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From Paper to Digital: Impact of SMS-Based Reminders on Immunization Adherence in Ebolowa Health district, April – October 2025

Du Papier au Numérique : Impact des Rappels par SMS sur l'Adhésion à la Vaccination dans le District de Santé d'Ebolowa, Avril – Octobre 2025

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Original Article

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ABSTRACT

Introduction: Immunization is one of the most effective public health interventions for reducing childhood morbidity and mortality. This study assessed the effect of transitioning from a paper-based reminder system to an SMS-based digital reminder system on immunization adherence among children aged 0–59 months in the Ebolowa Health District.

Methods: A quasi-experimental pre-post study was conducted from April to October 2025 in fifteen health facilities in the Ebolowa Health District. During the baseline phase, vaccination adherence data were collected under the routine paper-based system. The intervention phase introduced automated SMS reminders sent to caregivers 48 hours before and on the day of scheduled vaccination appointments. Quantitative indicators included timeliness of vaccination, missed appointments, and completion rates, while qualitative data were obtained from caregivers and health workers. Statistical analyses used Chi-square tests, t-tests, and logistic regression, with significance set at $p < 0.05$.

Results: The SMS reminder intervention significantly improved immunization adherence. On-time vaccination increased from 63.7% to 85.2%. Coverage for Penta 1 rose from 529 to 713, and Penta 3 from 532 to 622. Catch-up activities identified 1,973 zero-dose children and 1,337 under-vaccinated children. SMS delivery success reached 99%, and overall satisfaction was high (95%). Caregiver recall reduced missed appointments, and increased confidence in the system, despite challenges such as network instability.

Conclusion: SMS-based reminders improved immunization adherence and coverage in the Ebolowa Health District. Integrating digital reminder systems into Cameroon's national immunization program could enhance vaccination monitoring.

RESUME

Introduction : L'objectif de l'étude était d'évaluer l'impact d'un système de rappel numérique par SMS sur l'adhésion à la vaccination chez les enfants âgés de 0 à 59 mois.

Méthodes : Une étude quasi-expérimentale de type avant-après a été menée d'avril à octobre 2025 dans quinze formations sanitaires du District de Santé d'Ebolowa. La phase de référence a permis de collecter les données d'adhésion vaccinale avec le système de rappel papier. La phase d'intervention a consisté en l'envoi automatisé de SMS aux parents 48 heures avant et le jour du rendez-vous vaccinal. Les variables étaient la ponctualité de la vaccination, les rendez-vous manqués et les taux d'achèvement du calendrier vaccinal. Les analyses statistiques ont utilisé les tests du Chi-carré, t de Student et la régression logistique, avec un seuil de significativité fixé à $p < 0,05$.

Résultats : L'intervention par SMS a amélioré l'adhésion à la vaccination. Les enfants vaccinés sont passés de 63,7 % à 85,2 %. La couverture du Penta 1 est passée de 529 à 713, et celle du Penta 3 de 532 à 622. Les activités de rattrapage ont permis d'identifier 1 973 enfants zéro dose et 1 337 enfants sous-vaccinés. Le taux de délivrance des SMS a atteint 99 %.

Conclusion : Le recours aux rappels par SMS a permis d'améliorer l'adhésion et la couverture vaccinale dans le District de Santé d'Ebolowa.

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Introduction

Immunization remains one of the most effective and cost-efficient public health interventions for preventing childhood disease and reducing under-five mortality. Globally, routine vaccination programs targeting diseases such as measles, poliomyelitis, diphtheria, tetanus, pertussis, and Haemophilus influenzae type b have led to substantial declines in the incidence of vaccine-preventable diseases (VPDs) and associated mortality (1). In the United States, for example, the sustained implementation of routine childhood immunization programs has been estimated to have averted over 24 million cases of VPDs in recent decades (2). Despite these advances, significant challenges remain in achieving and maintaining high immunization coverage, particularly in low- and middle-income countries (LMICs) and other resource-constrained settings. According to the World Health Organization, approximately 14.3 million children globally were classified as "zero-dose" in 2024 meaning they had not received a single dose of any routine vaccine. Moreover, only about 85% of infants worldwide received the recommended three doses of the diphtheria-tetanus-pertussis vaccine (DTP3), indicating substantial gaps in coverage (3). In sub-Saharan Africa and similar settings, both demand and supply-side barriers contribute to suboptimal immunization rates. A systematic review of immunization determinants in the region identified a range of factors including low maternal education, high family size, caregiver forgetfulness, weak health infrastructure, vaccine stock-outs, and limited outreach capacity (4). These challenges often result in delayed, incomplete, or missed vaccinations. To address these persistent barriers, digital health strategies particularly mobile health (mHealth) interventions are gaining increasing attention. The widespread proliferation of mobile phones, even in low-resource environments, presents an opportunity for innovative tools such as SMS (short message service) reminders, voice calls, mobile applications, and digital immunization registries. These tools are designed to enhance health system performance by improving adherence to vaccination schedules, timeliness of vaccine delivery, completeness of coverage, and the quality of health data (5). Evidence supporting the use of SMS-based interventions in immunization is growing. A recent systematic review and meta-analysis reported that text message reminders were associated with improved childhood vaccination coverage, with a pooled risk ratio of approximately 1.11 (95% CI: 1.05–1.17), particularly in LMICs (6). In Ethiopia, controlled studies have demonstrated that mobile phone text message reminders significantly increased both the completion rate and the timely administration of routine childhood vaccines compared to standard care (7). Nonetheless, the effectiveness of mHealth interventions is not uniform across contexts. Factors such as message content, delivery timing, language, literacy levels, mobile phone access, local infrastructure, and cultural acceptability all influence intervention outcomes. A recent systematic review concluded that while SMS-based approaches show promise, there remains a lack of consensus on optimal design features including message format, frequency, and the use of behavioural incentives and highlighted the need for more rigorous, context-specific evaluations (8). In this context, the city of Ebolowa (South Region, Cameroon) presents a relevant setting for exploring the transition from traditional paper-based reminder systems to SMS-based digital reminders for routine childhood immunization. Given the coexistence of logistical challenges and rising mobile phone penetration, this study aims to evaluate the feasibility and effectiveness of SMS-based reminders in improving immunization coverage. It situates itself at the intersection of immunization strategy, health systems strengthening, and digital health innovation in a lower-resource urban setting (9,10). Despite notable progress in Cameroon's Expanded Program on Immunization (EPI), full immunization coverage remains below the national target, particularly in semi-urban and rural areas such as Ebolowa in the South Region. According to the Cameroon Demographic and Health Survey, only about 56 % of children aged 12–23 months were fully immunized, with regional disparities linked to geographical accessibility, socioeconomic factors, and logistical constraints (11). In Ebolowa, routine health facility data and district health reports indicate persistent missed appointments, delays in completing vaccination schedules, and low coverage rates for key antigens such as DTP3 and measles (12). Many caregivers either forget vaccination dates or are unaware of follow-up schedules, leading to incomplete immunization and increased risk of vaccine-preventable diseases (13,4). The paper-based systems traditionally used for tracking vaccination schedules and issuing reminders present significant limitations. Health workers manually record appointments on vaccination cards or registers, which are prone to loss, damage, or errors. Moreover, paper-based registers make it difficult to systematically monitor defaulters or send timely reminders to caregivers (14). These logistical inefficiencies result in fragmented data management, hinder accurate reporting, and reduce the ability of health facilities to conduct effective follow-up (9). With the increasing penetration of mobile phones in Cameroon estimated at over 90 % of households (15) there exists an opportunity to leverage mobile health (mHealth) tools such as SMS-based reminder systems to bridge communication gaps between health facilities and caregivers. However, empirical evidence on the effectiveness and acceptability of such digital innovations in Ebolowa remains

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limited. This gap underscores the need to assess how transitioning from paper-based to SMS-based reminder systems can enhance vaccination adherence and ultimately improve immunization coverage in this setting (10,6).

Methodology

Study Design

This study employed a mixed-methods, quasi-experimental pre–post intervention design to assess the impact of SMS-based reminders on immunization adherence among caregivers of children aged 0–59 months in the Ebolowa Health District, located in the South Region of Cameroon. The quasi-experimental approach was selected to enable evaluation of the causal influence of the intervention within a real-world health system context, where random assignment of participants was not feasible (16,17). The qualitative component included focus group discussions and interviews to capture feedback on acceptability and challenges. The study was implemented over a period of eight months, encompassing a baseline phase, an intervention phase, and a post-intervention phase. During the baseline phase, data on vaccination timeliness, missed appointments, and default rates were collected under the routine paper-based reminder system. In the intervention phase, SMS reminders were sent to caregivers to alert them of upcoming vaccination sessions and follow-up visits. The post-intervention phase involved a comparative analysis of immunization adherence indicators before and after implementation of the digital system. This design enabled a robust within-group comparison to determine the effectiveness of SMS reminders in improving vaccination adherence (18). The research was conducted in selected public health facilities within the Ebolowa Health District, which represents a semi-urban environment characterized by both urban and peri-urban populations. The district serves as the administrative and health centre of the South Region and is part of the Cameroon Expanded Program on Immunization (EPI) network. Collaboration was established with the District Health Service and EPI focal points to facilitate data collection, supervision, and monitoring of the intervention (12).

Study Population

The study population consisted of caregivers of children aged 0–59 months residing within the Ebolowa Health District, as well as health workers involved in immunization activities under the Expanded Program on Immunization (EPI). This target group was selected because caregivers are primarily responsible for ensuring that children attend vaccination sessions, while health workers play a crucial role in scheduling, recording, and following up missed vaccinations (13). Caregivers were identified as parents or legal guardians through health facility immunization registers and enrolment records during routine visits.

Inclusion and Exclusion Criteria: Caregivers were eligible for inclusion if they (i) had at least one child aged 0–59 months enrolled in the EPI program within participating health facilities, (ii) possessed a functioning mobile phone capable of receiving SMS messages, and (iii) provided informed consent to participate in the study. Participants were excluded if they (i) did not have reliable mobile network coverage (defined as consistent access to mobile signals in their area of residence, verified through self-report and network testing at enrolment), (ii) were unable to read or understand SMS messages in French, or (iii) planned to relocate from the district during the study period. Health workers were included if they were directly involved in immunization service delivery and consented to participate in focus group discussions or key informant interviews regarding system implementation.

Sample Size and Participant Characteristics

The sample size was determined using the single population proportion formula: $n = Z^2 p (1-p) / e^2$ where $Z = 1.96$ (for 95% confidence level), p = expected proportion of improvement in full immunization coverage (0.15, based on similar studies), and e = margin of error (0.05). This calculation yielded a minimum of 384 caregiver participants, which was adjusted to 420 to account for potential non-response or attrition (7,6). Participants were recruited from fifteen purposively selected health facilities within the three health areas of Ebolowa Health District, to represent both urban and peri-urban catchment areas (not an exhaustive or stratified sampling). A separate sub-sample of health workers (n = 20) included vaccinators, nurses, and EPI focal persons responsible for data entry and immunization follow-up (they were not caregivers but provided complementary qualitative insights into system usability and operational feasibility from a provider perspective).

Description of the Intervention

The intervention involved the transition from a paper-based immunization scheduling system to a hybrid digital SMS-based reminder system (used alongside paper records for synchronization) aimed at improving adherence to vaccination appointments among caregivers of children aged 0–59 months in the Ebolowa Health District. Traditionally, vaccination appointments in the district were recorded manually on child health cards and in facility registers. This paper-based process was often associated with information loss, errors, and missed follow-ups due to the absence of a systematic mechanism for reminders (14). To address these limitations, a mobile health (mHealth) intervention was introduced to automate appointment tracking and caregiver reminders using short message service (SMS)

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technology. The digital system was developed in collaboration with the Ebolowa District Health Service, the Expanded Program on Immunization (EPI), and local telecommunications partners.

SMS Reminder System

The SMS reminder platform was designed to automatically send messages to caregivers ahead of scheduled vaccination appointments. Each caregiver received two types of reminders: a pre-appointment message sent 48 hours before the scheduled vaccination date, and a same-day reminder delivered on the morning of the appointment. Message content was developed in simple French, using culturally appropriate and easily understandable language. The messages contained the child's name, vaccine due, date of appointment, and the name of the health facility. Message template: "cher parent, le prochain rendez-vous vaccinal de votre enfant Melono Brigitte 2 est fixé au Mardi 30 Septembre 2025. Veuillez-vous rendre à votre centre habituel." Messages were sent using an automated digital health platform https://vaccii.com. The platform allowed health workers to input vaccination schedules, automatically triggering reminder messages through an integrated delivery gateway. The system also logged delivery confirmations and tracked missed appointments, enabling follow-up by facility staff.

Implementation Process

Implementation of the intervention was conducted in three stages. During the system setup and training phase, health workers received instruction on data entry, message scheduling, and use of the SMS platform. Existing paper-based records were digitized to establish an electronic immunization schedule database. The pilot testing phase involved deploying the system in two health facilities for one week to identify technical issues, assess message delivery reliability, and evaluate caregiver comprehension. Following successful validation, the full rollout phase extended the intervention to all participating health facilities over a six-month period. Throughout the process, stakeholder engagement was prioritized to promote acceptability and sustainability. Meetings were organized with local health authorities, EPI focal persons, and community representatives to present objectives, gather feedback, and address implementation challenges. Caregiver participation was further strengthened through community sensitization sessions facilitated by community health workers and local leaders (7,10). This participatory approach not only facilitated community buy-in but also improved system usability and adherence to vaccination appointments.

Data Collection

Data collection focused on assessing the effect of SMS-based reminders on immunization adherence, timeliness, and completion among children aged 0–59 months enrolled in the Ebolowa Health District immunization program. Data were collected during both the pre-intervention (paper-based system) and post-intervention (digital SMS-based system) phases to enable comparative analysis.

Indicators

The primary indicators were: adherence to scheduled vaccinations was measured as the proportion of children who attended their vaccination appointments on the exact scheduled date. Vaccination delays were defined as the number of days between the scheduled and actual vaccination dates for each antigen in the Expanded Programme on Immunization (EPI) schedule. Completion rates were calculated as the percentage of children who received all recommended vaccines within the first year of life, in accordance with the national EPI guidelines of the Ministry of Public Health, Cameroon (2023).

Secondary Indicators and Complementary Data

Missed appointments were defined as the proportion of scheduled vaccination sessions not attended within two weeks of the due date. This indicator effectively captured immediate drop-offs and served as a direct measure of the SMS reminders' ability to reduce forgetfulness among caregivers. Closely related, defaulter rates represented the proportion of children who dropped out before completing the full vaccination series. By assessing long-term retention, this metric highlighted critical breakpoints in the immunization pathway and underscored opportunities for targeted interventions. To gain a more comprehensive understanding of the intervention's impact, additional data were collected on caregiver engagement and satisfaction with the SMS reminder system. Response rates were used to measure the proportion of caregivers who acknowledged or replied to reminder messages, either through return SMS or in-person confirmation at the health facility. User satisfaction was assessed using structured post-intervention questionnaires that explored caregivers' perceptions of message clarity, usefulness, and timing. Furthermore, health worker feedback was gathered through focus group discussions to capture insights into system usability, perceived operational benefits, and implementation challenges. Taken together, these complementary datasets offered deeper insights into the behavioral and operational factors that influenced the intervention's overall effectiveness, extending beyond traditional quantitative coverage metrics (19,10).

Data Collection Tools and Timing

Quantitative data were extracted from health facility immunization registers, the digital SMS platform database, and child health cards. Standardized data extraction forms were used to ensure consistency

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across sites. Data were collected monthly during both the baseline (three months) and post-intervention (three months) periods. Structured questionnaires were used to collect information on caregiver satisfaction and socio-demographic characteristics. Data collection teams comprised trained field supervisors and EPI focal points, operating under the oversight of the District Health Service. Data quality was ensured through double-entry verification and cross-checking between electronic and paper-based records. Regular supervision visits and validation meetings were conducted to ensure completeness and accuracy (20).

Data Analysis

Data were analyzed to determine the effect of SMS-based reminders on immunization adherence, timeliness, and completion among children aged 0–59 months. Quantitative and qualitative analyses were performed using appropriate statistical methods and analytical software. This study adopted a two-phase mixed-methods design, integrating quantitative and qualitative approaches to evaluate the impact of digitalization and SMS reminders on vaccination adherence in the Ebolowa Health District (21).

Phase 1: Pre-Intervention (Baseline: Paper-Based System)

The baseline cross-sectional KAP (Knowledge, Attitudes, and Practices) survey was conducted in June 2025, prior to the implementation of the digital system. Data were collected using structured questionnaires (for parents and healthcare workers) and semi-structured interviews (for community leaders). A total of 906 parents of children aged 0–5 years and 87 healthcare workers were surveyed across all health areas of the district. Data entry and cleaning were performed using Microsoft Excel 2021 and exported to IBM SPSS Statistics version 26 for analysis. Comparative and associative analyses were conducted to identify predictors of SMS reminder acceptability. The Chi-square (χ^2) test was used to examine differences in acceptability according to parental education level and worker training. An independent t-test was performed to compare perceived usefulness between parents who owned a phone and those who did not. Finally, a binary logistic regression model was applied to determine the factors associated with positive digital attitudes, including age, education, phone ownership, and internet access, with adjusted odds ratios (ORs) and 95% confidence intervals (CI) considered statistically significant at $p < 0.05$. A qualitative component complemented these findings through 11 focus group discussions (FGDs) involving all 87 healthcare workers and semi-structured interviews with community leaders. Discussions addressed perceptions of digital acceptability, barriers to use, and workload implications. Data were transcribed verbatim and thematically analyzed using a deductive–inductive approach, generating themes such as knowledge gaps, attitudinal resistance, and practice barriers. Triangulation of quantitative and qualitative data ensured robust interpretation (21).

Phase 2: Post-Intervention (SMS-Based System Evaluation)

Following deployment of the SMS reminder platform, a post-intervention evaluation measured user satisfaction and system effectiveness. The mixed-methods survey included 518 caregivers and 63 healthcare workers across the same health areas. Data, collected via structured questionnaires and open-ended interview guides, were entered into Excel 2021 and analyzed using SPSS version 26. Comparative Analyses Comparative analyses revealed significant post-intervention improvements across several indicators. Results from the Chi-square (χ^2) test showed a notable increase in vaccination adherence rates (85.2%) and a reduction in the proportion of zero-dose children. Findings from the independent t-test indicated a significant decrease in vaccination delays and an overall improvement in timeliness. Furthermore, binary logistic regression analysis identified caregiver education and phone ownership as significant predictors of adherence (adjusted OR 1.45, 95% CI 1.12–1.88; $p < 0.05$).

Qualitative data from 9 FGDs and 12 interviews explored user experiences with message clarity, language preferences (85.9% French; suggestions for local dialects like Fang), and implementation barriers (poor network coverage, infrastructure variations). Transcripts were thematically analysed in NVivo 14 using a deductive inductive coding framework aligned with study objectives. Emergent themes captured trust in digital reminders, inclusivity for low-literacy groups, and perceived reduction in missed appointments. Thematic saturation was achieved after the third FGD. Integration of quantitative trends (e.g., 95% satisfaction) with qualitative narratives (e.g., “SMS reminders felt official and trustworthy”) provided a comprehensive understanding of behavioral adoption and system feasibility. Data Integrity and Quality Control Data integrity was rigorously maintained through double-entry verification, random cross-checks of facility registers, and consistency audits between paper records and electronic datasets. Outliers, inconsistencies, and missing values were systematically reviewed and resolved in accordance with WHO data quality assurance guidelines (14).

Results

Baseline Assessment (Pre-Intervention: Paper-Based System)

A cross-sectional Knowledge, Attitudes, and Practices (KAP) survey was conducted in June 2025 among 906 parents of children aged 0–5 years, 87 healthcare

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workers, and selected community leaders across all health areas in the Ebolowa Health District. Data were collected using structured questionnaires and semi-structured interviews, focusing on vaccination knowledge, perceptions of SMS reminders, acceptability of digital tools, and current immunization practices. To handle potential changes in responsible persons or telephone numbers, caregivers were required to update contact information at each facility visit; data on changes was obtained through facility logs and follow-up calls, with <5% of cases reporting changes during the study.

Key Findings

The assessment revealed satisfactory overall knowledge among respondents, with 80.0% of parents demonstrating a good understanding of the vaccination schedule and its importance. Regarding attitudes, there was a strong receptivity to SMS reminders, as 82.5% of parents expressed favorable opinions, while 67.8% of healthcare workers believed that patients would accept the system. In terms of practices and barriers, 77.6% of parents owned a smartphone with internet access, suggesting high technical feasibility for digital interventions. However, a significant gap was observed in health system readiness: 82.7% of healthcare workers reported not using any digital tools for immunization tracking, and 95.4% had never received training on digital vaccination platforms. Among parents, the main barriers identified were lack of personal phone ownership (18.0%), illiteracy (12.0%), and poor network coverage (24.0%), all of which could limit equitable access to digital reminder systems.

Post-Intervention Evaluation (SMS-Based System)

The data from the EPI shown in the table below demonstrate substantial post-intervention improvements in immunization performance across all key indicators.

Table I : vaccination indicators (Baseline vs. Post-Intervention Comparison)

Indicator	Before	After	Difference
Penta 1 administered	529	713	184
Penta 3 administered	532	622	110
RR 1 administered	417	551	134
Zero-dose children caught up	–126	1,973	2,099
Under-vaccinated children caught up	–24	1,337	1,361
Incompletely vaccinated children	340	1,11	770

The number of children who received Penta 1 and Penta 3 vaccines increased from 529 to 713 and 532 to 622, respectively. Similarly, the number of RR1 (measles-rubella first dose) vaccinations rose markedly from 417 to 551. The most significant gains were observed in catch-up immunization outcomes, with zero-dose children rising dramatically from a negative baseline (–126) to 1,973, and under-vaccinated children increasing from –24 to 1,337. Additionally, the number of incompletely vaccinated children rose from 340 to 1,110.

A follow-up mixed-methods survey was conducted among 518 caregivers of children aged 0–59 months and 63 healthcare workers from the same health facilities. The caregiver sample was predominantly female (87.1%), aged 20–39 years (84%), and well-educated (85.1% with secondary or higher education; 14.9% primary level only).

SMS Delivery, User Satisfaction, and Engagement

The intervention achieved excellent performance in message delivery and user engagement. A 99% SMS receipt rate was recorded, with 93.1% of respondents reporting on-time delivery of vaccination reminders. Overall user satisfaction was high (95%), encompassing both caregivers and healthcare workers, reflecting the system's reliability and acceptability. Notably, the highest participation rate (34.9%) was observed at CSIU N°2 Ebolowa, indicating strong facility-level adoption and community engagement in the digital immunization reminder program. Qualitative insights reinforced these gains, with users describing reminders as "official, reliable, and motivating," while emphasizing the need for multilingual messaging and sustained network support.

Caregiver and Health Worker Feedback

Among caregivers, 61% reported high satisfaction and 37% reported satisfaction with the SMS reminder system, citing its simplicity and timeliness. Health workers reported reduced workload associated with manual record tracing and improved data accuracy due to synchronization between digital registers and paper records.

Secondary Findings

SMS Delivery and Caregiver Engagement During the intervention period, a total of 3962 SMS reminders were sent to participating caregivers. The overall SMS delivery success rate was 94.6%, with only 5.4% of messages failing due to network interruptions or invalid phone numbers. Approximately 81% of caregivers reported reading the reminder messages within 24 hours of receipt, while 67% indicated that they acted on the message immediately by preparing for or attending the scheduled vaccination appointment. Caregivers expressed high levels of engagement with the digital reminder system, with 80.3% reporting that the SMS helped them better plan their time for immunization visits. Furthermore, 62% stated that they shared the SMS content with other family members or caregivers, contributing to broader

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community awareness about vaccination schedules. User Satisfaction and Usability Feedback Feedback gathered through post-intervention surveys indicated that 62.1 % caregivers were highly satisfied, while 37.3 % were satisfied with the SMS-based reminder system. They appreciated the clarity, simplicity, and relevance of the messages. The use of most spoken language (French) and short, action-oriented text improved comprehension and acceptability among users. 66.7 % of Health workers reported that the system reduced missed appointments and facilitated better tracking of defaulters. However, some expressed a need for continuous training and technical support to fully integrate the digital platform into routine immunization workflows. Implementation Challenges Several implementation challenges were encountered during the study. Network instability in rural parts of the Ebolowa Health District occasionally delayed SMS delivery. In addition, mobile phone ownership and literacy barriers limited full participation among a small subset of caregivers. Some health facilities experienced technical difficulties during the early stages of transitioning from paper-based registers to the digital system, particularly regarding data synchronization and record validation. Despite these challenges, the intervention was generally well-accepted and demonstrated the feasibility of integrating mHealth tools within existing immunization programs in low-resource settings.

Discussion

The introduction of an SMS-based reminder system and digital scheduling platform in the Ebolowa Health District led to significant improvements in vaccination adherence, timeliness, and completion rates. The proportion of children vaccinated on schedule increased from 63.7% to 85.2%, while missed appointments and delays markedly declined. These findings demonstrate that simple, low-cost digital interventions can effectively address key barriers to immunization adherence in low-resource settings. The positive outcomes observed can be attributed to several factors. Firstly, timely communication through SMS reminders helped caregivers remember vaccination dates, reducing forgetfulness a commonly reported cause of missed appointments. Secondly, the use of personalized and language-appropriate messages enhanced message comprehension and cultural acceptability, especially among caregivers with limited literacy. Thirdly, the transition from paper-based to digital systems improved record accuracy and facilitated more efficient tracking of defaulters, enabling health workers to provide targeted follow-up. Caregiver satisfaction and engagement further supported the success of the intervention. The high SMS delivery rate and positive feedback from both caregivers and health workers suggest that the intervention was both feasible and acceptable. However, challenges such as network instability, limited phone ownership, and digital literacy gaps underscore the need for contextual adaptation and complementary community strategies, such as in-person reminders or community health worker follow-up. Overall, the intervention's impact aligns with the broader recognition that digital health solutions can bridge communication gaps in immunization programs by providing timely, actionable information to caregivers (6,20). The results of this study are consistent with findings from similar interventions conducted across low- and middle-income countries (LMICs). In Kenya, an mHealth study demonstrated a 23% improvement in timely immunization following the introduction of SMS reminders to caregivers (10). Likewise, studies in Nigeria (9) and Ghana (4) reported enhanced vaccine uptake and reduced dropout rates when mobile reminders were integrated into routine immunization systems. In Tanzania, mothers receiving SMS reminders were significantly more likely to complete the full vaccination schedule compared to controls, emphasizing the role of consistent, automated communication (19). Similar interventions in Malawi and Zambia also confirmed that the success of SMS reminders depends on factors such as message timing, linguistic adaptation, and phone accessibility (7). This study contributes to the growing body of evidence supporting digital transformation in immunization delivery within Sub-Saharan Africa. Unlike many pilot studies that focus solely on SMS reminders, this intervention combined both digital scheduling and mobile communication, demonstrating a scalable model for integrating mHealth tools into primary health systems. Moreover, the findings reinforce WHO's Global Strategy on Digital Health (2020–2025), which highlights the potential of mobile technologies to improve health service coverage and equity in LMICs. By demonstrating feasibility, acceptability, and measurable improvement in vaccination adherence, the Ebolowa intervention represents an important step toward the sustainable digitalization of immunization programs in Cameroon and similar contexts (3). A major strength of this study lies in its quasi-experimental design, which enabled a direct comparison of vaccination adherence before and after the introduction of the digital intervention. This approach provided strong evidence of the causal relationship between SMS reminders, digital scheduling, and improvements in immunization outcomes. The use of multiple data sources including facility records, digital platform analytics, and caregiver surveys enhanced data triangulation and validity. Furthermore, the study was implemented under routine health service conditions, thereby increasing its external validity and relevance to real-world immunization settings. However, several limitations should be acknowledged. The study duration was relatively short, limiting assessment of the long-term sustainability of

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observed improvements. The sample size may not have been large enough to detect smaller effects or to allow for disaggregated analysis across subgroups such as rural versus urban settings. Additionally, network instability and occasional SMS delivery failures may have influenced the completeness of reminder dissemination. Caregiver literacy and phone ownership disparities could also have affected message comprehension and reach, particularly among lower socioeconomic groups. Lastly, while efforts were made to ensure data accuracy, some degree of reporting bias or missing data in facility records cannot be completely excluded. Despite these limitations, the study offers valuable operational insights into the integration of mHealth tools in immunization programs within low-resource contexts. The findings of this study hold significant implications for public health practice and policy in Cameroon and similar low and middle-income settings. Firstly, the demonstrated improvement in immunization adherence underscores the potential of digital technologies to strengthen routine immunization systems by bridging communication and tracking gaps between health workers and caregivers. Integrating SMS reminders into national immunization programs could serve as a cost-effective and scalable strategy to enhance service delivery, particularly in regions where human and logistical resources are limited. Secondly, this intervention aligns with Cameroon's National eHealth Strategy and WHO's Global Digital Health Framework, which advocate for the use of digital innovations to improve coverage and equity of essential health services. Policymakers should consider embedding such systems within existing health information platforms like DHIS2 to ensure sustainability and interoperability. Finally, the success of the digital scheduling and SMS system in Ebolowa suggests a model that could be replicated or scaled nationally, provided that challenges related to infrastructure, digital literacy, and technical support are addressed. Future programs should include capacity-building for health workers, continuous monitoring, and public-private partnerships with telecom providers to maintain reliable message delivery and long-term program viability.

Conclusion

This study demonstrated that the transition from paper-based immunization tracking to a digital scheduling system supported by SMS reminders significantly improved vaccination adherence among caregivers in the Ebolowa Health District, Cameroon. The intervention led to measurable gains in on-time vaccination, reduced missed appointments, and higher completion rates for the full immunization series. These results provide compelling evidence that mobile health (mHealth) interventions, when contextually adapted and effectively implemented, can strengthen immunization delivery systems in low-resource settings. The success of this initiative was largely driven by the accessibility and immediacy of SMS reminders, which served as an effective communication tool to overcome caregiver forgetfulness and logistical barriers. Additionally, the digital scheduling platform enhanced data accuracy, improved coordination between caregivers and health workers, and contributed to more efficient monitoring of vaccination progress. However, sustained success will depend on addressing operational challenges such as network instability, digital literacy, and infrastructure constraints. Integrating the system into Cameroon's national health information framework could enhance scalability and long-term sustainability.

Conflicts of interest: The authors declare that they do not have any conflict of interest.

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