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Examining ICT Interventions for Rural Health System Connectivity: Challenges and Gaps for Improvement: A Systematic Review

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Abstract

Community healthcare interventions in Low- and Lower-Middle-Income Countries (LLMICs) frequently face record management issues that hinder effective linkage between community services and national health systems, contributing to persistently high mortality rates. This study aimed to identify and analyze ICT-based community health interventions implemented in LLMICs, evaluate their effectiveness, and explore challenges limiting their impact. A comprehensive literature search was conducted in June 2024 across ACM Library, PubMed, ScienceDirect, and Google Scholar, focusing on studies published between January 2019 and May 2024. Inclusion criteria targeted ICT-based interventions conducted in LLMICs, available in English, with accessible full texts and clearly defined ICT components. Of the 792 records initially screened, only 9 met the eligibility requirements. Most interventions addressed individual components such as data collection, monitoring, consultations, referrals, and reminders. However, they often lacked integrated systems for data management, continuity of care, and follow-up, limiting their long-term effectiveness. While the review was restricted to open-access studies, the findings offer crucial insights into the design and implementation of ICT-based health solutions. The absence of process integration in current interventions remains a major barrier. Future research and policy development should focus on designing comprehensive, integrated ICT frameworks to strengthen community-to-health system linkages and improve health outcomes in LLMICs.

Keywords: ICT, Framework, Community Healthcare, Village Health Team, Health Information System

1. INTRODUCTION

Though health is the third United Nations Sustainable Development Goal [1] and the second most essential human need [2], many Low- and Lower-Middle-Income Countries (LLMICs) continue to bear a disproportionately high disease burden. These countries also experience extremely low health worker-to-patient ratios [3], which significantly limits the reach and responsiveness of

their health systems. As a result, the gap between communities and formal healthcare structures continues to widen, leading to delays in care delivery and sustained high mortality rates across various regions [4], [5], [6], [7].

To mitigate these challenges, there is a pressing need to explore feasible models for community-based health interventions [8], [9], particularly those that leverage data and information effectively [10]. Uganda, for example, has implemented the Village Health Team (VHT) program to close the community-health system gap and enhance health service quality [11], [12]. However, the program still faces a series of data management issues, including overlooked follow-up cases, difficulty in tracking patients due to disjointed and incomplete data, unreliable case records, weak performance monitoring systems, poor reporting from VHTs, and a lack of actionable data for informed policymaking [13], [14], [15], [16]. These limitations highlight a persistent disconnect between community-level health activities and the national health system [17].

While numerous ICT-based health interventions have been developed in LLMICs, most remain narrowly focused on specific services such as referrals [19], patient monitoring [20], data collection and storage [21], and remote consultations [22]. Although these solutions provide value within their individual scopes, they fail to address the broader need for integrated systems capable of unifying various services. This creates a gap in the literature and practice around ICT-based frameworks that offer holistic, interconnected solutions capable of effectively linking community services with central health infrastructures [18], [23], [24].

This review was designed to investigate the gaps in existing ICT-based community health interventions that limit their ability to effectively connect communities with health systems. It specifically seeks to understand how current tools and practices may fall short in facilitating this connection, particularly in rural and underserved regions. The study focuses on the technical, procedural, and systemic issues that impede successful integration and sustainability of these interventions within LLMICs' healthcare frameworks.

To address these concerns, the study was guided by three primary objectives: first, to identify and analyze existing ICT-based community health interventions implemented in LLMICs; second, to examine the challenges affecting their effectiveness in strengthening the community-health system link; and third, to provide a foundation for developing more effective, integrated models for rural healthcare delivery. The structure of this paper

includes the Abstract, Introduction, Research Methods, Results, Discussion, and Conclusion, offering a comprehensive review of the current landscape and future direction for ICT-based community health solutions in LLMICs.

2. METHODS

This study employed a systematic review approach to identify and assess ICT-based interventions in community healthcare across Low- and Lower-Middle-Income Countries (LLMICs). The aim was to determine how these interventions contribute to bridging the gap between communities and national health systems. To guide the review process, the research question was formulated using the PICO framework [25]. The components included: Population – community-based health programs; Intervention – ICT-based interventions; Control – not applicable; and Outcome – enhanced connectivity between community services and health systems. The central research question was:

What are the gaps in ICT-based interventions for community-based health programs that affect connectivity between the community and the health system?

The eligibility criteria were clearly defined to ensure relevance and quality. Studies were included if they reported on ICT-based health interventions implemented in LLMICs, were published between January 1, 2019, and May 31, 2024, and were written in English with free full-text access. Studies were excluded if they lacked an abstract, did not involve community or rural healthcare, had no ICT component developed, designed, analyzed, or evaluated, or were categorized as review articles, book chapters, conference proceedings, or paywalled resources.

The literature search was conducted using four well-established databases: ACM Library, PubMed, ScienceDirect, and Google Scholar, over a one-month period from June 1 to June 30, 2024. A structured search strategy was employed using a combination of key terms including ICT, framework, community healthcare, rural community, village health team, and health information system. Each database used a tailored query string to optimize results, which are detailed in Table 1 Search Strategy per Database.

Table 1. Search Strategy per Database

No	Database	Search Query/ String
1	ACM Library	[[[**Full Text**: "information and communication technology"] **OR** [**Full Text**: "e-health"] **OR** [**Full Text**: "mobile health"] **OR** [**Full Text**: "digital

		health"] **OR** [**Full Text**: ict]] **AND** [[**Full Text**: "community healthcare"] **OR** [**Full Text**: "community health"]] **AND** [[**Full Text**: "rural community"] **OR** [**Full Text**: "local community"] **OR** [**Full Text**: village]]] **OR** [**Full Text**: "village health team"] **OR** [**Full Text**: "community health worker"] **AND** [**E-Publication Date**: (01/01/2019 **TO** 05/31/2024)]
2	PubMed health	("information and communication technology" OR "e-health" OR "mobile health" OR "digital health" OR ICT) **AND (**"community healthcare" OR "community health") **AND (**"rural community" OR "local community" OR village) **OR (**"village health team" OR "community health Worker")
3	ScienceDirect	("information and communication technology" OR "e-health" OR "mobile health" OR ICT) **AND (**"community healthcare" OR "community health") **AND** "community" **AND** "village health team" OR "community health Worker"
4	Google Scholar	All words:(information and communication technology, ICT, community healthcare, community health Worker, low income and middle income, framework, information system, low-income country) Without the word:(systematic review, review, meta-analysis, animal) Atleast one of these word: (e-health, mobile health, village health team)

The selection of studies followed the PRISMA 2020 guidelines, which include four main phases: Identification, Screening, Eligibility, and Inclusion. During the identification phase, studies were retrieved using the predefined search queries. In the screening phase, titles and abstracts were reviewed against exclusion criteria. This included non-English papers, studies outside the date range, non-peer-reviewed works, and those not focused on ICT or community-based health. In the eligibility phase, full-text articles were assessed to ensure they involved a clearly defined ICT solution supporting community healthcare and improving linkage to health systems. Only those meeting all criteria were included in the final analysis. This entire process is illustrated in Figure 1 PRISMA Flow Diagram, which outlines the number of studies included and excluded at each stage.

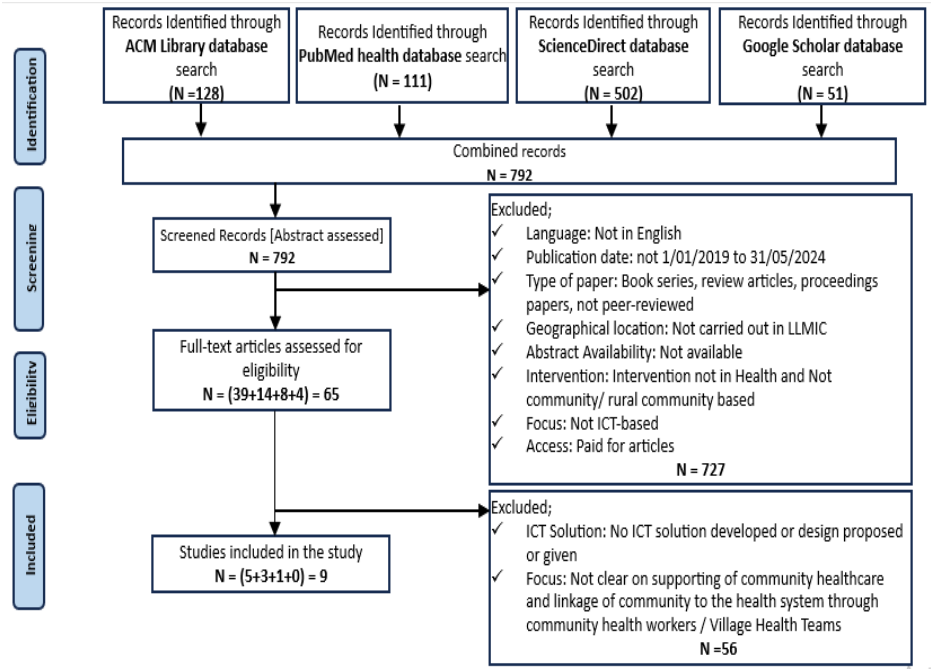

Figure 1. PRISMA Flow Diagram

Data extraction and synthesis were performed using Microsoft Excel, where relevant information was entered in a standardized format. Extraction focused on thematic areas such as the role and recruitment of community health workers, training, accreditation, availability of equipment and supplies, supervision, incentives, community involvement, opportunities for advancement, data management, and linkages to national health systems. This structured approach helped to clearly identify the focus and operational scope of each intervention.

To assess the methodological quality of the included studies, the Newcastle-Ottawa Scale (NOS) [26] was used. This scale evaluates studies based on three domains: selection, comparability, and outcome. Each study was rated on an 8-point scale, with scores of ≥7 indicating low risk of bias, 4–6 indicating intermediate risk, and ≤3 indicating high risk. The assessment results are presented in Table 2 Risk of Bias Assessment, which shows that all nine included studies were of low risk—four studies scored 8 points and five scored 7 points. This level of quality reinforces the credibility and reliability of the findings drawn from this review.

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Table 2. Risk of Bias Assessment table

Sn	Studies	Newcastle - Ottawa Quality Assessment Scale									Overall Risk of Bias
		Selection				Comparability	Outcome			TOTAL /9	
		Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for	Adequacy of follow up of cohorts		
1	[19]	*	No control group	*	*	**	*	*		7	LOW
2	[20]	*	No control group	*	*	**	*	*	*	8	LOW
3	[21]	*	No control group	*	*	**	*	*		8	LOW
4	[22]	*	No control group	*	*	**	*	*		7	LOW
5	[27]	*	No control group	*	*	**	*	*		7	LOW
6	[28]	*	No control group	*	*	**	*	*		7	LOW
7	[29]	*	*	*	*	**	*	*		8	LOW
8	[30]	*	*	*	*	**	*	*		8	LOW
9	[31]	*	No control group	*	*	**	*	*		7	LOW

3. RESULTS AND DISCUSSION

3.1. Overview of Included Studies

From an initial pool of 792 records identified through the search strategy, only nine studies met all inclusion criteria and were selected for comprehensive review. These studies varied in design, target populations, intervention types, and geographic focus. Most were conducted in India, with others from Malawi, Kenya, Bangladesh, and Uganda. None of the studies retrieved from Google Scholar passed the inclusion thresholds.

To facilitate comparison, key details of the included studies are compiled in Table 3. This table outlines each study's authorship, intervention description, study design, methods, and location. Additionally, it highlights the specific

community healthcare settings addressed, the type of ICT-based intervention deployed, and the expected outcomes. The information provides a snapshot of the diversity and commonalities across the included interventions.

Table 3. Characteristics of Included Studies

No	Author(s), Year, DOI/ Access link, Database	Study Title	P: Population	I: Intervention	C: Comparator	O: Outcome(s) Objective(s)	S: Study design/ Method/ Study location
1	**Dixon et al., 2023** [19] https://doi.org/10.1145/3624773 **ACM**	Community and Facility Health Information System Integration in Malawi: A Comparison of Machine Learning and Probabilistic Record Linkage Methods	Patients in antiretroviral and non-communicable disease programs	eTrace workflow: Advanced algorithms for data matching and record linkage between community health facility health (OpenMRS) datasets.	Records for patients in antiretroviral and non-communicable disease programs	**Objective:** Develop a machine learning-based record linkage model; Compare machine learning-based and probabilistic approaches to record linkage and Evaluation **Outcome:** Improved accuracy and completeness of health data integration	**Study design:** Case study **Methods for data Collection:** Secondary data from community health records and facility-based health information systems. **Location:** Malawi
2	**Meena et al., 2022** [20] https://doi.org/10.1145/3555177 **ACM**	Counting to be Counted: Anganwadi Workers and Digital Infrastructures of Ambivalent Care	Anganwadi workers: Serving as daycare providers and CHWs	ICT-based Real-Time Monitoring System. App intended to collect data for efficient delivery of state services	POSHAN Abhiyaan program	**Objective:** Understand how technologies of governance and datafication under the POSHAN Abhiyaan, shape, change, and affect the nature of care-work **Outcome:** Mobile data collection app	**Study design:** Case study **Methods for data Collection:** Auto-ethnography, Interview **Location:** India
3	**Tasmin et al., 2022** [21] https://doi.org/10.1145/3530190.3534846 **ACM**	NOTE: Unavoidable Service to Unnoticeable Risks: A Study on How Healthcare Record Management Opens the Doors of Unnoticeable Vulnerabilities for Rohingya Refugees	Rohingya refugees in Bangladesh	A record management model, its analysis using a data provenance approach	Medical records of Rohingya refugees	**Objective:** Develop a record management model; Analyze the model using a data provenance approach; Identify the limitations of the existing record management **Outcome:** A record management model; Limitations in the existing record management	**Study design:** Case study **Methods for data Collection:** Interviews **Location:** Bangladesh
4	**Raj et al., 2021** [22] https://doi.org/10.1145/3462741.3466649 **ACM**	Assisted Telemedicine Model for Rural Healthcare Ecosystem	Rural healthcare ecosystem [CHWs, citizens, health app]	A blue-print of an Assisted Telemedicine app for catering to the healthcare needs during and beyond Covid-19.	Patient-health worker interactions on a telemedicine platform	**Objective:** Analyze and validate the relevance and feasibility of an "Assisted Telemedicine" model to address accessibility gaps **Outcome:** Customized app for "assisted telemedicine" catering to the healthcare consultation needs	**Study design:** Participatory design **Methods for data Collection:** Interviews **Location:** India
5	**Okeke et al., 2019** [27] https://doi.org	Opportunities and challenges in connecting care	Beneficiaries, community health workers, and their	Feedback systems that connect care	Health process in Kenya	**Objective:** Explores design of feedback systems that connect care recipients to	**Study design:** Case study Qualitative research

	/10.1145/3287098.3287111 **ACM**	recipients to the community health feedback loop	supervisors	recipients to the community health feedback loop		the CH feedback loop **Outcome:** Uncover practices on feedback; collection, type, use, socio-technical factors	**Methods for data Collection:** Interviews and focus group **Location:** Kenya
6	**Ggita et al., 2020** [28] Doi: 10.1186/s12889-020-8427-0 **PubMed**	Experiences and intentions of Ugandan household tuberculosis contacts receiving test results via text message: an exploratory study	Ugandan household TB contacts receiving test results via text message	Home-based mHealth intervention, use of automated short-messaging services (SMS) to deliver test results	Tuberculosis diagnostic results	**Objective:** Explore how household contacts experience test results delivered via SMS, and how these experiences influence follow-up. **Outcome:** Contacts may feel relieved of anxiety when they receive TB diagnostic results via SMS	**Study design:** Cross sectional, qualitative study **Methods for data Collection:** Interviews **Location:** Uganda
7	**Patel et al., 2018** [29] Doi: 10.1111/mcn.12850 **PubMed**	M-SAKHI-Mobile health solutions to help community providers promote maternal and infant nutrition and health using a community-based cluster randomized controlled trial in rural India	Rural women, <=20 weeks of pregnancy through delivery until their infant is 12 months	(M-SAKHI): "Mobile Solutions Aiding Knowledge for Health Improvement" to be delivered by rural community health workers/Accredited SocialHealthActivists	Maternal and infant nutrition and health	**Objective:** Assess the effectiveness of mobile phone intervention package, compared with the standard of care with rural women during prenatal, natal, and post-natal periods to reduce the prevalence of stunting and improve infant development in children. **Outcome:** Evidence on the efficacy and cost effectiveness of M-SAKHI.	**Study design:** RCT **Methods for data Collection:** Interviews Questionnaires **Location:** India
8	**Peiris et al., 2019** [30] doi: 10.1371/journal.pone.0213708 **PubMed**	SMARThealth India: A stepped-wedge, cluster randomised controlled trial of a community health worker managed mobile health intervention for people assessed at high cardiovascular disease risk in rural India	People assessed at high cardiovascular disease risk in rural India	Mobile-based household CVD risk assessments by village-based CHWs using mobile tablet; electronic referral and clinical decision support for PHC doctors; Tracking system for follow-up	Cardiovascular diseases (CVD)	**Objective:** Link village-based assessments to doctor level care **Outcome:** The mHealth platform helped link village-based assessments to doctor level care and supported systematic follow-up care in the majority of patients who needed such care.	**Study design:** RCT **Methods for data Collection:** Observation / Involvement **Location:** India
9	**Zaman et al., 2022** [31] https://doi.org/10.1016/j.hlpt.2022.100681 **ScienceDirect**	Usability and acceptability of the software 'Arogya Sahyog' to assess non-communicable diseases in rural India	Patients with non-communicable diseases (NCDs)	A tablet-based decision support application (app), called 'Arogya Sahyog', to support CHWs in the field.	Non-communicable diseases	**Objective:** Assess usability of the app for screening, providing lifestyle advice, and referring patients. **Outcome:** Arogya Sahyog was well accepted and achieved an excellent usability rating, supporting its use by CHWs	**Study design:** Case study, mixed methods **Methods for data Collection:** Questionnaires **Location:** India

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3.2. Assessment of Intervention Components

To further understand how these ICT-based interventions support or hinder connectivity between communities and health systems, we assessed each study using a hybrid framework. This framework draws from the Health Metrics Network (HMN) structure and WHO's guidance on institutionalizing community health worker (CHW) programs [32][33]. It evaluates 10 critical components: CHW role and recruitment, training, accreditation, equipment and supplies, supervision, incentives, community involvement, career advancement, data flow, and health system linkages. Table 4 summarizes how each intervention addressed or failed to address these components. It reveals the strengths and gaps in the integration and operationalization of CHWs within the digital health ecosystem. Most interventions showed strong data collection capabilities but struggled with sustainability aspects like career pathways and formal supervision structures.

Table 4. Intervention Assessment

		Assessment Components										
	No	**Components for Community Healthcare interventions**	**Role and recruitment**	**Training**	**Accreditation**	**Equipment and supplies**	**Supervision**	**Incentives**	**Community involvement**	**Opportunity for advancement**	**Data**	**Linkages to the national health system**	**Overall Observation**
		How CHW recruitment, their role and scope of work are designed and clarified by the health system design	How pre-service training is provided to prepare CHWs for their role	How health knowledge and competencies are assessed and certified prior to practicing	How the requisite equipment and supplies are made available	How supportive supervision is carried out	How a balanced incentive package is provided	How a community supports CHW programme	How CHWs are provided career pathways	How community-level data flow to the health system and back to the community	The extent to which the ministry of health has policies that integrate and include CHWs in health system	
INCLUDED STUDIES	**1**	**Dixon et al., 2023** [19]	CHWs receive follow-up task by SMS from trace, visit patient/ defaulter &report	Not discussed	Not discussed	Not discussed	Site-supervisors access trace follow-up reports, communicate findings	Not discussed	Not discussed	Not discussed	Hardcopy report from OpenMRS to clinics, SMS from clinics to CHWs, CHWs submit follow-up report on webapp (Trace)	Reports from CHWs sent to OpenMRS (Facility-based) for assessment by field supervisor	Not all information flow is in the system. Indicates a disconnect in information and facts generated

2	**Meena et al., 2022** [20]	Anganwad - CHWs; data collection, preschool training, health awareness	Not discussed	Minimum education: Class 10 high school Unofficial: Basic computer knowledge	Not discussed	Based on collected data, both the worker and the beneficiary are monitored	Monthly salary, standard incentive on uploading 60% of the data	Collect maternal and child health data from homes	Not discussed	Collect maternal and child health data from homes. Done with a mobile application	Data is uploaded on the monitoring app owned by a government program under the ministry of women and child development	Focus is on data collection, not the entire health care service composition
3	**Tasmin et al., 2022** [21]	HWs stationed at the health camps. Capture patients' medical information, generate authentication token for the patient	Not discussed	Medical personnel	Computer gadget to allow online platforms access	Not discussed	Not discussed	Patient goes to a medical camp	Not discussed	Token generated for patient by token generator authority (nurse, paramedic, medical assistant), used to generate Token ID and recorded in a record book (logbook/ register book) which documents current and future medical treatment related records	Reports are uploaded in the system, and the patients use the prescriptions to receive free medicines from healthcare organizations	Focus more on identifying the patient to enable linkage of one visit record to another but doesn't exactly cater for CHW services to feed national health system
4	**Raj et al., 2021** [22]	Not discussed	Not discussed	Not discussed	A tablet device compatible cloud-based software application for doing tele-consultations with other required provisions and functionalities	Medical professionals instruct health workers on practical cases that need follow-up though not exactly supervising them	Not discussed	Not discussed	Not discussed	Access control and user authentication; **HWs:** Record patient records and demographic, vitals & upload past prescriptions/ test reports, Store electronic health records, generate an e-prescription; **Practitioners & HWs:** pending & completed consultations on dashboard, Mechanism to join a common video-consultation room; **Practitioners:** access patients' demographics, vitals, past prescriptions and reports, enter medicine, dosage, prescription, instructions for HWs to do patient follow-ups	Provision for both CHW and medical professionals to handle a case jointly. However, concentration is on the consultations with the medical professionals and not follow-up on work done by the CHWs	Has facility-based health professionals at the Centre of health care and not CHWs. The CHWs are majorly involved as record takers and follow-up personnel not taking charge of the healthcare itself

5	**Okeke et al., 2019** [27]	Not discussed	Not discussed	Not discussed	All CHWs are equipped with Android smartphones to access the Smart Health mobile app	Not discussed	Feedback informs impact of services,improve training, motivate CHWs, &detect fraudulent behavior	CHWs expected to earn commissions from selling health products to beneficiaries	Not discussed	System includes the Smart Health mobile app for CHWs, supervisor mobile app & a web dashboard for supervisors to monitor CHW performance. Data flow is by; Direct Phone Calls to Households, CHW Informal Report to Supervisors, Chance Encounters & Public Events	Work in partnership with Ministry of Health.	Focus is on giving CHWs feedback on their performance and not the complete healthcare process components
6	**Ggita et al., 2020** [28]	Household contacts help with communication; health workers are at health centres	Not discussed	Not discussed	Mobile phone	Not discussed	Not discussed	Not discussed	Household contact sends a "HELP" SMS in case of need	Provide testing results, instructions about evaluation or treatment, reminders to go to the clinic for evaluation. Contacts send "HELP" messages if their symptoms do not improve	Household contacts communicate with medical personnel at the health centres	The nature of information flow does not allow for centralized storage hence challenges in case follow-up
7	**Patel et al., 2018** [29]	ASHA health workers to be engaged in counselling services	Not discussed	Not discussed	Need for a computing device to access the service app	Involves a field supervisor who feeds information in the supervisor's app	Not discussed	Not discussed	Involved in counselling sessions	Data collection in real-time and face-to-face counselling, Delivery of pushed text, voice and alert (text) Messages, Mobile phone to mobile phone counselling, Field supervisory app, health-promoting audio and video counselling messages	Linked to the government health project which monitors in real-time the data collected by ASHA (CHWs)	Apart from counselling, the CHWs are not seen to be actively involved in this intervention. Information & guidance mostly auto-generated by the system. Leaves a gap in the human involvement
8	**Peiris et al., 2019** [30]	Not discussed	ASHAs and PHC doctors were trained for 5 days on how to use the tool	Not discussed	Each ASHA (tablet, Bluetooth enabled BP monitor, glucometer, hard copy training manual, census list)	Support team with supervisors visit the ASHAs and doctors on a periodic basis	Not discussed	Patients found at home; data entered in the system by ASHA	Not discussed	ASHAs collect health-related information, inform the subject of their risk status, provide lifestyle advice, diet and tobacco and alcohol, and refer high risk patients to the PHC doctor. Provides decision support to doctors for medication prescription	Data was asynchronously uploaded to a shared electronic medical record (OpenMRS)	OpenMRS was not integrated with government health information managements systems

9	Zaman et al., 2022 [31]	ASHAs promote health lifestyles among community members	Not discussed	Not discussed	A computing device	Not discussed	Not discussed	Receive health advise from the CHWs	Not discussed	Reminders and interactive prompts for CHWs to promote healthier lifestyle in patients with NCDs	Not discussed	Governance issues not addressed and no clear app usage detail given

The analysis in Table 4 reveals several important trends across the reviewed interventions. Most notably, pre-service training, accreditation, and career advancement pathways for CHWs were rarely addressed in the documented interventions. Only a few studies, such as Peiris et al. [30], included structured training for CHWs and health professionals prior to ICT tool deployment. Similarly, supportive supervision was inconsistently discussed, and formal systems for supervising CHW activities were often underdeveloped or absent. Regarding incentives, some interventions (e.g., Meena et al. [20] and Okeke et al. [27]) integrated financial or performance-based motivators, while others made no mention of CHW compensation mechanisms. Additionally, equipment provision was generally ensured mostly in the form of mobile phones, tablets, or monitoring tools but there was limited discussion on maintenance, upgrades, or supply chain challenges.

One of the most consistently addressed components was data flow, with several studies enabling data collection via apps or SMS and sending results back to healthcare facilities. However, bidirectional data sharing where health systems also provide feedback or instructions back to CHWs or communities was largely missing. This one-way data model undermines the full potential of CHWs as active links between the community and the formal healthcare system. Finally, the integration of CHWs into national policies and health strategies an essential factor for sustainability was poorly documented across most studies. Without strong policy alignment, many of these ICT interventions risk being treated as pilot projects without long-term impact. In summary, Table 4 highlights a critical disconnect: while digital tools may support specific healthcare functions, the absence of broader systemic integration significantly weakens the long-term effectiveness and scalability of these community-based interventions. To fully bridge the gap between rural communities and health systems, future interventions must address these overlooked institutional and structural dimensions.

3.3. Summary of Key Findings and Gaps

Beyond structural analysis, we extracted each study's stated findings and identified associated gaps. These insights are essential for understanding what

has been achieved and what still hinders effective community-health system integration in ICT-driven programs. Table 5 lists the key contributions and limitations for each study. While many interventions improved specific aspects like monitoring or remote diagnosis, few offered comprehensive frameworks to link CHW efforts with formal health services at scale. These persistent gaps are critical in informing future intervention design.

Table 5. Key Findings and Gaps in Included studies

No	Study	Key Findings	Gaps
1	[19]	Machine learning methods outperformed traditional probabilistic methods in accuracy and speed of data integration, highlighting the potential for improved health information management in Malawi	▪ Concentrates on linking records and ignores other aspects of health care ▪ Doesn't suggest components for a complete framework to resolve the linkage issue
2	[20]	The real-time monitoring apps were found to serve the state's need for performing care through data rhetorics produced but at the expense of the professional and personal well-being of the workers, and the communities.	▪ Concentrates on data collected other than actual case follow-up ▪ Does not state the expected app components to aid in bridging the gap between the community and the health system
3	[21]	Existence of vulnerabilities in ID management and security practices in healthcare record management	▪ Concentration is on authentication of patients and health personal in the system as opposed to the complete health care process ▪ Doesn't clearly show the involvement of CHWs, generalizes the health worker and doesn't recognize the variation in level of service
4	[22]	▪ Most villagers did not possess mobile phones, those who did were not skilled enough to use smart phones ▪ Doctors had limited time to attend to patients on the app ▪ Different doctors handle a case, hence challenges in case follow-up ▪ Need to pair technology with a human facilitator, "assisted tele-medicine"	▪ Focus is not on CHWs but villagers accessing professional doctors ▪ Scope is limited to consultations and not the entire case management process

No	Study	Key Findings	Gaps
5	[27]	▪ Feedback is collected in no systematic way [direct phone calls to households, indirect CHW reports that are sometimes shared with supervisors, and chance encounters in public places]. ▪ Feedback informs on the impact of services, improve training, motivate CHWs, and detect fraudulent behavior.	▪ Focus is on service feedback not the entire healthcare process ▪Challenges in making meaning of collected data.
6	[28]	▪ Patients less confident about results delivered via SMS than by Lay Health Workers (LHWs). ▪ Delivery of results by SMS should complement continued interaction with LHWs, not replace them. ▪ The intervention provides testing results, instructions about additional evaluation or treatment, and reminders to go to the clinic for evaluation as needed ▪ Information flows from health facility to patients	▪ Limited to SMS alerts as the form of communication ▪ No provision for information flow from patients to the health facility
7	[29]	▪ Mobile phones being used for behavior change ▪Solution involved: communication to ASHA app for real-time data collection and face to face counselling; Delivery of pushed text, voice and alert (text) Messages; Mobile phone to mobile phone counselling; Field supervisory app	▪ Lack clarity on the integration and linkage of CHW services to the main health system services
8	[30]	▪ Given the shortages of doctors, it is a promising strategy to engage ASHAs to triage high risk individuals to the doctor.	▪ There is need to: try different task sharing models which may include an increased prescribing role for CHWs; engage other workers such as nurses, pharmacists and allied health professionals; increase patient engagement through use of mobile technology; deeper integrate the intervention into the prevailing system incorporating supply chain management and

No	Study	Key Findings	Gaps
			human resource intervention.
9	[31]	▪ The app provides reminders and interactive prompts for CHWs to promote healthier lifestyle in patients with NCDs. ▪ CHWs are considered the strengths of the app to include functions to support task-automation and real-time monitoring. ▪ Reported difficulty in using the inbuilt keyboard.	▪App does not cater for aspects of governance ▪Does not contain all aspects of patient management for CHW care.

An in-depth review of Table 5 reveals several recurring themes that cut across most interventions. First, while several studies introduced technical advancements, such as machine learning for record linkage ([19]) and mobile-enabled counselling ([29]), these solutions rarely formed part of a comprehensive health system strategy. For instance, [19] focused solely on data accuracy but did not extend its intervention to case follow-up or treatment planning, thereby limiting real-world impact despite technical efficiency.

Second, most interventions lacked integration of CHWs into the full care continuum. For example, Meena et al. [20] reported on the effectiveness of Anganwadi workers in data collection, but there was little emphasis on their involvement in actual care delivery or referral processes. Similarly, Raj et al. [22] focused on telemedicine, but the role of CHWs remained peripheral—limited to assisting physicians without substantial decision-making responsibility or capacity development.

Third, unidirectional information flow was a major limitation. Several systems (e.g., [28], [31]) successfully transmitted alerts or updates to community members but failed to establish two-way communication or feedback mechanisms between CHWs and health facilities. This disconnect limits the ability to monitor patient outcomes, conduct timely follow-ups, or adjust treatment plans based on feedback from the field.

Moreover, governance and sustainability aspects were underrepresented in nearly all interventions. For instance, while some studies like [30] implemented structured training and monitoring, they lacked integration with existing government health information systems, leaving them vulnerable to discontinuation after project funding ends. Zaman et al. [31] even identified usability challenges with their application, yet no adjustments were made to

align the software with CHW workflows or improve governance mechanisms.

Another key observation is the limited scope of service delivery. Many studies focused on a single element such as record keeping, test result delivery, or basic data capture without incorporating broader care processes such as diagnosis, referral, treatment, and patient education. Without an integrated service model, the full value of CHW involvement is lost, and interventions fail to create lasting community-health system bridges.

Collectively, these findings emphasize that while ICT innovations in LLMICs are advancing, they remain fragmented and task-specific, failing to offer holistic, system-integrated solutions. CHWs though central to many of these interventions are often treated as passive data collectors rather than empowered health actors. Without intentional design that embeds CHWs within national policy frameworks, supports career progression, ensures quality assurance, and builds long-term feedback loops, these digital solutions cannot truly close the gap between rural communities and health systems. Going forward, effective ICT interventions must be guided by comprehensive frameworks that support not only technology deployment but also human resource development, governance integration, and process continuity. These elements are critical for transitioning from short-term digital fixes to sustainable, scalable health system solutions in LLMICs.

3.4. Discussion

The aim of this review was to systematically identify, analyze, and critique existing ICT-based interventions implemented in community health settings across Low- and Lower-Middle-Income Countries (LLMICs). The primary objective was to uncover how these interventions contribute or fall short in strengthening the critical linkage between community-based healthcare efforts and national health systems. From an extensive search of four major academic databases, nine studies met the inclusion criteria and formed the basis of the analysis. These interventions collectively reflect the diverse ways digital technologies are being deployed in rural health contexts, addressing domains such as electronic health record integration, mobile-enabled data collection, automated alerts, teleconsultations, and case tracking.

The review found a promising array of digital innovations. For instance, in Malawi, machine learning techniques enhanced the accuracy of patient data matching across systems [19], improving the integration of community and facility records. In India, mobile apps facilitated real-time monitoring and decision support for both maternal and non-communicable disease care [20],

[29], [30]. Other interventions used SMS platforms to deliver diagnostic results and treatment instructions directly to patients in hard-to-reach areas [28], while others supported structured telemedicine services [22]. These interventions have clearly advanced certain operational aspects of rural healthcare delivery such as timeliness, access, and the fidelity of health data.

However, these gains remain fragmented and function-specific. A closer examination reveals that most interventions addressed isolated tasks within the healthcare ecosystem data collection, referrals, test results delivery, or consultations without integrating these functions into a comprehensive service delivery model. Few, if any, of the reviewed studies provided evidence of holistic planning that aligned digital innovations with core public health principles, community health worker (CHW) institutionalization frameworks, or national health information strategies. As a result, while interventions may have improved specific workflows, they did not resolve the systemic disconnect between frontline service delivery and centralized healthcare management systems.

1) Gaps and Implications for Future ICT-Based Interventions

The World Health Organization and other global health authorities have consistently emphasized that the effectiveness of community health systems depends not only on technology, but also on institutional coherence, human resource empowerment, and policy alignment [33], [36]. The 10-component framework used in this study (based on CHW institutionalization models) includes elements such as recruitment standards, pre-service training, supervision mechanisms, accreditation processes, incentives, data flow, and integration with formal health systems. Yet, none of the reviewed interventions addressed these components in full. In fact, most ICT solutions were developed in silos, with limited or no reference to broader structural requirements for scale-up or sustainability.

This piecemeal approach is a fundamental barrier to progress. For example, while SMS-based systems can deliver test results quickly [28], they rarely provide a structured mechanism for patient follow-up, case escalation, or real-time CHW guidance. Similarly, data captured through mobile apps may remain within the local device or software interface, with no pipeline for integration into national health information systems [31]. Consequently, CHWs often operate without the decision support, supervision, or systemic recognition required to maximize their effectiveness.

The consequence of this design fragmentation is the persistent underutilization of CHWs not due to their lack of capability, but due to a failure in the digital infrastructure to institutionalize their role within health systems. CHWs are too often relegated to data collectors or messengers, rather than empowered agents of care delivery, referral, and patient monitoring. Moreover, interventions generally failed to address CHWs' career progression, training upgrades, and feedback loops factors which are essential for workforce motivation, accountability, and retention.

Future ICT-based interventions in LLMICs must therefore move beyond standalone app development toward framework-based design thinking. This involves the co-creation of solutions with CHWs, policy makers, and community leaders; ensuring technological tools are embedded within existing workflows; and aligning innovations with national health priorities. Only by integrating all these elements can ICT truly bridge the longstanding divide between the community and formal health systems.

2) Strengths and Limitations of the Review

This review contributes a much-needed perspective on a relatively under-explored but critically important area in global health. By focusing specifically on ICT-based community health interventions in LLMICs, it fills a notable gap in current literature. Its use of an institutionalization-based framework offers a robust lens for understanding why many digital health tools fall short of expectations, even when technically sound. The structured analysis provides actionable insights for developers, policy-makers, and global health funders about what has worked, what hasn't, and why.

A further strength lies in its multidisciplinary approach—combining health systems thinking, digital technology analysis, and CHW institutional perspectives. This convergence allows for a deeper, more systemic understanding of community health gaps, moving beyond simplistic "technology-fixes" toward more sustainable, scalable solutions.

Nevertheless, the review is not without limitations. First, while the search strategy was comprehensive, the decision to include only free-access, English-language studies may have excluded significant interventions published in other languages or behind paywalls. This language and accessibility bias is a common but acknowledged limitation in unfunded systematic reviews. Second, the heterogeneity of study settings and intervention types made synthesis complex. Differences in context, healthcare infrastructure, CHW training, and government engagement could influence intervention outcomes,

making cross-comparison less straightforward. Moreover, the small number of included studies (n=9) limits the ability to generalize findings across all LLMICs. It also points to a possible publication gap or underreporting of such interventions. Future reviews should consider multilingual searches, funding for access to paywalled studies, and perhaps direct communication with organizations and governments implementing ICT-based community health solutions to uncover grey literature.

4. CONCLUSION

This review affirms that significant progress has been made in utilizing ICT-based interventions to improve community healthcare in Low and Lower-Middle-Income Countries (LLMICs). The studies analyzed provide clear evidence that digital tools can enhance healthcare delivery through improved data collection and management, better information flow, performance tracking, data integration, case referral and follow-up mechanisms, as well as support for community health worker training. These innovations have shown measurable benefits in increasing access to healthcare services and improving operational efficiency in underserved communities. However, despite these advancements, most interventions remain fragmented and lack the comprehensive design required to fully bridge the gap between community-level care and formal health systems. Critical elements such as the institutionalization of community health workers, clear supervisory frameworks, integration with national health policies, and robust governance mechanisms are often missing. Without these foundational components, ICT-based interventions risk operating in isolation and failing to deliver sustained, system-wide impact.

To address these shortcomings, future interventions must be guided by holistic and integrated frameworks. Such frameworks should be built around the full-scale engagement of community health workers and promote seamless connections between the community and the broader health system. Successful implementation will require inclusive collaboration among stakeholders, including policymakers, healthcare practitioners, researchers, and community leaders. These efforts should ensure that interventions are adaptable, sustainable, and tailored to the local context.It is also essential that knowledge gained from ongoing ICT-based healthcare implementations, particularly regarding their adoption, effectiveness, and feasibility within African and other LLMIC settings, is shared widely. Making such information freely accessible can accelerate innovation, inform policy, and support future research. Finally, expanding future studies to include paid-access and non-English publications will enrich the evidence base and provide a more

comprehensive understanding of global best practices in ICT-enabled community health interventions.

REFERENCES

[1] K. Buse and S. Hawkes, "Health in the sustainable development goals: ready for a paradigm shift?," *Globalization and Health*, vol. 11, no. 1, p. 13, Mar. 21, 2015, doi: 10.1186/s12992-015-0098-8.

[2] A. H. Maslow and C. D. Green, "A Theory of Human Motivation," *Classics in the History of Psychology*, 1943. [Online]. Available: http://www.livrosgratis.com.br

[3] E. E. Ajari and D. Ojilong, "Assessment of the preparedness of the Ugandan health care system to tackle more COVID-19 cases," *J. Glob. Health*, vol. 10, no. 2, pp. 1–3, Dec. 2020, doi: 10.7189/jogh.10.020305.

[4] H. I. Zhang, G. Fink, and J. Cohen, "The impact of health worker absenteeism on patient health-care seeking behavior, testing and treatment: a longitudinal analysis in Uganda," *PLoS One*, vol. 16, 2021, doi: 10.1371/journal.pone.0256437.

[5] H. M. D. M. Vozzella and J. Cardiovasc, "Cardiovascular Nursing Workforce Challenges: Transforming the Model of Care for the Future," *J. Cardiovasc.*, 2023, doi: 10.14797/mdcvj.1188.

[6] A. E. Alunyu et al., "Investigating the impediments to accessing reliable, timely and integrated electronic patient data in healthcare sites in Uganda," in *Proc. HEALTHINF 2021 – 14th Int. Conf. Health Informatics*, BIOSTEC, 2021, pp. 522–532, doi: 10.5220/0010266705220532.

[7] N. Dowhaniuk, "Exploring country-wide equitable government health care facility access in Uganda," *Int. J. Equity Health*, vol. 20, no. 1, Dec. 2021, doi: 10.1186/s12939-020-01371-5.

[8] S. Salve et al., "Community health workers and Covid-19: Cross-country evidence on their roles, experiences, challenges and adaptive strategies," *PLOS Glob. Public Health*, vol. 3, no. 1, p. e0001447, Jan. 2023, doi: 10.1371/journal.pgph.0001447.

[9] A. Rahimi, R. Kassam, Z. Dang, and R. Sekiwunga, "Challenges with accessing health care for young children presumed to have malaria in the rural district of Butaleja, Uganda: a qualitative study," *Pharmacy Practice (Granada)*, vol. 17, no. 4, 2019.

[10] M. Bagyendera, P. Nabende, and J. Nabukenya, "Critical factors influencing data use and utilization in health systems: a focus on data and interoperability standards for health information exchange (HIE) in Uganda's health care system," *Oxford Open Digital Health*, vol. 1, Jan. 2023, doi: 10.1093/oodh/oqad015.

[11] S. Agarwal et al., "Impact of a recognition package as an incentive to strengthen the motivation, performance, and retention of village health teams in Uganda: a study protocol for a cluster randomized controlled trial," *Trials*, vol. 24, no. 1, Dec. 2023, doi: 10.1186/s13063-023-07426-6.

[12] E. A. Nalugga et al., "It Takes A Village; Involvement of Village Health Teams to Develop Tools and Resources to Communicate about Antiretroviral Use in Pregnancy and Breastfeeding at Community Level in Uganda," *Wellcome Open Res.*, vol. 8, 2023, doi: 10.12688/wellcomeopenres.19088.1.

[13] N. Chen et al., "The Community Health Systems Reform Cycle: Strengthening the Integration of Community Health Worker Programs Through an Institutional Reform Perspective," *Global Health Science & Practice*, 2021. [Online]. Available: https://www.ghspjournal.org

[14] S. A. Namanda and R. Hamala, "Exploring supervision for volunteer community health workers in Mukono District, Uganda: An exploratory mixed-methods study," *Global Public Health*, 2021, doi: 10.1080/17441692.2021.1969671.

[15] S. Pandya et al., "Understanding Factors That Support Community Health Worker Motivation, Job Satisfaction, and Performance in Three Ugandan Districts: Opportunities for Strengthening Uganda's Community Health Worker Program," *Int. J. Health Policy Manag.*, vol. 11, no. 12, pp. 2886–2894, Dec. 2022, doi: 10.34172/ijhpm.2022.6219.

[16] H. T. Nansikombi et al., "Timeliness and completeness of weekly surveillance data reporting on epidemic prone diseases in Uganda, 2020–2021," *BMC Public Health*, vol. 23, no. 1, Dec. 2023, doi: 10.1186/s12889-023-15534-w.

[17] K. Hoxha, Y. W. Hung, B. R. Irwin, and K. A. Grépin, "Understanding the challenges associated with the use of data from routine health information systems in low- and middle-income countries: A systematic review," *Global Health Sci. Pract.*, Sep. 1, 2022, doi: 10.1177/1833358320928729.

[18] L. Karni, K. Dalal, M. Memedi, D. Kalra, and G. O. Klein, "Information and communications technology-based interventions targeting patient empowerment: Framework development," *J. Med. Internet Res.*, vol. 22, no. 8, Aug. 2020, doi: 10.2196/17459.

[19] A. Dixon et al., "Community and Facility Health Information System Integration in Malawi: A Comparison of Machine Learning and Probabilistic Record Linkage Methods," *ACM Journal on Computing and Sustainable Societies*, vol. 1, no. 2, pp. 1–16, Dec. 2023, doi: 10.1145/3624773.

[20] M. S. P. Azhagu Meena, P. Vaghela, and J. Pal, "Counting to be Counted: Anganwadi Workers and Digital Infrastructures of Ambivalent Care," *Proc. ACM Hum. Comput. Interact.*, vol. 6, no. CSCW2, Nov. 2022, doi: 10.1145/3555177.

[21] F. T. Jaigirdar et al., "Unavoidable Service to Unnoticeable Risks: A Study on How Healthcare Record Management Opens the Doors of Unnoticeable Vulnerabilities for Rohingya Refugees," in *Proc. ACM Int. Conf. Proc. Series*, Jun. 2022, pp. 614–622, doi: 10.1145/3530190.3534846.

[22] D. Raj and T. K. Srikanth, "Assisted Telemedicine Model for Rural Healthcare Ecosystem," in *Proc. ACM Int. Conf. Proc. Series*, Jun. 2021, pp. 86–91, doi: 10.1145/3462741.3466649.

[23] E. Sacks et al., "Beyond the building blocks: integrating community roles into health systems frameworks to achieve health for all," *BMJ Glob. Health*, vol. 4, no. 6, pp. e001192, 2019, doi: 10.1136/bmjgh-2019-001192.

[24] A. Iuliano et al., "Linking communities and health facilities to improve child health in low-resource settings: a systematic review," *Health Policy Plan.*, Jul. 1, 2024, doi: 10.1093/heapol/czae028.

[25] L. R. Leonardo, "Evidence Based Medicine and Practice," *Evid. Based Med.*, 2018, doi: 10.4172/2471-9919.1000115.

[26] I. Kalaycioglu, A. Veilleux Carpentier, and M. Keezer, "Inter-rater reliability of risk of bias tools for non-randomized studies," *Res. Syn.*, 2023.

[27] F. Okeke et al., "Opportunities and challenges in connecting care recipients to the community health feedback loop," in *Proc. ACM Int. Conf.*, Jan. 2019, doi: 10.1145/3287098.3287111.

[28] J. M. Ggita et al., "Experiences and intentions of Ugandan household tuberculosis contacts receiving test results via text message: An exploratory study," *BMC Public Health*, vol. 20, no. 1, Mar. 2020, doi: 10.1186/s12889-020-8427-0.

[29] A. B. Patel et al., "M-SAKHI—Mobile health solutions to help community providers promote maternal and infant nutrition and health using a community-based cluster randomized controlled trial in rural India: A study protocol," *Matern. Child Nutr.*, vol. 15, no. 4, Oct. 2019, doi: 10.1111/mcn.12850.

[30] D. Peiris et al., "Smarthealth India: A stepped-wedge, cluster randomized controlled trial of a community health worker managed mobile health intervention for people assessed at high cardiovascular disease risk in rural India," *PLoS One*, vol. 14, no. 3, Mar. 2019, doi: 10.1371/journal.pone.0213708.

[31] B. S. Zaman et al., "Usability and acceptability of the software 'Arogya Sahyog' to assess non-communicable diseases in rural India," *Health Policy Technol.*, vol. 11, no. 4, Dec. 2022, doi: 10.1016/j.hlpt.2022.100598.

[32] A. F. Klaib and M. S. Nuser, "Evaluating EHR and health care in Jordan according to the international health metrics network (HMN) framework and standards: A case study of hakeem," *IEEE Access*, vol. 7, pp. 51457–51465, 2019, doi: 10.1109/ACCESS.2019.2911684.

[33] M. G. M. Krieger et al., "How do community health workers institutionalise: An analysis of Brazil's CHW programme," *Glob. Public Health*, vol. 17, no. 8, pp. 1507–1524, 2022, doi: 10.1080/17441692.2021.1940236.