Medicor : Journal of Health Informatics and Health Policy
E-ISSN : 3030-9166
Volume. 3 Issue 4 October 2025
Page No: 260-272

Reengineered DHIS 2 to Capture Maternal and Child Data at Point of Service for Prompt Intelligent Decision Making and Data Visualisation: A Case of Kiambu County

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Received : September 23, 2025
Accepted : October 23, 2025
Published : October 30, 2025

Citation: Waiganjo, S, N,. Wafula, J, M., & Karanja, S. (2025). Reengineered DHIS 2 to Capture Maternal and Child Data at Point of Service for Prompt Intelligent Decision Making and Data Visualisation: A Case of Kiambu County. Medicor : Journal of Health Informatics and Health Policy, 3(4), 260-272. https://doi.org/10.61978/medicor.v3i4

ABSTRACT: Reengineering of health information systems (HIS) involves restructuring system functionality to improve efficiency, usability, and reliability for rapid, evidence-based decision-making. This study presents a reengineered District Health Information Software 2 (DHIS2) prototype designed to capture maternal and child health (MCH) data at the point of service in Kiambu County, Kenya. By integrating key measures of data quality – namely completeness, timeliness, accuracy, and consistency – the prototype aligns with the four Vs of big data. A cross-sectional study involving 23 health facilities used questionnaires, interviews, and desk research to assess existing data management processes. Findings revealed heavy reliance on manual registers, resulting in duplicated entries, incomplete records, and delayed reporting. The reengineered DHIS2 prototype automated these processes, enabling real-time data capture and improved tracking of maternal and child health indicators. Testing at a pilot facility demonstrated improved attendance tracking, reduced data entry errors, and real-time dashboard and GIS analytics supporting decisions on ANC follow-up, HIV prevention, and maternal delivery outcomes. The number of mothers served per day increased from an average of 60–100 to 120–150, while reporting timeliness improved from 20% to over 95%. This study highlights the potential of customizing DHIS2 to strengthen maternal and child health data systems in resource-limited settings, offering a cost-effective alternative to proprietary electronic health records.

Keywords: Reengineered DHIS2, Maternal and Child Health, Data Quality, Big Data, Kiambu County.

INTRODUCTION

Reliable maternal and child health (MCH) data are essential for informed decision-making and improved health outcomes in low- and middle-income countries (Lasim et al., 2022);(Rambo et al., 2024). However, many health facilities in Kenya continue to depend on paper-based registers for antenatal care (ANC), maternity, postnatal care (PNC), and child welfare clinics (CWC) (Wittenauer et al., 2023). These manual systems are prone to errors, incomplete records, and delays

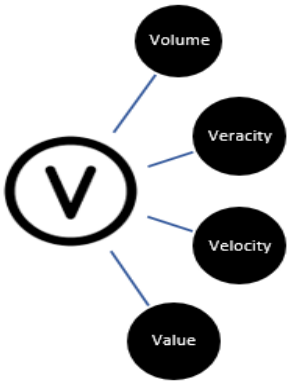
in reporting, undermining the quality and usability of the data for timely interventions (Das, S., Radovich, E., Karki, S., 2023).

Reengineering in health information systems (HIS) is defined as restructuring existing systems to enhance their efficiency, usability, and reliability for evidence-based decision-making (Orhan, 2021). District Health Information Software 2 (DHIS2) is widely used across sub-Saharan Africa for routine health data reporting (Byrne & Sæbø, 2022) but is often under-utilised for real-time data capture and analysis (Farnham et al., 2023); (Rahman et al., 2022); (Dehnavieh, 2018)(Moradzadeh et al., 2023). In Kenya, routine MCH data remain inconsistent and variably complete. A nationwide evaluation using composite KHIS scores found a mean completeness score of 61.1% (SD 27.0) across facility-quarters, while consistency scored higher (mean 80.0%, SD 16.4), indicating important gaps in the completeness dimension of electronic reporting(Odeny et al., 2023). Earlier facility audits reported monthly report completeness of 86.9% and timeliness of 78.7% (Manya & Nielsen, 2017); (Lasim et al., 2022). These studies suggest that despite some strengths, persistent gaps in completeness and timely reporting constrain real-time decision-making for MCH services in Kenya. These weaknesses contribute to poor tracking of antenatal attendance and high maternal mortality 355 per 100,000 live births;(Kenya National Bureau of Statistics & ICF, 2022);(WHO, 2023)

Similarly, previous studies have demonstrated the successful customization of DHIS2 for diverse health programs. For example, Ghana's eTracker monitors HIV/ART treatments and immunizations (Asah et al., 2020), while Botswana's nutrition tracker supports growth monitoring and vaccination coverage (United Nations Children's Fund, 2020). Unlike these contexts, Kenya's DHIS2 largely supports aggregate reporting with limited patient-level functionality, creating data fragmentation and delayed decision-making (Oware et al., 2025); (Grif & Pabon-rodriguez, 2025); (Zerfu et al., 2025), Customising DHIS2 for maternal and child health therefore presents a practical opportunity to streamline data capture, reduce duplication, and improve timeliness and accuracy of reporting.

This study describes the development and testing of a reengineered DHIS2 prototype tailored for MCH data capture in Kiambu County. The prototype was designed to replace manual registers with a web-based system, enabling real-time entry of maternal and child data at the point of care. By improving data completeness, timeliness, accuracy, and consistency, the reengineered DHIS2 aims to enhance decision-making and service delivery for mothers and children.

Figure 1. 4 Vs



METHOD

Study Design and Setting

This study was conducted in two phases to evaluate and improve maternal and child health (MCH) data management in Kiambu County, Kenya. Phase 1 assessed existing data capture and reporting processes, while Phase 2 involved the development and pilot testing of a reengineered DHIS2 prototype. Kiambu County, with a population of approximately 2.4 million and 23 MCH facilities across level 4 and 5 hospitals (County Goverment Of Kiambu, 2023)(County Goverment Of Kiambu, 2024) was selected due to its robust ICT infrastructure and accessibility.

Phase 1: Assessment of Current Data Management Practices

A cross-sectional survey was carried out between November 2017 and January 2018 across 23 health facilities. Data were collected using a combination of quantitative and qualitative methods, including structured questionnaires, interviews, and desk reviews of maternal and child health registers (Abutabenjeh, 2018).

Sub-county Health Records and Information Officers (HRIOs) and nurses in charge of MCH services were purposively sampled. HRIOs were included because they are responsible for aggregating and entering facility-level data into DHIS2. Nurses were selected because they directly serve mothers and children, record data in manual registers, and compile summary forms for reporting. In total, 23 participants (11 HRIOs and 12 nurses) completed the survey.

Desk research was conducted to review the registers used in maternal and child health services (e.g., MOH 405 for ANC, MOH 406 for PNC, MOH 333 for maternity, MOH 204A for children under five, and MOH 511 for child welfare clinics). These reviews informed the identification of redundant data fields, inconsistencies, and opportunities for system improvement.

Phase 2: Development and Pilot Testing of the Reengineered DHIS2 Prototype

Based on the findings from Phase 1, a reengineered DHIS2 prototype was developed to capture MCH data at the point of care. Fields from the manual registers were harmonized, and redundant attributes were eliminated through data mapping that aligned all registers into a unified database schema in DHIS2. Common data fields and primary keys were established to ensure consistency

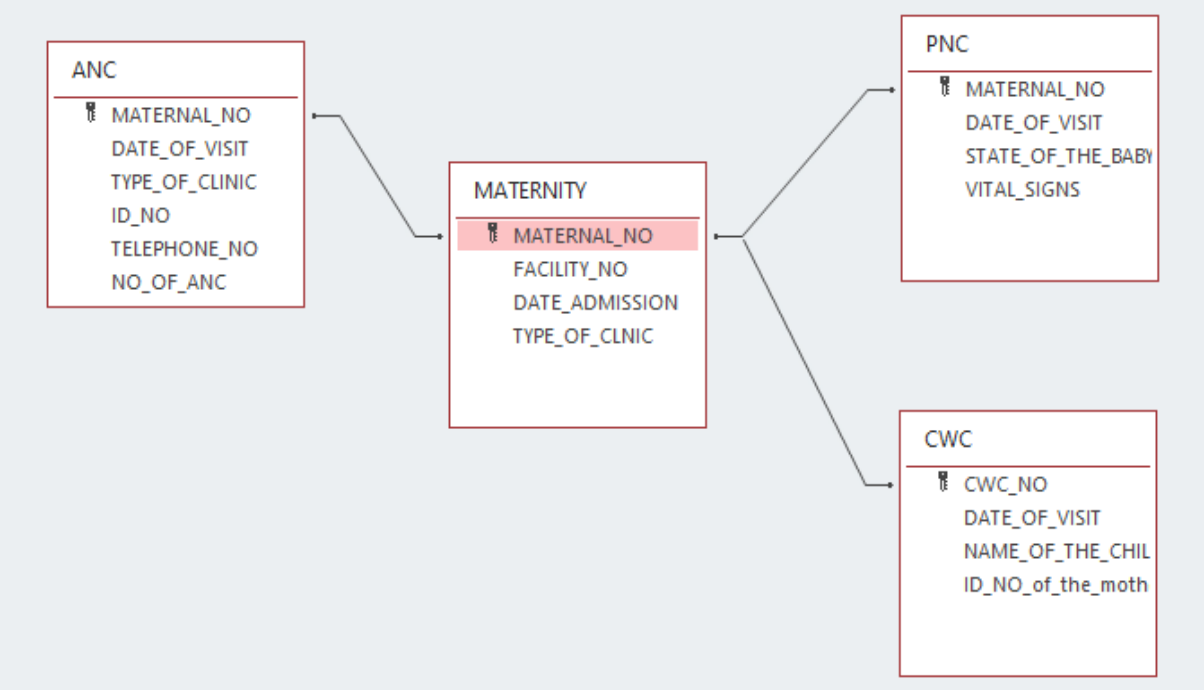
and prevent duplication. The DHIS2 program module was customized to include maternal and child attributes guided by the reviewed registers.

A user interface was created to allow nurses to log into the system and select the appropriate service (maternal or child) being provided. Returning clients could be retrieved using a unique maternal number or child welfare clinic (CWC) number, while first-time clients were registered directly into the system.

Pilot testing was conducted over a three-month period (February–April 2018) in one Level 4 facility in Kiambu County. Six nurses and one Health Records and Information Officer (HRIO) participated in daily use of the prototype, capturing approximately 350 maternal and 210 child records. The system was hosted on a local Ubuntu LTS 22.04, server running DHIS2 version 2.29 with a PostgreSQL 9.6 database and Tomcat 7 web server. Access was via desktop computers connected to the hospital's local area network.

The pilot phase focused on evaluating system usability, data quality, and reporting timeliness. User feedback was collected through observation and short debrief interviews after routine service sessions. Figure 2 presents the data flow within the reengineered DHIS2, showing how client-level data entered at the point of care were validated, stored in the central database, and aggregated for analytics and reporting.

Figure 2: Relationships and fields



Pilot Testing

The prototype was piloted in one of the participating facilities. Nurses entered MCH data directly into the system during routine service delivery. Feedback was collected through semi-structured

interviews and observation to assess usability, data accuracy, and the potential impact on workflow efficiency.

Data Analysis

Quantitative data from Phase 1 were summarized using descriptive statistics to identify common gaps in completeness, timeliness, and accuracy. Qualitative feedback from nurses and HRIOs was analyzed thematically to highlight operational challenges and opportunities for improvement. Findings from both phases informed refinements to the prototype.

Ethical Considerations

Ethical approval for this study was obtained from the appropriate county and facility authorities. All participants provided informed consent prior to participation. No personal identifiers were collected, and data confidentiality was maintained throughout the study.

RESULT AND DISCUSSION

Reliance on Manual Registers.

All respondents (100%) reported that maternal and child health (MCH) data in Kiambu County were recorded manually using paper-based registers. Specific registers included MOH 405 for antenatal care (ANC), MOH 406 for postnatal care (PNC), MOH 333 for maternity, and MOH 511 for child welfare clinics. Nurses reported that repetitive entries such as names and dates of birth were required across multiple registers, increasing the risk of transcription errors and inconsistencies.

Figure 3: Sample CWC fields from MOH registers

Village/Estate	Weight in Kg
Age	Weight categories
Marital status (Codes 1-5)	Height in centimeters
Parity	Stunted: (1= Stunted; 2= Sev. Stunted)
	MUAC-Mid Uppper Arm Circumference
Gravidae	Vit A Supplementation (6-59 months) (Y/N)
Date of Last Menstrual Period (LMP)	Dewormed (Y/N)
Expected Date of Delivery (EDD)	Exclusive Breastfeeding (0-6 months) (Y/N)
Gestation at Birth (Weeks)	Any Danger signs this visit
Diagnosis	Any Disability
	Type of Follow-up

Fields in MOH 333 **Fields in MOH 511**

Challenges with Identifiers and Data Consistency

Mothers attending ANC were assigned unique identifiers formatted as YYYY/MM/XXXX. However, tracing mothers across visits or facilities was difficult, particularly when they changed service locations. Similar inconsistencies were observed for PNC identifiers and maternity admission numbers, which were not standardized across facilities. Table 1 summarizes observed gaps in data quality.

Table 1. Data quality assessment of sampled records (n=10 per subcounty)

Component	Average (%)	Key Issues Identified	Example(s)
Completeness	80	Non-mandatory fields often left blank	Location or village/estate
Consistency	78	Variation in date formats	15/02/2018 vs. 15th Feb 2018
Accuracy	86	Estimated ages and inconsistent spellings	"Hanah" vs. "Hannah"
Timeliness	20	Late submission of aggregated reports	Records submitted after 5th

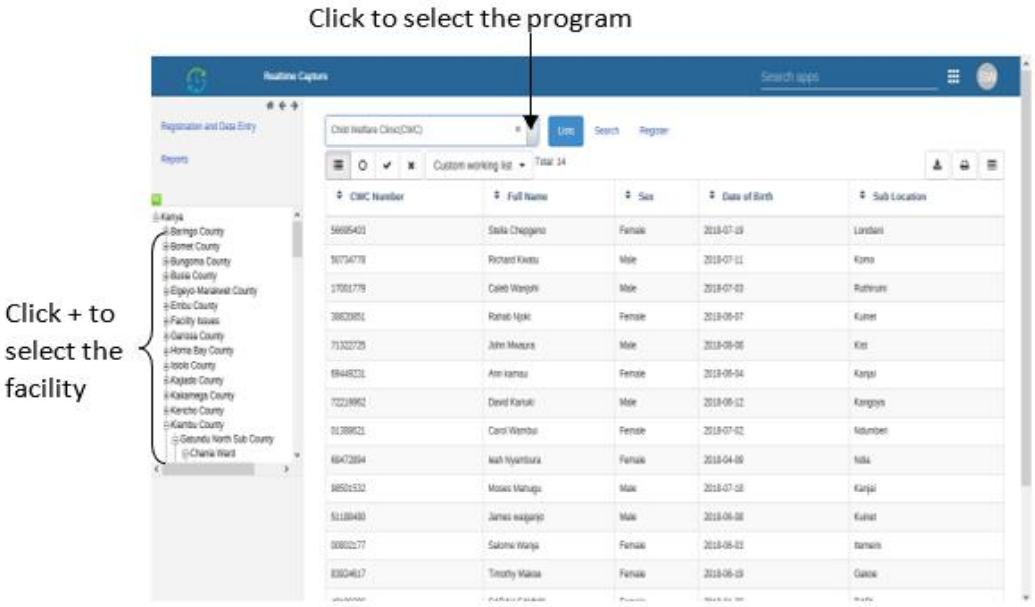
Data Aggregation Process

At the end of each day, nurses tallied service data on summary sheets. Aggregated monthly data were submitted to sub-county HRIOs by the 5th of the following month for entry into DHIS2. This process often resulted in delayed availability of data for decision-making.

Reengineered DHIS2 Prototype Functionality

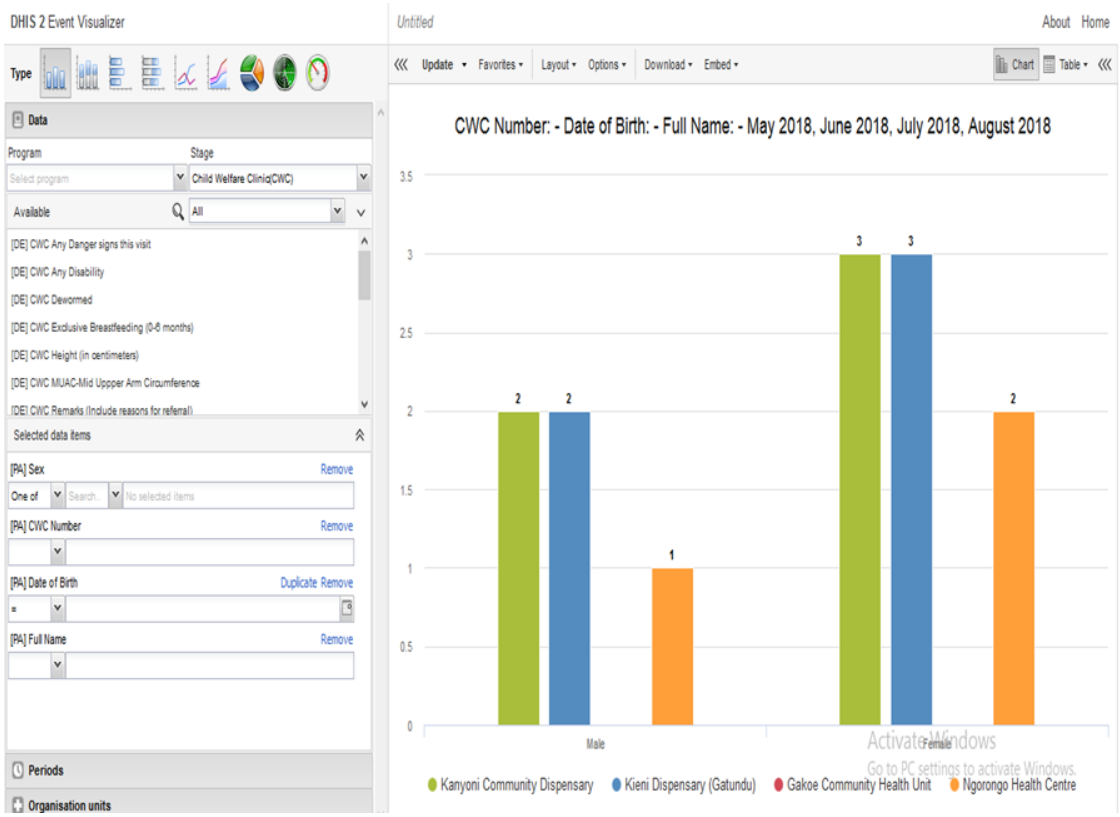
The reengineered DHIS2 prototype addressed key data management challenges by enabling real-time entry of maternal and child records at the point of service. Compared to manual registers, the system reduced transcription errors and allowed retrieval of patient histories across ANC, maternity, and PNC through a unified maternal number (MNo).

Data validation rules and automated field checks improved record completeness from 80 % to >95 %, consistency from 78 % to >90 %, and accuracy from 86 % to 95 %. Nurses reported faster record retrieval (average <30 seconds per client) and fewer duplicate entries. These outcomes demonstrate that the system's harmonized data structure enhanced accuracy and usability without the repetitive manual entry previously required.



The data analytics

Figure 4: Comparison between the manual and reengineered DHIS 2 processes



While Figure 4 illustrates the overall workflow differences between the manual and reengineered DHIS2 processes, specific improvements in how mothers and children are identified across services are summarized in Table 2.

Table 2: Comparison of identifier formats in manual and reengineered DHIS2 systems

Service Stage	Manual Identifier Format	Reengineered Identifier Format	Observed Issues	Solution/Improvement
Antenatal Care (ANC)	YYYY-MM-XXXX	MaternalNo (FacilityID/ID-BCNo-YYYY-MM-XXXX)	Difficult to differentiate mothers across facilities	Added Facility ID and ID/BC number to ensure uniqueness.
Maternity	Admission No. (YYYY-MM-XXXX)	MaternalNo (linked to ANC record)	Tracking mothers during delivery was inconsistent	Single number links maternity to ANC data.
Postnatal Care (PNC)	PNC No. (YYYY-MM-XXXX)	MaternalNo (same as ANC/Maternity)	Mothers received multiple identifiers for each birth	One identifier used across ANC, Maternity, and PNC visits.

Improved Data Volume and Timeliness

Pilot testing revealed that the number of mothers served per day increased from an average of 60 -100 to 120- 150, effectively doubling service throughput due to reduced time spent on repetitive data entry. Reporting timeliness improved from 20% under the manual system to over 95% with the reengineered DHIS2, as data were captured and transmitted in real time. The system also provided immediate analytics on ANC attendance trends, HIV testing outcomes, and delivery locations, supporting prompt evidence-based decision-making.

Example Analytics from the Prototype

The reengineered system generated automated statistics, such as:

- ANC attendance: 31% of mothers completed all four recommended ANC visits, while most attended only two: at early pregnancy and shortly before delivery.
- HIV testing trends: Several mothers who tested HIV-negative during their first ANC visit tested positive at later visits.
- Facility deliveries: Approximately 75% of mothers delivered in health facilities, particularly first-time mothers.

Summary of Key Findings

This study demonstrated that reengineering DHIS2 to capture maternal and child health (MCH) data at the point of service can significantly improve data quality, timeliness, and usability in resource-limited settings. Manual registers in Kiambu County were found to be error-prone, repetitive, and inefficient, contributing to delayed reporting and reduced reliability of health

information. A recent nationwide evaluation in Kenya (Odeny et al., 2023) found substantial variation in completeness and consistency of DHIS2 data, underscoring the need for validation rules and structured identifiers. The reengineered DHIS2 prototype addressed these limitations by harmonizing data fields, introducing unique identifiers, and enabling real-time entry of maternal and child records. These findings align with previous research highlighting the challenges of manual health information systems in sub-Saharan Africa (Orhan, 2021);(Manya & Nielsen, 2017);(Farnham et al., 2023). Similar efforts to customize DHIS2 for specific health programs, such as Ghana's eTracker for HIV/ART treatment monitoring (Rahman et al., 2022) and Botswana's nutrition tracker for growth monitoring(Asah et al., 2020), have demonstrated improved accuracy and accessibility of routine health data. Our results suggest that similar customizations for maternal and child health are both feasible and effective in the Kenyan context (Penumetsa et al., 2020).

Implications for Maternal and Child Health Services

Improved timeliness and accuracy of MCH data support evidence-based decision-making at both facility and county levels. For example, the prototype's automated analytics identified gaps in ANC attendance and revealed cases where HIV status changed during pregnancy, which are critical insights for strengthening prevention of mother-to-child transmission programs (Ministry of Health Republic of Kenya, 2020); (Penumetsa et al., 2020). Additionally, the increased data volume and reduced duplication improved workflow efficiency, allowing nurses to serve more mothers and children per day. This aligns with recent evidence from Kenya showing that routine DHIS2-based indicators can reveal county-level inequalities in RMCH services and help target interventions((Kariuki et al., 2016); Karimi et al., 2025)

Unlike previous DHIS2 customizations such as Ghana's eTracker (Asah et al., 2020), or Botswana's nutrition tracker dedicated to growth monitoring (Ministry of Health and Wellness Republic of Botswana., 2020) the reengineered DHIS2 prototype developed in this study integrated both maternal and child health data within a single program module. This integration, supported by a unified maternal identifier, enabled seamless continuity of care across antenatal, maternity, and postnatal services(Meidani et al., 2022). Furthermore, unlike most existing DHIS2 implementations that depend on aggregated monthly uploads, the prototype facilitated real-time, point-of-service data entry and automated analytics, including detection of changes in HIV status and ANC attendance trends (Rahman et al., 2022). These features collectively represent a novel contribution to DHIS2 customization in Kenya by demonstrating how routine MCH data can be transformed from static reports into dynamic decision-support tools.

In terms of scalability, three main challenges were identified. First, infrastructure limitations – particularly inconsistent internet connectivity and outdated hardware in some facilities – may hinder real-time synchronization. Second, human resource capacity is of concern; while nurses and HRIOs adapted well during pilot testing, broader rollout would require structured digital literacy training and user support mechanisms. Third, financial sustainability must be considered, as maintaining local servers and upgrading DHIS2 versions incur recurrent costs. Addressing these

challenges through phased implementation, integration with national KHIS infrastructure, and targeted capacity-building would be essential for sustainable scale-up(Hagel et al., 2020).

Addressing the Four Vs of Big Data

The reengineered DHIS2 prototype responded effectively to the four Vs of big data – volume, velocity, veracity, and value (Sylla & Diallo, 2024). In this context, data volume refers to the increased quantity of maternal and child records captured per day, as the system enabled real-time entry for 120–150 clients compared to 60–100 using manual registers. Velocity was reflected in the improved speed of data capture and transmission, with reporting timeliness increasing from 20% to over 70%. Veracity improved through built-in validation rules and standardized identifiers that reduced duplication and data-entry errors, while value was enhanced through automated analytics supporting evidence-based decisions on ANC attendance, HIV testing, and delivery outcomes. These improvements are consistent with recommendations for strengthening health information systems in low-resource settings (United Nations Children's Fund, 2020)(Oware et al., 2025);(Teklegiorgis et al., 2016).

Strengths and Limitations

A key strength of this study was its participatory approach, involving both HRIOs and frontline nurses in the design and testing of the prototype. This ensured that the solution addressed real-world challenges in MCH data management. However, the study was limited by its pilot implementation in a single facility, which may not capture variations across different service contexts. Additionally, some figures could not be evaluated due to quality issues in the original registers. Future work should include multi-site pilots, integration with national systems, and evaluation of long-term impacts on maternal and child health outcomes.

Recommendations for Future Research and Practice

Further research should explore scaling the reengineered DHIS2 across multiple counties and service levels, as well as assessing cost-effectiveness compared to proprietary electronic health record systems. Training and capacity-building for healthcare workers will be essential to ensure sustainable adoption. Policymakers should also consider aligning DHIS2 customizations with national health strategies to avoid fragmentation and ensure interoperability.

CONCLUSION

The reengineered DHIS2 prototype demonstrated that maternal and child health (MCH) data can be captured accurately, consistently, and in real time at the point of service. By harmonizing data fields, automating repetitive entries, and introducing standardized identifiers, the system addressed

key weaknesses of manual registers; namely incomplete records, delayed reporting, and difficulties in tracking mothers and children across services.

Pilot testing in Kiambu County showed that the prototype improved workflow efficiency, doubled the number of mothers served per day, and generated timely analytics for decision-making. These results highlight the potential of leveraging existing DHIS2 infrastructure to strengthen health information systems in resource-constrained settings, offering a cost-effective alternative to proprietary electronic health record solutions. Policymakers should thus consider adopting customized DHIS2 modules nationwide to strengthen real-time MCH monitoring.

To maximize impact, future implementations should include wider testing across multiple facilities, integration with national health strategies, and comprehensive training for health workers. Adoption of customized DHIS2 solutions in the country of Kenya, could enhance evidence-based planning and service delivery (Odeny et al., 2023), ultimately contributing to improved maternal and child health outcomes.

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