


**REVIEW**

# Research gaps in routine health information system design barriers to data quality and use in low- and middle-income countries: A literature review

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**Summary**

Despite the potential impact of health information system (HIS) design barriers on health data quality and use and, ultimately, health outcomes in low- and middle-income countries (LMICs), no comprehensive literature review has been conducted to study them in this context. We therefore conducted a formal literature review to understand system design barriers to data quality and use in LMICs and to identify any major research gaps related understanding how system design affects data use. We conducted an electronic search across 4 scientific databases—PubMed, Web of Science, Embase, and Global Health—and consulted a data use expert. Following a systematic inclusion and exclusion process, 316 publications (316 abstracts and 18 full papers) were included in the review. We found a paucity of scientific publications that explicitly describe system design factors that hamper data quality or data use for decision making. Although user involvement, work flow, human-computer interactions, and user experience are critical aspects of system design, our findings suggest that these issues are not discussed or conceptualized in the literature. Findings also showed that individual training efforts focus primarily on imparting data analysis skills. The adverse impact of HIS design barriers on data integrity and health system performance may be even bigger in LMICs than elsewhere, leading to errors in population health management and clinical care. We argue for integrating systems thinking into HIS strengthening efforts to reduce the HIS design-user reality gap.

**KEYWORDS**

health information systems, health policy, health services, public health informatics

## 1 | INTRODUCTION

The ability of low- and middle-income countries (LMICs) to monitor and measure their progress toward sustainable health-related development goals depends on the ability of national routine health information systems (RHISs) to capture, store, manage, and share both individual and population-level health data.<sup>1</sup> However, health information system (HIS) design barriers reduce data quality and limit the ability of LMICs to use RHIS data to inform health care decisions.

The HIS design encompasses factors and processes that define a system's architecture, components, modules, user interfaces, user and system behavior, and data to meet the specified information needs of the health system. The HIS design can be distorted by technical, human, organizational, economic, political, legal, and ethical factors that influence data sharing<sup>2</sup> and use. Consequent system design barriers such as poor HIS architecture and usability, lack of policy and incentives to use data, weak financial and skilled human resource capacity, lack of data security and confidentiality laws, and limited user engagement suppress the sharing and use of data within and across an organization and often contribute to HIS failure.<sup>3</sup> These HIS failures adversely affect the ability of the health system to meet the needs of those it supports. For example, a recent report from The Joint Commission focusing on electronic health records in the United States stated that human/computer interface (33%) and work flow and communication (23%) account for 56% of the country's unexpected health events.<sup>4</sup> These findings imply that HIS design must address human-computer interaction, work flow and communication, and other issues related to system design to improve health outcomes.

Despite the potential impact of HIS design barriers on health data quality and use and, ultimately, health outcomes in LMICs, no comprehensive literature review has been conducted to study them in this context. To address this gap, we conducted a formal literature review focused on the implications of system design barriers on HIS data quality and use within LMICs. The review aimed to answer 2 key questions: (1) what does the published literature tell us about HIS system design barriers to data quality and use in LMICs and (2) what, if any, are the main research gaps related to understanding how HIS system design affects data use.

## 2 | METHODS

We adopted a two-pronged strategy to conduct a comprehensive yet focused literature search from September 1 through October 31, 2016. To guide the literature review and analysis, we identified 6 key concepts (Table 1) based on our understanding of the problem and the questions our review aimed to answer. These concepts helped to define the search terms and guide analysis and organization of literature review findings.

First, we conducted an electronic search across 4 scientific databases: PubMed, Web of Science, Embase, and Global Health. Three sets of search terms (Table 2) were used to search each of the 4 databases. The search terms related to "routine health information system" and "health management information system" were finalized in consultation with an international HIS expert from the US Agency for International Development (USAID)-funded MEASURE Evaluation project and a health sciences librarian at the University of North Carolina at Chapel Hill. To obtain a broad sample of the literature, we did not limit this electronic search by dates or geography but focused on English language publications.

Second, to identify any other relevant publications that the electronic search might have missed, we consulted another expert<sup>6</sup> from the MEASURE Evaluation project who has extensive experience with data use issues in LMICs. The expert provided a manually curated list of relevant publications from both the scientific and the gray literature for inclusion in our review.

We downloaded the documents that emerged from these two strategies into the Mendeley desktop reference management system. A manual review was then performed to merge duplicates across all the search results, following a systematic process for inclusion and exclusion of publications. The included papers were then manually reviewed in detail in light of the concepts identified earlier.

**TABLE 1** Definitions of key concepts

#	Concept	Definition
1	RHIS	An HIS that records routine health data from facility and community. Data that are recorded routinely without being directly linked to any explicit research question are considered routine data. <sup>5</sup> A range of national and local routine data such as deaths, hospital admissions, disease prevention data, diagnostics, demographic data, and geographic data are widely available. The terms HIS and RHIS are used interchangeably in this paper because the focus is on system design barriers.
2	System design	Factors and processes that define the system's architecture, components, modules, interfaces, user and system behavior, and data to meet the specified information needs of the health system.
3	Data use	The analysis, synthesis, interpretation, and review of data as part of decision-making processes such as program monitoring, policy development, and resource allocation, regardless of the source of the data.
4	Users	The end users who use HIS data in decision making.
5	Barriers	Obstacles that can delay or prevent the availability of, access to, and use of data from an HIS.
6	Capacity building	Building the individual and institutional ability to perform functions required to ensure quality of data and use of data in decision making at all levels of the health system.

**TABLE 2** Search terms for the 3 electronic searches performed with each of the 4 scientific databases

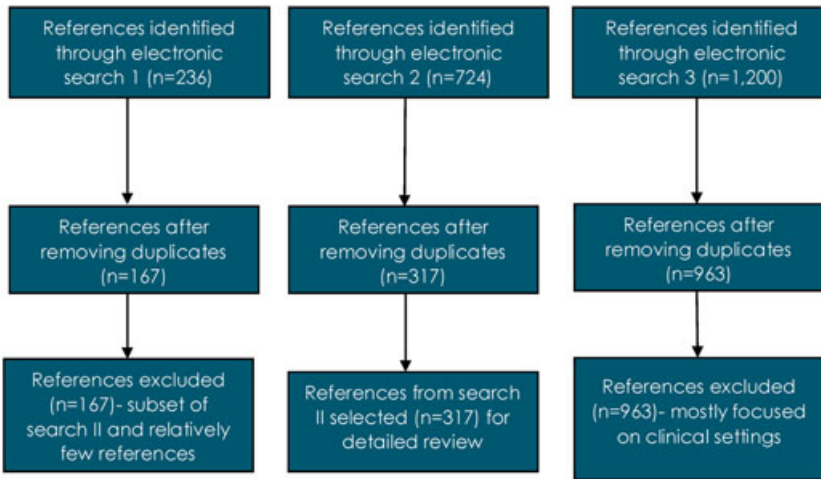
Search Term #	Search Terms
Terms 1	("routine health information system" OR "routine health information systems" OR "routine health management information system" OR "health management information system" OR "health management information systems") AND "developing countries"
Terms 2	"routine health information system" OR "routine health information systems" OR "routine health management information system" OR "health management information system" OR "health management information systems"
Terms 3	("health information system" OR "health information systems" OR "management information system" OR "management information systems" OR "routine health information system" OR "routine health information systems" OR "routine health management information system" OR "health management information system" OR "health management information systems") AND "developing countries"

### 3 | RESULTS

Table 3 summarizes the results from the 3 electronic searches of each database, showing 236 publications from the first search, 724 from the second search, and 1200 from the third search. However, the publications from the first search were a subset of those identified through the second search and were eventually excluded. A review of about 100 abstracts from the third search showed that they were focused on clinical information systems rather than RHIS, so the publications identified through the third search were also excluded (Figure 1).

**TABLE 3** Summary of electronic search results

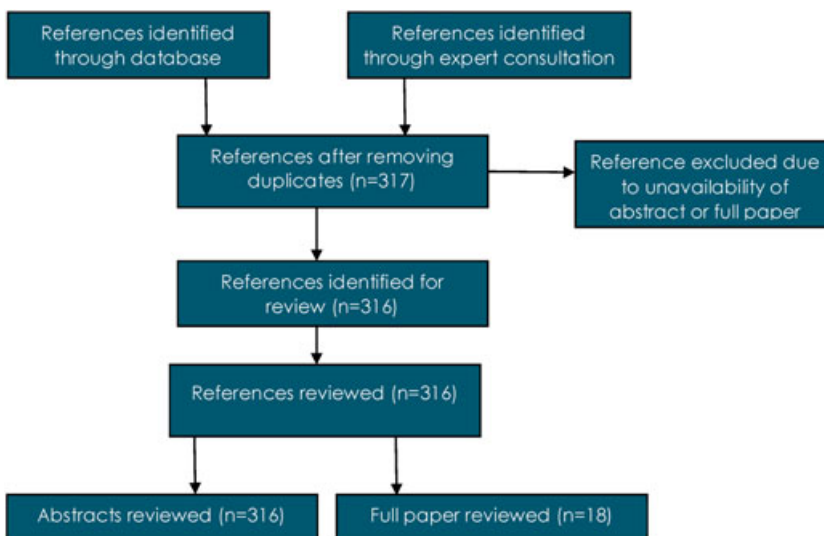
#	Database Name	Terms 1	Terms 2	Terms 3
1	Embase	18	200	87
2	PubMed	31	207	153
3	Web of Science (search in category "topic")	54	168	333
4	Global Health	133	149	627
	Total search results	236	724	1200
	No. (%) of results with no duplicates among databases	167 (70.70)	307 (42.40)	963 (80.25)



**FIGURE 1** Selection of publication for review

The remaining publications were combined with 10 publications identified through expert consultation (Figure 2). After duplicates were removed and one publication was found to be unavailable, a total of 316 publications (316 abstracts and 18 full papers) were included in the detailed review.<sup>7</sup>

Below, we have organized the findings of our literature review into 3 sections. The section on publication focus and distribution describes publications across different searches, geographies, and relevance to the purpose of this review. The section on barriers to data quality and data use includes conceptual technical, organizational/political, behavioral, economic, legal, ethical, and capacity building barriers. Barriers specific to system design are discussed in detail in the third section. The purpose of having a separate section for system design barriers was to highlight the limited literature on this topic and how system design was conceptualized, implemented, and assessed.



**FIGURE 2** Distribution of references according to inclusion and exclusion criteria

### 3.1 | PUBLICATION FOCUS AND DISTRIBUTION

An important finding was that terms such as HIS, RHIS, health management information system (HMIS), routine HMIS, and district HMIS were used interchangeably in the same publications.<sup>8,9</sup> Review of all 316 abstracts showed that 53 did not focus on data quality or data use barriers pertaining to RHIS or HMIS. These publications were focused on vertical disease programs, including estimation of malaria incidence<sup>10</sup>; access to malaria rapid diagnostic tests<sup>11</sup>; health systems research<sup>12</sup>; maternal death reviews<sup>13</sup>; and different aspects of malaria,<sup>14,15</sup> maternal health,<sup>16,17</sup> uptake of mental health services,<sup>18</sup> and health worker performance.<sup>19</sup>

The publications described the review, synthesis, analysis, and interpretation of data to answer a research question, but data use was not aligned with decision making. Even though these publications did not explicitly discuss system design barriers, they explained issues related to data integration, data flow, data entry, and data analytics. The RHIS data were used in many of these publications as an additional data source to validate findings of research studies and assessments. Use of RHIS data to validate research findings implied growing confidence in the quality of data. A total of 61 abstracts focused on issues such as health financing, environmental health issues, health issues of automakers, health system strengthening,<sup>20</sup> leadership in health facilities,<sup>21</sup> and epidemiological studies.<sup>22</sup> Even though the focus of the review was on LMICs, 21 abstracts from developed countries were included.

More than half (52%) of the publications referred to the work conducted in or relevant to 10 countries: India (28), Uganda (23), Kenya (22), Tanzania (18), Nigeria (18), Malawi (14), Pakistan (11), Zambia (11), South Africa (10), and Ethiopia (9). The review revealed that one abstract was published in two different journals. Therefore, there were only 305 unique abstracts from the electronic search.

### 3.2 | BARRIERS TO DATA QUALITY AND DATA USE

The review identified several frameworks<sup>6</sup> that aimed to strengthen HIS or provide a road map to improve demand for and use of data in decision making. However, system design was not explicitly defined in any of these frameworks. One of the systematic reviews selected for the detailed review identified 20 potential barriers to sharing routinely collected public health data across country borders.<sup>2</sup> These barriers were divided into 6 categories: technical, motivational, economic, political, legal, and ethical. Technical barriers such as restrictive data formats, lack of metadata and standards, and absence of technical solutions (e.g., interoperability) hampered data sharing and use. These technical challenges were compounded by a lack of incentives for using data in decision making. Data collection, storage, analysis, and sharing required investment in people, infrastructure, and organizational processes. These economic factors acted as barriers to data sharing and use. Political barriers to data sharing included lack of trust, lack of guidelines, and restrictive policies. Legal factors such as ownership, copyright, and data privacy affected how data were shared and used. The purpose of data use and its impact on data producers influenced how the data were shared and used. Another systematic review concluded that quality and availability of health and facility data, human dynamics, and financial constraints were the key challenges to district-level decision making in LMICs.<sup>23</sup>

An assessment of surveillance systems to improve access to high-quality and timely public health information in 5 developing countries found that the most common problems concerned people (e.g., inadequate number of skilled and motivated personnel and weak supervision) and dissemination.<sup>24</sup> The 6 systems included in the assessment each reported one or more of 6 system deficiencies (i.e., lack of timeliness, lack of accuracy, lack of simplicity, lack of flexibility, lack of acceptability, and lack of usefulness) that affected data use for decision making. Health care service quality was also reported as an important determinant of HMIS usage.<sup>25</sup>

Despite the fact that engaging data users in HIS design and use affected usage of both the data and the system, individual capacity building interventions aimed at HIS strengthening neglected competencies related to system design. Most of the capacity building efforts were focused on training individual health workers from various levels of health systems in data analysis tools and techniques for improving quality, analysis, interpretation, and use of HIS data.<sup>24,26-28</sup> Further, these studies emphasized the importance of organizational culture that incentivizes data

use. A study in India reported that change management and capacity building issues were key factors affecting the performance of key national and state-level HIS.<sup>29</sup> Studies found that HMIS usage and increased acceptance of HMIS among health workers<sup>30</sup> was important for uptake of HMIS and that individual motivation and skills affected data quality.<sup>31</sup> However, one study reported that data quality issues were compounded by information work flow barriers and unfriendly software features that adversely affected data flow and required institutional capacity building in addition to individual trainings.<sup>32</sup> Another study found that gaps in the HMIS were linked to lack of training of health care providers, staff shortages and workloads, and poor supervision.<sup>33</sup>

### 3.3 | SYSTEM DESIGN BARRIERS

Because a health system is composed of subsystems, information system design must include components and modules that meet the requirements of the specific subsystems. The lack of findings related to system design highlighted the lack of systems thinking in HIS design and development. An assessment of the surveillance systems in 5 developing countries to improve access to high-quality and timely public health information found that the most common problems concerned the design of the system (e.g. complexity and usability).<sup>24</sup> These surveillance systems were reported to have one or more of the 6 system deficiencies (i.e., lack of timeliness, lack of accuracy, lack of simplicity, lack of flexibility, lack of acceptability, and lack of usefulness) that affect data use for decision making. A study in India examined the architectural constraints that constituted a common problem across various HIS in the country at both national and state levels.<sup>29</sup> Another study on reliability and usability of the District Health Information Software 2 in Tanzania recommended improvements in the user interface to reduce human errors in data entry.<sup>34</sup> To assess viability, utilization, and effectiveness of a district HMIS, it was important to in-build pre-implementation, concurrent, and post-implementation evaluation criteria.<sup>35</sup> These evaluation criteria would foster contextual design, an adaptive system, and alignment with user expectations.

The review also found that lack of users in system design and inadequately designed systems contributed to failure of HIS to fulfill the information needs of decision makers.<sup>7</sup> Another study highlighted policy implications of design and implementation barriers to strengthening an HIS for mental health.<sup>36</sup> That study underlined the need for increased user engagement during design, consideration of implementation challenges during design, and improved understanding of interactive relationships among factors such as resources, working approaches, and the low priority of mental health that influenced HIS design and implementation. Assessment in multiple countries showed that system design issues were related to complexity of systems, multiple forms to enter and use, and system responsiveness to user information needs.<sup>24</sup> The people-related problems were similar across different studies and included motivation to use data, data use training, and supervisory support.<sup>33,37,38</sup>

## 4 | DISCUSSION

Global interest is growing in strengthening HIS, improving data quality, and increasing data use in LMICs to build these countries' capacity for decision making. While some countries are in the process of designing and rolling out national HIS that collect and organize aggregate health care service delivery data, many others are planning to scale up existing HIS across districts or facilities. The ultimate goal of strengthening national HIS is to improve health and health equity in ways that are responsive, are financially fair, and make the best or most efficient use of available resources. Thus, it is timely and pertinent to analyze how system design barriers lead to problems with the quality of the data these systems generate, compromising their usefulness.

Despite the importance of this topic, we found a paucity of scientific publications that explicitly describe information system design factors that hamper data quality (both input and output) or data use for decision making. Even though user involvement, work flow, human-computer interactions, and user experience are critical aspects of system design, our findings suggest that these issues are not discussed or conceptualized from that perspective in the

literature. Furthermore, review findings showed that individual training efforts primarily focus on imparting data analysis skills and neglect system design skills, such as requirement gathering, user-centered design, and usability evaluation, even though evidence shows that poor system design accounts for most of the issues that HIS users encounter.<sup>39</sup> Training and capacity building programs must integrate system design and analysis competencies into the training curricula. Undoubtedly, enhancing individual knowledge and skills is essential for improving data quality and use through the data management cycle.

Even though some of the studies confirmed that system design constraints hamper data quality and data use for decision making,<sup>40</sup> none of the studies explicitly described a need for skills required to perform functions of a business analyst and a system analyst. Besides, training users only might not address all user-related problems, because many user issues are the result of poor system design.<sup>39</sup> In the low-resource settings of LMICs, the adverse impact of HIS design barriers on data integrity and health system performance might be even bigger than it is elsewhere, leading to errors in population health management and clinical care. We argue for applying systems thinking to HIS design, both to document the impact of these barriers on health system performance and health outcomes and to overcome them.

## 5 | CONCLUSION

Our review showed that barriers pertaining to organizational, behavioral, information system, capacity building, and economic issues affect data quality and use in LMICs. However, we found limited literature describing system design barriers to data quality and use in these settings. Because an HIS operates in complex, adaptive health system settings, attention to the impact of system design factors and processes in development, implementation, use, and performance of the HIS is needed from researchers, implementers, and all other stakeholders wanting to strengthen HIS efforts in LMICs. Global and national HIS design, implementation, research, and capacity building should integrate systems thinking from the outset to ensure that system design is closer to user reality. Integrating system design into overall HIS strengthening efforts can address many of the system design barriers, enhance data quality, and aid data use for decision making.

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