frontiers in Public Health

TYPE Original Research
PUBLISHED 24 November 2026
DOI 10.3389/fpubh.2026.1987935

Check for updates

OPEN ACCESS

EDITED BY
Tommi Kärki,
European Centre for Disease Prevention and Control (ECDC), Sweden

REVIEWED BY
Siti Andini Utiarahman,
University of Gorontalo Ichsan, Indonesia
Moslem Sarani,
Golestan University of Medical Sciences, Iran

*CORRESPONDENCE
Adekunle Akerele
✉ Sunday@integralglobal.net

RECEIVED 03 September 2026
REVISED 02 November 2026
ACCEPTED 05 November 2026
PUBLISHED 24 November 2026

CITATION
Akerele A, Khan H, Mehmood A, Pervaiz A, Khakwani JM, Alam F, Laghari MA, Safdar MR, Mohamed A, Franka R and Mbaeyi C (2026) Implementation and user satisfaction evaluation of a digital health information system for decision support in the national stop transmission of polio program in Pakistan, 2023–2025. *Front. Public Health* 14:1987935. doi: 10.3389/fpubh.2026.1987935

COPYRIGHT
© 2026 Akerele, Khan, Mehmood, Pervaiz, Khakwani, Alam, Laghari, Safdar, Mohamed, Franka and Mbaeyi. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Implementation and user satisfaction evaluation of a digital health information system for decision support in the national stop transmission of polio program in Pakistan, 2023–2025

Adekunle Akerele[1,2]*, Hafizullah Khan[3], Amjad Mehmood[3], Aslam Pervaiz[3], Jamshed Maqbool Khakwani[3], Fawad Alam[4], Mumtaz Ali Laghari[3], Muhammad Rana Safdar[4], Abdinoor Mohamed[1], Richard Franka[1] and Chukwuma Mbaeyi[1]

[1]Global Immunization Division, Centers for Disease Control and Prevention, Atlanta, GA, United States, [2]Integral Global, Atlanta, GA, United States, [3]National Stop Transmission of Polio (NSTOP) Program, Islamabad, Pakistan, [4]Data and Analytics Team, Integral Global, Islamabad, Pakistan

Background: Pakistan remains one of two countries with circulating wild poliovirus. The National Stop Transmission of Polio (NSTOP) program relies on field officers to support grassroots eradication efforts, although their routine monitoring process was hindered by a cumbersome, fragmented reporting workflow utilizing multiple Microsoft Excel files. To modernize this information architecture and enhance data-driven decision-making, an integrated, R-based digital health information system comprising a digital dashboard and online data-entry system was deployed across four provinces in November 2024. This study documents the implementation of the information system and evaluates user satisfaction.

Methods: The R-based digital health information system was developed, implemented and deployed in 2 phases. The system integrated a digital dashboard with an online data-entry platform and was deployed across four provinces in Pakistan. To evaluate the implementation of this digital health intervention, we conducted an online cross-sectional survey in March 2025 among all 86 deployed NSTOP officers, assessing system usability, data reliability, user satisfaction, and perceived influence on decision-making.

Results: The survey achieved a 100% response rate. Of the 86 officers surveyed, 77 (90%) reported familiarity with the information system. Among these 77 respondents, 60 (78%) expressed overall satisfaction with the dashboard. Respondents who reported a significantly higher ability to make data-driven decisions were more likely to be satisfied with the dashboard (88.5% vs. 56%, $p = 0.005$) and to report ease of learning and navigation (83.6% vs. 40%, $p = 0.006$), perceived information reliability (83.8% vs. 33.3%, $p = 0.003$), and satisfaction with data visualizations (91% vs. 40%, $p < 0.001$). Overall, 66% of officers demonstrated a positive perception of data ownership and system utility.

Conclusion: This study demonstrates the operational implementation and user evaluation of an integrated digital health information system in a national disease eradication program. These findings provide practical and transferable lessons for modernizing routine public health information and surveillance workflows in resource-constrained settings.

10.3389/fpubh.2026.1987935

KEYWORDS

digital, frontline workers, immunization systems, monitoring and evaluation, Pakistan, polio, public health informatics, satisfaction

Background

Pakistan is one of two countries where wild poliovirus type 1 (WPV1) remains in circulation (1). A combination of factors, including inadequate vaccination coverage, misinformation about vaccines, mistrust in the healthcare system as well as cultural beliefs (2) contribute to continued transmission of the virus. Despite ongoing efforts to eradicate polio, health workers in some parts of the country face significant challenges in administering vaccines due to security concerns or geographical barriers (3). Local experts have a deeper understanding of contextual challenges and are better positioned to propose locally acceptable solutions. Security constraints often limit international experts from operating in high-risk polio transmission areas of Pakistan. Consequently, engaging local public health officials from these areas and equipping them with epidemiological skills remains the most effective approach to improving community acceptance and strengthening technical capacity to achieve program objectives (4, 5). By leveraging the knowledge and relationships of local personnel, polio eradication efforts can become more efficient, sustainable, and ultimately successful in achieving the goal of a polio-free world.

Accordingly, the National Stop Transmission of Polio (NSTOP) program was designed to train local public health professionals in polio eradication and routine immunization and deploy them to high-risk districts identified by the polio program. Medical professionals with a minimum of 2 years of public health experience were recruited from the public sector, including Field Epidemiology and Laboratory Training Program (FELTP) alumni/residents or those who had completed a four-week specialized training in surveillance and outbreak detection and response by FELTP Pakistan. The Pakistan NSTOP program is supported and funded by the U.S. Centers for Disease Control and Prevention (CDC) with the aim of enhancing polio eradication efforts at the grassroots level through community engagement and collaboration between government agencies, non-governmental organizations, and external partner agencies (5, 6). NSTOP focuses on building capacity in immunization among frontline health workers, coordinating activities across the partnership, improving surveillance systems, and mobilizing local communities to participate in vaccination campaigns. The program deploys medical officers to designated provinces and districts that have ongoing or are at risk of WPV1 circulation (7). NSTOP officers facilitate supervisory training, monitor immunization sessions to ensure quality, and help in maintaining data quality to support corrective actions and target high-risk areas as well as implement innovative outreach methods to reach underserved populations.

Timely access to accurate program data is essential for identifying and addressing public health threats and guiding operational responses. Since NSTOP officers in Pakistan are assigned to provincial and district emergency operations centers (EOCs), their roles include ensuring transparency and effectiveness in the fight against polio using data for evidence-based decision-making to guide the process. Accurate data collection and timely reporting ensure accountability and transparency in the implementation of polio eradication activities. These processes provide reliable data to measure vaccination coverage, track virus transmission, assess the impact of interventions and effectively coordinate response activities. An important aspect of documenting the activities of NSTOP officers is to ensure the credibility and visibility of their contributions towards polio eradication. Although indicators have been developed to document officers' activities, the reporting process was cumbersome, limiting the use of activity data to improve performance and inform decision-making within the polio program. The monthly spreadsheet-based reporting system was time-consuming and delayed, further constraining timely data analysis and evidence-based decision-making.

These information bottlenecks highlight the importance of digital public health information systems that can integrate routine reporting, data management, analysis, visualization, and decision support within public health programs. These interventions are increasingly recognized as important for modernizing disease surveillance and strengthening the use of routine health information. To address the limitations of the existing NSTOP reporting workflow, we developed an open-source, R-based digital health information system that facilitated data collection, analysis, and visualization. Based on prespecified indicators, officers submitted their monthly activity data through an online system linked to a MySQL database, while a dashboard analyzed the data in real-time and displayed visualizations for users. The digital health information system modernized the existing spreadsheet-based reporting workflow into a more effective integrated architecture, with the aim of improving data-driven decision-making and allowing officers to focus more on data use rather than data compilation.

To assess whether the digital health information system fulfilled its intended purpose of facilitating reporting, we incorporated an evaluation of user satisfaction into its implementation. User satisfaction is an important component of evaluating how effectively a health information system meets users' information needs (8). In this study, we evaluated the implementation of the R-based NSTOP digital health information system among officers working across Pakistan's polio program. Specifically, we assessed user satisfaction, system usability, perceived information reliability, and perceived influence on data-driven decision-making, and examined factors associated with overall satisfaction. We also explored dashboard familiarity and use, including the continued use of other reporting mechanisms. By examining these aspects together, the study highlights two practical implementation challenges: the persistence of reporting processes outside the dashboard and the gap between familiarity with a digital system and its actual use. These findings provide practical evidence to inform efforts to improve the integration and sustained use of digital health information systems in public health programs.

Methods

Study population

NSTOP officers were deployed across 66 districts in the provinces of Balochistan, Khyber Pakhtunkhwa, Sindh, and the federal capital, Islamabad, during 2024–25 based on risk categories of districts as determined by the National Emergency Operations Center for Polio Eradication (Figure 1). NSTOP officers acted as team leads and technical support officers at the provincial EOCs, served as task force officers at the division level, and as coordinators of polio surveillance and vaccination activities or as officers of the Expanded Programme on Immunization (EPI) at the district level.

Rationale and approach

Provincial, divisional, and district NSTOP officers carry out activities in accordance with their respective Terms of Reference (TORs). These TORs are aligned with Pakistan's National Emergency Action Plan for Polio (NEAP) and encompass key components of polio eradication, including vaccination campaigns, acute flaccid paralysis (AFP) surveillance, and routine immunization. Officers report their activities through monthly reporting indicators developed by the program in line with their TORs. Each hierarchy level of NSTOP officers has a defined set of indicators that must be reported monthly (Supplementary Information S2). The collated monthly reports are shared with funders as a statutory requirement to demonstrate NSTOP's contributions and to inform critical programmatic decisions.

Prior to designing the digital health information system, NSTOP officers entered activity data in a Microsoft Excel template and emailed the Excel workbook from the district to the province where data were collated and then shared with the federal team. The complexity associated with collecting, collating, and reporting these activity indicators every month using the Excel templates was cumbersome and required extra hours.

Recognizing these challenges, the NSTOP program worked with experts from CDC to develop a system that improved their data management practices. Several sessions were held with the NSTOP leadership to discuss the existing data management process: data flow, report generation, revision of the indicator list, reporting timelines, automating the reporting process and developing visualizations. The NSTOP federal office in Islamabad provided relevant materials, including previous reports, data collection tools, revised indicator lists, geographical distribution of officers, and officers' roles and responsibilities. Proposed software choices for the dashboard included R, Tableau, Microsoft Excel, and Microsoft PowerBI (Table 1). Consensus was reached to use R because open-source licensing eliminates licensing fees (cost-effectiveness), its mature CRAN repository supports long-term sustainability, and its rich package ecosystem delivers exceptional flexibility and advanced analytics capability (9–11).

Digital health information system development

The digital health information system was designed in two phases to avoid disruption of program reporting obligations while progressively transitioning from spreadsheet-based reporting to an integrated online information system. The development process incorporated stakeholder input, iterative testing, indicator refinement, and phased implementation.

Phase 1: Development of visualization

R Markdown and the Flex dashboard framework were used to develop the initial dashboard. Officer categories were organized into

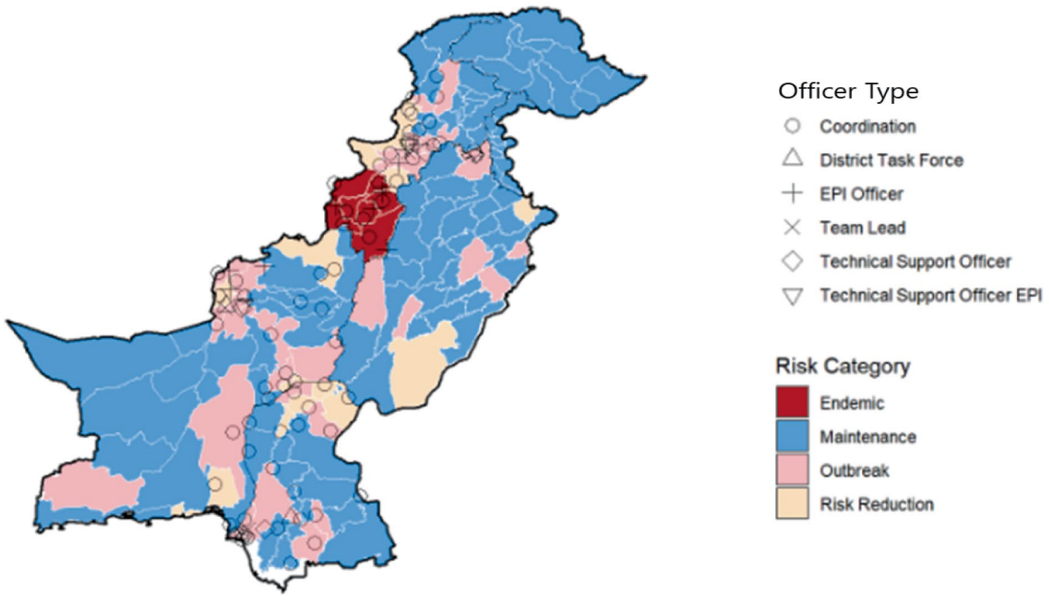

FIGURE 1
Distribution of national stop transmission of polio (NSTOP) officers across Pakistan.

10.3389/fpubh.2026.1987935

TABLE 1 Comparison of software options considered for the NSTOP digital health information system.

Criterion	R	Microsoft excel	Tableau	Microsoft power BI
Licensing cost	Open-source; no R software licensing fees	Commercial Microsoft product; licensing depends on the edition and subscription	Commercial product; licensing depends on the plan	Licensing depends on the edition, subscription, and deployment
Sustainability	Established CRAN package repository and open-source community	Supported within the Microsoft ecosystem	Commercial vendor support and product ecosystem	Supported within the Microsoft ecosystem
Flexibility and analytics	Extensive packages for customized data processing, statistical analysis, and visualization	Spreadsheet-based analysis, formulas, and automation	Strong visual analytics and dashboard development	Strong reporting, data modeling, and business intelligence
Customization	High flexibility to customize data processing and reporting through code	Customization through formulas, macros, and spreadsheet structures	Visual dashboard customization using the platform's capabilities	Report and dashboard customization using its data modeling and visualization tools
Suitability for NSTOP requirements	Supported integration of data processing, statistical analysis, and visualization using R Markdown and Flexdashboard	Existing tool for monthly reporting, but spreadsheet submissions required additional consolidation and processing	Capable of developing dashboards, but would require adoption of a separate commercial platform	Capable of developing integrated reports and dashboards, subject to licensing and deployment considerations

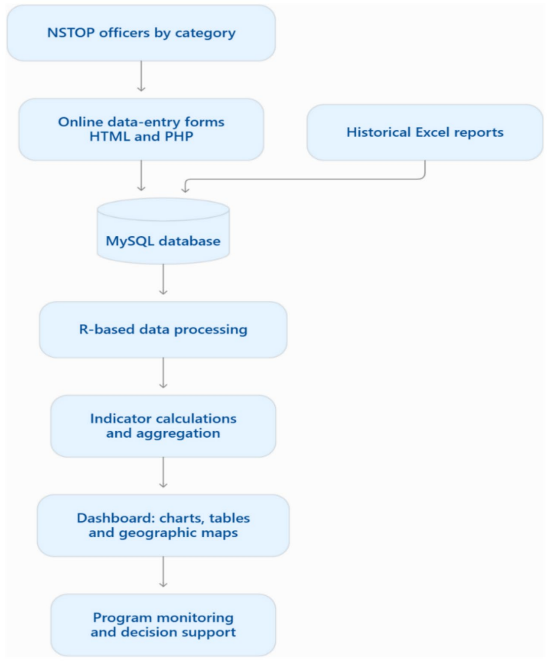

FIGURE 2
Data flow for the NSTOP digital health information system.

eight tabs, with district-level information accessed through dropdown menus and aggregated views available at the provincial level. Cascading menus and customized CSS were used to organize the user interface and facilitate navigation. Existing Microsoft Excel reporting templates were transformed into structured data formats that could be updated monthly and processed through R. Indicators supplied by the NSTOP program were organized into thematic dashboard panels, with charts, tile maps, and geographic maps used to display reporting patterns, polio-risk districts, and officer locations (Figure 2).

Phase 2: Online reporting system integration

Online data-entry forms were developed using HTML and PHP for the different NSTOP officer categories to replace submission of activity reports through Microsoft Excel. Data submitted through the online platform were stored in a MySQL database connected directly to the dashboard, enabling automated data processing and visualization. Historical data from the existing Excel reporting system were migrated into the database to maintain continuity and support trend analysis. Following deployment of the online reporting component, dashboard visualizations were automatically updated from the database. This phased approach enabled the program to retain existing reporting information while progressively transitioning to an integrated digital workflow linking data entry, database storage, analysis, visualization, and decision support.

System architecture, hosting, authentication, and access control

Supplementary Information S1 shows the system architecture. The NSTOP digital health information system comprised five interconnected components: an online data-entry platform, a MySQL database server, an R-based data-processing and indicator-generation component, an interactive dashboard, and dashboard users. The online data-entry platform was developed using HTML and PHP, while MySQL was used to store submitted data and migrated historical Excel records. R was used for automated data extraction from MySQL, data cleaning, indicator calculation, aggregation, and generation of analytical outputs. R Markdown

and Flexdashboard supported the presentation of interactive charts, tables, and maps.

The system was hosted on a cloud server and accessed through a web browser, without requiring desktop installation. Individual usernames and passwords were issued to NSTOP officers. The implemented access model provided uniform visibility of the dashboard and underlying dataset without restrictions based on officer category, province, or district. This arrangement facilitated shared access to program information across administrative levels. Role-specific and geographic restrictions on data visibility were not implemented; row-level access permissions could be considered in future updates if more granular access control becomes necessary. The architecture diagram also identifies secure web connections (HTTPS), regular backups, and system maintenance as components of the hosting and access environment. Backup frequency, recovery procedures, encryption arrangements, and maintenance protocols were not documented in the implementation information available for this study. Figure 2 shows the structure of the system.

Digital health information system implementation

Figure 3 below demonstrates the implementation timeline for the system. As shown in the figure, implementation of the digital information system took place between January 2023 and November 2024. Following conceptualization and stakeholder engagement sessions to understand the problem, collect relevant files, and agree on the software to deploy, development work commenced. Team Leads and Technical Support Officers also gave input into the design of the system. In June 2023, an initial design was tested at the federal level in Islamabad, which led to revisions and improvements in architecture. Phase 1 was deployed in December 2023 with access granted to all NSTOP officers. Based upon the NSTOP officers' feedback, we reviewed the design and revised some indicators between May–October 2024. Phase 2 was deployed in Nov 2024 including online data-entry component and integration with the MySQL database using the revised indicators. Provincial and district officers received cascaded training on the online reporting system in December 2024. Following the training, online reporting commenced, with federal officers continuing to mentor district level officers on reporting, dashboard use and data quality.



FIGURE 3
Timeline for dashboard implementation.

Satisfaction survey – data collection

The online cross-sectional survey was conducted during March 17–22, 2025, i.e., 4 months after Phase 2 implementation. All 86 NSTOP officers who had commenced monthly reporting on the digital information system were targeted. The survey aimed to evaluate the performance of the system, assess user experiences and satisfaction with the dashboard, identify challenges encountered during use, and obtain suggestions for improvement.

The 23-item questionnaire was developed for this program-specific evaluation and included both quantitative and qualitative questions. The questions covered users' familiarity with and use of the dashboard, satisfaction with its visualizations and functionality, perceived ease of use and reliability, challenges encountered, perceived contribution to data-driven decision-making, and suggestions for improvement. The complete questionnaire is provided as Supplementary Material S3.

Google Forms was used to design and administer the survey. The survey link was emailed to all 86 eligible officers during March 17–22, 2025. To encourage candid responses and protect respondents' privacy, demographic and location information were not collected; only respondents' job categories were recorded. Participation was voluntary, and no personally identifying information was collected. Permission to conduct the survey was obtained from the NSTOP program leadership in collaboration with Integral Global Health and the U.S. Centers for Disease Control and Prevention (CDC).

The questionnaire domains overlapped with selected concepts addressed by the Technology Acceptance Model (TAM), particularly perceived usefulness and perceived ease of use. However, the questionnaire was developed for a program-specific evaluation and was not designed as a formal operationalization of TAM. The model was used to interpret relevant findings rather than to define or validate the survey instrument. Formal content-validity assessment, pilot testing, and internal-consistency reliability analysis, including Cronbach's alpha, were not conducted.

Data analysis

Variables considered in this analysis included familiarity with and use of the dashboard defined as having accessed and used the system for data entry during the 4 months preceding the survey. Other variables included overall satisfaction experience, frequency of dashboard use, ease of learning and navigating the dashboard, length of time required to complete data entry, ease of viewing district/officer specific dashboards, satisfaction with charts and visualizations, training

received on the use of the dashboard for data entry, ease of getting support when needed, dashboard influence on improved use of data defined as using dashboard data to guide decisions on appropriate vaccination interventions to ensure children are reached for vaccination.

Satisfaction with the dashboard was assessed by asking the question "*How satisfied are you with your overall experience using NSTOP dashboard?*." Respondents that selected "Very Satisfied" or "Satisfied" were categorized as satisfied while those who selected "Neutral,"" Not satisfied,"" Very Dissatisfied" were categorized as "Not Satisfied." This categorization created a binary outcome for comparing overall dashboard satisfaction, distinguishing respondents who expressed positive satisfaction from those who did not. However, neutral responses did not necessarily indicate dissatisfaction and were grouped with dissatisfied responses for the purpose of this analysis.

Sensitivity analysis was conducted to assess the impact of neutral-response classification on the estimated proportion of officers satisfied with the NSTOP dashboard. Three approaches were compared: (1) classifying neutral, dissatisfied, and very dissatisfied responses as not satisfied; (2) classifying neutral responses as satisfied; and (3) excluding neutral responses entirely from the satisfaction calculation. The resulting estimates were compared to evaluate the extent to which the overall satisfaction estimate depended on the classification of neutral responses.

For the association analysis, crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to assess the relationship between overall dashboard satisfaction and eight explanatory variables. Fisher's exact tests were used to assess statistical significance because of the small sample size and sparse cell counts in some categories. Holm's method was applied to adjust the Fisher exact test p-values for multiple comparisons across the eight associations. Adjusted odds ratios and 95% CIs were estimated using Firth penalized logistic regression to address potential small-sample bias and separation arising from sparse data. The models adjusted for officer category. Reporting level was excluded from the adjusted models because it was perfectly confounded with officer category in the study data and could not be estimated independently. Statistical significance was assessed using a two-sided p-value threshold of 0.05.

Perception of data ownership and responsibility defined as ability of respondents to respond correctly to all options in variable Q17 was measured by asking the question, "*Who do you think is the owner and user of the data from the dashboard?*" with multiple selection options such as Officers, Provincial leads, Federal officers, or Leadership. Respondents with at least 4 correct responses were categorized as having good perception while respondents with less than 4 correct responses had poor perception. This study-specific scoring rule reflected the assumption that respondents should recognize all four stakeholder groups as owners and users of dashboard data for program decision-making. Analyses were conducted using the R statistical software package.

Ethical consideration

Permission to conduct the program evaluation survey was obtained from the leadership of the National Stop Transmission of Polio (NSTOP) program in collaboration with Integral Global Health and the U.S. Centers for Disease Control and Prevention (CDC). Participation in the survey was voluntary. No personally identifying information was collected, and demographic and location information were not requested; only respondents' job categories were recorded. Given the nature of the study as part of a program evaluation, it was deemed not to be human subjects research by the CDC and informed consent was neither required nor obtained.

Results

Use of the dashboard by NSTOP officers

At the time of the survey, NSTOP had 86 officers in the provinces where the digital information system had been deployed and all the officers responded, resulting in a 100% reporting rate. The officers were categorized as follows: 64 (74%) were district coordination officers, 11 (13%) were district EPI officers, 2 (2%) were divisional task officers, 3 (3%) were team leaders, and 6 (7%) were provincial technical support officers. Ninety percent of the NSTOP officers reported being familiar with the dashboard and using it for reporting. Among the 9 (10%) officers who reported not using the dashboard, whether or not they were familiar with it, 5 were coordination officers, 3 were EPI officers and 1 was a technical support officer. Figure 4 shows the distribution of officers by familiarity and use of the dashboard.

Overall satisfaction with use of dashboard

Among the 77 (90%) NSTOP officers who were familiar with and using the dashboard, 60 (78%) reported satisfaction with the dashboard (Figure 5). Among officers working at the district level, 80% (54/67) were satisfied with the dashboard compared with 60% (6/10) of officers working at the provincial and divisional levels.

Sensitivity of overall satisfaction was assessed based on classification of neutral response as not satisfied, 78% (60/77) of respondents recording satisfaction. This was compared to 91.0% (70/77) when neutral responses were counted as satisfied and 89.7% (60/67) when 10 neutral responses were excluded. Estimated satisfaction proportion ranged from 78.2% to 91.0%, demonstrating that the classification of neutral responses substantially influenced the estimate.

Factors associated with dashboard satisfaction

Table 2 presents factors associated with overall satisfaction with the NSTOP dashboard. Users who found the dashboard easy to learn and navigate were significantly more likely to report satisfaction than those who found it difficult (83.6% versus 40.0%; OR = 7.35, 95% CI: 1.47–41.85; $p = 0.006$). This association remained significant after adjustment for officer category (adjusted OR = 5.63, 95% CI: 1.32–27.33). Satisfaction with the dashboard's charts and visualizations was also strongly associated with overall satisfaction. Among users

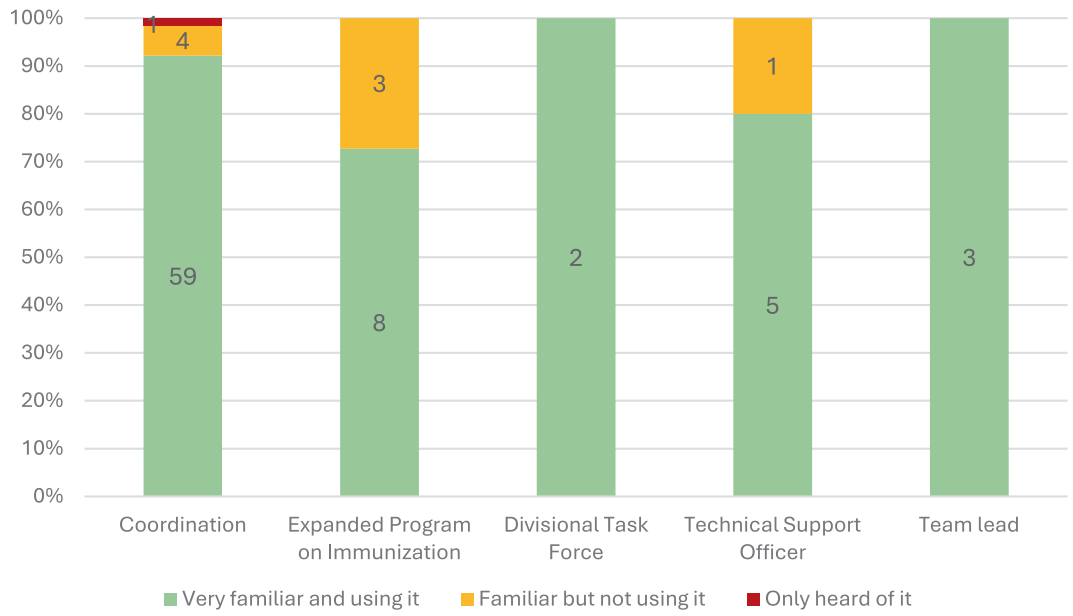

FIGURE 4
Familiarity and use of dashboard by Officer Category.

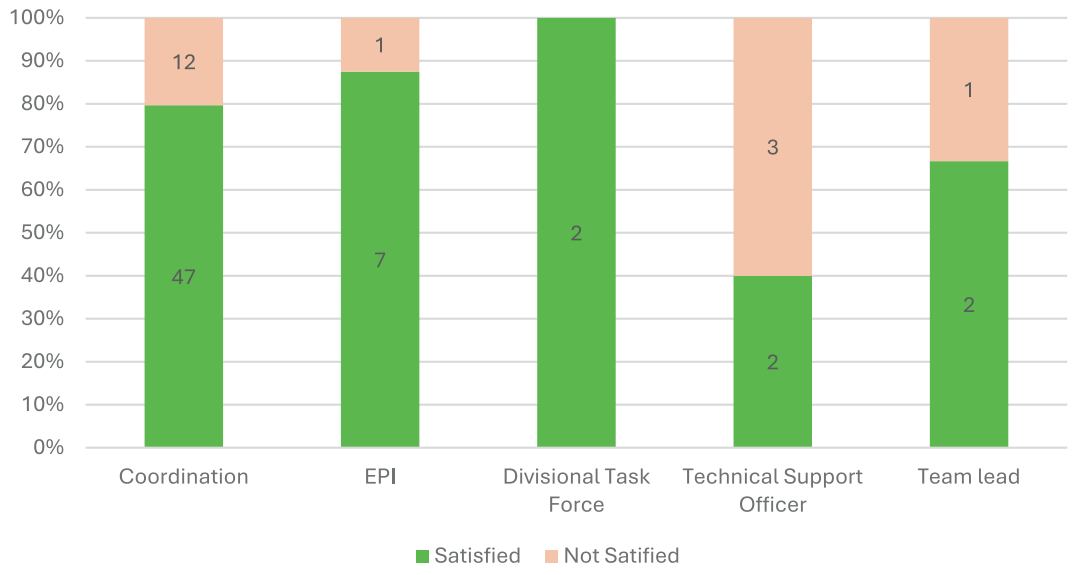

FIGURE 5
Satisfaction with dashboard by officer category.

satisfied with the visualizations, 91.2% reported overall satisfaction, compared with 40.0% of those dissatisfied with the visualizations (OR = 14.76, 95% CI: 3.71–69.59; $p < 0.001$). The adjusted odds ratio was 13.50 (95% CI: 3.78–59.68). Similarly, users who perceived the dashboard as reliable in providing accurate and up-to-date information reported higher satisfaction than those who considered it unreliable (83.8% versus 33.3%; OR = 9.91, 95% CI: 1.80–70.62; $p = 0.003$). This association remained after adjustment (adjusted OR = 7.87, 95% CI: 1.89–37.95). Users who reported that the dashboard improved their ability to make data-driven decisions were also more likely to be satisfied than those who reported no improvement (88.5% versus 56.0%; OR = 5.86, 95% CI: 1.64–23.14; $p = 0.003$). The adjusted odds ratio was 5.13 (95% CI: 1.67–17.43).

Overall satisfaction did not differ significantly between frequent and infrequent dashboard users (66.7% versus 80.0%; OR = 0.51, 95% CI: 0.11–2.65; $p = 0.447$). The adjusted odds ratio was 0.84 (95% CI: 0.20–4.05). Satisfaction was also not significantly different among trained and untrained users (77.8% versus 78.1%; OR = 0.98, 95% CI: 0.28–3.32; $p = 1.000$), with an adjusted odds ratio of 1.10 (95% CI: 0.34–3.50). Although satisfaction was higher among users who reported easy access to technical support than among those who found access difficult (80.9% versus 55.6%), this difference was not statistically significant (OR = 3.32, 95% CI: 0.58–17.96; $p = 0.102$). The adjusted odds ratio was 3.60 (95% CI: 0.86–14.56). Satisfaction was also not significantly different between users reporting long and short data-entry times

10.3389/fpubh.2026.1987935

TABLE 2 Factors contributing to satisfaction with dashboard.

Variable	Category	Not Satisfied % (*N*)	Satisfied % (*N*)	Total (*N*)	OR (95% CI)	Fisher exact test *p*-value	Holm-adjusted *p*-value	Adjusted OR (95% CI)
How often do you use the NSTOP dashboard	Frequent users	33.3% (4)	66.7% (8)	12	0.51 (0.11–2.65)	0.447	1	0.84 (0.20–4.05)
	Not frequent users	20.0% (13)	80.0% (52)	65				
How easy is it to learn and navigate the NSTOP dashboard	Easy	16.4% (11)	83.6% (56)	67	7.35 (1.47–41.85)	0.006	0.031	5.63 (1.32–27.33)
	Difficult	60.0% (6)	40.0% (4)	10				
How long reporting does it take to complete data entry on the dashboard	Long Entry Time	0.0% (0)	100.0% (4)	4	Not estimable	0.57	1	2.05 (0.18–269.26)
	Short Entry Time	23.3% (17)	76.7% (56)	73				
How satisfied are you with the charts and visualization	Satisfied	8.8% (5)	91.2% (52)	57	14.76 (3.71–69.59)	<0.001	<0.001	13.50 (3.78–59.68)
	Not satisfied	60.0% (12)	40.0% (8)	20				
Were you trained on how to use the dashboard for data entry and reviewing the charts	Trained	22.2% (10)	77.8% (35)	45	0.98 (0.28–3.32)	1	1	1.10 (0.34–3.50)
	Not trained	21.9% (7)	78.1% (25)	32				
How easy was it to get support whenever you needed help with using the NSTOP dashboard	Easy	19.1% (13)	80.9% (55)	68	3.32 (0.58–17.96)	0.102	0.409	3.60 (0.86–14.56)
	Difficult	44.4% (4)	55.6% (5)	9				
How reliable is the dashboard in providing accurate and up-to-date information	Reliable	16.2% (11)	83.8% (57)	68	9.91 (1.80–70.62)	0.003	0.018	7.87 (1.89–37.95)
	Not reliable	66.7% (6)	33.3% (3)	9				
Has the dashboard improved your ability to make data-driven decisions	Yes	11.5% (6)	88.5% (46)	52	5.86 (1.64–23.14)	0.003	0.018	5.13 (1.67–17.43)
	No	44.0% (11)	56.0% (14)	25				

(100.0% versus 76.7%; $p = 0.570$). Although the adjusted odds ratio was estimated at 2.05 (95% CI: 0.18–269.26), the extremely wide confidence interval indicates substantial uncertainty in this estimate. The crude odds ratio for this comparison was not estimable because no respondents in the long-entry-time category reported being dissatisfied.

After Holm adjustment for multiple comparisons, ease of use, satisfaction with visualizations, perceived reliability, and improved

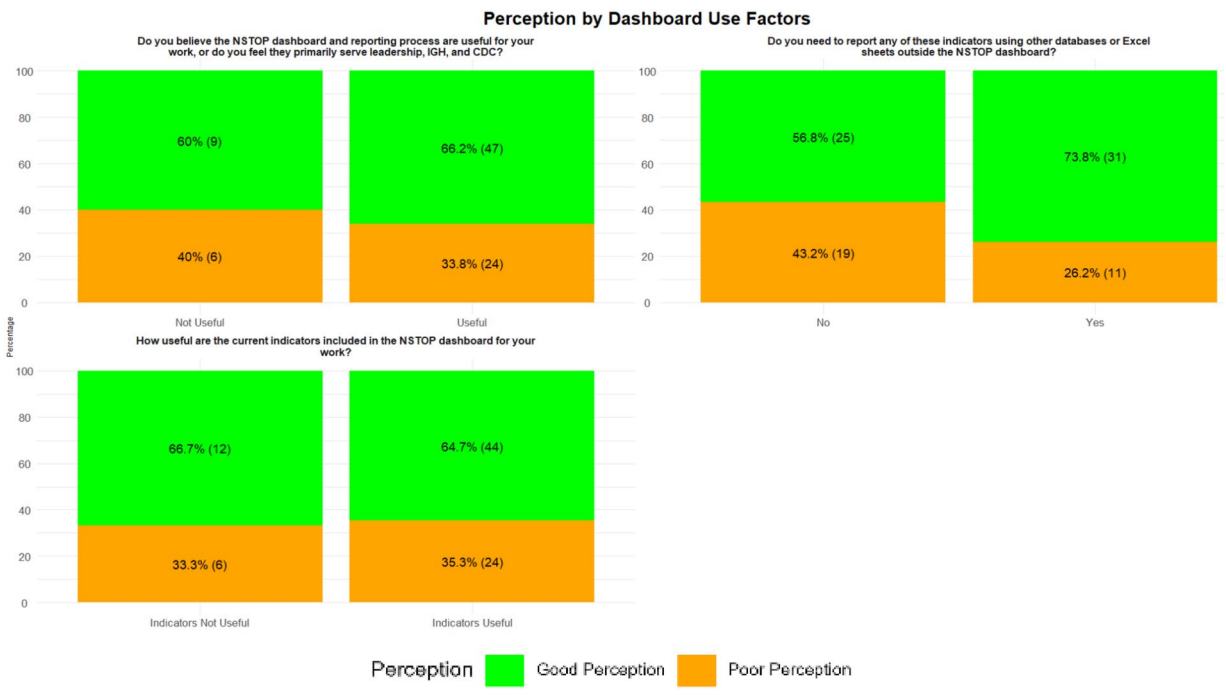

FIGURE 6
Factors contributing to perception of dashboard.

decision-making remained statistically significant in the crude Fisher exact tests (adjusted $p = 0.031$, $p < 0.001$, $p = 0.018$, and $p = 0.018$, respectively). The Holm-adjusted p-values apply to the crude Fisher exact tests rather than the adjusted odds ratios.

Overall perception of dashboard data for decision making

Figure 6 shows perception of data ownership and responsibility. Fifty-seven (66%) respondents had a good perception of data ownership (i.e., answered correctly who owned and used the data). This included 43 (67%) coordination officers, 1 (50%) divisional task force officer, 6 (55%) EPI officers, 2 (66%) team leaders, and 5 (100%) technical support officers. Among respondents who considered the dashboard and reporting process to be useful for their work, 66% demonstrated a good perception compared with 60% who considered the process not useful. Among respondents that said *No* to being required to externally report indicators using other databases, 57% reported a good perception compared to 74% of those who reported *Yes*. Furthermore 49% of respondents documented the need to use other databases outside the NSTOP dashboard or Excel spreadsheets for indicator reporting.

Qualitative findings contextualizing quantitative results

The qualitative findings complement quantitative results by illustrating how visualization quality, usability, perceived information reliability, and the fit between the dashboard and existing reporting workflows may shape users' experiences. Because these findings are based on open-ended comments, they identify opportunities to improve the system, including streamlining reporting, refining indicators, providing appropriate response options, and strengthening training and data-access functionality.

Regarding visualizations, respondents suggested improvements to graphics, font and theme, comparative trends, and filters for monthly and cumulative reports. These comments provide context for the quantitative finding that satisfaction with dashboard visualizations was strongly associated with overall satisfaction.

Respondents highlighted usability and performance concerns. Some reported difficulty opening the dashboard, slow loading, navigation challenges, and a need for continuous refresher training. Others described the dashboard as simple, user-friendly, and well organized. This indicates variation in user experience and contextualized the association between ease of learning, navigation and overall satisfaction.

Responses on information reliability reflected in comments that submitted data not seen on the dashboard and sometimes officers had to re-upload their monthly report. These are consistent with the quantitative association between perceived reliability and overall satisfaction, although the qualitative responses did not establish the frequency of these technical problems.

Continuous use of other data sources and reporting channels were reported. They recommended consolidating reporting processes further, reducing duplicate data entry, and enabling data export and correction within the dashboard. These comments provide context for the quantitative finding that satisfaction was higher among respondents who reported improved ability to make data-driven decisions, while the continued use of external reporting tools suggests that some analytical and reporting needs remained unmet.

Discussion

This study explored the familiarity, usage, satisfaction, and perception with the implementation of a R-based digital information

system among officers of the NSTOP program in Pakistan, offering important insights into the factors that influence its use. The high response rate among officers provides a complete representation of the officers and reflects strong engagement with the platform. The findings revealed a high level of familiarity and usage of the dashboard, indicating successful initial integration within the program. The officers who reported limited familiarity or non-use were predominantly in district-level positions. Continued targeted orientation and support may therefore be useful for achieving more consistent adoption across officer categories.

User satisfaction levels were generally high, particularly among district-level officers, compared to their provincial counterparts. This variation may stem from differences in workflows, data reporting responsibilities, or the perceived relevance of the dashboard to daily operations. District officers may have reported higher satisfaction because the dashboard's design appears to be more closely aligned with operational data entry and reporting tasks typically performed at the district level rather than the aggregation and analytical functions required at higher administrative levels. This observation is consistent with prior studies highlighting the role of perceived usefulness in the Technology Acceptance Model and the influence of workflow alignment on digital health system adoption (12, 13). These perspectives provide a useful framework for interpreting user experiences; however, the present findings do not demonstrate that organizational hierarchy or proximity to frontline responsibilities determines satisfaction with the NSTOP dashboard. The sensitivity analysis demonstrated that the estimated proportion of officers satisfied with the NSTOP dashboard varied according to the classification of neutral responses. This variation highlights the importance of explicitly defining neutral responses when measuring user satisfaction, as their classification can materially influence the reported estimate. Although the primary analysis provides a consistent basis for comparison with the original analysis, classifying neutral responses as not satisfied may underestimate satisfaction among respondents who do not express a negative opinion. Conversely, classifying neutral responses as satisfied may overestimate satisfaction. These findings support interpreting the satisfaction estimate alongside alternative classifications and underscore the value of further examining neutral responses to better understand users' experiences and identify opportunities for improving the dashboard.

Several factors emerged as strong drivers of user satisfaction. Perceived usefulness in supporting data-driven decision-making was a key determinant. This also aligns with the Technology Acceptance Model (12), which identifies perceived utility as a critical factor influencing user engagement and satisfaction with information systems (14). Ease of learning and intuitive navigation also contributed to positive experiences, underscoring the importance of user-centered design principles in health information technologies (15). While prior studies have established perceived usefulness and usability as key drivers of technology adoption across health IT contexts (16, 17), this study demonstrates their direct impact on decision-making practices within a large-scale immunization program. By situating these determinants in the operational realities of immunization systems, the study underscores the importance of dashboards that are not only functional but also directly relevant to frontline programmatic decision-making.

Our analysis did not demonstrate a statistically significant association between perceived ease of obtaining support and overall dashboard satisfaction. This finding contrasts with previous studies that highlighted the potential role of responsive technical support in facilitating the use of digital health platforms (18). Nevertheless, accessible technical support may remain an important implementation consideration when introducing and sustaining digital health platforms. Similarly, perceived reliability and accuracy of dashboard data were significantly associated with overall satisfaction, reflecting broader findings that data quality and integrity are foundational for effective decision-making in health systems (19). Taken together, these findings suggest that users' perceptions of system reliability are associated with overall satisfaction, while the potential role of responsive support warrants further investigation (18, 20). Previous studies have also highlighted the importance of trusted data (19, 21, 22). These findings and the supporting literature underscore the potential value of maintaining high data integrity and accessible user support when scaling digital health platforms for immunization programs, although the present study does not establish their causal effects on satisfaction or sustainability.

Although the association between data-entry time and overall dashboard satisfaction was not statistically significant, the relationship between reporting efficiency and user satisfaction may warrant further investigation. The high satisfaction observed among respondents reporting longer data-entry times should be interpreted cautiously because this group was small and does not establish that longer entry times improve satisfaction or reporting efficiency. Regular dashboard use may promote familiarity and confidence, potentially reinforcing engagement over time; however, the present findings did not demonstrate a significant association between frequency of use and overall satisfaction. Therefore, the proposed relationship between repeated use, satisfaction, and sustained engagement remains hypothetical and requires further investigation. Satisfaction with the dashboard's charts and visualizations was significantly associated with overall dashboard satisfaction, consistent with dashboard design principles emphasizing clarity and intuitive visual presentation (23–25). While previous work has emphasized general principles of effective dashboard design (23), the present findings highlight the relevance of users' perceptions of visualizations to overall satisfaction. Whether familiarity gained through repeated use contributes to sustained engagement remains an important question for future research.

The association between training and overall dashboard satisfaction was assessed but was not statistically significant. This finding does not establish that training was ineffective, as the analysis assessed the association between training exposure and satisfaction rather than the quality, duration, or effectiveness of training. Previous studies have highlighted the importance of organizational support and training in health information technology adoption (26), provided frameworks for understanding technology acceptance (27), and identified workforce training and strengthened health information systems as strategies for improving health-system resilience (28). Similarly, the GEEKS initiative in Nigeria provides a relevant implementation context for considering mentorship and capacity strengthening in routine immunization data management (29). Nevertheless, these external findings should not be interpreted as evidence that training increased satisfaction in the present study. Further research could examine whether the content, quality, and intensity of training influence dashboard use and user experience.

Overall perceptions of the dashboard's utility for decision-making were positive, though there were variations among officer categories.

For some groups, the dashboard fully met their data needs, while others relied on supplementary tools such as external databases or Excel worksheets. This pattern suggests that while the dashboard serves as a valuable resource, there may be gaps in functionality or data coverage that require users to engage with additional systems. Further exploration of these external reporting practices may provide insights into opportunities for integrating these functions within the dashboard, thereby creating a more seamless user experience. By documenting this dynamic, the study advances understanding of how digital platforms must evolve to meet diverse and evolving user needs, emphasizing the importance of system interoperability and adaptability (30–32).

This study has several limitations. First, findings are based on self-reported data from officers, which may be subject to bias particularly in reporting satisfaction and usage. To minimize potential bias and encourage candid responses, no personal identifying information was collected, and respondents were informed that individual responses would remain anonymous and would not be shared with supervisors or program leadership. The sample sizes for categories above the district level (team leads, technical support officers and divisional task force) were very small, which limits the ability to generalize study findings to similar cadres of frontline health workers. The study focused on user perceptions without a direct link to performance or health outcomes, constraining the ability to assess the broader impact of dashboard utilization. Future studies that integrate longitudinal data and performance indicators could provide a more comprehensive understanding of the dashboard's role in strengthening immunization systems. The instrument was not validated, and most constructs were measured as single item. Also, system performance was not analyzed, although the data is available as it is not part of the manuscript objectives.

Conclusion

The findings of this study highlight the significant progress made in developing and integrating an R-based dashboard into routine NSTOP program operations. High levels of familiarity, and overall satisfaction among officers underscore its growing role as a tool for data-driven decision-making within the Pakistan polio program. Key factors contributing to these positive outcomes include the perceived usefulness of the dashboard in supporting work processes, its user-friendly design, the reliability and accuracy of the data it provides. Despite these successes, variations in satisfaction and perceptions across different officer categories suggest that further refinement is needed to ensure the dashboard meets the diverse needs of all users. Addressing challenges such as optimizing data entry workflows, enhancing the visual appeal of dashboards, and integrating functionalities that currently require the use of external reporting tools could strengthen the system's utility and efficiency. Continued investment in tailored training programs and responsive support systems will be essential to sustaining user engagement and maximizing the dashboard's potential. By building these strengths and addressing identified gaps, the NSTOP dashboard can further solidify its role as a useful resource for advancing data-informed public health action and improving program outcomes across all levels of the health system.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://docs.google.com/spreadsheets/d/1rFcxfXf9d-koBBi2V4c4Z_iQcIDAHRZoq3RjLbfmn2s/edit?resourcekey=&gid=181726638#gid=18,726638.

Author contributions

AA: Funding acquisition, Software, Methodology, Writing – original draft, Conceptualization, Supervision, Formal analysis, Visualization, Resources, Investigation, Writing – review & editing, Project administration, Validation, Data curation. HK: Conceptualization, Writing – review & editing, Project administration. AMe: Project administration, Writing – review & editing, Supervision, Methodology, Visualization, Conceptualization, Validation. AP: Project administration, Writing – review & editing. JK: Writing – review & editing, Supervision. FA: Conceptualization, Writing – review & editing, Project administration, Visualization. ML: Conceptualization, Writing – review & editing, Project administration. MS: Conceptualization, Project administration, Writing – review & editing. AMo: Data curation, Writing – review & editing, Supervision, Conceptualization. RF: Writing – review & editing, Supervision, Project administration, Conceptualization, Visualization, Methodology, Formal analysis. CM: Writing – review & editing, Supervision, Data curation, Conceptualization, Formal analysis, Methodology, Visualization, Project administration.

Funding

The author(s) declared that financial support was received for this work and/or its publication. Funding for the design and implementation of the dashboard was provided by Center for Disease Control through Integral Global. The NSTOP program is one of the major implementation organizations for Polio program in Pakistan. Centers for Disease Control and Prevention funds the NSTOP program. Integral Global is the managing organization for the NSTOP program.

Acknowledgments

The authors appreciate the contributions of all the officers of NSTOP program and acknowledge the support of Omotola Akerele andMatthew Aduloju for their contributions during the development of the system.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was used in the creation of this manuscript. Chat GPT. Generative AI was used to assist with language editing, clarity, and organization of the manuscript. The authors reviewed and verified all AI-assisted content and remain fully responsible for the accuracy, interpretation, and integrity of the manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Author disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official positions of their affiliated institutions.

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2026.1987935/full#supplementary-material

References

1. Syed ARS, Raza SSM, Zakir SJ, Chishti MAS, Ahmad S, Khan HD, et al. Mission of polio eradication in Pakistan—a review on challenges and future recommendations. *New Microbes New Infect*. (2025) 64:101571. doi: 10.1016/j.nmni.2025.101571

2. Soofi SB, Vadsaria K, Mannan S, Habib MA, Tabassum F, Hussain I, et al. Factors associated with vaccine refusal (polio and routine immunization) in high-risk areas of Pakistan: a matched case-control study. *Vaccines (Basel)*. (2023) 11:947. doi: 10.3390/vaccines11050947

3. Siddiqui E, Khalid M, Khan MS, Waafira A. Polio resurgence in Pakistan: unraveling the causes and addressing the consequences. *Infect Ecol Epidemiol*. (2024) 15:2447092. doi: 10.1080/20008686.2024.2447092

4. Asghar RJ. Why is polio still here? A perspective from Pakistan. *Lancet Glob Health*. (2020) 8:e177–8. doi: 10.1016/S2214-109X(19)30524-8

5. Jones DS, Dicker RC, Fontaine RE, Boore AL, Omolo JO, Ashgar RJ, et al. Building global epidemiology and response capacity with field epidemiology training programs. *Emerg Infect Dis*. (2017) 23:S158–65. doi: 10.3201/eid2313.170509

6. Pervaiz A. Assessment of the NSTOP (FELTP) program progress towards polio eradication in Pakistan, 2011–2016 Abstracts of the 9th TEPHINET Global Conference 2017 Aug 7–11; Chiang Mai, Thailand. Available online at: https://www.tephinet.org/learning/fead/assessment-nstop-feltp-program-progress-towards-polio-eradication-pakistan-2011-2016

7. Kerr Y, Mailhot M, Williams AAJ, Swezy V, Quick L, Tangermann RH, et al. Lessons learned and legacy of the stop transmission of polio program. *J Infect Dis*. (2017) 216:S316–23. doi: 10.1093/infdis/jix163

8. Saghaeiannejad-Isfahani S, Jahanbakhsh M, Habibi M, Mirzaeian R, Nasirian M, Rad JS. A survey on the users' satisfaction with the hospital information systems (HISs) based on DeLone and McLean's model in the medical-teaching hospitals in Isfahan City. *Acta Inform Med*. (2014) 22:179–82. doi: 10.5455/aim.2014.22.179-182

9. R Core Team. *R: a Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing (2025).

10. Hornik K. The comprehensive R archive network. *Wiley Interdiscip Rev Comput Stat*. (2012) 4:394–8. doi: 10.1002/wics.1212

11. Wickham H, Averick M, Bryan J, Chang W, McGowan LDA, François R, et al. Welcome to the tidyverse. *J Open Source Softw*. (2019) 4:1686. doi: 10.21105/joss.01686

12. Venkatesh V, Davis FD. A theoretical extension of the technology acceptance model: four longitudinal field studies. *Manag Sci*. (2000) 46:186–204. doi: 10.1287/mnsc.46.2.186.11926

13. Ludwick DA, Doucette J. Primary care physicians' experience with electronic medical records: barriers to implementation in a fee-for-service environment. *Int J Telemed Appl*. (2009) 2009:853524. doi: 10.1155/2009/853524

14. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q*. (1989) 13:319–40. doi: 10.2307/249008

15. Zhang J, Walji MF. TURF: Toward a unified framework of EHR usability. *J Am Med Inform Assoc*. (2011) 44:1056–67. doi: 10.1016/j.jbi.2011.08.005

16. Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. *Manag Sci*. (1989) 35:982–1003. doi: 10.1287/mnsc.35.8.982

17. Luo J, Ahmad SF, Alyaemeni A, Ou Y, Irshad M, Alyafi-Alzahri R, et al. Role of perceived ease of use, usefulness, and financial strength on the adoption of health information systems: the moderating role of hospital size. *Humanit Soc Sci Commun*. (2024) 11:516. doi: 10.1057/s41599-024-02976-9

18. Gagnon MP, Desmartis M, Labrecque M, Car J, Pagliari C, Pluye P, et al. Systematic review of factors influencing the adoption of information and communication technologies by healthcare professionals. *J Med Syst*. (2012) 36:241–77. doi: 10.1007/s10916-010-9473-4

19. Weiskopf NG, Weng C. Methods and dimensions of electronic health record data quality assessment: enabling reuse for clinical research. *J Am Med Inform Assoc*. (2013) 20:144–51. doi: 10.1136/amiajnl-2011-000681

20. Stroetmann KA, Artmann J, Stroetmann VN, Protti D, Dumortier J, Giest S, et al. *European Countries on Their Journey towards National eHealth Infrastructures*. Luxembourg: Publications Office of the European Union (2011).

21. Chen H, Hailey D, Wang N, Yu P. A Review of Data Quality Assessment Methods for Public Health Information Systems. *Int. J. Environ. Res. Public Health*. (2014) 11:5170–207. doi: 10.3390/ijerph110505170

22. Liaw ST, Rahimi A, Ray P, Taggart J, Dennis S, de Lusignan S. Towards an ontology for data quality in integrated chronic disease management: a realist review of the literature. *Int J Med Inform*. (2013) 82:10–24. doi: 10.1016/j.ijmedinf.2012.10.001

23. Few S. *Information Dashboard design: the Effective visual Communication of data*. 2nd ed. Burlingame (CA): Analytics Press (2013).

24. Shenvi E, Boxwala A, Sittig D, Zott C, Lomotan E, Swiger J, et al. Visualization of patient-generated health data: a scoping review of dashboard designs. *Appl Clin Inform*. (2023) 14:913–22. doi: 10.1055/a-2174-7820

25. Bucalon RB, Shaw T, Brown K, Kay J. State-of-the-art dashboards on clinical indicator data to support reflection on practice: scoping review. *JMIR Med Inform*. (2022) 10:e32695. doi: 10.2196/32695

26. Cresswell K, Sheikh A. Organizational issues in the implementation and adoption of health information technology innovations: an interpretative review. *Int J Med Inform*. (2013) 82:e73–86. doi: 10.1016/j.ijmedinf.2012.10.007

27. Holden RJ, Karsh BT. The technology acceptance model: its past and its future in health care. *J Biomed Inform*. (2010) 43:159–72. doi: 10.1016/j.jbi.2009.07.002

28. Mosadeghrad AM, Afshari M, Isfahani P, Ezzati F, Abbasi M, Farahani SA, et al. Strategies to strengthen the resilience of primary health care in the COVID-19 pandemic: a scoping review. *BMC Health Serv Res*. (2024) 24:841. doi: 10.1186/s12913-024-11278-4

29. Rachlin A, Adegoke OJ, Sikare E, Adeoye OB, Dagoe E, Adeyelu A, et al. Lessons learned from early implementation of the growing expertise in E-health knowledge and skills (GEEKS) program in Nigeria, 2019–2021. *Pan Afr Med J*. (2023) 46:81. doi: 10.11604/pamj.2023.46.81.38588

30. Sheikh A, Sood HS, Bates DW. Leveraging health information technology to achieve the "triple aim" of healthcare reform. *J Am Med Inform Assoc*. (2015) 22:849–56. doi: 10.1093/jamia/ocv022

31. Braa J, Hanseth O, Heywood A, Mohammed W, Shaw V. Developing health information systems in developing countries: the flexible standards strategy. *MIS Q*. (2007) 31:381–402. doi: 10.2307/25148796

32. Shigayeva A, Coker RJ. Communicable disease surveillance and health system strengthening: ensuring effective integration. *Health Policy Plan*. (2015) 30:56–67. doi: 10.1093/heapol/czu005