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How Can Digital Health Technologies Bridge Disparities in Maternal Health Outcomes in Nepal

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List of abbreviations and acronyms

ABDM	Ayushman Bharat Digital Mission
ANC	Antenatal Care
ASHA	Accredited Social Health Activist
CHW	Community Health Worker
DHT	Digital Health Technology
DTO	Digital Transformation Office
EHR	Electronic Health Records
FCHV	Female Community Health Volunteer
HMIS	Health Management Information System
IFAD	International Fund for Agricultural Development
IVR	Interactive Voice Response
LMIC	Low- and Middle-Income Country
mHealth	Mobile Health
MoH	Ministry of Health
MoHP	Ministry of Health and Population
MMR	Maternal Mortality Rate
NGO	Non-Government Organisation
PPP	Public–Private Partnerships
RCH	Reproductive and Child Health
SBA	Skilled Birth Attendant
SDA	Safe Delivery App
SDG	Sustainable Development Goal
SMS	Short Message Service
TBA	Traditional Birth Attendant
WHO	World Health Organization

Definition of key terms

Community Health Workers (CHWs)

The World Health Organisation defines community health workers as health care providers who live in the community they serve and receive lower levels of formal education and training than professional health care workers such as nurses and doctors (WHO, 2017:viii). While the term CHW is universal and will thus be used in different contexts throughout this research, it may also be used in substitution of country-specific community-based health workforces. This research will reference Accredited Social Health Activists, Mothers Group, Posyandu, Female Community Health Volunteers, and other national CHW programmes, which may be substituted for 'CHWs' during discussion to facilitate comparison and retain continuity of language.

Digital Health Technology (DHT)

Digital health technologies, as defined by the World Health Organization, use a wide range of communication devices and connected equipment to improve health (WHO, 2021a:39). This definition has informed our narrowed area of study, and thus we will not address innovations in medical technologies, such as those designed to improve surgical accuracy or enhance non-digital diagnostics and treatment.

Interoperability

The World Health Organisation describes interoperability as the ability of different applications to access, exchange, integrate, and cooperatively use data in a coordinated manner using shared application interfaces and standards, within and across organisational, regional, and national boundaries, to provide timely and seamless portability of information and optimize health outcomes (WHO, 2021a:42).

Abstract

Digital technologies' deployment in the healthcare sector continues to increase as their potential to bridge gaps in health access and enhance diagnostic efficiency and accuracy is realised. For low- and middle-income countries, governments' interest in such investment is often piqued by the promise of addressing enduring systemic gaps in health access, caused most widely by economic and geographical constraints. While we have observed consistent shortfalls in LMICs' national e-health strategies' acknowledgement of maternal health as a distinct area of concern or opportunity, numerous initiatives, government, not-for-profit and private, are attempting to address maternal health needs through digital health technologies.

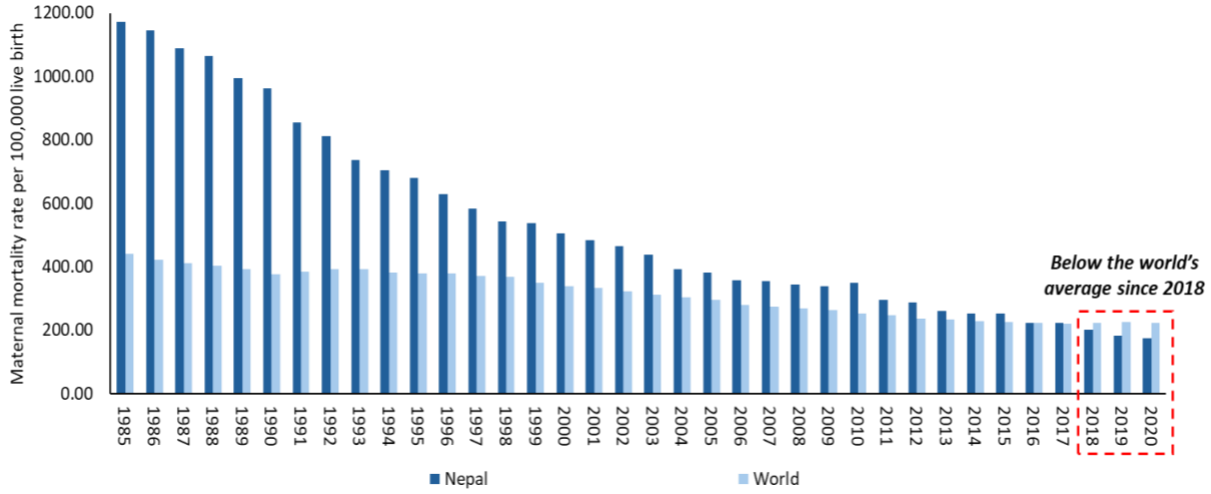
This research will focus on digital health technologies for maternal health in Nepal, complemented by comparative studies of digital health technologies in Cambodia, Indonesia, and India to assist in developing context-specific recommendations. While significant infrastructural, educational and health investment is necessary to truly elevate Nepal's maternal health outcomes, our paper prioritises recommendations that can be mobilised within the current state of development. As such, while we propose recommendations that primarily address Nepal's Ministry of Health and Population, we emphasise that collaboration across government departments is crucial. Where investment in maternal health technologies in low- and middle-income countries is low, our paper argues the importance of prioritising solutions that circumvent systemic and structural obstacles while addressing the needs of those already operating at the interface of health systems and communities. Combining findings from our literature review, comparative studies and interviews with key stakeholders, we will provide realistic, operational and sensitised recommendations for Nepal that promote public-private partnerships to fill funding and technology deficits, encourage prioritisation of interoperability, and promote digital health technologies that mobilise community health workers for improved maternal healthcare delivery.

1. Introduction

Maternal health, the physical, mental and social well-being of women during pregnancy, childbirth, and postpartum (WHO, 2017), is a critical measure of a nation's health system and broader socio-economic development. It reflects the effectiveness of a nation's healthcare infrastructure and has far-reaching impacts on families and communities, as healthy mothers are more likely to raise healthier children and contribute more actively to economic growth (Mudiyanselage et al., 2024). Despite global efforts, maternal health remains a pressing public health challenge, particularly in low- and middle-income countries (LMICs). In 2020, approximately 287,000 women died due to complications during and after pregnancy or childbirth (WHO, 2024). Notably, an unproportionally large portion of these maternal deaths occurred in LMICs (WHO, 2023), reflecting the persistent inequality in health access and the disproportionate burden borne by LMICs.

Nepal exemplifies both progress and ongoing disparities in maternal health outcomes. Since 1985, the country has significantly reduced its maternal mortality rate (MMR) from a staggering 1,171 maternal deaths per 100,000 live births in 1985 to 174 in 2020 (WHO, 2020). This improvement places Nepal's MMR below the global average of 223 per 100,000 live births. However, the dial has shifted minimally since this drastic improvement, and so the country has failed to meet its own interim targets of reducing MMR to 116 by 2022, 99 by 2025 (MoHP, 2022) and is off track to meet the Sustainable Development Goal (SDG) target of less than 70 per 100,000 live births by 2030 (WHO, 2021b). Persistent disparities, particularly for women in rural areas, those with limited education, or from lower wealth quintiles, hinder progress toward these milestones (Shreezal, 2023:995).

Figure 1. The World's and Nepal's MMR from 1985 to 2020 (Source: WHO Statistics).



While traditional interventions, such as improving access to essential obstetric care, training skilled birth attendants (SBAs) and expanding institutional deliveries, have yielded significant improvements for Nepal's maternal health outcomes, an enduring urban-rural divide continues to leave marginalised communities behind. With nearly 80% of Nepal's population residing in rural areas (IFAD, 2023), limited health infrastructure, inadequate skilled personnel, and logistical challenges brought by its unique geographical landscapes exacerbate these inequities (Khatri, 2017). Under-resourced traditional healthcare interventions alone have proven insufficient to address these gaps, necessitating innovative solutions.

In many LMICs, including Nepal, community health workers (CHWs) play a crucial role in bridging healthcare equity gaps, particularly in maternal and child health (Ahmed et al., 2022). CHWs act as intermediaries between formal healthcare systems and rural or marginalised populations, delivering essential maternal health services, educating communities, and facilitating access to skilled care (LeBan et al., 2021). However, their work is often constrained by resource limitations, logistical challenges, and a lack of real-time clinical support.

In this context, digital health technologies (DHTs) present a promising pathway to enhance maternal healthcare accessibility and equity. By leveraging tools such as telemedicine, mobile health applications, digital record systems, and AI-assisted diagnostic systems, DHTs have the potential to overcome geographic and socio-economic barriers, bringing maternal healthcare services to remote and underserved regions (Collins et al., 2023). Moreover, DHTs can serve as critical enablers for CHWs, equipping them with digital tools for storing patient data, tracking pregnancies, providing remote consultations, delivering maternal health education, and ensuring timely referrals to medical facilities (Feroz et al., 2021).

Globally, DHTs have gained momentum as innovative, scalable, and cost-effective solutions, with the World Health Organisation encouraging their adoption through country-specific strategies. As a result, over 120 member states have developed policies to incorporate digital health strategies into their national frameworks (WHO, 2021a). This research will highlight the particular emphasis due to CHWs in achieving the WHO's vision of country-specific strategies, as contextually-sensitive implementation of DHTs has the potential to transform healthcare systems into resource-constrained LMICs by enhancing efficiencies, accuracy and connection between mothers, CHWs and formal health services.

The following section will provide our methodological approach to identifying key barriers and arriving at relevant solutions.

2. Research question

Our research seeks to understand how digital health technologies can bridge disparities in maternal health outcomes in Nepal. To answer this central question, we have focused our research on:

a) understanding the current strategies, policies and approaches produced by the Nepal government;

b) examining these policies' degree of implementation at different levels and rurality of healthcare delivery;

c) evaluating whether and how these technologies align with the needs of CHWs and mothers in rural areas.

3. Research methodologies and limitations

3.1. Methodologies

Desk research

To develop an understanding of the aforementioned areas of exploration, we began with significant desk research on the current state of maternal health in Nepal, the configuration of Nepal's health system, and its use of DHTs, with particular focus given to the maternal health field. We examined peer-reviewed journal articles, policy reports, and government publications published primarily in the

past ten years. Thematic areas reviewed included structural barriers to maternal care, existing disparities across geography and socioeconomic status, and the effectiveness of various digital tools in improving maternal health outcomes in Nepal and other comparable low-resource settings.

Interviews

To enrich this research, we completed 6 semi-structured interviews with key stakeholders that operate in diverse sectors within the health ecosystem. We sought to capture the opinions of people working in government, private sector, healthcare and community development to understand the successes and challenges faced in implementing digital health technologies in Nepal.

Case studies

Having developed a foundational knowledge of Nepal's maternal and digital health status through our literature review and refined our focus through semi-structured interviews, we then completed case studies of DHTs from three countiries to inform our recommendations. Through examination of digital health technologies' deployment in maternal health in India, Indonesia and Cambodia, we compiled realistic recommendations that co-opted successful or promising initiatives from within the region. These case studies do not seek to exhaustively map each country's health system, nor do we identify gaps or critique failures. Rather, the contents of our case studies are guided by our efforts to form appropriate recommendations, refining our focus to positive and adaptable solutions. Thus, these case studies were selected due to their comparability to Nepal, as detailed below.

Figure 2. Rationale for selection of comparative country case studies.

Country	Reason of selection
Nepal (Major focus)	Nepal serves as the focal point of this study. As a LMIC with a predominantly rural population and mountainous geography, Nepal faces significant challenges in healthcare access. In selecting comparator countries, this study does not assume any perfect analog to Nepal; rather, it seeks countries that share relevant characteristics to offer transferable lessons.
India	India was selected due to its cultural, economic, and healthcare delivery parallels with Nepal. Both countries have large rural populations, significant socio-economic inequalities, and complex health systems that mix public and private actors. Like Nepal, India also faces persistent disparities in maternal health outcomes among marginalised groups. However, India differs significantly in its scale, institutional capacity, and technological investment, which may promote direct translatability of some solutions.
Indonesia	Indonesia offers a relevant comparison due to its archipelagic geography and large rural population, which present logistical and access challenges similar to Nepal's mountainous terrain. Both countries contend with decentralization in health service delivery and rely heavily on CHWs. Its experience integrating digital tools into decentralized and resource-constrained environments offers practical lessons for Nepal.
Cambodia	Cambodia, with a comparable GDP per capita to Nepal, provides an important perspective as a smaller-scale LMIC with similarly constrained fiscal and healthcare resources. Both countries have relatively young digital health ecosystems and have relied on external development partners to pilot maternal health technologies. Cambodia's recent digital health developments offer more modest, adaptable models that may be more directly transferable to Nepal's context than larger-scale systems.

3.2. Research limitations

While the research employs a rigorous methodology, it is subject to several limitations. Firstly, secondary desk research may be constrained by the availability, reliability and granularity of data, primarily for Nepal and secondarily for India, Cambodia and Indonesia, where reporting systems are often underdeveloped. Secondly, logistical constraints limit the research to interviews with a selected group of stakeholders. Although these interviews provided valuable insights, they may not fully

capture diverse perspectives, especially those of rural mothers and their communities whose healthcare situations are the primary focus of this research. To mitigate this limitation, the study deliberately engaged with actors who played a critical role in bridging maternal health gaps, such as health care workers and community development NGOs. These actors possess deep contextual knowledge and maintain direct contact with the individuals that this research is unable to directly access. Further, while the selection of case study countries aims to ensure comparability, inherent differences in healthcare systems and socioeconomic factors may limit the direct applicability of findings across countries. Finally, due to resource constraints and limited access to primary data, the research does not include direct surveys or quantitative analysis. A mixed-methods approach with quantitative assessments would strengthen future research by providing measurable evidence of the effectiveness and impact of DHTs.

3.3. Scope limitations

The obstacles Nepal faces in implementing DHTs to uplift maternal health are numerous and multifaceted. As disclaimed in our recommendations section, we acknowledge the simultaneous progress Nepal must pursue in education, financial planning and equitable resource distribution to support an ecosystem that can host and sustain DHTs. Due to time and resource restrictions, this research does not attempt to form whole-of-government recommendations that detail the MoHP's potential engagements with the Ministry of Education, Finance or Communication and Information Technology. Rather, we focus our research and recommendations on actions within the remit of the MoHP, or that could be raised in federal decision-making spaces and led by the MoHP.

4. Literature Review

This literature review will begin with an exploration of the status of maternal health in Nepal. Following this context-setting, we will examine the current efforts of the Nepalese government towards digital health and maternal health as distinct pursuits, drawing attention to the lack of cohesion between these outputs. Here, we will introduce CHWs as a stakeholder of central relevance, whose positioning in maternal healthcare provision necessitates their consideration and integration into digital health frameworks and strategies. Finally, the literature review will examine the key friction points in the implementation of Nepal's relevant digital health policies to identify the deficiencies in need of further development.

4.1. Current state of maternal health disparities in Nepal

Despite national-level improvements in maternal health indicators, Nepal's progress has remained stagnant. As a result, significant disparities in maternal health outcomes persist. This section will explore the multifaceted causes of ongoing maternal health inequality in Nepal.

As highlighted in Nepal's Demographic and Health Survey (MoHP, 2021), access to formal healthcare is largely predicated on the social determinants of wealth, education and geography, creating considerable gaps in access to ANC coverage, institutional delivery, SBA assistance and postnatal care coverage. The difference in coverage can be as large as 50%.[1] To understand these disparities more comprehensively, it is essential to examine how a combination of factors, including diverse

[1] Calculated as the coverage percentage enjoyed by the highest quintile minus the coverage percentage enjoyed by the lowest quintile.

geographical terrain, financial constraints, socio-cultural inequalities, harmful practices, and systemic gaps in healthcare infrastructure, compound to hinder maternal health outcomes across Nepal.

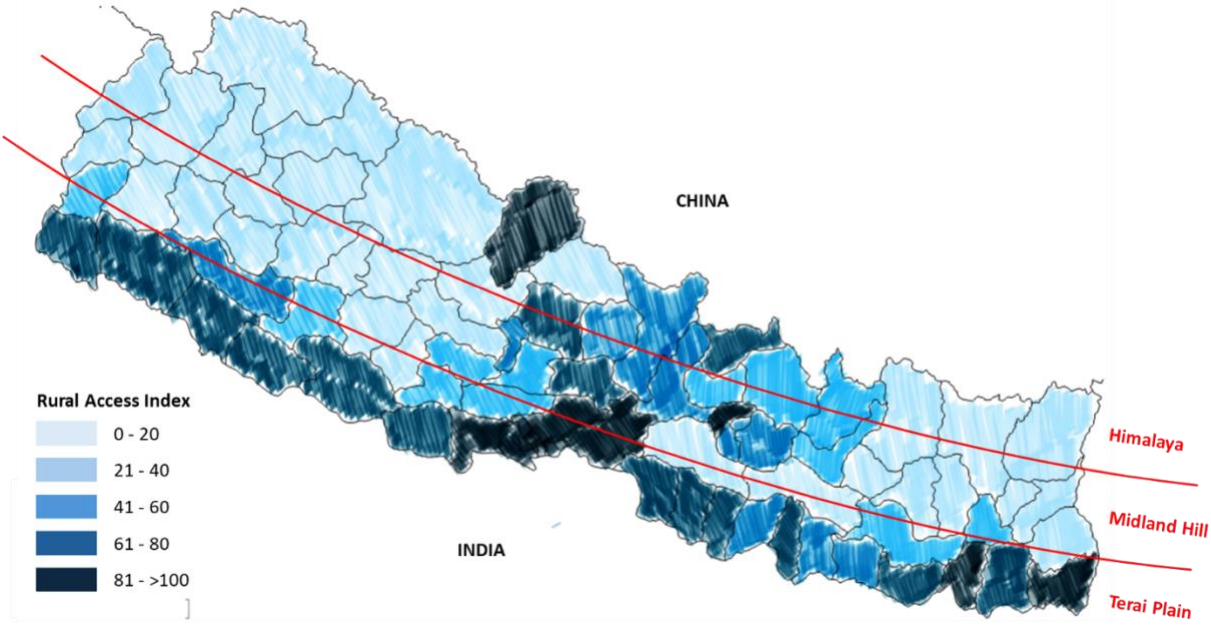
Figure 3. Maternal health service utilization in Nepal (Source: 2022 Demographic and Health Survey)

Maternal health services	Total coverage (%)	Wealth quintile		Education		Residence	
		Highest	Lowest	Above secondary level	No education	Urban	Rural
Antenatal care coverage	83.6%	95.5%	73.8%	94.5%	73.3%	87.0%	79.5%
Institutional delivery	57.4%	89.6%	33.9%	85.4%	36.4%	68.6%	44.2%
Delivery assisted by skilled provider	58.0%	88.7%	33.9%	84.9%	37.6%	67.7%	46.8%
Postnatal care coverage	56.7%	81.2%	36.7%	80.2%	41.7%	63.9%	48.4%

Diverse geographical terrain

Nepal is a landlocked country located in South Asia, bordered by China to the north and India to the south, east, and west. Its diverse topography includes three distinct geographical regions: the Terai plains in the south, the hilly midlands, and the towering Himalayas in the north. 80% of Nepal's 30 million inhabitants live in rural areas (IFAD, 2023). Of these 24 million people, over 10 million rural residents face acutely low access to transportation and mobility. According to World Bank's Rural Access Index (RAI), which measures the proportion of rural people who live within 2 kilometers of an all-season road, the sparsely connected northern mountainous and hilly regions often record RAI figures below 20%, due to rugged terrain, sparse infrastructure, and geographic isolation, while the southern Terai region reaches 80% RAI in some districts (Edie et al., 2016). This stark disparity in transportation access severely limits access to maternal health services for women in remote areas, as observed by a Nepalese MoHP representative (Appendix I, February 3, 2025). As highlighted in our interview with a Nepalese development practitioner (Appendix IV, March 24, 2025), healthcare workers frequently struggle to reach remote communities, particularly in the monsoon season when landslides and flooding make roads impassable. Consequently, delays in accessing emergency obstetric care often led to preventable maternal deaths. Notably, the Nepalese MoHP representative also mentioned that 43% of maternal deaths in Madhesh Province occur at home or en route to a healthcare facility, before the women receive any medical assistance (Appendix I, February 3, 2025).

Figure 4. RAI and topology demonstration of Nepal (Source: World Bank Statistics in 2015).



Socio-cultural inequalities

Socio-cultural disparities disproportionately affect women from marginalised groups, including lower castes (e.g. Dalit), indigenous groups (e.g. Musahar), and religious minorities (e.g. Muslim) (Doss et al., 2022:13-25). These women often work in physically demanding, low-paying jobs, leaving them with minimal time, energy or financial flexibility to prioritise their health (Dangol et al., 2020). This occupational divide intersects with cultural marginalisation, compounding barriers to accessing maternal healthcare. According to the Nepal Demographic and Health Survey, less than one-third of women from these communities access ANC or SBA services during childbirth (MoHP, 2022), in contrast to higher utilisation rates among more privileged groups such as upper Terai castes.

Structural gender inequities further magnify these maternal health disparities. Women often lack decision-making authority within households, relying on male family members, typically a father or husband, to determine whether and when they can seek care (Shreezal et al., 2023). Financial dependency on male relatives and lack of ownership of technologies amplify these challenges, with many women delaying seeking care until complications arise, as they may require permission or financial support from their male relatives to access both technologies and healthcare services (Appendix IV, March 24, 2025).

Systemic gaps in healthcare infrastructure and digital health

Gaps in healthcare infrastructure disproportionately affect maternal health outcomes in rural Nepal, as compounding marginalised identities perpetuate exclusion. A chronic shortage of skilled healthcare providers, with a physician-to-population ratio of 0.17 per 1,000 people (Gyawali et al., 2024:288-292), far below the WHO-recommended ratio of 2.3 per 1,000 (WHO, 2006:10), creates the preconditions for the deprioritisation of women's health. This shortfall is magnified by the urban-rural divide, where urban centres benefit from better-equipped hospitals, while rural areas rely on poorly resourced primary health centres that are often without SBAs or basic emergency obstetric care (Dangol, 2020).

Nepal's digital health infrastructure is also underdeveloped and unevenly implemented. Telemedicine initiatives have been launched to connect remote populations with urban healthcare providers, but limited internet penetration, which stood at 38% in healthcare infrastructure in 2022 (Kemp, 2022), coupled with frequent power outages, undermines their reliability (Parajuli, 2022). Many rural health posts and primary care centres lack connectivity, digital equipment, and trained personnel to effectively integrate telemedicine or mobile health solutions (Nagendra, 2023). Moreover, the absence of comprehensive digital training programs for community healthcare workers and low digital literacy among patients limit the uptake of these technologies (Parajuli, 2022).

Compounding these issues are fragmented data systems across Nepal's health sector. The current reliance on paper-based health records, highlighted in the National eHealth Strategy as error-prone, cumbersome and expensive, not only complicates recordkeeping but also constrains the potential for data-driven decision-making (Ravi, 2023). In rural areas, the implementation of electronic systems and digital tools is significantly more time and resource-intensive, as infrastructural barriers are compounded by the low literacy and digital literacy rates amongst CHWs (Appendix I, February 3, 2025).

4.2. Efforts to bridge gaps in maternal healthcare through DHTs

In the context of maternal healthcare, DHTs encompass a range of tools, including mobile health (mHealth) applications for monitoring maternal health, telemedicine for remote antenatal consultations and electronic health records (EHRs) for streamlined documentation. Advanced tools, such as wearable devices for real-time vitals tracking and AI-based diagnostics, are also emerging in the international market but are often less feasible in LMICs due to cost and infrastructural challenges (Jones-Esan et al, 2024).

Nepal's journey in developing DHTs began in 1995 with the introduction of HealthNet, a national government-led initiative providing affordable internet services to enhance healthcare access (Bhatta et al., 2015:149-153). According to an interview with a Nepalese MoHP representative (Appendix I, February 3, 2025), the MoHP launched the Health Management Information System (HMIS), a national digital platform that enables systematic data reporting from local health facilities to provincial and national authorities. These early investments have laid the groundwork for digitally tracking maternal health indicators.

Over time, the Government of Nepal has advanced a more coordinated approach to digital health, including the Nepal Health Sector Strategy (2015–2020) (MoHP, 2015), which emphasises evidence-based decision-making, and the National eHealth Strategy (2017) (MoHP, n.d.), which provides overarching frameworks for the country's current digital health efforts. The newer Nepal Health Sector Strategic Plan (2023–2030) (Government of Nepal, 2023) builds on earlier efforts by focusing on quality, coverage and the interoperability of digital systems. Meanwhile, the Digital Nepal Framework identifies health as one of eight key sectors and lays out an ambitious plan to digitise healthcare delivery, envisioning the centralisation of healthcare facility information to enable appointment booking and integrate EHRs, HMIS, and health registries. While public–private partnerships (PPPs) are not explicitly defined in every strategic document, their influence is evident in government collaborations with NGOs and technology companies to co-develop tools (Citrin, 2018).

Despite these strategic national policies, the implementation of digital health tools remains uneven and fragmented (Ravi, 2023), and lacks explicit emphasis on maternal health (Dangol, 2023). Specific goals or monitoring indicators related to maternal outcomes are limited or absent (Ali et al., 2023). While platforms proposed under the Digital Nepal Framework have potential applications in maternal care, such as tracking ANC visits or delivery planning, these functions are rarely framed with a focus on maternal health equity.

Recognising this gap, Nepal has witnessed the rise of government-supported and NGO-partnered mHealth applications tailored to maternal care (Bashshur, 2011:484-94). In 2020, the MoHP launched Hamro Swasthya, an official app offering pregnancy-related information, symptom checkers, and connections to nearby health facilities (Nepal Health Research Council, 2024). Complementing this are community-based apps such as Ama-ko-maya, which support mothers and CHWs with vital pregnancy-related information, SMS reminders for ANC visits, and mobile-based guidance on delivery and postpartum care. These applications also disseminate health education in local languages, improving awareness of danger signs during pregnancy among rural women to make informed maternal decisions (Kayastha et al. 2021). These mHealth tools have proven impactful when successfully deployed in other contexts, with one pilot study finding that pregnant women who received SMS reminders were 48 times more likely to attend all recommended ANC visits (Flueckiger, 2019: 806-808). However, our interview with a Nepalese MoHP representative emphaisised scalability as an enduring barrier to achieving similarly transformative results in Nepal (Appendix I, February 3, 2025). Low digital literacy limited mobile phone ownership, and language barriers among marginalised women restrict technological access, and thus undermine opportunities for contextually appropriate or direct-to-patient mobile interventions (ibid). Ama-ko-maya has only 1,500 pregnant women actively enrolled in Nepal, an illustration of the barriers to reaching underserved populations even with well-designed tools (1WorldConnected, n.d.).

Beyond mHealth, telemedicine platforms have gained traction as a means to bridge geographic gaps in care. Platforms such as TeleCare Nepal (developed in partnership with IBM) (Telecare, n.d.) and Hamro Doctor (founded by a private initiative) (Hamro Doctor, n.d.) have been in operation since 2015. Rather than directly serving individual patients, telemedicine in Nepal operates through tele-consultation centres where experienced doctors and health professionals guide less-skilled CHWs across local healthcare facilities. The use of this technology to equip CHWs rather than to meet directly with patients is a necessary redirection, as conventional telemedicine provisions have not had success in Nepal (Appendix IV, March 24, 2025). Beyond this low community uptake, there is a noticeable gap that inhibits telemedicine's application to maternal health, neither platform adequately acknowledges maternal health as a distinct area of service provision, with Hamro Doctor listing only ten facilities for pregnancy-related treatments on its website and TeleCare Nepal with less than five. As a result, their role in addressing maternal health inequities remains limited.

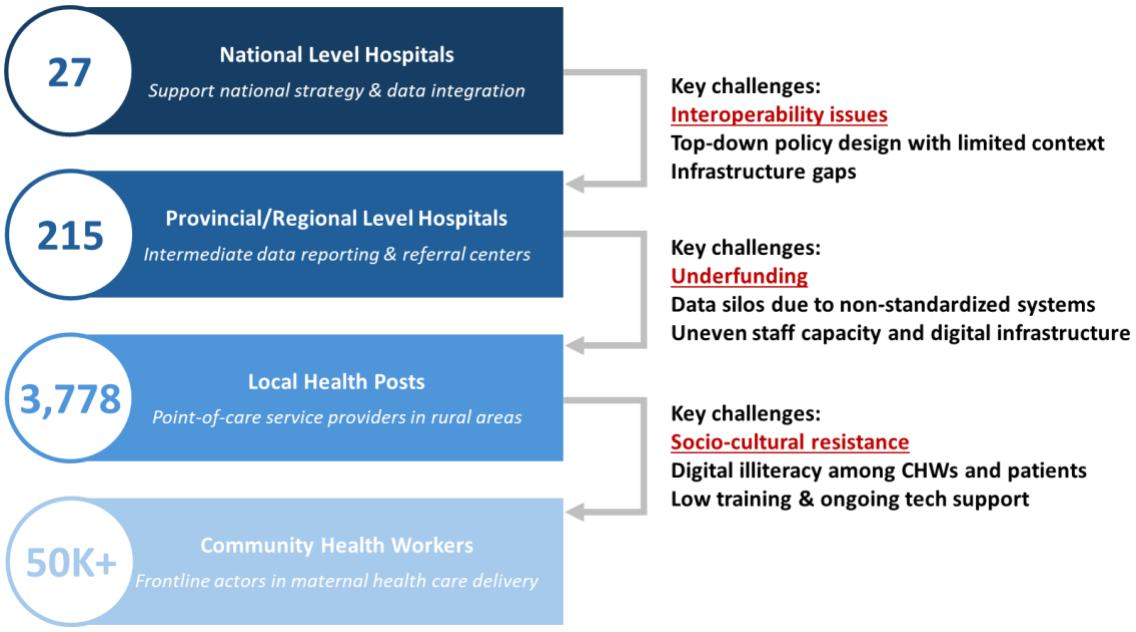
Nepal has also taken important steps in developing EHR systems, including the National EHR 2.0 (MoHP, n.d.) and a dedicated e-Maternal Care system designed to maintain accurate medical records for pregnant women and children (E-Maternal Care, n.d.). These systems enhance healthcare quality by improving record-keeping, data sharing, and maternal health monitoring, particularly important in rural settings where manual systems are prone to error (Nepal Health Research Council, 2018). However, most EHR initiatives have been isolated efforts, with limited coordination across facilities or

integration into the broader national health framework (Appendix I, February 3, 2024). While notable exceptions, like implementations in Birendara Sainik Hospital, have prioritised interoperability and aim to inform a future nationwide rollout (Ravi, 2023), many hospitals still rely on EHRs primarily for administrative functions such as billing, rather than clinical decision-making (Parajuli et al., 2022). Moreover, digital processes often coexist with manual steps, undermining efficiency and accuracy (Parajuli et al., 2022).

4.3. Implementation status: from national strategies to community realities

The digital health system in Nepal follows a cascading structure: from national strategies to regional implementations, to applications at the local health posts (MoH Nepal, 2023), and finally to the thousands of CHWs (Williams, 2020) embedded within rural populations. However, as digital tools move down this chain, they often lose coherence and impact due to systemic bottlenecks, as demonstrated in Figure 6 (Parajuli et al, 2022). An interviewee from the World Health Organisation also emphasised that the success of digital maternal health tools in low-resource settings like Nepal hinges less on the technology itself, and more on the readiness of the health system (Appendix V, April 2, 2025).

Figure 5. The friction points at each level of implementation from the national down to the community level. (MoHP Public Health Update 2023, Nepal Health Facility Survey 2021)



One of the most pressing issues and persistent barriers to health system readiness is interoperability. Our interview with a Nepalese development practitioner revealed that the digital systems used at national and regional levels often fail to integrate with those at local health posts (Appendix IV, March 24, 2025). Many peripheral facilities still depend on paper-based records or fragmented software, resulting in data inconsistencies, duplication, and loss of critical information. This lack of connectivity hinders timely decision-making and undermines accountability in maternal health tracking (Wasti et al, 2023: 117).

Compounding this issue is chronic underfunding. While national strategies present ambitious digital visions, financial constraints at the sub-national level often derail these plans. Health posts frequently

lack basic infrastructure, such as internet access, functioning computers, or stable electricity, and limited budgets restrict ongoing training, system maintenance, and technological updates (Appendix IV, March 24, 2025). These financial gaps make digital systems hard to sustain over the long term.

Lastly, socio-cultural barriers and resistance to digital adoption also shape outcomes. CHWs, often older women from within the community, may lack digital literacy or confidence in using new technologies (Ibid). In some cases, there is also a reluctance to replace long-established traditional paper-based practices with digital systems. Without continuous training, localised design, and supportive supervision, digital health tools risk being seen as burdensome rather than empowering (Erku et al, 2023: 6854). As a WHO officer noted, digital technologies should be supportive enablers, not replacements (Appendix V, April 2, 2025). If introduced without sensitivity to users' realities, they risk alienating the very people they aim to empower.

4.4. Importance of female community health volunteers in Nepal

Nepal's efforts to improve maternal healthcare have been supported by CHWs who have long been glorified as the answer to universal health coverage and regarded as the vital link between formal health systems and rural and underserved communities (Sathyamala 2008). In the Nepalese context, they are formally referred to as the Female Community Health Volunteers (FCHVs) or 'Mahila Swoyemsevikas', and are often credited for the improvement in maternal health in rural Nepal (Panday et al., 2017). Their work in delivering last-mile healthcare has been recognised with the FCHV program being hailed as one of the most "successful" CHW models brought to scale (Tikkanen et al., 2024).

The FCHV program was developed in 1988 by the Ministry of Health and Population. While FCHVs have been integrated as a recognised part of the government healthcare system, they are positioned as the lowest level of Nepal's public health framework. As of 2023, more than 50,000 FCHVs form a critical human resource for both government and non-government agencies (Ministry of Health and Population, 2023) to receive 18 days of basic training in maternal, newborn and child health issues (Lee, 2020). Existing within Nepal's rugged geographical and mountainous terrain, they reach the communities by making door-to-door visits, conducting monthly meetings with the mothers and pregnant women, and providing them with supplements such as iron and folic acid tablets, information on healthy behaviours and government services, and basic maternity care (Ibid). In most cases, FCHVs are accessible every day of the week at all hours (Panday et al., 2017).

FCHVs' inherent separation from formal healthcare systems and embeddedness with their communities fosters a unique trust relationship that positions them to alleviate maternal health outcomes by circumventing institutional distrust and barriers formed by language, poverty or traditionalism. As noted by a Nepalese MoHP representative during an interview that every community level health intervention is dependent upon the FCHVs as they are closer to the community, know the community and the mothers feel comfortable confiding in the FCHVs (Appendix I, February 3, 2025). This trusted position further enables them to challenge persisting harmful cultural practices, such as Chhaupadi, a tradition that isolates postpartum women into unsanitary sheds, increasing their risk of infection and delaying access to medical care (Joshi and Acharya, 2022).

FCHVs face consistent structural challenges related to inadequate training, low levels of literacy and digital illiteracy, and insufficient remuneration (Dreishbach, 2019). However, studies conducted with FCHVs capture how opportunities for self-development, empowerment, social recognition and community contribution foster a strong commitment to primary healthcare provisions despite these challenges (Panday et al., 2017). This reliance on altruistic volunteerism to support a crucial cadre of Nepal's health system alludes to an important development that must progress adjacent to the recommendations we have distilled. While this topic will not be explored in this discussion, we note that greater financial and social support for FCHVs is necessary to fortify this vital workforce, and thus to continue progress in primary healthcare and maternal healthcare provisions in rural Nepal.

4.5. Gaps discovered

The existing literature on this topic provides insights into maternal health disparities in Nepal, currently implemented DHT interventions, and barriers to adoption. However, there is limited research that assesses these topics together to identify high-level institutional and infrastructural gaps with the expressed purpose of moving national strategies towards DHT mobilisation for maternal health outcomes. Additionally, there is a lack of cross-context, DHT-specific learnings applied to the Nepalese context. These two gaps have shaped the direction of our research, capturing practical insights from key stakeholders through qualitative interviews and cross-country comparative analysis to draw actionable lessons for Nepals' MoHP.

To address these gaps, the following section examines case studies from India, Indonesia and Cambodia to identify transferable lessons and inform actionable recommendations.

5. Findings

5.1. Case Studies

The following case studies of DHTs in Indonesia, India and Cambodia seek to identify existing approaches to the obstacles observable in Nepal. These case studies do not seek to form an assessment of each country's DHT status, nor do we assume exact transferability of learnings between countries. Rather, observing how countries with comparable resource constraints, geographical obstacles and cultural barriers have approached DHTs informs learnings for Nepal on potential approaches to partnership models, systems approaches and appropriate technologies.

5.1.1. Indonesia: navigating fragmentation and rural divides through adaptive digital solutions

Indonesia has significantly improved its MMR since the turn of the century, falling from 299/100,000 in 2000 to 173/100,000 by 2020 (Syairaji et al, 2024). Despite this critical improvement, Indonesia has the fourth-highest MMR in Southeast Asia, sitting far above Asia's average of 134/100,000 (Ibid). The use of DHTs in Indonesia has dramatically increased since Covid-19, with telemedicine usage increasing sevenfold between 2019 and 2021 alone (Deloitte, 2022). As this dramatic growth was prompted by Covid-19, the Indonesian government's digitisation efforts focus heavily on communicable diseases and pandemic preparedness (MoH Indonesia, 2024). In their most recent strategy, the Blueprint for Digital Health Transformation 2024, some references are made to primary healthcare in the context of immunisation, but minimal attention is paid to the unique experiences and needs associated with infant and maternal health (Ibid).

Despite this crucial omission, efforts are being made at the government, not-for-profit and community level to utilise digital technologies to enhance maternal health outcomes. However, a lack of integration into national strategies has undermined the interoperability of these technologies (Lazuardi et al, 2021). Indonesia's imbalanced urban-rural divide creates chasms in infrastructural equality across the country and in maternal health outcomes (Leung, 2024), necessitating the refinement of digital solutions to adjust to poor digital connectivity and availability, and account for vulnerabilities unique to mothers and children.

Public private partnerships

The Indonesian Business Council has emphasised that PPP can support the country's vision of becoming a developed country by 2045, providing private sector expertise for greater innovation, distributing financial risks and increasing technological adoption for last-mile service delivery (Business Council Indonesia, 2023). The Department of Health Policy also positions PPP as a mechanism to address budget constraints and persistent infrastructural gaps (Basabih, 2023). The Indonesian government's commitment to PPP is concentrated on infrastructural development, managed by Presidential Regulation 38 (2015). Its focus on broadened infrastructural developments responds to critiques that focusing resources solely on education and healthcare is too narrow to support higher economic growth. Although health is listed as only one of the nineteen infrastructure types under Presidential Regulation 38 (2015), with major investments (59% of the USD 429 billion infrastructural investment from 2020-2024) channelled into sectors such as drinking water, education, urban facilities, telecommunications, electric power, and transportation, these investments indirectly improve health outcomes and digital connectivity (World Bank, 2021).

With health deprioritised in PPP, and maternal health unmentioned in key PPP policies and strategies, there are few case studies from DHTs in Indonesia of perfect relevance. As such, instances of PPP in healthcare do not fall under a cohesive coordinated framework and tend to be more standalone. PPP can be mobilised to support governmental development by accessing private sector expertise to strengthen strategy and governance. The Indonesian Ministry of Health is collaborating with the Health Innovation Exchange to establish a Digital Transformation Office (DTOs), which provides advisory services and practical support for the digitization of health provisions (HiEx, n.d.). Indonesia's DTO has become a working unit under the MoH with a particular focus on integrating national health data and supporting healthcare workers' digital access and skills (HIMSS Global, n.d.). This example speaks to the interconnectedness of PPP, interoperability and equipping health workers, as fortifying government capacities through PPP holds the potential to improve digital health provisions at all levels of contact and delivery.

Interoperability and governance

Application: Kata Hat-I

As of 2021, there were eighteen DHTs available in Indonesia that address the continuum of care connected to maternal health, with the highest concentration focusing on the first 1000 days of life (Lazuardi et al 2021, 317). Despite their existence in the market, dispersed ownership of these technologies without overarching coordination undermines interoperability and ultimately reduces users 'awareness of or desire to adopt available technologies (Ibid, 323). Lazuardi et al assert that technological interoperability is underdeveloped in Indonesia, only functionally achieved at the health

office and MoH level to the exclusion of rural health posts, non-government initiatives or community-driven solutions (Ibid, 317).

Kata Hat-I, also known as the Indonesian Health Data Dictionary, is a digital innovation that attempts to address this dispersed ownership of technologies by simplifying the process of integration for local and independent digital health solutions (ibid). While Kata Hat-I is not strictly a maternal health DHT, its generalist and inclusive approach is important to avoid disconnecting maternal healthcare from broader health systems. Rather than siloing DHTs according to their practice or client base, Kata Hat-I addresses the need for all health systems to be able to communicate, a key feature of successful interoperability. By providing information about data requirements, standardizing health terminology and facilitating communication between platforms, Kata Hat-I seeks to improve interoperability and data governance by supporting applications to be easily integrated, read and exchanged between systems (Ibid, 324).

Application: MPosyandu

Posyandu is a majority volunteer workforce of over 1 million CHWs, launched by the Indonesian government in the mid-1980s to address maternal and infant mortality. Previously, CHWs have written their observations into notebooks and kept physical records, or, where possible, entered them into a digital database after meeting with mothers and children within their community. MPosyandu is a digital innovation that has been designed to assist these CHWs with better reporting options, providing a mobile app for real-time reporting, efficient filing, and easy data-sharing (Alkhudari et al, 2021).

MPosyandu encountered issues with low internet connectivity across Eastern Indonesia and in highly rural areas. While addressing infrastructural shortcomings is key to bridging digital divides and reducing maternal mortality, Mposyandu pursued a solution that focused on the aspects of access within their realm of influence. An offline version of Mposyandu was developed to circumvent connectivity barriers, allowing CHWs to continue to utilise the mobility and convenience of this technology regardless of location (Ibid, 13). This solution demonstrates a productive approach to an immediate issue, as while they acknowledge that the barrier is structural and systemic, they understand that the solution must be adaptive and creative.

It must be noted that the uptake of MPosyandu is critically low despite its effective circumvention of connectivity barriers (Ibid), due in part to the availability of technologies with duplicate functions that fragment users. In conversation with a community midwife in Indonesia, the overlap of applications' functions was raised as a barrier to effective and efficient use of digital technologies (Appendix III, March 19, 2025). They noted that they may need to enter the same data several times into different locations, or repetitively into software that failed to reliably save input data. This midwife voiced that the solution was not to create additional digital technologies, which would function to further burden CHWs and healthcare providers, but emphasised the need for a single, reliable approach (ibid). This aligns with Lazuardi et al,'s observations of how the ease of digital-based health information systems in Indonesia is undermined by a lack of systems integration (Lazuardi et al, 2021).

To achieve this image of streamlined and simplified technology, interoperability is paramount. By ensuring that systems are connected, overlaps become self-evident and technologies can be

consolidated. The current isolation of DHTs, owned by different levels of government or private corporations (Ibid), without an effective space for cohesion, undermines the potential for interoperability and thus simplified functionality.

Application: KIA

Digital health solutions that seek to directly interact with or educate mothers on infant and maternal health may benefit from being complementary to physical health services, rather than trying to replace them. This argument is demonstrated by mothers' feedback on KIA, a mobile application that attempts to provide mothers in Indonesia with pre- and ante-natal education. Adidharma et al's (2024) qualitative research found that users of KIA rated its usability and usefulness as low to average, citing inconsistency in the health information provided, lack of detail on fatal progress, user unfriendly interfaces and inappropriate paywalls. After listening to the concerns of mothers accessing KIA, Adidharma et al determined that it should remove paywalls and focus on being an intermediary between women and health workers. This critique speaks to the importance of complementary DHTs that elevate connectivity to vital health services and promote CHW's role in democratising maternal health access (ibid).

5.1.2. Cambodia: bridging the gaps through community-linked digital tools

Cambodia, a Southeast Asian nation with a population of approximately 17 million (United Nations, 2024), faces similar maternal health challenges as observed in Nepal. As of 2023, Cambodia's maternal mortality rate remains high at 218 deaths per 100,000 live births (WHO, 2023), significantly surpassing regional averages.

Over the past decade, Cambodian's MoH has responded with a series of national strategies to reduce maternal mortality, including the Fast-Track Initiative Road Map for Reducing Maternal and Newborn Mortality (Ministry of Health of Cambodia, 2016), the Emergency Obstetric and Newborn Care Improvement Plan (Ministry of Health of Cambodia, 2016), and the National Strategy for Reproductive and Sexual Health (Ministry of Health of Cambodia, 2017). These frameworks underscore a strong political commitment to maternal health. However, similar to Nepal, implementation has been constrained by persistent resource limitations, fragmented health infrastructure, and a lack of real-time data systems, particularly at the last mile (Ong et al., 2020).

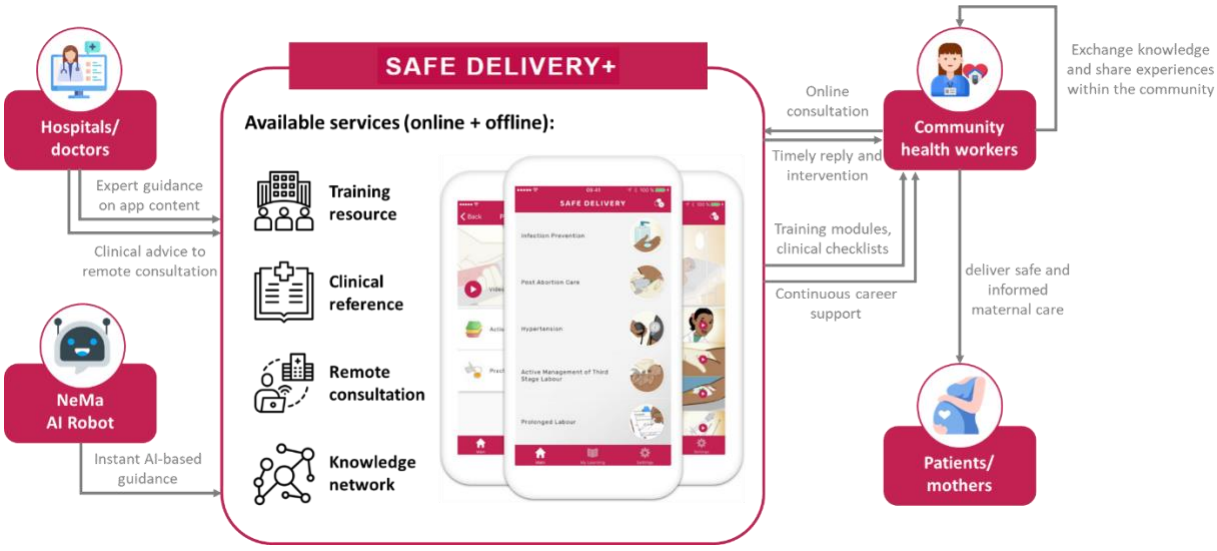
In recent years, Cambodia has increasingly turned to DHTs to address these structural gaps. Supported by development partners and framed by the Cambodia Digital Government Policy 2022–2035 (Ministry of Posts and Telecommunications of Cambodia, 2022), the country has piloted and scaled a range of DHTs focused on maternal health, as shown in the below table. These include electronic registries, telemedicine platforms, and digital learning tools for midwives (Appendix VI, April 5, 2025).

Among these interventions, Safe Delivery App (SDA) stands out as a promising example of how digital tools can be effectively localised and embedded within community-based health systems, as shown in Figure 4 below. Developed by the Maternity Foundation in collaboration with the MoH, the app is not a replacement for human care in Cambodia, but a powerful enabler that strengthens the capacity of maternal care providers, especially CHWs.

Figure 6. Examples of government-led DHTs that support maternal healthcare in Cambodia.

Technologies	Description (in chronological sequence)
Health Information System (HIS)	Supported by Reproductive and Child Health Alliance (RACHA) of Cambodia, the HIS was launched by the MoH in 2016 to strengthen digital data collection and management. To date, it connects across 260 health centers, with a focus on maternal and reproductive health records. It builds health staff capacity in planning and monitoring (Reproductive and Child Alliance of Cambodia, n.d.).
E-Immunization Registry (*KhmerVacc*)	Developed by the MoH of Cambodia with UNICEF support in 2021, KhmerVacc is Cambodia's first digital immunization registry. The mobile app, with 15.8 million users, allows mothers and families to register for vaccinations, track children's immunization status, and receive SMS reminders that support maternal and child health follow-ups (UNICEF, 2023).
National e-learning platform	Developed by the government with support from Alive & Thrive and Clinton Health Access Initiative in 2020, this platform offers e-learning courses on reproductive, maternal, and child health. It facilitates continuous professional development for health workers (National Maternal and Child Health Centre , n.d.).
Safe Delivery App (SDA)	Adapted by Cambodia's MoH from the Maternity Foundation's global platform in 2021, the app offers Khmer-language training and clinical support for healthcare workers, especially midwives. Accessible both online and offline, the app provides self-directed learning modules and practical guidance on key maternal and newborn health topics to more than 3,000 CHWs. It also enables midwives to remotely consult with doctors at selected hospitals on sexual and reproductive health issues. (Nozaki et al., 2023: 178-183).
i-MOMCARE	A digital health tool developed by the MoH in 2023 with support from the National University of Singapore, i-MoMCARE enables real-time data collection, SMS-based appointment reminders, follow-up alerts, and serves as a digital record of patient data. It is currently in the pilot stage and has not yet been scaled nationally (Saing et al., 2023).

Figure 7. Flowchart demonstration of SDA (Source: Maternity Foundation website, Appendix VI)



At its core, SDA provides CHWs with localised training modules, clinical checklists, and animated video guides in their local languages. These cover essential topics such as infection prevention, postpartum haemorrhage, prolonged labour or post-abortion care, which allow CHWs to refresh their knowledge and follow evidence-based protocols even in offline settings (Nozaki et al., 2023). The app also includes step-by-step guides that are quick to access during critical moments (Ibid). Beyond training, the app enables two-way interaction between CHWs and health professionals (Ibid). Through online consultation features, CHWs can seek timely clinical advice from hospital staff when they encounter complex cases, which ensures faster decision-making and reduces delays in care. This directly addresses one of the core challenges faced in countries like Nepal i.e. limited support systems for CHWs operating in remote areas (Appendix VI, April 5, 2025).

In addition, the app is piloting an innovative AI-powered chatbot named NeMa. The bot offers instant, conversational guidance by answering user questions on pregnancy, childbirth, and emergency responses. This AI component enhances real-time support, especially when CHWs are alone in the field and need quick and accurate advice to manage complications (Maternity Foundation, 2024).

Importantly, SDA also has a portal that allows peer-to-peer exchange among CHWs and enables them to share experiences within their local networks. This community-driven design not only builds confidence but reinforces CHWs' sense of purpose and professional identity (Tarun, 2022). Ultimately, these digital features empower CHWs to deliver safer, more informed maternal care while remaining embedded within the social fabric of the communities they serve.

By supporting, rather than replacing, frontline health workers, SDA offers a compelling model for scalable digital health solutions that directly addresses several core implementation bottlenecks mentioned above. Its thoughtful integration of training, connectivity, and AI innovation makes it a compelling model for Nepal and other low-resource settings aiming to strengthen maternal health outcomes through digital tools.

5.1.3. India: scaling maternal digital health through systemic integration

India, home to over 1.2 billion people, borders Nepal and shares similar preventable causes of maternal mortality. Familiar to Nepal, most maternal deaths are concentrated in remote areas and are among the least likely to be recorded (Meh et al., 2022:550). However, India has made significant progress in reducing MMR. India's MMR dropped from 137 per 100,000 live births in 2015 to 97 in 2020. The WHO has recognised India's rapid improvement as a model of groundbreaking progress (WHO, 2018).

India's reduction in MMR is reflective of successful government-led and stakeholder-driven initiatives, such as the Safe Motherhood programme (1992), the Reproductive and Child Health Program (1997) and the National Health Mission (2005) (Meh et al., 2022:556). The National Health Mission lays a crucial role in India's efforts to reduce maternal mortality as it includes the Reproductive, Maternal, Newborn, Child, Adolescent Health, and Nutrition (RMNCAH+N) strategy, which is built on the continuum of care concept and is holistic in design, encompassing interventions aimed at addressing the causes of maternal mortality and improving maternal health outcomes (National Health Mission, n.d.)

India's National Health Policy (2017) emerged with the vision to ensure universal access to necessary health services without financial hardship (Bhatia et al., 2021:8). A central component of this vision was the adoption of DHTs to enhance health service efficiency and reach. Since then, India has made substantial strides in digital health transformation, particularly maternal care (Narayan et al., 2024). Several mHealth applications and telemedicine services, such as Kilikari, mMitra, and E-sanjeevani, complement electronic health record efforts through the Reproductive and Child Health (RCH) portal. The success of these DHTs can also be credited to the improved internet connectivity and increased uptake of smartphones in rural areas (The New Indian Express, 2023).

Figure 8. Examples of DHTs that support maternal healthcare in India

Technologies	Description
Kilkari	As a mobile health education service, it uses Interactive Voice Response (IVR) technology to deliver timely, accessible, accurate and relevant reproductive, maternal health, and child health information to pregnant women, new mothers and their families. It is implemented in partnership with the Ministry of Health and Family Welfare, India. As the largest mobile-based maternal messaging programme in the world, it has reached 53 million women and their children across 27 states and union territories in India and currently has 4.3 million active users. (ARMMAN, n.d.)
mMitra	A free automated mobile voice call service that sends timed and targeted preventive critical information on maternal and infancy care to the phones of the enrolled women weekly/biweekly in their chosen timeslot and language. Community Health Workers (known as mMitra Sakhis) are trained on how to enroll the women. (ARMMAN, n.d.)
E-Sanjeevani	eSanjeevani facilitates quick and easy access to doctors and medical specialists from one's smartphones. Pregnant women can access quality health services remotely via eSanjeevani by visiting the nearest Ayushman Bharat Health and Wellness Centre. It is a widely used application and at present it has served It involved Assisted Telemedicine service which employs Community Health Officers at Ayushman Bharat Health and Wellness Centers who speak the language of the rural area in which they are stationed to facilitate assisted consultations between the patients and the doctors and specialists. Moreover, it is easily integrated with the Ayushman Bharat Health Account which is then fed into the existing digital health records. (e-Sanjeevani, n.d.)

Kilkari

The Government of India launched Kilkari in 2016, a nationwide mHealth service developed by BBC Media Action in partnership with the Gates Foundation, to help new and expecting mothers make informed health decisions (GSMA, 2016:7). Three years later, India's MoHFW partnered with a non-profit organisation ARMMAN to scale the Kilkari programme. (ARMMAN, n.d.). Today, Kilkari is the world's largest mHealth messaging program for maternal and childcare, with over 4.3 million active users, and spread across 27 states and union territories of India (ibid). It uses Interactive Voice Response (IVR) technology to deliver free, timely and accurate reproductive, maternal health, and child health information directly to women and their families (ibid). The messaging begins in the second trimester of pregnancy and continues until the child is one year old. The data of the pregnant women is accessed from the RCH portal to Kilkari through a web service (ibid).

An independent impact evaluation performed by the Johns Hopkins Bloomberg School of Public Health found that Kilkari positively influenced child immunisation, played a role in mothers' decisions about their children's diets, and increased mothers' seeking out of CHWs and healthworkers for advice on early childhood development (BBC Media Action, n.d.). Notably, Kilkari was co-designed with low-income rural women across six Indian states, taking into account literacy barriers, gender norms, and shared mobile usage. This human-centred, gender-sensitive design played a key role in its high uptake and impact (Ibid).

Mobile Academy

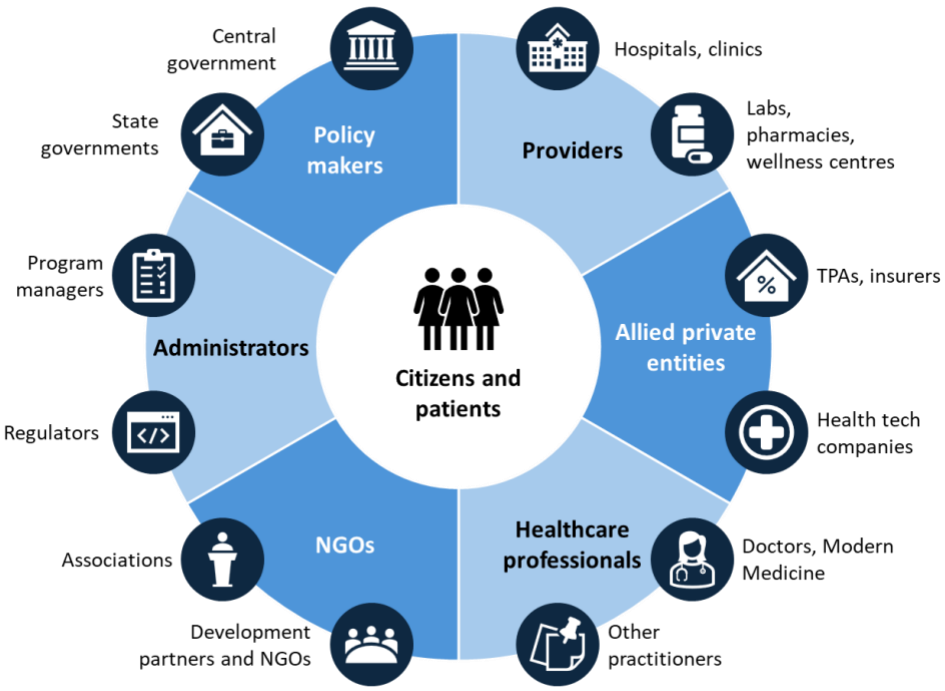
Similar to Nepal's FCHVs, India has a large pool of CHWs known as Accredited Social Health Activists (ASHAs), who play a vital role in ensuring the effectiveness of healthcare service delivery in India (Saprii et al., 2015). Recognising their importance, ARMMAN and the Government of India jointly run Mobile Academy, a mobile learning platform that trains ASHAs to improve the quality of their knowledge and

engagement with pregnant women, mothers, and children (ARMMAN, n.d.). Mobile Academy has reached 150,000 ASHAs and is expected to reach 216,000 in the next three years (Skoll Foundation, n.d.). Efforts are being made to make the program more personalised by incorporating multimedia content (including videos, digital posters/images, audios, quizzes and notifications), delivered via multiple delivery channels, such as WhatsApp, to enrich the quality and effectiveness of learning for ASHAs (ARMMAN, n.d.).

Interoperability: Ayushman Bharat Digital Mission

Beyond digital tool development, India's digital health acknowledges the importance of a cohesive data structure and systemwide interoperability for a competently digitised health sector (Narayan et al., 2024). The Ayushman Bharat Digital Mission (ABDM), launched as a unified digital health ecosystem, (Ibid) has been recognised by the World Economic Forum as a global leader in promoting interoperability and equitable access to digital health solutions (World Economic Forum, 2025). The ABDM is crucial for achieving seamless data exchange, coordination of care, integration of health services, enabling healthcare providers to access and share patient information across different systems and organisations, and facilitating timely and informed decision-making (National Health Authority, n.d.). By enabling coordination between various stakeholders in the healthcare ecosystem, such as hospitals, doctors, private sector, healthcare providers, and non-profit organisations, it is transforming healthcare service delivery (Narayan et al., 2024). Central to this ABDM is a unique 14-digit health identifier for every citizen (Ibid). The ABDM mobile application provides individuals with an accessible EHR that can be used and managed securely and privately by individuals (Ibid). The government is currently undertaking significant efforts to improve the harmony between the Reproductive and Maternal Health Portal and ABDM, which would ensure stronger interoperability through seamless data sharing of the maternal records (Luthra, 2023).

Figure 9. Demonstration on the ADBM ecosystem (Source: Government of India, ABDM)



Public-private partnerships are the nucleus of ABDM and have played a pivotal role in its evolution. From technology providers and healthcare providers, to private insurance companies and government involvement, these collaborations have been crucial for ABDM's continued growth (World Bank, 2023: 16) Though there have been some concerns flagged with the intensity of private sector engagement regarding data security, data privacy, efforts are being made to mitigate the challenges, and their support has helped in the development of the ADBM ecosystem (Ibid, 18).

5.2. Lessons learned

This section will reflect on the aforementioned DHT case studies in the context of Nepal to inform recommendations.

5.2.1. Harness PPPs to bridge funding and tech gaps

Across the countries studied, PPP emerged as critical enablers for mobilising resources and scaling DHTs - yet the scale, structure, and institutionalisation of these partnerships vary, which offers insights for Nepal's journey.

India's experience illustrates the power of embedding PPPs within a coherent national digital health architecture. As seen in initiatives like Kilkari and eSanjeevani, PPPs in India have brought together philanthropic organisations, international partners, and state governments to support maternal health outcomes through scalable and sustainable DHTs. These collaborations succeeded not just because of funding support, but due to mechanisms such as shared ownership models, clear institutional roles, and long-term capacity-building. In addition, the centrality of PPPs in its ABDM demonstrates how open architecture and shared digital infrastructure, like digital health IDs, can allow private players to co-create interoperable tools that align with national standards.

On the other hand, Indonesia offers a more pragmatic and infrastructure-focused model of PPPs. While health has not been a central priority within the national PPP policy, partnerships with global tech players and health-focused entities (such as the HiEx) have shown that even in a fragmented PPP ecosystem, targeted collaborations can address key digital and infrastructural gaps. The Indonesian Ministry of Health's partnership to establish the DTO also highlights how PPPs can be used not just to build tools, but to enhance institutional capacities in digital governance and workforce digital readiness. What also stands out in Indonesia's case is how partnerships evolved quickly in response to public health needs, supported by flexible regulatory approaches and a willingness to work with existing private sectors that had scale and user trust.

Cambodia offers another case of DHTs being co-created through PPPs. None of the core digital health platforms in the maternal health space have been developed by the government in isolation. Besides SDA mentioned above, The HIS was developed in partnership with the RACHA (Reproductive and Child Alliance of Cambodia, n.d.), while the national e-immunization registry involved UNICEF (UNICEF, 2023). Similarly, its national e-learning platform and key mHealth apps were developed with international NGOs or renowned university academia (National Maternal and Child Health Centre, n.d.). These examples show how PPPs can be pivotal for bringing in global expertise, adapting tools to local languages and contexts, and embedding technical assistance within national systems. However, the Cambodian case also highlights a key tension: the high reliance on external partners can lead to

fragmented ownership and difficulty in sustaining tools once donor funding ends (Knittel et al., 2023). The lack of a standardised, government-led framework for coordinating digital health PPPs has resulted in multiple platforms operating in silos (Appendix VI, April 5, 2025).

In the context of Nepal's constrained public financing and uneven digital infrastructure, context-specific PPPs can become a cornerstone of digital health development, provided they are pursued through structured, transparent, and mutually reinforcing arrangements.

5.2.2. Building interoperability through national and institutional support

From our analysis of Nepal and the comparative case studies, it is evident that interoperability is a critical area for the success of scaling DHTs to improve maternal health outcomes.

Achieving interoperability has been a significant challenge across Nepal and our comparative case studies due to a lack of standardisation, making it difficult to integrate data from different sources. The fragmentation and independence of systems, with multiple DHTs owned by various health providers for different functions, such as patient registration and electronic health records, has led to data silos, redundancy, and increased workload. Our conversation with an Indonesian midwife confirmed the unnecessary workload that the CHWs had to undertake when she expressed entering data repeatedly across multiple applications and platforms (Appendix III, March 19, 2025). Limited funding, technical expertise, and adequate infrastructure, coupled with the absence of a unified governance framework and poor coordination among different stakeholders, often hinder the successful implementation of interoperability in health information systems.

India's Ayushman Bharat Digital Mission showcases India's effort to build an integrated digital health ecosystem, which is necessary to bring all the stakeholders together to create longitudinal electronic health records for every citizen that can then be accessed by different healthcare providers. The digital health ecosystem created by ABDM is still at a nascent stage, and efforts to harmonise the RCH portal are underway. Moreover, the need to integrate with the government is well recognised by the DHTs providers, as it is beneficial to have a unified governance interface in place that provides a platform to support continuity of care across primary, secondary, and tertiary healthcare in a seamless manner.

It is to be noted that India's success lies in the country realising its responsibility and commitment to follow the WHO's guidelines on interoperability and aligning its digital systems to best achieve it. While less literature is available on whether technologies and NGO-developed systems are compatible with the ABDM, India's approach remains revolutionary. A WHO officer we interviewed mentioned that it is imperative to develop proper national strategies and long-term infrastructure that are also compatible with NGO-developed platforms and national databases, to avoid the risk of these promising tools getting underutilised (Appendix V, April 2, 2025). The ability to pilot in the sandbox environment provides India with an opportunity to test if NGO tools work and reform the system in the long run to maximise utility of these tools (National Health Authority, 2020). As Nepal advances its efforts towards interoperability, it must recognise the need for a proper institutional setup and resource allocation for expanding e-health. India's ABDM serves as a suitable model and best practice, providing insights on how similar approaches could be adapted to enhance interoperability within Nepal's digital health ecosystem, ensuring the maximisation of health data exchange potential.

Indonesia's Kata Hat-I represents a valuable attempt to integrate dispersed DHTs, a promising model that Nepal would benefit from replicating with the necessary institutional and financial support. Kata Hat-I's central function points to a vital trait of an interoperable system, demonstrating that forming a common language is a prerequisite for DHTs' integration into a single interoperable system. This centralisation of common data standards is a fundamental learning that has proven successful in India's unique identifier system and must carry into the Nepalese context to support DHT's ability to integrate.

5.2.3. Deploy simplified and consolidated DHTs as CHW enablers

When examining last-mile healthcare, it is well established that frontline CHWs are best positioned to bridge cultural, economic, literacy and geographical divides (Ahmed et al, 2022). Thus, to elevate health outcomes, the aforementioned recommendations, PPP and interoperability, must be operationalised with the central objective of equipping this vital informal workforce. One interviewee summarised their need for 'digital tools as enablers, not replacements' (Appendix VI, April 5, 2025), informing our recommendation to improve and simplify existing technologies that support CHWs' activities as preferable to introducing new or complex technologies that may seek to directly interact with mothers or perform remote diagnostics. The prioritisation of the CHW is particularly pertinent in the maternal health context, as stronger cultural barriers to accessing institutions and lower literacy rates amongst rural women necessitate face-to-face health provisions. While this recommendation is specific to rural settings, we note that innovation potential may be higher in urban settings and should be facilitated where possible to uplift Nepal's digital health status.

Fostering PPPs that fill funding and entrepreneurial gaps to improve Nepal's digital health provisions creates the preconditions for strong interoperability and efficiency. To support a contextually relevant product of these recommendations for rural communities, the needs of health workers, those at the interface of the national health system and Nepal's least accessible populations, must be centred. One midwife we interviewed expressed that she may have to enter patients' health data several times into numerous digital applications due to overlapping digital reporting systems or poor saving capacity (Appendix III, March 19, 2025). In conversation with a Nepalese development practitioner, rural Nepal's insufficient digital connectivity led them to the conclusion that Nepal was thirty to fifty years away from having adequate infrastructure and rural literacy to support complex digital health interventions in rural settings (Appendix IV, March 24, 2025). Coupled with the idiom of 'enablers, not replacements' (Appendix VI, April 5, 2025), we have formed the following recommendations based on the input of frontline health workers and development practitioners from within Nepal and case study countries.

6. Recommendations

The following recommendations target solutions within the MoHP's remit of influence, but we stress that collaboration is essential to achieve improved maternal health outcomes in Nepal. For the following recommendations, we encourage the MoHP's close collaboration with the Ministry of Communications and Information Technology and also recognise the important role the Ministries of Education and Finance will play in securing funding opportunities, hosting complex interoperable systems, and supporting CHWs in their adoption of DHTs.

6.1. Mobilise public-private partnerships

6.1.1. Lay the groundwork with fundamental digital infrastructure with PPPs

To build an enabling environment for DHTs on maternal health, it would be important for Nepal to first strengthen its basic digital health infrastructure, and this is where PPPs can play a catalytic role. One Nepalese development practitioner observed that Nepal's efforts to integrate digital tools into the national healthcare system remain fragmented and slow-moving (Appendix IV, March 24, 2025). Therefore, it's important to leverage private sector capacities to accelerate this groundwork and co-develop essential building blocks for future digital health innovation.

Rather than focusing prematurely on specialised maternal health applications, early-stage PPPs should consider targeting the creation of shared infrastructure that benefits the entire health system. This includes basic but vital components such as digitised registries or low-cost data collection platforms. For example, India's early partnerships under the ABDM discussed above, focused first on establishing unique health IDs and interoperable data systems, core elements that made later maternal and child health innovations more effective and scalable.

In Nepal's case, PPPs can be mobilised to support phased local pilots that test the development of such foundational tools in coordination with provincial and municipal governments. This may include co-investments in cloud-based servers for district health offices and offline-compatible data entry applications in rural health posts. By embedding infrastructure development within Nepal's existing decentralised governance framework, such partnerships can ensure that foundational systems are both contextually appropriate and institutionally embedded. Private partners should also support local adaptation beyond funding but also with technology transfer on maintenance training and system integration. With such a base, maternal health-specific technologies will have less risk of becoming isolated or not able to be sustained in the long-term.

6.1.2. Design PPPs with strong governance and accountability

The success of any PPP depends on how it is governed. As learned from our interview with a health consultant based in Cambodia, some of Cambodia's donor-driven digital health pilots that lacked local ownership often suffer from vague roles or imbalanced power dynamics, which eventually undermined trust and led to project failures (Appendix VI, April 5, 2025). In contrast, India's and Indonesia's experience, discussed under section 5, shows that PPPs work best when guided by a clear national strategy, robust institutional oversight and enforceable agreements.

For Nepal, establishing a dedicated digital health PPP framework could help formalise these conditions. This framework could include standardised procurement procedures, mechanisms for joint decision-making and performance reviews linked to measurable health outcomes. PPP contracts should go beyond financial terms to include data governance and service delivery targets. By creating cross-sectoral steering committees or public-private working groups, the government can ensure that partnerships remain adaptive and anchored in public interest. Accountability mechanisms could also be designed to monitor compliance and enable public dialogue.

6.1.3. Encourage inclusive, locally anchored partnerships

One of the most powerful insights from Indonesia's digital health initiatives is that locally embedded partnerships tend to be more responsive and sustainable. While global platforms offered scale, tools

like *MPosyandu*, developed through partnerships with community organizations and district health offices, succeeded because they reflected local languages and cultural norms. Nepal can learn from this by building PPPs that prioritise inclusion and local anchoring.

Also, rather than relying solely on multinational firms or donor-funded pilots, Nepal's government could consider fostering collaboration with domestic health tech startups, local NGOs, academic institutions and community health networks. These actors bring irreplaceable contextual knowledge and relationships that can significantly enhance the design, relevance and adoption of digital tools for maternal health. For instance, local developers working alongside FCHVs or rural midwives can co-create features that respond directly to frontline challenges, such as offline operability or voice-based interfaces.

And to support this, Nepal could consider establishing innovation hubs or public grant schemes that lower the entry barriers for local partners while maintain regulatory clarity and quality assurance. Regulatory sandboxes can also allow for small-scale experimentation before wider scale-up and give both public and private actors the opportunity to iterate on solutions together. It could also consider involving CHWs and rural practitioners in advisory roles to improve accountability and ensure that solutions serve the diverse realities of maternal health delivery in Nepal.

6.2. Prioritise interoperability

6.2.1. Strengthen electronic reporting

As one WHO officer noted, "without national digital health strategies and infrastructure, ensuring data integration and system compatibility remains a major barrier" (Appendix V, 2 April 2025). This observation captures the situation in Nepal where health workers still rely on paper-based health records and disconnected digital tools, particularly in rural areas. Echoed by a Nepalese MoH representative (Appendix I, February 3, 2025), this fragmented digital ecosystem also increases workloads for providers and results in inconsistent or unreliable data. Our recommendation, therefore, emphasises the systematic adoption of standardised national EHRs as a foundational step towards building long-term interoperability.

India's experience with ABDM offers instructive lessons towards this recommendation. By taking responsibility for centralising and coordinating interoperable health architecture, the Nepalese MoHP can achieve harmony and communication between systems with different owners. This will be supported by providing every citizen with a unique health ID that is available to all verified DHT providers to store all health records electronically in a common ecosystem. This digital infrastructure will allow for seamless data sharing, retrieval and exchange between diverse healthcare providers. This is particularly important to maternal and child health, as it will support continuity of care regardless of a mother or child's physical location.

6.2.2. Align coordination among the existing health information systems

In addition to building a better ecosystem, Nepal could also improve the siloed nature of its existing HMIS. Currently, the digital health landscape of Nepal is fragmented with the various national e-health initiatives and DHTs operating in isolation. Cambodia provides a cautionary example that despite many investments in digital maternal health, the absence of coordinated governance and system integration

led to overlapping digital tools supported by different donors and ministries. This has complicated nationwide rollouts of new digital tools and undermined data reliability.

Therefore, seamless coordination between different health solutions is indispensable to address data silos and achieve interoperability. The Indonesian example of Kata Hat-I is a valuable example of a provision that enhances communication between diverse digital health platforms by enabling them to read, share and exchange data efficiently. Coupled with aforementioned learnings from India's ABDM, Nepal should pursue a comprehensive model that brings together the various healthcare providers into an integrated digital ecosystem, allowing for seamless health data flow through common data standards. For Nepal, this means new investments in maternal DHTs shall be contingent on the alignment of existing government systems such as HMIS and eLMIS as mentioned under Section 3. Also, it will be more ideal that coordination can be institutionalised with the Nepalese MoHP establishing a central digital health integration unit for vetting tools, managing APIs and ensuring that data flows between systems.

6.3. Centre community health workers

6.3.1. Prioritise educational technologies that equip CHWs above DHTs that target mothers and children

With most DHT interventions in Nepal failing to penetrate communities beyond health posts, technologies must first meet the needs of CHWs before attempting to engage rural mothers. In rural Nepal, this recommendation is centrally concerned with women's illiteracy and digital access, concluding that directing DHTs to these women is premature and inappropriate. Hesitancy towards patient-focused technologies is supported by the assessment of KIA in Indonesia, where even in a setting with higher literacy and digital connectivity, a qualitative review by users led to the recommendation that this technology should be redesigned to focus on connecting mothers to health services, rather than replacing face-to-face healthcare (Adidharma et al, 2024). Thus, integrating these learnings into the MoHP's defining of target audiences is vital to ensure technologies are contextually appropriate.

Several interviewees raised the potential benefit to be derived from promoting DHTs that provide on-demand educational or training information to support CHWs' daily activities (Appendix I, February 3, 2025) (Appendix II, February 10, 2025). The availability of this training will be particularly pertinent to support CHWs to transition to electronic reporting systems, facilitated by the unique identifier number, to address digital illiteracy as DHTs' rural implementation increases. The Nepalese MoHP should be careful to promote educational DHTs that complement daily decision-making, rather than substitute in-person trainings or convenings. Cambodia's Safe Delivery App is a comprehensive example of a mobile application that provides training materials and connects CHWs to doctors for remote consultations. Importantly, this technology places the onus of initiation upon the CHWs, only requiring them to engage this DHT when it is of benefit to their practice. This application also provides the option to download training materials to be accessed offline, demonstrating contextual sensitivity to potential low connectivity.

6.3.2. Consolidate and simplify technology-based data-input responsibilities of CHWs

One interviewee's assessment of rural Nepalese FCHVs' capacity for technological complexity cut off at quantitative data entry (Appendix IV, March 24, 2025), thus making it an appropriate place to begin.

As a product of enhanced interoperability, investment must be directed to producing high-quality, low-quantity technologies that connect to a national system, reducing the burden on CHWs to a single digital entry per data point per patient. This recommendation learns from the burdens of technological oversupply in Indonesia's fragmented digital health system by responding to the opportunity presented by Nepal's low DHT penetration by refining and consolidating technologies before they are rolled-out to CHWs. This will reduce technological burden and fatigue amongst Nepal's FCHVs by avoiding retrospective consolidation, as is now necessary in Indonesia.

6.3.3. Mobilise AI for efficiencies and accessibility

Where more advanced technologies are available for deployment, the tenet of 'enablement' must remain central to avoid implementing technologies that may burden or replace CHWs. While AI diagnostics are a promising and positive innovation, the MoHP should prioritise AI deployment for rural accessibility to first address digital and health divides between rural and urban Nepal. As a first step, we recommend Nepal deploy AI to translate health data, policies and practices into local languages to equalise access to information. Nepal has begun to develop these capacities through Medic Mobile and Ama-ko-maya, forming the foundation from which this technology can be developed and applied to other DHTs. For communities that cannot rely on internet access to facilitate this kind of technology, AI has displayed promise in supporting offline versions of DHTs. By emphasising AI as a tool to enhance back-end efficiencies and accessibility rather than as an additional digital skillset CHWs are expected to learn, CHWs will be better positioned to continue to provide vital maternal healthcare.

7. Conclusion

This research set out to explore how DHTs can be mobilised to improve maternal health in Nepal. Through a combination of desk research and expert interviews, a consistent theme emerged: while DHTs offer immense potential, their effectiveness is currently constrained by persistent and interconnected barriers. While some stakeholders expressed optimism that is important for fostering ambitious innovations, others voiced their concerns about Nepal's readiness, both socially and infrastructurally, to support the effective deployment of DHTs.

These barriers affect all levels of the healthcare system, from policy and planning at the national level to service delivery in remote communities. Guided by the insights of practitioners and the comparative experiences of India, Indonesia, and Cambodia, this study identified three strategic pillars for Nepal's digital health future: (1) mobilising inclusive public-private partnerships, (2) building interoperable digital systems, and (3) simplifying and strengthening digital tools to support frontline community health workers. Together, these interconnected recommendations aim to ensure that DHTs are not only introduced but embedded meaningfully within the national health system and tailored to the realities of Nepal's rural and maternal health contexts.

Ultimately, while our recommendations respond to Nepal's present-day constraints, unlocking the full transformative potential of DHTs will require broader structural reform. This includes sustained investment in digital infrastructure, cross-sector collaborations, and stronger institutional capacity to govern and scale innovations. Only with such a foundation can Nepal ensure that digital health advances truly serve the needs of mothers, children, and communities across the country.

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