: how can an obstetric monitoring system contribute to improving the quality of healthcare and ensuring more effective and humanized care for pregnant women in Mozambique, in sub-Saharan Africa?

## METHODOLOGICAL PROCEDURES

The description of the e-Gestante system's main functional components was developed based on a requirements analysis involving various stages of data collection and processing. The requirements-gathering process began with the administration of questionnaires and interviews, duly authorized by the HCM and Joaquim Chissano University, to healthcare professionals and pregnant women at Maputo Central Hospital (HCM). The study population consisted of two strata: healthcare professionals (physicians, nurses, and midwives) from the obstetrics department directly involved in providing care to pregnant women; and pregnant or postpartum women who were currently receiving, or had previously received, obstetric care at the HCM. The non-random sample, selected using purposive and convenience sampling, was defined based on participants' availability and relevance to the study's objectives. Women aged 18 to 45 receiving prenatal or postpartum care, and professionals in the field of maternal health were included in the example. The study sample had 21 participants, specifically five[5] healthcare professionals and sixteen[16] pregnant women, with the sample size determined by data saturation of the respondents' answers; their contributions provided insights into the needs, limitations, and potential benefits associated with implementing the e-Gestante system at the HCM. The implemented project was submitted to and approved by the HCM's Ethics and Research Directorate.

This process enabled the identification of essential functionalities, such as clinical record-keeping, appointment scheduling, risk alerts, pre- and post-natal care, medical history tracking, and the reporting of obstetric violence. In addition to interviews and questionnaires, on-site observations were conducted in the HCM clinical environment to understand workflows, map operational challenges, and observe the interactions between healthcare professionals and patients. Based on the collected data, the requirements were organized and modeled into functional and non-functional tables (see appendices). Subsequently, UML diagrams were developed to represent use cases, describing the interactions between actors and the system, as well as class diagrams, which defined the system's structure through entities such as pregnant women, healthcare professionals, appointments, and medical exams.

Based on this analysis and modeling process, the key functional components of the e-Gestante system were defined: user registration and management, prenatal care, childbirth and postpartum care, reporting of obstetric violence, and an educational information module. This procedure ensured clarity regarding the system's scope and components, guaranteeing alignment between user needs and project objectives.

The development of the e-Gestante system for the Maputo Central Hospital (HCM) was carried out by adopting an iterative and agile development approach, using Oracle APEX and Oracle Database as the primary technologies. The process was organized under the Kanban methodology, which enabled the visualization of progress, the prioritization of activities, and the promotion of continuous value delivery. The Trello tool was used for task tracking.

The e-Gestante system was designed as a Progressive Web App (PWA), a technology that combines the characteristics of mobile applications with the flexibility of web applications. PWAs are distinguished by their ability to be accessed across various devices (computers, tablets, or smartphones), function even under conditions of limited connectivity, and offer features typical of native applications, such as notifications and offline access [12]. Following the system's development, a simulation was conducted to validate its operational functionality. The purpose of this simulation was to validate the system's functionality and usability within the context of obstetric care processes. The system was hosted in a test environment using Oracle APEX and Oracle Database, accessible via computers, tablets, and smartphones. Test data was employed to replicate typical usage scenarios. Specific scenarios were developed to cover the system's core functionalities. Pregnant women and HCM professionals interacted with the system by following these predefined scenarios. Following each session, questionnaires were administered to assess user satisfaction, identify strengths and weaknesses, and gather suggestions for improvement.

The same structured questionnaire previously developed for system requirements gathering was used to present the incidence rates of the types of obstetric violence faced by pregnant women at the HCM, adapted and administered to



DOI: 10.32443/2175-2990 (2025)504

pregnant women receiving care at the Maputo Central Hospital. Data collection was conducted via Google Forms on an anonymous and voluntary basis, ensuring informed consent, confidentiality, and anonymity for the participants. The sample, purposive and convenience-based in nature, consisted of 16 pregnant women. The collected data were exported to a spreadsheet and subjected to descriptive statistical analysis (calculation of absolute and relative percentage frequencies), which enabled the identification and characterization of the incidence rates of the different types of obstetric violence at the HCM.

## RESULTS

Based on the simulations performed and the observed functionalities, a set of components was identified that structures the system into interconnected functional modules, fostering greater efficiency in the clinical and administrative management of pregnant patients. The module for the registration and management of pregnant women is prominent among these components, which enables the comprehensive registration of the patient, classification by risk level (low, medium, or high), and immediate access to her medical history. This module incorporates real-time indicators, search filters, and organization capabilities based on criteria such as age, contact details, neighborhood, and weeks of gestation, offering professionals a consolidated overview of the entire population of pregnant women under their care.

The system also encompasses modules for prenatal consultations, examinations, and diagnostics, childbirth and postpartum care, health education, and clinical reports and indicators, and obstetric care experienced by the respondents. This simulation allowed for testing the performance of the system modules across various scenarios, evaluating navigation fluidity, the ease of data entry and editing, as well as the clarity of the presentation of clinical indicators.

During the simulation, fictitious pregnant patients with varying clinical profiles and risk classifications were registered, enabling the verification of the system's capacity to generate visual alerts, automatically update appointments, record requested exams, and present follow-up reports. The clinical records enabled the digital reconstruction of each patient's journey, reducing the need for physical forms and centralizing information in a secure electronic format.

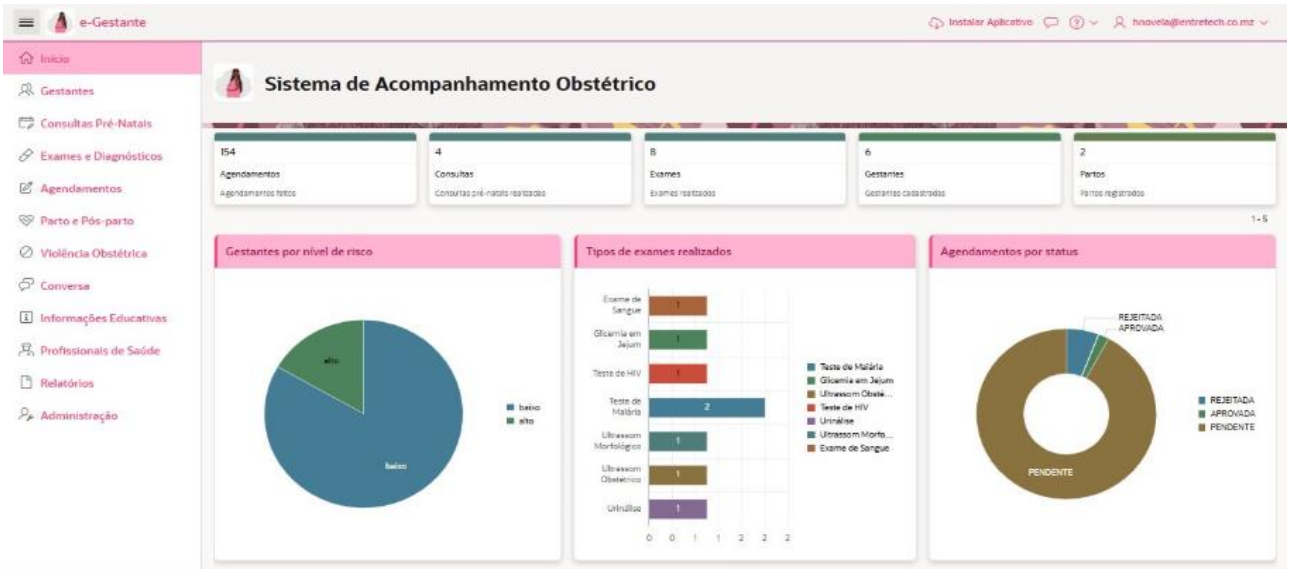
a component for automated notifications and reminders, a feature of particular importance for promoting adherence to scheduled appointments and examinations. Each of these modules fulfills a distinct yet interconnected functional role, ensuring a seamless flow of care from the initial contact through the postpartum period. A user-friendly interface, patient categorization, mandatory data fields, and a chronological record of clinical events constitute key elements of this technological solution, which directly addresses the challenges identified by healthcare professionals in the administered questionnaire. The system was designed with a focus on efficiency, speed, visual clarity, and integration among healthcare professionals, with the ultimate goal of enhancing the quality of obstetric care.

The pilot study sample consisted of 21 participants: five (5) healthcare professionals and sixteen (16) pregnant women. The e-Gestante system was developed with a focus on scalability and operational simplicity. Its development took into account common limitations found in peripheral health centers, such as a lack of continuous connectivity, a scarcity of computing equipment, and the need for professional training. During the development process, database structures were modeled, interfaces for data entry and visualization were created, a permission control system based on user type was structured, and the capability to generate customized reports was integrated. The technical construction was accompanied by the design of navigation flows that simulate a pregnant woman's journey through the healthcare service, from initial registration to obstetric outcome. Functional simulation of the e-Gestante system, conducted through practical exercises, replicated real-world scenarios of

The tests demonstrated that the system is functional, efficient, and offers considerable gains in information access time, continuity of obstetric care, and the generation of data relevant to hospital management. This stage proved crucial for validating the technical feasibility of the system and substantiating future recommendations for its implementation in a real-world setting.

Figure 1 represents the main screen, or dashboard, which serves as a central control panel, offering an aggregated overview of the system's most important information. Its objective is to provide healthcare professionals and administrators with quick access to vital statistics and trends.

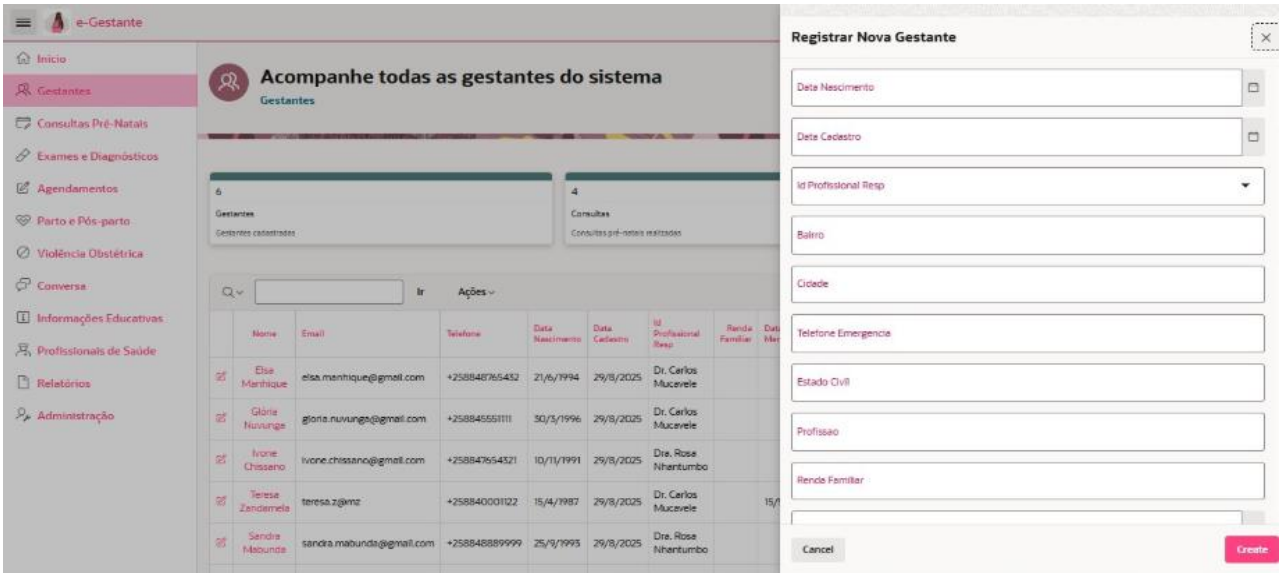
**Figure 1** – System Home Screen (Dashboard)




Source: created by the author.

Figure 2 shows the e-Gestante system module designed for the detailed viewing of the list of pregnant women already registered in the database. This section is dedicated to the comprehensive management of patients. The main screen lists all pregnant women registered in the system, while a modal form allows for the addition of new patients.

**Figure 2** – Registered Pregnant Women Screen




Source: created by the author.



DOI: 10.32443/2175-2990 (2025)504

One of the critical aspects addressed by the study was the identification and quantification of the types of obstetric violence experienced by pregnant women receiving care at the Maputo Central Hospital, as reflected in the questionnaire responses. The data indicated that 72.2% of the pregnant women reported limited support during childbirth, and 63.6% stated that they were not treated with courtesy by the nursing staff. Additionally, 68.8% of the pregnant women stated that they had heard of obstetric violence, and 25% declared having witnessed or experienced concrete situations at the HCM.

The negligence, verbal abuse, non-consensual procedures, and lack of respect identified by the participants correspond to the classic forms of obstetric mistreatment described by Bowser & Hill (2010) and reinforced by Freedman (2014).

Although the figures may reflect a limited scope, they confirm the presence of practices that must be eliminated from the care delivery process, a situation that raises ethical and clinical concerns regarding the quality of care provided. The absence of digital records for these episodes hinders the institutional handling of the problem.

The integration of a system such as e-Gestante could allow for the inclusion of fields for reporting complaints or evaluating care from the user's perspective, thereby fostering a culture of accountability and continuous improvement. This point underscores the importance of the system not merely as a clinical tool, but also as a mechanism for protecting the rights of pregnant women.

## DISCUSSION

The e-Gestante system was designed with a set of components aimed at comprehensively addressing the clinical and operational gaps at the HCM. The digital clinical record, automated appointment scheduling, clinical risk alerts, an integrated medical history, and, innovatively, a confidential channel for reporting obstetric violence are highlighted among its components. This proposal aligns with international initiatives such as SmartCare (Zambia) and MomConnect (South Africa), which have also prioritized the integration of clinical, educational, and communication functionalities [3,4]. However, unlike those systems, e-Gestante introduces an explicit mechanism to bring visibility to cases of obstetric violence, filling a gap often overlooked in digital maternal health solutions.

Regarding the confidentiality of reports of obstetric violence, the module was designed with layers of two-factor authentication and end-to-end encryption. Data entered by users is immediately encrypted and stored in an isolated table, accessible only to a limited number of system administrators upon formal justification and audit logging. Before being made public in aggregated reports, the data undergo an anonymization process that removes any direct identifiers (name, phone number, address) and indirect identifiers (date of birth, occupation), ensuring that no individual report can be traced back to its author.

The choice of a modular architecture developed in Oracle APEX also warrants examination. Authors such as Kimaro and Nhampossa [8] warn that overly rigid and complex systems are among the primary causes of digital transformation failure in Africa. The selection of a low-code platform proves to be a coherent choice, as it enables rapid prototyping, low costs, and greater operational simplicity. The modeling of the database and interfaces was directly inspired by the clinical protocols and administrative workflows of the HCM system, ranging from the registration of pregnant women to the recording of births and postpartum care.

It is crucial to explore the potential of e-Gestante to enhance the care to pregnant women, even though the study reinforces the technical aspects of the software's development in several respects. The system can improve care by enabling the standardized recording of clinical information, ensuring that no stage of prenatal care is overlooked; by generating automated risk alerts, assisting professionals in prioritizing critical cases; by delivering educational information directly to pregnant women, empowering them to recognize warning signs and demand respectful care; and by providing aggregated data for hospital management, facilitating the identification of patterns of obstetric violence and the implementation of corrective policies.

The simulation of the e-Gestante system at Maputo Central Hospital constituted a key moment for assessing its practical applicability. The results showed that 75% of the participants considered the system relevant for improving obstetric care, which confirms the importance attributed to the perception of utility. During the simulation, a significant reduction was observed in the time dedicated to manual record-keeping and searching for clinical information, allowing for greater availability for direct care activities, corroborating the findings of Fraser et al.[9].

The analysis of data regarding obstetric violence revealed alarming results: 72.2% of pregnant women reported limited support during childbirth, and 25% stated that they had experienced or witnessed instances of obstetric violence at the HCM. The negligence, verbal abuse, non-consensual procedures, and lack of respect cited by the participants correspond to the classic forms of obstetric mistreatment described by Bowser & Hill[6] and reinforced by Freedman [7]. These figures expose a structural problem that transcends the technical dimension, constituting a systematic violation of human rights.

When addressing pregnant women's interest in using the system, little mention was made throughout the study regarding their actual use of the software. Also, the need for access to smartphones and mobile data plans, prerequisites for using the software, was mentioned only when discussing the system's limitations. This identifies a critical constraint: a digital inclusion bias stemming from the premise of universal access to smartphones and mobile data plans, whereas the Mozambican reality is characterized by profound technological inequalities[10]. To address this challenge, it is necessary to move beyond a strictly digital perspective and adopt a multichannel architecture, such as the future integration of a complementary module via USSD (Unstructured Supplementary Service Data), a technology that enables access to essential information on any type of mobile phone, including the most basic models.

The simulation also showed challenges that temper the positive results. The need for continuous training, ongoing technical support, and resistance to change were identified as potential barriers. Here, the study aligns with the cautionary note from Nutley & Reynolds [11], who emphasize that technology, in and of itself, does not resolve structural problems; its effectiveness depends on an ecosystem of institutional support that includes committed leadership, investment in infrastructure, and digital capacity building.

## CONCLUSION

The e-Gestante system was developed as a modular system comprising a digital clinical record, automated scheduling, risk alerts, medical history, and a channel for reporting obstetric violence. The simulation at HCM confirmed its technical feasibility and demonstrated a high level of acceptance, with participants acknowledging its utility as a system for improving healthcare delivery. The data collected also revealed the occurrence of cases of obstetric violence, with 25% of participants stating that they had experienced or witnessed such situations, a finding that validates the relevance of the reporting module. The system demonstrated the capacity to identify cases of obstetric violence; however, while the tool offers a secure channel for reporting, the eradication of this phenomenon requires cultural and institutional changes that extend beyond technology.

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DOI: 10.32443/2175-2990 (2025)504

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**Statement of responsibility**: We declare that all authors participated in the construction, development, and preparation of the work.

**Funding**: There was no funding or source of financial support for this research.

**Conflict of interest**: The authors declare that there is no conflict of interest regarding the research, authorship, or publication of this article.

**How to cite this article**: Novela H, Miguel LLAJ. E-Gestante Obstetric Monitoring System Implemented at the Maputo Central Hospital (HCM), Mozambique. Latin Am J Telehealth. Belo Horizonte, 2025;12(2): 152-159.