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Technical Brief: Digital Health Interventions to Support Health Workers Providing Immunisation Services

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Executive Summary

Health workers are essential to the success of immunisation programs. They vaccinate, generate demand, manage cases, engage with communities, and educate the general population. They also generate data that is essential for immunisation planning, service delivery, and monitoring. Many health systems struggle with issues such as inadequate training for health workers, limited supportive supervision, limited communication, incomplete data reporting and ineffective mechanisms for tracking unvaccinated or under-immunised children.

Digital technology presents a transformative opportunity to support the efforts of health workers in delivering immunisation services. Digital health interventions, such as mobile health (mHealth) applications, electronic immunisation registries (EIRs), geo-location-enabled case management tools, clinical decision support tools, and checklists, provide innovative solutions by streamlining data capture, improving communication and quality of health service delivery, and enabling triangulation with disease occurrence data to support real-time decision-making. These tools help health workers enhance the accuracy and efficiency of immunisation services and contribute to better health outcomes, such as timely completion of immunisation schedules and reduced loss to follow-up.

This Technical Brief, developed as part of the effort by Gavi, the Vaccine Alliance to expand beyond Digital health Information to Digital Health, documents the opportunities that digital health interventions provide to health workers to address critical challenges in immunisation delivery and enhance overall health system performance. The brief reviews existing literature and draws on insights from key stakeholders to provide a comprehensive overview of digital health interventions for health workers and their impact on immunisation services. It outlines strategic recommendations for integrating these technologies into immunisation programs to maximise their benefits, emphasising the need for robust digital infrastructure, training, and stakeholder engagement.

Key Recommendations

1. **Invest in Digital Health Tools and EIRs:** Reduce administrative workload and support health workers in increasing vaccination coverage and reducing missed opportunities by implementing targeted mHealth tools and electronic immunisation registries, ultimately boosting their performance and service delivery.
2. **Integrate with the Broader Digital Health Ecosystem and Architecture:** Align health worker tools for immunisation with the country's digital health strategy, ideally linking to a Health Information Exchange and using well adopted standards such as FHIR to aid the generation of a longitudinal health record of the patient accessible by the immunisation service providers but also clinicians at all tiers of the health system as needed for continuity of care.
3. **Deploy Digital Health Interventions For Remote Areas:** Use portable, offline-capable digital health tools to ensure continuous care in remote and underserved regions.
4. **Implement Blended Learning Models:** Combine eLearning modules with hands-on training to improve healthcare worker knowledge retention and application.
5. **Integrate Health Interventions into MNCH Platforms:** Embed digital tools within existing MNCH platforms to enhance health workers' efficiency, streamline service delivery, and improve coordination in patient care.
6. **Develop Gender-Sensitive Health Interventions:** Design gender-sensitive mHealth tools that are practical, user-friendly, and accessible, addressing digital literacy of the health workforce and, in particular, the unique challenges faced by female health workers.
7. **Adopt Change Management Strategies and Foster Support Networks:** Actively involve health workers in the design process and clearly communicate the benefits of digital tools to mitigate resistance. Establish a continuous feedback loop, enabling health workers to contribute insights and participate in regular user testing, ensuring that user-centred approaches remain highly acceptable. Additionally, provide technical assistance, peer support, and resources to facilitate the effective use of digital interventions and promptly address emerging challenges.
8. **Collaborate with Local Tech Providers:** Partner with local technology companies to develop health interventions that address health worker challenges like low-tech skills and limited internet access, ensuring these tools are well-supported and effective in local contexts.
9. **Enhance Data Analytics Systems:** Invest in data analytics and reporting systems that empower health workers with actionable insights, improving their ability to track vaccination coverage and disease trends, detect outbreaks, and make informed decisions on immunisation strategies.

Background

In many low- and middle-income countries (LMICs), health workers—including midwives, nurses, Frontline Health Workers, and Community Health Workers (CHWs)—are often the cornerstone of healthcare delivery, serving as the primary or the only point of contact for individuals seeking health services. Despite their critical role, these workers are frequently overwhelmed by a multitude of challenges, including heaving workloads, accurately recording and updating patient data, managing complex tasks with limited resources and time, and maintaining up-to-date skills and performance (Lorenzetti et al., 2020). These constraints not only strain the healthcare workers but also contribute to inefficiencies in service delivery, particularly in routine childhood immunisation. The WHO classification of digital health interventions, services and applications (WHO, 2023) identified several health challenges that can hamper the effectiveness and quality of service delivery, including health worker competence, burden of manual processes, low adherence to protocols, inadequate supportive supervision, loss to follow-up, and lack or inadequate referrals.

Digital health interventions have emerged as a transformative solution to these challenges, offering critical support to healthcare workers and enhancing the accessibility and quality of healthcare delivery (Agarwal et al., 2015; WHO, 2023). These tools streamline various functions, such as household and individual registration, targeted communication for demand generation as well as health worker support, personal health tracking, ensuring accurate data collection and guiding healthcare workers in adhering to government protocols during patient visits. By reducing administrative burdens and facilitating better scheduling, digital interventions significantly improve health worker efficiency and quality of service delivery.

Such digital health interventions enhance program monitoring by providing real-time access to patient level data, enabling better coordination, and timely follow-ups. This capability is crucial for improving immunisation programs and addressing gaps in healthcare delivery, ultimately leading to improved immunisation coverage and better overall health outcomes (Layer et al., 2023). By addressing the unique challenges faced by healthcare workers in LMICs, digital health interventions have the potential to not only alleviate the workload of health workers but also to significantly boost immunisation rates and enhance the effectiveness of healthcare services.

Supporting Gavi's priorities

Scaling up vaccine coverage and reaching under-immunised and zero-dose children are foundational priorities for Gavi's 5.0 Strategy and a key focus for Gavi 6.0. These priorities emphasise the importance of building trust and confidence in immunisation services, expanding program coverage, preventing and responding to outbreaks, and supporting country-led design of services that meet the needs of caregivers and underserved communities. Ensuring the quality delivery of vaccination services by healthcare workers is crucial to achieving these goals.

Digital health interventions play a vital role in enhancing the performance and effectiveness of health workers delivering immunisation services. By investing in digital tools and technologies, Gavi can improve health worker support, leading to increased immunisation coverage, equity, and quality. This includes enhancing data collection and use, improving communication and coordination, and streamlining vaccine management. The Digital Health Information Strategy 2022-2025 underscores Gavi's dedication to digitally transforming immunisation information systems, recognizing the potential of digital health information to accelerate progress towards its mission.

To further harness the potential of digital health, Gavi has prioritised an effort to move beyond information systems to more effective use of digital technology for improved service delivery to make a meaningful difference in the lives of millions, ensuring that lifesaving vaccines reach all individuals, especially in underserved communities. This requires a coordinated approach, leveraging partnerships, and supporting countries to develop and implement effective digital health interventions that strengthen immunisation programs and improve health outcomes.

Review of literature and experiences

A rapid review of published, peer-reviewed literature was conducted to provide an overview of the state of evidence and experiences implementing digital health interventions to support healthcare workers who provide immunisation services and community volunteers who promote immunisation demand and follow-up in the community (see Appendix A for more details). In addition, key informant interviews were conducted with 15 digital health and immunisation experts to understand current usage of digital health interventions for health workers, gaps and needs in their implementation, and priorities for improvement and scale.

The review of the literature includes 84 peer-reviewed articles reporting on the use of digital health interventions to support the responsibilities and roles of healthcare workers in their provision of routine immunisation (RI) activities in LMICs. The selected articles include outcome evaluations, process evaluations, case studies, implementation reports and literature reviews that fall into four broad topic categories, including digital job aids for health workers; eLearning and remote training; data record keeping, including electronic immunisation registries, and peer support and mentorship.

Digital job aids for health workers

Digital job aids for health workers encompass tools made available on mobile phones, tablets or other portable devices that support the frontline health worker in their day-to-day responsibilities of providing community-based or facility-based services. Clinical decision-support systems are a type of job aid that combines digitised protocols for the health provider with prompts and reminders at the point-of-care to guide them in counselling, scheduling and compliance with recommended immunisation schedules (Agarwal et al., 2021). These tools have the potential to improve the quality of care, counselling, adherence to recommended immunisation schedules and to reduce missed opportunities for vaccination. In a review of an immunisation-focused decision support tool for health workers in Pakistan and Bangladesh, the tool was appreciated by end-users for being fast and easy to use but was limited by the parallel paper-based reporting requirements and mistrust of some of the parameters that didn't align with their own understanding of the immunisation schedule (Siddiqi et al., 2023). More commonly, clinical decision support functions for scheduling vaccinations are integrated with other job aid packages discussed below.

Job aids may take the form of a library of audio or video resources that the health worker can use to complement one-on-one or group counselling sessions to promote demand and align to approved messages and program guidelines. These multimedia resources can help stimulate discussion and convey accurate and tested messages in the local language. In Afghanistan, a video library of messages for use during counselling sessions helped community health workers reinforce their own understanding of health topics and saved time since the beneficiaries were able to understand the key messages quickly (Lorenzetti et al., 2020). Interactive voice

response (IVR) messages shared during counselling sessions in India increased community health workers' self-confidence and led beneficiaries to initiate discussions in the community outside of the counselling session (Ward et al., 2020).

Other tools in the job aid category are reminders and alerts to the health worker for follow-up with defaulters or other missed milestones related to immunisation or broader maternal and child health services. Automatically generated reminders sent to health workers in Thailand to follow-up with scheduled vaccine appointments resulted in improved on-time vaccination (Kaewkungwal et al., 2010).

The job aid features highlighted above are often integrated into platforms covering a suite of maternal, neonatal and child health services, including routine childhood immunisation. These platforms may incorporate other functions such as performance monitoring, immunisation and health data collection, reporting and analysis, and training modules as well. A number of comprehensive digital job aid packages are designed for community health workers or volunteers, members of the community who provide regular check-ins, referral and counselling to pregnant women and mothers with young children. This cadre of community health workers provide critical outreach for static health services and national immunisation programmes and play an important role in demand generation. Even though they are not always involved in directly administering vaccines, many of the digital job aids focus on improving their delivery of key immunisation messages, counselling and communication skills with beneficiaries in the community. Community health workers in India report that a comprehensive digital job aid platform helped them prioritise and schedule home visits and helped them recommend the next appropriate immunisation date to keep the child on track for the recommended schedule of vaccines (Carmichael et al., 2019). Job confidence, trust and status in the community are also shown to improve when community health workers have digital job aids to help them in their daily responsibilities (Carmichael et al., 2019; Ward et al., 2020; Lorenzetti et al., 2020). Digitally-enabled counselling guidance can result in more systematic and structured sessions with beneficiaries (Shah et al., 2019). Digital data entry and reporting saves time and reduces the community health worker's record-keeping burden (Saha & Quazi et al.,2022; Lorenzetti et al., 2020).

> *Key informants emphasised that "digital tools designed to fit the existing workflows and familiar technologies of women and health workers help them feel more empowered and knowledgeable." They also pointed out that "educating female health workers through these tools is crucial, as it enhances their understanding and skills, making them feel more capable and confident in their roles."*

However, evaluations of digital job aid packages for community health workers show no measurable impact on routine childhood immunisation coverage rates (Prinja et al., 2017; Carmichael et al., 2019; Ward et al., 2021; Modi et al., 2019; Saha & Quazi 2022; Ward et al., 2020; Hategeka et al., 2019). This lack of demonstrated impact on childhood immunisation outcomes may stem from the fact that CHWs are not administering the vaccines themselves but are referring caregivers to the next tier of health service delivery locations which may suffer from stock-outs or other demand-related barriers that limit or discourage access to immunisation services (Modi et al., 2019; Ward et al., 2020). Other reasons discussed in the literature could be issues with overly technical health messages or a gap in the CHWs' delivery and understanding of counselling topics (Ward et al., 2021; Carmichael et al., 2019).

eLearning, distance learning and remote training

eLearning, facilitated by digital technologies using Transmission Control Protocol (TCP) and Internet Protocol (IP) standards, commonly referred to as online, web-based, or networked, offers significant advantages over traditional learning methods, with some modalities also having offline applicability.(Mastellos et al., 2018 ;WHO 2020). It provides increased accessibility, improved content delivery, on-demand availability, self-paced learning opportunities, and reduced costs, with the added benefit of customizable learning plans. This flexibility makes it an effective tool for various users, including frontline healthcare workers, nurses, staff, program managers, leaders, and policymakers involved in the immunisation field (Stokx et al., 2016; Masresha et al., 2021; Masresha et al., 2020; Kartoglu et al., 2017).

Keeping up with the latest information is crucial for healthcare workers (HCWs) and their supervisory staff. Regular in-service training is necessary to address evolving needs from new vaccines, emerging technologies, and an expanding scope of immunisation programs that now extend beyond infancy into adulthood (Masresha et al., 2021). A study conducted in 9 countries in the WHO African Region revealed that 98.3% of program officers participating in an immunisation program identified skill gaps and a need for training (Masresha et al., 2021). Online training has been shown to enhance the capacity of mid-level program managers in immunisation programs (Masresha et al., 2021).

In India, an effective mHealth tool for eLearning among ASHA (Accredited Social Health Activist) workers is Mobile Academy, which uses Interactive Voice Response (IVR) technology to deliver training. This audio-based course, which is accessible through a basic feature phone, covers various topics like reproductive, maternal, and child health, including immunisation. ASHA workers can progress through the course at their own pace, and it requires minimal digital literacy skills. This tool has proven to enhance accessibility, improve communication skills, and boost user confidence. Due to its value, the app has been adopted in 13 states in India, reaching over 171,451 ASHA workers (Bashingwa et al., 2021; Chamberlain et al., 2021; Scott et al., 2022).

eLearning can be implemented through various formats such as DVDs (Stokx et al., 2016), smartphones (Mastellos et al., 2018; Salehi et al., 2023), Interactive Voice Response (IVR) systems (Chamberlain et al., 2021) and tablets, laptops and desktops etc. (Georgeu-Pepper, D et al., 2022) Interactive and engaging content, complemented

by visually aided materials and delivered in regional languages, effectively addresses diverse learner needs and contexts. This approach has been shown to enhance retention and improve comprehension (Stokx et al., 2016). Kaewwimol et al., (2023) demonstrated that repeated exposure to eLearning improved healthcare workers' knowledge and problem-solving abilities, which are essential for vaccine administration and outbreak management. Ensuring the quality and relevance of material, along with small-sized downloads and flexibility for revision, helped minimise barriers for HCWs (Salehi et al., 2023; Mastellos et al., 2018).

eLearning that incorporates real-world tasks along with engaging content has proven to be most beneficial (Kartoglu et al., 2017). For example, GLO wheels, created by WHO Global Learning Opportunities, are designed to help learners gain deep expertise through hands-on and interactive experiences,allowing participants to gain deep expertise by physically travelling along the cold chain, observing real-time vaccine management, and interacting with operational staff at storage, warehousing, and healthcare facilities. This approach provides learners with a comprehensive, interactive, and immersive understanding of vaccine management processes (Kartoglu et al., 2017). Assessments based on real-life scenarios and receiving human support were particularly well-received (Kartoglu et al., 2017). Collaborative and peer-based learning, combined with remote methods, significantly improve problem-solving and knowledge sharing, and help in better retention of the training material (Mastellos et al., 2018; Kartoglu et al., 2017).

Watkins et al. (2022) highlight the benefits of peer-learning through The Geneva Learning Foundation's (TGLF) Immunization Training Challenge Hackathons (ITCH). Participants provided feedback emphasising the importance of peer support, which enhanced their training outcomes. Additionally, Mastellos et al. (2018) found that blended learning—merging self-paced eLearning with traditional in-person training methods—was more cost-effective for training CHWs in Sub-Saharan Africa compared to conventional methods, especially when complemented by on-site training and peer support.

> *According to key informant interviews, "proper training and ongoing technical support are vital to the successful implementation of digital health tools."*

Despite their success in controlled settings, scaling eLearning solutions has proven challenging, as evidenced by the lack of nationally scaled programs. In-person training often disrupts patient care by requiring health workers to leave their posts. Key obstacles include resource constraints, addressing diverse user needs, digital literacy challenges, the gender digital divide, and infrastructural limitations. To effectively scale digital health tools, it is crucial to adopt a flexible, context-sensitive approach, backed by sustained investment and strategic planning to overcome these barriers (Chamberlain et al., 2021).

Electronic medical records, electronic immunisation registries & community information systems

A Health Management Information System (HMIS) is designed to systematically organise the collection, storage, retrieval, and processing of health-related data (Kasambara et al., 2017). Electronic Medical Records (EMRs) and Electronic Immunization Registries (EIRs) are components of HMIS that enhance data management by enabling clients to be digitally registered, with subsequent data entered about services delivered. These systems are not only intended to address the inefficiencies and errors associated with paper records but also to directly support health workers by improving the accuracy and efficiency of patient care and documentation, including epidemiological monitoring and generating information for action (Jalloh et., al 2020; Shuaib et., al 2016; Lee et al., 2022; Äijö et al., 2020). EMRs and EIRs help health workers by generating a longitudinal record that simplifies ongoing patient management, thereby reducing the time spent on manual record-keeping and minimising the risk of errors and reducing administrative burdens (Äijö et al., 2020; Numair et al., 2021). Additionally, many of these health interventions offer integrated decision support, making it easier for health workers to report data and adhere to vaccination schedules, ultimately enhancing their ability to deliver timely and effective care (Shuaib et al., 2016; Haider et al., 2022).

Research suggests that for an mHealth-based HMIS to be successfully implemented, it is essential that health workers in community health facilities—who are at the forefront of managing health data—accept and embrace the new system (Zaidi et al., 2020). The integration of EMR systems, coupled with technical training and supervisory visits, has led to significant improvements in the completeness of child vaccination records (Shuaib et al., 2016). For instance, Shuaib et al. (2016) reported enhanced record-keeping practices when EMRs were tailored to fit health care workers' daily routines. Additionally, EMRs have streamlined data storage and improved interactions between providers and patients, allowing for better engagement during consultations. However, challenges related to infrastructure and training still need to be addressed (Haider et al., 2022).

> *A key informant pointed out,*
> *"The digital public infrastructure remains a huge gap."*

Health data management remains a significant challenge in low-resource settings, where reliance on paper-based records often leads to poor data quality and labour-intensive processes (Lee et al., 2022). To tackle these inefficiencies, several digital health interventions have been introduced to support maternal and child health (MCH) services. Notable examples include the etracker in Ghana (Lee et al., 2022), the Teeko app in Pakistan (Zaidi et al., 2020), and a computer-based tracking system in India (Nagarajan et al., 2016). These tools, operated on tablets without the need for continuous internet access have the potential to enhance HCWs capacity by enabling

them to register children, record vaccination data, track outreach visits using GPS, schedule future immunizations, and identify missed vaccinations.

Similarly, the VaxTrac system in Sierra Leone utilises biometric data to improve vaccine tracking and ensure accurate immunisation records. By assigning a unique identifier to each child, VaxTrac addresses issues of incomplete or duplicate records, significantly enhancing data accuracy and streamlining vaccination processes (Jalloh et al., 2020).

These digital health interventions have streamlined data management, reducing the administrative burden on health workers. These improvements enhance efficiency and data accuracy by addressing issues such as incomplete or duplicate records and streamlining vaccination processes, thereby supporting better decision-making and service delivery (Lee et al., 2022). For instance, the Teeko app in Pakistan has been particularly valuable by offering peer support opportunities, allowing health workers to connect and share best practices, which further aids in managing maternal and child health (MCH) services (Zaidi et al., 2020). Collectively, these interventions enable health workers to dedicate more time to direct patient care, leading to more effective and equitable health outcomes in MCH services (Nagarajan et al., 2016; Lee et al., 2022; Zaidi et al., 2020; Jalloh et al., 2020).

In Nigeria, DHIS2 (District Health Information System 2) was customised with a RI module and indicator dashboard to improve data management and analysis of RI services (Tchoualeu et al., 2021). It strengthened the technical skills of public health staff and enhanced data access, which is crucial for effective immunisation management (Tchoualeu et al., 2021). A similar process was adapted in Uganda, as detailed by Kiberu et al. (2014), the customization of the DHIS2 system to fit the Ugandan environment led to significant improvements in the timeliness and completeness of reporting routine outpatient, inpatient, and health service usage data from the district to the national level. This streamlined data reporting and benefited health workers by reducing their paperwork and administrative tasks, allowing them to focus more on patient care.

> *Key informants emphasised the challenges in digital tool adoption, with one noting, "A big issue is basic digital literacy and capacity. For example, not being able to log back into DHIS2 was a barrier." Another highlighted the gender disparity, stating, "Seventy percent of the health workforce are women, and this increases digital divide issues." Additionally, they pointed out that "remembering to charge devices, including connectivity issues—even making real-time decisions will be hampered."*

The MyChild system, which is also implemented in Uganda, provides every child with a MyChild Card at birth. This program includes vouchers where health information is manually recorded during each visit to a healthcare provider. These vouchers are collected monthly and brought to a central scanning station in the district, where they are digitised using a Smart Paper Technology Engine. The electronic health records are then automatically compiled and stored in the MyChild system's cloud database. The aggregated data is manually fed into the DHIS2 system, enabling the district health office to receive summary reports. This approach has reduced administrative burdens and improved data management by accurately processing and digitising paper records, achieving a reported 97% accuracy rate.Although currently implemented in only three out of 111 districts, its potential to streamline data management is substantial, offering significant improvements in efficiency and cost-effectiveness as it scales (Äijö et al., 2020).

Recent health interventions like SMS messaging systems (SMS text messaging to transmit daily RI data) and the Open Data Kit (ODK) implemented in Nigeria have improved data quality and monitoring (Akerele et al., 2021; Odii et al., 2023). The SMS system has been successful in enhancing data quality and monitoring across 18 states, while ODK facilitates real-time data collection with features such as built-in error checks and pre-filled answers, help health workers in timely decision making and identification of service delivery gaps and assisting support in timely manner to the staff (Akerele et al., 2021; Odii et al., 2023). In Cameroon, training community volunteers to use WhatsApp for collecting and transmitting immunisation data has led to notable improvements in vaccination timeliness, completeness, and coverage (Ateudjieu et al., 2022).

Despite these advancements, implementing digital health interventions in resource-limited settings presents several challenges. Limited infrastructure, insufficient training, and the coexistence of paper and digital systems can hinder effective data management (Odii et al., 2023; Jalloh et al., 2020; Numair et al., 2021). Facilities using exclusively electronic systems often report better outcomes compared to those employing both paper and digital records (Shilpa et al., 2020; Carnahan et al., 2020). Basic digital literacy issues, connectivity problems, and gaps in digital infrastructure further complicate the implementation of these tools (Jalloh et al., 2020). However, it is emphasised in the research that health workers' acceptability is a must for the successful implementation (Zaidi et al., 2020).

Peer support and mentoring

Digital tools, especially mobile instant messaging (MIM) platforms like WhatsApp, have notably enhanced peer support and communication among health workers, driving improvements in healthcare practices and immunisation services. The integration of these digital tools into healthcare systems has facilitated collaborative learning and mentoring, significantly impacting health worker performance.

Hossain et al., (2021) demonstrated that WhatsApp is an effective platform for peer mentoring among maternal and child health nurses in Kenya. This platform supported a non-hierarchical, collaborative learning environment where mentors addressed

knowledge gaps, offered practical support, and improved immunisation practices, however issues related to content moderation and misinformation persist. The familiarity of health workers with mobile phones and WhatsApp was crucial to the model's success, allowing for high engagement in group discussions regardless of age.

According to Pimmer et al., (2017), in rural settings, such instant messaging tools improve communication through features such as group chats, voice notes, and emoticons, which offer real-time feedback and support multilingual interactions. These tools facilitate professional networking and resource sharing, allowing skilled users to mentor less experienced colleagues. Despite challenges like varying digital literacy skills and high data costs, MIMs help bridge gaps in technical knowledge and resource access. This integration supports health workers and advances immunisation efforts by providing a robust platform for information dissemination and peer support (Pimmer et al., 2017).

Similarly, the NurseConnect platform, a capacity-building tool aimed at supporting midwives and nurses in maternal and child health services, was evaluated by Fischer et al. (2019). The study, conducted in 18 healthcare facilities across South Africa and involving 110 nurses and midwives, utilised smartphones and WhatsApp for engagement. Despite challenges like high data costs, the platform successfully improved engagement and effectiveness by leveraging existing smartphone use.

Xeuatvongsa et al. (2016) provided evidence from the Lao People's Democratic Republic, where mobile phones and training significantly boosted Hepatitis B birth dose (HepB-BD) coverage. Peer support among Village Health Volunteers (VHVs) was instrumental in this improvement, offering motivation, knowledge sharing, and practical assistance. Enhanced communication through mobile phones led to more timely birth notifications and higher HepB-BD coverage, showing the impact of peer support on overcoming barriers and improving immunisation rates. (Xeuatvongsa et al., 2016)

These studies collectively show that digital tools and peer mentoring establish a robust framework for enhancing health worker performance and increasing immunisation coverage. Key facilitators include the existing use of mobile phones, the diverse communication features of MIM platforms, and the capacity for real-time feedback. Addressing barriers such as high data costs and varying technical skills will be crucial for maximising the effectiveness of these interventions. By leveraging these strengths and overcoming challenges, digital health interventions can create a more effective and motivated healthcare workforce, ultimately improving health outcomes.

Key Considerations & Recommendations

In reviewing the evidence and experiences with digital health interventions to support health workers in providing immunisation services, several key considerations and recommendations emerge. Despite challenges such as managing dual paper-based and digital records and unreliable connectivity, integrating job aids into existing health platforms is crucial for enhancing care quality and ensuring adherence to immunisation schedules. Utilising these health interventions for structured counselling can provide systematic support to beneficiaries.

To address skill gaps and resistance among healthcare workers (HCWs), eLearning tools should be employed to offer self-paced, repeated learning opportunities, keeping HCWs and program managers current with the latest practices. Adopting blended learning approaches—combining online and in-person training—proves to be a cost-effective solution, providing flexibility, accountability, and real-time feedback. Managing resistance to new digital systems requires effective change management strategies, demonstrating the benefits of the tools, and involving HCWs in the design and implementation process. Ensuring these tools are easy to use and well-accepted by health workers is key, with an emphasis on integrating them with familiar, existing systems to facilitate adoption. Additionally, creating value for HCWs to adopt and engage with these digital tools is essential, fostering a culture of continuous learning and improvement within healthcare systems.

Ensuring data confidentiality and quality is essential; governments must develop and enforce robust policies and protocols to protect patient information. Providing continuous technical support, including help desks, troubleshooting guides, and regular updates, is necessary to maintain system reliability. Therefore, it is imperative to provide portable, internet-independent devices that are easy to operate by health workers with varying levels of digital literacy, particularly in regions where internet connectivity is unstable or limited. Addressing barriers to peer support is also critical; solutions should include subsidies for high data costs, free access to educational platforms, and tailored support programs for varying technical skill levels among HCWs. Customising digital tools to local contexts and ensuring they are user-friendly, especially for female healthcare workers, will significantly enhance their adoption and effectiveness. It is important to integrate these services into existing MCH services, thereby decreasing the workload. Additionally, targeted investments in digital infrastructure, improved connectivity, and addressing digital literacy issues are crucial for maximising the impact and sustainability of digital health interventions to strengthen the overall effectiveness and durability of these initiatives.

Key informants have emphasised the importance of utilising familiar tools to empower female HCWs and build their confidence in using technology. Integrating and improving pre-existing tools is beneficial, and understanding specific barriers and contexts is essential for successful implementation. By focusing on these considerations and recommendations, Gavi, the Vaccine Alliance can significantly enhance the effectiveness of digital health interventions, offering better support for health workers and improving immunisation services.

Conclusion

This technical brief demonstrates ways in which digital health interventions present a promising avenue for improving the effectiveness and efficiency of immunisation programs in Gavi-supported countries. By expanding the use of digital job aids, enhancing eLearning programs, advancing digital record-keeping systems, strengthening supervision tools, and fostering collaborations such as leveraging local mentorship networks and integrating health interventions with existing health systems, Gavi can significantly contribute to scaling vaccine coverage and addressing critical challenges in routine childhood immunisation and vaccination services and can further amplify these efforts and drive meaningful improvements at all levels. Continuous evaluation and adaptation of these interventions will be crucial in achieving sustainable improvements in health outcomes and advancing Gavi's mission to support global immunisation efforts.

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Appendix A
Literature Review methodology

A semi-systematic review of published articles in peer-reviewed journals was conducted to better understand the applications, evidence and documented experiences with digital tools, technologies or approaches to support vaccinators, facility-based health workers and community health workers who administer or promote routine childhood vaccinations.

Documents were identified from a systematic database search using standard key words (see box below) and review of references in selected articles. From an initial 10,226 unique citations identified, 84 peer-reviewed articles related to the use of digital technologies for health workers were included in the review. An ad hoc review of other unpublished documents, grey literature and project reports contributed to this review.

Details of search methodology

PubMed, Cochrane Library, Clinical Trials, and Google Scholar were searched for relevant literature from 2000 to 2024 using combinations of the following keywords:

- vaccin*/ inoculat* / immuniz* / immunis* / EPI / Child health
- Remote / Virtual / Distance / real-time / Online / Internet / Ehealth / mHealth / Electronic / Computer / tablet / Mobile / Digital / Digital health / Technology / smart phone / SMS / Whatsapp / RapidPro / Job aid / eLearning
- Workforce / Frontline / health worker / CHW / Volunteer / community / Provider / Vaccinator /
- Task-shifting / Confidence / Motivation / Satisfaction / Accountability / Workload / Burden / Competency / competen* / Decision-making / Workflow / Human resource* / Problem-solving / Training / Learning / Skills

Exclusion criteria

- Published before 2000
- In language other than English, Spanish Portuguese or French
- non-LMIC setting
- zoonosis
- not a vaccine preventable disease
- No immunisation programing or immunisation outcomes included
- Patient-facing or caregiver-facing tools or interventions

Inclusion criteria

- A digital tool or technology to facilitate any task or job responsibility for health workers, community volunteers, immunisation service-delivery, facility-level staff
- LMIC setting
- Includes some outcome or experiences related to routine childhood immunisation

Appendix B
Costing Digital Tools for Digital Health Worker Tools

Implementing a new health intervention as part of a country's national health system requires information on costs of intervention implementation and maintenance as well as information on the expected effectiveness of the selected intervention. When considering the cost-effectiveness of digital health interventions the same holds true. However, data on both costs and effectiveness are nascent. Because digital health interventions tend to develop both iteratively and quickly, and often have multiple intended users (1), it can be challenging to apply the standard methods of cost and effect estimation.

Related to cost, information is lacking on necessary financial resource requirements and investment guidance to achieve a successful digital transformation of health systems. Where information does exist, critical data is often missing as agreement on what should be included is lacking. This makes cost estimates unreliable (2). In the absence of robust guidance for national decision makers, this appendix is intended to assist Gavi and national immunisation program country stakeholders to understand the cost considerations when deliberating on the inclusion of digital tools to help support health workers to improve immunisation programs. This appendix considers the following cost categories:

- National immunisation and health worker support program readiness
- Digital health enablers
- Priority digital health intervention investment areas
- Illustrative country budget
- Cost savings/cost drivers

National Immunisation and Health Worker Support Program Readiness

To ensure the success of a digital intervention to support health workers in immunisation programs, a functioning national immunisation program and national community health worker program must be in place (for digital tools for CHWs) . The readiness of these programs will affect the ability to integrate the digital health intervention. This in turn affects the resulting program and health outcomes achieved by the digital health intervention. The Digital Implementation Investment Guide (DIIG) provides a tool to assess the current state of the programs and identify challenge areas for improvement that will inform the design of digital health intervention.

1. https://link.springer.com/article/10.1007/s40273-024-01366-y
2. https://static1.squarespace.com/static/59bc3457ccc5c5890fe7cacd/t/64e5ed0a7fcc8c3e665ab71f/1692790028648/Digital-Square-Costing-Resources-Overview_Final+8.18+%281%29.pdf

Digital Health Enablers

The maturity of the digital health ecosystem will affect the country's readiness and thus ability to integrate a digital health intervention into the receiving program. Specific to digital health worker support tools in immunisation programs, the following digital health enablers are most proximally linked to the success of the intervention and should be assessed to understand their maturity, strength, and weaknesses.

- **Digital infrastructure** - A robust and flexible digital and digital health infrastructure in the country is necessary to accept the digital health worker support intervention. Also critical is for the digital health worker support solution to be implemented in accordance with the national digital health strategy and architecture.
- **Standards and interoperability** - Compliance with existing open-source health data standards that aim for reusable systems including interoperability of health information systems both at national and international levels will facilitate implementation, scale and sustainability of the digital health worker support intervention. This also facilitates iIntegration into existing digitally enabled immunisation programs.
- **Digitally enabled health workforce** - The digital health worker support intervention will perform best if it is overlaid on a current digital intervention targeting health care workers in the delivery of immunisation programs. In this scenario, the health workforce is already digitally enabled and digital literacy is higher, thus facilitating the acceptance of the intervention by the primary intervention recipients (see cost savings, cost drivers section below).
- **Digital health worker support existing tools** - Leveraging an existing digital health worker support system, facilitates the implementation of the digital health worker support intervention because key data/ workflow and interoperability elements are already established. Maturity of these enablers will significantly affect the resulting program and health outcomes achieved by digital health intervention. The Global Digital Health Monitor provides insights into the digital health maturity of countries across seven digital health enabling environment component areas.

Priority Digital Health Intervention Investment Areas

Budgeting for all costs associated with owning, operating and maintaining a digital health intervention is critical to its success. The expenditure categories over the the lifecycle of the intervention falls into the three categories listed below.

- **Design and development phase** - functional requirements definition process, software licensing and customization, application installation and configuration, hardware and device needs, and interoperability costs.
- **Deployment phase** - end user testing, training, rollout, and the costs of connectivity and power.
- **Sustained operations** - integration and interoperability, voice and data services, maintenance, refresher training, transfer of ownership, scale-up, monitoring, evaluation and learning, program management and governance.

For a detailed example of the costs associated with the implementation of a digital health worker support intervention see the illustrative country budget below.

Illustrative Country Budget- ImTeCHO mHealth Program- Gujarat, India

In this study, Modi et al. (2020) conducted a randomised controlled trial (RCT) to evaluate the cost-effectiveness of the ImTeCHO mHealth program, which was integrated into routine maternal, neonatal, child health care, and immunisation services in Gujarat, India. The study involved 561 Accredited Social Health Activists (ASHAs) across 22 primary health centres in the state. The primary goal was to assess the incremental cost per life-year saved and cost per death averted, thereby determining the program's overall value and its potential for broader application.

India's digital health maturity is rated at level 4 by the Global Digital Health Monitor. The ImTeCHO program, serving as a comprehensive job aid, supports health workers in tribal and rural areas with a digital tool to improve maternal, child health, and immunisation services.

The budget assumes the following:

- Existing health infrastructure and support systems are operational.
- Personnel and staff costs for the digital intervention, including program managers, trainers, and technical support, are covered under existing health budgets.

Note: *While this example extends beyond immunisation, it illustrates the effectiveness of an integrated intervention, highlighting how a combined approach to maternal, child health, and immunisation services can enhance overall health outcomes.*

Digital Intervention Budget

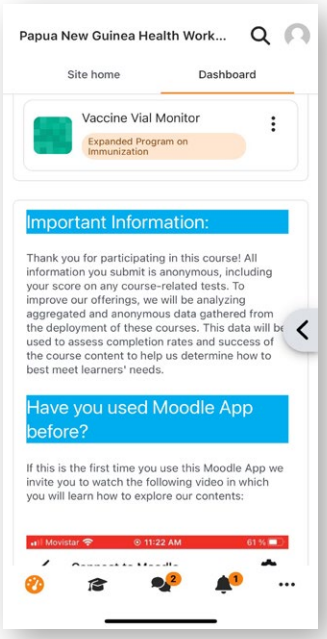
Category	Item	Annualised Cost (USD)
Design and Development	Software Development Cost	7,951
	Vehicles	1,135
	Mobile Handset	11,873
	Other IT Equipment	397
	Total	**21,356**
Deployment	Initial Training Cost	24,291
	Total	**24,291**
Sustained Operations	Personnel	24,919
	Software Annual Development and Maintenance	49,599
	Training Cost (Ongoing)	256
	Travel	2,123
	ASHA Incentives	35,166
	IT Expenses	12,935
	Office Expenses	1406
	Total	**126,405**
Grand Total	Design and Development	21,356
	Deployment	24,291
	Sustained Operations	126,405
	Grand Total	**172,052**

The implementation of the ImTeCHO intervention in Gujarat, India, which involved 561 Accredited Social Health Activists (ASHAs) across 22 primary health centres, led to a significant reduction in infant mortality, with a rate of 56.4 per 1000 live births compared to 67.2 in the control area. This 16% decrease translated into 735 additional life years. The program proved cost-effective, with an annual incremental cost of USD $54,360 per 1000 live births, equating to USD $74 per life year saved and USD $5,057 per death averted. With a 2016 per capita GDP of USD $1,709, ImTeCHO's costs are justified by its health benefits, maintaining cost-effectiveness even with a 50% reduction in effectiveness.

Cost Savings / Cost Drivers

As digital literacy and health ecosystems advance, the potential for cost savings in future digital health interventions grows. The ImTeCHO mHealth program, though requiring substantial initial investment, aims to provide long-term savings by improving efficiency and health outcomes. Key cost drivers include the upfront expenses for software, hardware, and training, as well as ongoing operational costs. However, as digital infrastructure becomes more integrated and scalable, the program's ability to streamline processes and enhance health services can lead to significant long-term savings, making it a cost-effective solution for improving maternal and child health.

Illustrative Country Budget- MoodleCloud eLearning Initiative- Papua New Guinea



Another program, which was deployed in Papua New Guinea, utilised MoodleCloud for an eLearning initiative aimed at healthcare workers.This digital intervention is designed to provide consistent and effective training, offer accurate information, and support healthcare workers in improving vaccine stock management and ultimately increasing vaccine coverage.

Moodle offers two main solutions with distinct cost structures: Moodle LMS and MoodleCloud.

Moodle LMS is a self-hosted platform requiring installation on your own servers or through a third-party hosting provider. This approach necessitates in-house technical expertise for setup, updates, backups, and overall maintenance. Costs for Moodle LMS can vary significantly depending on the complexity of the deployment and the hosting environment. Typically, initial setup and configuration costs can range from a few hundred to several thousand dollars, with ongoing maintenance adding further expenses.

MoodleCloud, being a pre-configured platform, eliminates **design and development** costs. Pricing begins at $120 per year based on user numbers and storage, with a custom domain plan available for $1,720 annually. During the **deployment phase**, the costs are included in MoodleCloud's pricing plan, which adjusts according to the number of users. For the **sustained operations phase**, MoodleCloud offers stable costs with updates and maintenance managed directly by Moodle, ensuring ongoing support without additional expenses.

Conclusion

The integration of digital tools for health worker support into national immunisation programs represents a promising avenue for improving immunisation program quality, effectiveness and health outcomes. The nascent nature of data on costs and effectiveness, coupled with the rapid development and iterative nature of digital technologies, poses challenges to traditional methods of cost estimation.

Key considerations when applying these tools to digital interventions for health worker support include assessing the readiness of national immunisation and supervision programs, evaluating the maturity of digital health enablers such as infrastructure, standards, workforce digital literacy, and existing health worker support systems.

As digital health ecosystems mature, programs scale and digital literacy grows, there is potential for cost savings through the sharing of digital health infrastructure and leveraging existing digital health interventions. This underscores the importance of continually monitoring and adapting to the evolving digital landscape to maximise the impact and cost-effectiveness of digital health worker support interventions in improving immunisation programs. By addressing these cost considerations, leveraging available resources and the transforming digital health ecosystem, stakeholders can integrate digital tools for health worker support into immunisation programs and contribute to improved immunisation outcomes on a national scale.