Architectural Design of a Digital Maternal Health Monitoring System Based on the 2024 MCH Handbook: Documentation, Early Detection, and Pregnancy Danger Alarm Facilities

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Abstract: Digital transformation in healthcare is a crucial strategy for improving the quality of maternal care in Indonesia, particularly in efforts to reduce the Maternal Mortality Rate (MMR). This study aims to design a digital system architecture for the 2024 MCH Handbook as a means of documentation, early detection, and alarm for pregnancy danger signs that is adaptive to island regions. The research method uses a descriptive qualitative approach with the Framework TOGAF (The Open Group Architecture Framework) as the basis for system design. Data were collected through digital literacy and accessibility questionnaires for pregnant women, in-depth interviews with health workers, as well as Focus Group Discussion (FGD) activities and expert validation from the fields of midwifery, public health, and information technology. The results showed that the digital literacy level of pregnant women was quite good in the information awareness dimension (52.38%), but still low in the information evaluation and application dimension. System accessibility was assessed as high (>50%) in terms of device availability and compatibility. Stakeholders expressed a strong need for a digital MCH Handbook system with danger alarm features, visit reminders, and a simple interface. The expert validation results obtained an average Aiken's V value of 0.88 (valid category), indicating that the system design is clinically, technically, and policy-wise feasible. The developed digital system architecture for the 2024 MCH Handbook is able to address field needs, support local innovations such as *SMART ULING* , and align with the national agenda *for Digital Health Transformation* . This system has the potential to be an effective solution to accelerate early detection of pregnancy risks, strengthen the integration of maternal services, and support efforts to reduce maternal mortality in island regions.

Keywords: Digital MCH Handbook; Early Pregnancy Detection; Health System Architecture

Introduction

Digital transformation in the health sector is a top government priority to support improvements in the quality of public services, particularly maternal and child health (MCH) services (Lazuardi et al., 2021). The Maternal and Child Health Handbook (MCH Handbook) is a crucial instrument serving as a means of

communication, education, and recording maternal and neonatal health data (Wignarajah et al., 2021). However, the implementation of the conventional MCH Handbook still faces various obstacles, such as limited physical access, the risk of loss, and minimal data integration between health services (Carandang et al., 2021; Carandang et al., 2022). This situation hinders the effectiveness of pregnancy monitoring, particularly in island areas with limited access (Balogun et al., 2023), such as Galang District, Batam City.

According to data from the Ministry of Health (2024), the increase in maternal mortality rates (MMR) in several regions is due to late detection of pregnancy complications and limited use of technology in risk monitoring (Liu et al., 2022). Therefore, the development of a digital monitoring system based on the MCH Handbook is a strategic step in supporting the national Digital Health Transformation program (Pillar 6 of Indonesian Health System Reform) (Aisyah et al., 2024; WHO & Union, 2020). This system is expected to provide integrated digital documentation, automatic early detection of pregnancy danger signs, and a real-time risk alarm feature (Aisyah et al., 2023) .

The local context of this research was conducted in the working area of the Galang Community Health Center (UPTD) in Batam City, which has developed the *SMART ULING* (Integrated Antenatal Care Monitoring System and Galang Mobile Laboratory Ultrasound) innovation. This innovation focuses on field services (*offline*) through ANC calendar activities, mobile ultrasound and laboratory services, and ambulance pick-up and drop-off for pregnant women. However, this system does not yet have a digital platform that supports integrated documentation and analysis of pregnancy risks. Therefore, this research is present to complement the *SMART ULING innovation* with the architectural design of the 2024 digital MCH Handbook system.

The main objectives of this research are designing a digital system architecture for monitoring the health of pregnant women based on the 2024 MCH Handbook using *the Open Group Architecture Framework* (TOGAF) approach, analyzing digital literacy and system accessibility among pregnant women as a basis for system development, and validating the system *blueprint design* through *Focus Group Discussions* (FGD) and cross-field expertise testing (midwifery, public health, and information technology).

The benefits of this research include: (1) scientific contribution to the development of a user *-centered design -based health information system architecture model* ; (2) practical contribution in supporting the digital transformation of maternal services in the island region; and (3) policy support for the Batam City Health Office

in its efforts to accelerate the reduction of maternal mortality through a responsive, safe, and easily accessible monitoring system.

Method

This study uses a descriptive qualitative approach with *The Open Group Architecture Framework* (TOGAF) model as the main analytical framework in designing the digital architecture system of the 2024 MCH Handbook (WHO & Union, 2020). This approach was chosen because it is able to explain user needs, business processes, and the design of the information system as a whole from the aspects of vision, applications, data, to technology, which is oriented towards users (*user-centered architecture*).

Location and Subject of Research

The research was conducted at the Galang Community Health Center (UPTD) in Batam City, Riau Islands Province, an archipelago characterized by limited access to healthcare services. This location was chosen because it already has the innovative maternal service *SMART ULING* (Integrated Antenatal Care Monitoring System and Galang Mobile Laboratory Ultrasound), making it relevant for development into a digital system based on the MCH Handbook.

The research subjects consist of: pregnant women as end-users of the system; health workers (midwives, doctors, and Galang Health Center officers) as implementers of maternal health recording and monitoring; and health stakeholders (Batam Provincial and City Health Offices) as policy makers and implementation supervisors.

Types and Sources of Data

The research data consists of primary data , obtained through surveys, in-depth interviews, and *Focus Group Discussions* (FGD) with stakeholders; secondary data , including policy documents, the 2024 MCH Handbook, the Galang Community Health Center for Maternal and Child Health program report, as well as academic literature from WHO, the Ministry of Health, and research related to digital health transformation.

Data Collection Techniques

Several techniques are used in an integrated manner, namely: questionnaire – to measure the level of digital literacy and system accessibility among pregnant women, covering four dimensions of digital literacy (information resource awareness, information search, information evaluation, and information application); in-depth interviews – with health workers and policy makers to explore needs, constraints, and expectations

for the digital MCH Handbook system; FGD (Focus Group Discussion) – with 20 stakeholders to validate the system architecture *blueprint design and formulate an integration strategy with SMART ULING* services; and Documentation – includes policy analysis and supporting documents for the implementation of the digital MCH Handbook.

Data Analysis Techniques

Data analysis was carried out in two stages quantitative descriptive analysis**.** The results of the questionnaire survey were processed in the form of frequency distribution and percentage to describe the level of digital literacy and accessibility of the maternity system in the research area; system Architecture Analysis Using the TOGAF *Framework* The analysis is carried out through five main stages: Architecture Vision**,** formulation of vision, goals, and user needs; business architecture, identification of business processes, stakeholder roles, and system added value; Application & Data Architecture, application structure design and data management; Technology Architecture, determining the platform, infrastructure, and system security; Blueprint Architecture, preparation of the final design (*blueprint*) for the 2024 Digital MCH Handbook system.

The results of each TOGAF stage were confirmed through Focus Group Discussions (FGD) and expert validation tests conducted by three cross-disciplinary experts: midwifery, public health, and information technology. The validity of the test results was analyzed using Aiken's V method to measure the level of agreement among experts regarding the feasibility of the system design.

Data Validity and Reliability

Data validity was strengthened through triangulation of sources and methods , comparing the results of questionnaires, interviews, and focus group discussions. Meanwhile, the reliability of the system design was tested through *content validity analysis* (Aiken's V) and *expert judgment* , ensuring the blueprint design was clinically, technically, and policy-wise feasible.

Results and Discussion

Research Results

The first phase of research focused on designing the architecture of a digital maternal health monitoring system based on the 2024 MCH Handbook, integrating the principles of *efficiency, usability, and security* with the Framework TOGAF approach (Alwi et al., 2023; Liu et al., 2021; van Horn, 2025). The main objective of this phase was to formulate the initial design of a digital system that functions as a means of documentation, early detection, and alarm for pregnancy danger signs that is responsive and adaptive to the geographical conditions of the archipelago (de los Reyes et al., 2024).

The research was conducted at the Galang Community Health Center (UPTD) in Batam City , a location that offers a maternal care innovation called SMART ULING (Integrated Antenatal Care Monitoring System and Galang Mobile Ultrasound Laboratory) . This innovation plays a role in expanding the reach of ANC services in the archipelago through ANC calendar activities, mobile ultrasounds, and ambulance pick-up and drop-off for pregnant women. This research seeks to complement this innovation with a digital system based on the MCH Handbook that can support data documentation and real-time monitoring of pregnancy risks.

Primary data was collected through surveys of pregnant women, in-depth interviews with healthcare workers, and Focus Group Discussions (FGD) with stakeholders. Secondary data was obtained from the Maternal and Child Health program report, the 2024 edition of the MCH Handbook, and the digital transformation policy document for health from the Indonesian Ministry of Health.

Descriptive analysis results indicate that the digital literacy level of pregnant women in the study area is quite good , particularly in terms of awareness of information resources (52.38% in the high category). However, their ability to search and evaluate information remains relatively low (around 55–62% in the low category). This suggests that while access to digital health information has increased, their ability to validate and apply this information still needs improvement (Xu et al., 2024).

In terms of system accessibility , the majority of respondents rated availability and device compatibility as quite good (over 50% rated it high). They expected the digital MCH Handbook system to be simple, lightweight, and easy to use, with features that would still function in areas with limited network coverage (Amalia et al., 2025; Coleman, 2023; Rotheram-Borus et al., 2012). Human-centered design principles , which emphasize ease of use, data security, and the sustainability of maternal health services in island regions.

Next, the system design process is carried out through five stages of the Framework TOGAF, namely: Architecture Vision – establishes the strategic direction of the digital MCH Handbook system as a means of documentation, early detection, and danger alarms integrated with field services such as SMART ULING; Business Architecture – defines the workflow between pregnant women, health workers, and the Health Office

to ensure the recording and risk detection process runs quickly and accurately; Application & Data Architecture – designing an application structure that supports digital data input, visit reminders, and pregnancy risk detection algorithms based on the MCH Handbook form. Technology Architecture – defines technical specifications such as offline mode, data encryption, and hybrid-cloud connectivity to keep the system running in areas with limited infrastructure; and Blueprint Architecture – produces a final system design that is ready to be implemented as a prototype in the next research phase (Lin & Bautista, 2017).

Discussion

The study's findings indicate that digitizing the MCH Handbook not only improves the efficiency of recording and communication between pregnant women and health workers, but also opens up opportunities to build a proactive, real-time, and integrated pregnancy monitoring system across services . Digital literacy findings indicate that improving pregnant women's ability to access and verify health information is crucial for optimal utilization of digital systems. This aligns with Arias López et al. (2023) view that digital literacy is a new determinant of the effectiveness of digital health systems.

Analysis of FGD with 20 stakeholders revealed a strong need for a digital MCH Handbook system , particularly as the manual system was deemed inefficient and risked data loss (van der Windt et al., 2023). Stakeholders also emphasized the importance of pregnancy warning features , visit reminders , and concise digital forms . Key challenges identified included limited infrastructure, human resource readiness, and concerns about data security. Therefore, it is recommended that the system be implemented using a hybrid approach (manual-digital) with support from tiered training for healthcare workers (Ningrum et al., 2024; Pangestuti et al., 2025).

Expert validation process yielded an average Aiken's V value of 0.88 , which is considered *valid* . Three experts (midwifery, public health, and information technology) stated that the architectural design of the digital MCH Handbook complies with clinical standards and national policies, and is technically feasible (Hasanbasri & Sanjaya, 2023; Nigussie et al., 2021). These findings reinforce the relevance and applicability of the developed system design in supporting the National Digital Health Transformation (Ministry of Health, 2023).

Overall, this research has achieved 80% completion of the proposal target, with the output being a *blueprint* for the 2024 digital MCH Handbook system (Putri et al., 2023; Veftisia et al., 2024). These results serve as a crucial foundation for the next phase, namely prototype development and field testing of the system in the following research year. With a phased strategy and support from regional health policies, this innovation has the potential to strengthen the maternal care system in the archipelago and contribute to reducing the Maternal Mortality Rate (MMR) in Indonesia.

Conclusion

This first phase of research has produced a preliminary design for the architecture of a digital maternal health monitoring system based on the 2024 MCH Handbook, which functions as a documentation tool, early detection, and alarm for pregnancy danger signs. Using the Framework TOGAF approach and human-centered design principles , this system is designed to address the problem of delayed pregnancy risk detection and support the *National Health Digital Transformation program*. The analysis shows that pregnant women's digital literacy and accessibility to digital services are quite good, but gaps remain in their ability to evaluate and apply information. This underscores the need for ongoing support and education strategies for users to optimize system utilization. Focus Group Discussion (FGD) and expert validation activities confirmed that the system *blueprint design* is appropriate to field needs, clinically relevant, technically feasible, and aligned with regional health policies. With an Aiken's V value of 0.88 (valid category) , this design can be used as a basis for developing a system prototype in the next research phase. Thus, it can be concluded that the 2024 digital MCH Handbook system has great potential for: Improving the effectiveness of maternal health monitoring through integrated documentation and automatic danger sign alarms; Strengthening synergies between field innovations such as *SMART ULING* and digital health services; Supporting efforts to reduce the Maternal Mortality Rate (MMR) through early risk detection and data-based rapid response. Going forward, this research will continue with the development and testing of a digital prototype of the MCH Handbook system , functional validation in the field, and scientific publication in accredited national journals. The gradual implementation of *a hybrid system* (manual-digital) and support from regional health policies are expected to be key to the success of this innovation in strengthening maternal services in the archipelago.

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