Understanding the challenges associated with the use of data from routine health Information systems in low- and middle-income countries: A systematic review

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Abstract

Background: Routine health information systems (RHISs) are crucial to informing decision-making at all levels of the health system. The use of RHIS data in low- and middle-income countries, however, is limited due to concerns regarding quality, accuracy, timeliness, completeness, and representativeness.

Objective: This study systematically reviews the technical, behavioural, and organisational/environmental challenges that hinder the use of RHIS data in low- and middle-income countries (LMICs) and strategies implemented to overcome these challenges.

Methods: Four electronic databases were searched for studies describing challenges associated with the use of RHIS data, and/or strategies implemented to circumvent these challenges in LMICs. Identified articles were screened against inclusion and exclusion criteria by two independent reviewers.

Results: Sixty studies met the inclusion criteria and were included in this review: fifty-five of which described challenges in using RHIS data and twenty of which focused on strategies to address these challenges. Identified challenges and strategies were organised by their technical, behavioural, and organisational/environmental determinants, and by the core steps of the data process. Organisational/environmental challenges were the most commonly reported barriers to data use, while technical challenges were the most commonly addressed with strategies.

Conclusion: Despite the known benefits of RHIS data for health system strengthening, numerous challenges continue to impede their use in practice.

Implications: Additional research is needed to identify effective strategies for addressing the determinants of RHIS use, particularly given the disconnect identified between the type of

challenge most commonly described in the literature and the type of challenge most commonly targeted with interventions.

Keywords

Health information systems; developing countries; public health informatics; patient generated health data; public reporting of healthcare data; data science; systematic review

Introduction

Routine health information systems (RHISs) are increasingly being recognised as an essential tool for health system strengthening (Hotchkiss et al., 2012; Wickremasinghe et al., 2016), and aim to improve health service management through the ongoing collection of information on the supply and use of health services in health facilities. Defined as "any system of data collection, distribution, and use that provides information at regular intervals" (Hotchkiss et al., 2012), RHISs capture data on health status, health services, and health resources within a population, and represent rich information sources, vital for informing decision making at all levels of the healthcare system, including resource allocation, day-to-day management, strategy development, and policy making (AbouZahr and Boerma, 2005; World Health Organisation, 2007; Leon and Daniels, 2015; Wagenaar et al., 2016).

In many low- and middle-income countries (LMICs), however, RHISs remain fragmented and disorganised, and concerns regarding the quality, accuracy, timeliness, completeness, and representativeness of RHIS data are widespread (Odhiambo-otieno, 2005; Mutemwa, 2006; Dehnavieh et al., 2018). Indeed, a number of studies have assessed the quality of RHISs in LMIC settings, and have identified several technical, behavioural, and organisational challenges to the introduction, implementation, and use of these systems (Aqil et al., 2009; Hotchkiss et al. , 2012; Dehnavieh et al., 2018; Kumar et al., 2018). At the technical level, for instance, a lack of knowledge, skills, and specialized technical infrastructure can hinder the collection and use of high quality data, while at the behavioural level, poor demand for RHIS data, as well as motivation and competency among health workers, can impede its use (MEASURE Evaluation, 2019; Leon et al., 2015). Organisationally, inadequate governance and management, a lack of training, supervision, and resources, and the failure to promote a culture

of data use have been identified as issues (Leon et al., 2015; MEASURE Evaluation, 2019). These challenges often render RHIS data unreliable or irrelevant, impeding their usefulness in practice, and contribute to the continued preference for intermittent cross-sectional population-based surveys as the primary source of data for tracking population health, risk factors, and health service coverage (Aqil et al., 2009; Wagenaar et al., 2016; Ashton et al., 2017).

Given that strong RHISs that capture, store, manage, and transmit health information are necessary for improving the quality of healthcare in LMICs, as well as for tracking progress towards achieving targets such as those outlined in the Sustainable Development Goals (SDGs) (Thomas et al., 2016), a greater understanding of the factors that inhibit the effective use of RHIS data and potential strategies to address these factors is required. Although health information technology in general has been previously explored in a number of systematic and scoping reviews, for example that by Ndabarora et al. (2014), who assessed data quality issues associated with health information at the community and district levels in LMICs, the majority of these articles focused on the effect of such technologies on specific health outcomes, with very few looking solely at RHISs, or at LMIC populations. Indeed, only one systematic review by Hotchkiss et al. (2012) has investigated the challenges associated with RHISs in LMICS to date, however it described the effectiveness of interventions to improve RHIS performance rather than challenges in implementation and use more broadly, and was primarily concerned with the role of RHISs at the local level. While a protocol for an additional, similar review by Leon et al. (2015) was identified, that study also intended to focus on interventions to improve RHISs, and the results have yet to be released. Given that RHISs can improve health system functioning at all levels, and that the challenges associated with RHISs have been widely described in studies focusing on the implementation of such systems in addition to those evaluating interventions to

improve them, a broader review of the determinants of RHIS data use and strategies to improve RHISs is warranted.

This review aims to systematically identify the common challenges associated with the use of RHISs in LMICs, as well as strategies implemented to mitigate these challenges. Specifically, we aimed to identify the technical, behavioural, and organisational/environmental determinants of RHIS data use in LMICs and evaluate the effectiveness of interventions that have targeted them (Aqil et al., 2009; MEASURE Evaluation, 2019). The findings of this study will provide new insights into the challenges that impede the use of RHIS data and may inform the development of future strategies to reduce these challenges and improve RHIS functioning and use in LMICs.

Methods

Key definitions

For the purposes of this review, RHISs were defined as systems designed to collect, process, and use health information at regular intervals of a year or less to meet predictable information needs within healthcare systems (Hotchkiss et a., 2012; Dagnew et al., 2018). This includes information on clinical service delivery, medicine, or diagnostic service provision, as well as routine administrative systems and management information systems, which aim to improve health care management decisions. Conversely, individual-level data collected for clinical decision-making purposes and pilot projects testing the implementation of a new data collection method were not considered RHISs. RHIS data was defined as information retrieved from the RHIS by stakeholders with the intent to use the data, for decision-making or otherwise.

Search strategy

A comprehensive literature search strategy was developed and was tested and refined for each of four electronic databases: PubMed, Scopus, EMBASE, and EconLit, current as of February 20th, 2019, inclusive. These databases were selected based both on previous reviews of similar topics, for example those by Hotchkiss et al. (2012), who searched PubMed, and Leon et al. (2015), who searched Embase, as well as on what was available at the authors' institutions. After searching the four databases listed, the authors identified substantial saturation in results and thus opted to end the search. Within each database, varied phrases to describe RHISs such as 'routine health information system', 'health information system', or 'health management information system', were included, along with a list of LMICs as defined by the World Bank's 2019 classification system (see Appendix 1 for search strategy). Database filters were used to eliminate all non-English language studies. A review protocol was not registered prior to undertaking the literature search.

Eligibility criteria

Articles were selected for inclusion in this review if they met the following criteria: (1) were published in English, (2) were an original research study, and (3) described or investigated challenges associated with RHIS data use or strategies implemented to improve RHIS data use in at least one LMIC. Studies were excluded if: (1) their description of RHIS data use challenges was not presented as part of the main findings, but was included as background information or discussion only, or (2) they focused only on the challenges of RHIS implementation, without any link to data use. Studies for which the full-text could not be located, even after attempts were made to contact the authors, were also excluded. All retrieved studies were classified as challenge articles or strategy articles. Challenge articles were defined as studies that described

any factor that was perceived to impede the use of RHIS data. Strategy articles included studies that discussed an intended solution to improve or correct a perceived challenge.

Selection of studies

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The screening process, including the number of records excluded at each stage, is outlined in Figure 1. In total, 2,310 records were retrieved from the database search and were imported into Covidence systematic review software (Covidence systematic review software, 2013). After the removal of duplicates, 1,459 articles were independently screened against the inclusion and exclusion criteria by two reviewers, KH and YH, in two stages: 1) title and abstract, and 2) full text. Disagreements at each stage were resolved through discussion, and a third reviewer, BI, was consulted when required. For convenience sake, the authors served as the reviewers. Where there was insufficient information to determine eligibility at the title and abstract screening stage, the article was included for full-text screening. Title and abstract screening resulted 396 records progressing to full-text assessment. Of these, 60 met the inclusion criteria and were extracted. No risk of bias assessment was conducted, due to the fact that our systematic review was not concerned with the results of the individual included studies and did not seek to undertake any statistical analyses.

[Insert Figure 1. PRISMA diagram summarizing study selection process]

Data extraction

Data from all included studies were extracted by three authors, KH, YH, and BI, using a modified extraction form. Background information including the article's first author, year of publication, journal, and location of study, was collected first, along with study information,

including study design, objective, participants (if applicable), description of RHIS data used (if applicable), description of challenges that impeded the use of RHIS data (if applicable), description of strategies implemented to improve RHIS use or circumvent data quality issues (if applicable), and study recommendations and conclusions.

The extracted data was synthesized narratively. Challenges and strategies described in each study were categorised according to their technical, behavioural, and organisational/environmental determinants as introduced in the PRISM framework (Aqil et al., 2009; MEASURE Evaluation, 2019), and multiple determinants within a single study were permitted. Technical determinants refer to factors related to the specialised knowledge and technology that are required to develop, improve and manage RHISs, such as software development and data collection form design. Behavioural determinants include user-focused factors such as users' demand, motivation, confidence and competence to perform RHIS tasks. Organisational/environmental determinants encompass organisational processes and structures such as human and financial resources, management, leadership and supervision. Within each determinant, challenges were organised by the specific stage of the RHIS data process they occurred at: the information needs stage, the data collection stage, the data transmission stage, the data processing/analysis stage, and the dissemination of processed information stage (Aqil et al., 2009; MEASURE Evaluation, 2019).

Results

Study characteristics

The general characteristics of the 60 studies included in this review are presented in Table 1. Overall, the majority of studies described RHIS data use in countries in Sub-Saharan Africa

(67%). Most of the studies were recent, with more than half published after 2014 (60%), and

mixed-methods studies were the most common study design (27%). Of the included studies, 92%

described challenges that hindered the use of RHIS data at different levels of the health system,

while a third presented or described strategies implemented to improve the use of RHIS data. A

quarter of the articles described both challenges associated with the use of RHIS data, as well as

strategies that were implemented in order to overcome these challenges. The majority of the

studies (n=35, 58%) were undertaken at the subnational health system level, while only 5 (8.3%)

occurred at the district level. A third of the included studies identified both national and

subnational levels.

[Insert Table 1. General characteristics of included studies]

Challenges associated with the use of RHISs

The most common challenges associated with RHIS data use are summarised in Table 2.

Challenges presented in the articles were grouped based on similarities, then categorised

according to the definitions of determinants and the core components of health information

system data processes, as described in the PRISM framework (Aqil t al., 2009; MEASURE

Evaluation, 2019).

[Insert Table 2. Common challenges identified in included studies]

Technical determinants

Of the 55 articles that presented challenges in RHIS data use, 21 (38%) described technical

issues, which occurred across the information needs, data collection, data transmission, data

processing/analysis, and dissemination of processed information stages. At the information needs stage, the majority of technical issues were related to limitations with the data collection forms, which prevented researchers from accurately assessing the current state of health in a population. In Peru, for example, Iguiñiz-Romero and Palomino (2012) identified the poor structure of forms as a major challenge to collecting high quality data, finding an absence of standardized case definitions, as well as information on patient characteristics such as sex. This made it impossible to accurately estimate maternal mortality, because the sex of the deceased patients was unknown (Iguiñiz-Romero and Palomino, 2012). Similarly, Abajebel et al. (2011) observed that in Ethiopia, the forms used to collect RHIS data were not regularly updated to include data on emerging diseases and that this hindered use (Abajebel et al., 2011).

At the data collection stage, the method of collection was identified as an important factor, and discrepancies in the information recorded using multiple different reporting systems and tools were reported in Uganda and Botswana, resulting in discordant estimations and missing data (Seitio-kgokgwe et al., 2015; Ward et al., 2017). In line with this, Mutale et al. (2013)'s evaluation of a series of interventions aimed at enhancing health information systems for decision making in sub-Saharan Africa, known as the Population Health Implementation and Training (PHIT) Partnerships, concluded that community-level data was poorly integrated with RHISs in Tanzania. These technical issues in data collection yielded discrepancies and missing information, discouraging the use of the resulting data (Qazi and Ali, 2009; Mutale et al., 2013).

Technical determinants also presented challenges at the data transmission and processing stages, and Njuguna et al. (2017), Qazi and Ali (2009), Mpofu et al. (2014), and Chikumba and Ramussen (2016) all described issues with inconsistent and poor quality internet, which limited

the use of web-based tools, hindering data entry and transmission (Qazi and Ali, 2009; Mpofu et al., 2014; Chikumba and Rasmussen, 2016; Njuguna et al. , 2017). Moreover, Qazi and Ali (2009) observed the submission of RHIS data in formats that could not be accessed by other data users in Pakistan, resulting in delays in processing the data and publishing reports (Qazi and Ali, 2009). Additionally, unreliable reporting by health facilities and inaccuracies in the population estimates in Papua New Guinea prevented proper data processing and analysis (Field et al., 2018). The use of multiple reporting platforms also delayed information dissemination due to conflicting information (Tshimanga et al., 1997; Mpofu et al., 2014).

Behavioural determinants

Over a third (38%, n=21) of the included studies investigated behavioural challenges associated with RHIS data use, which generally resulted from inadequately trained health workers. At the information needs and data collection stages, for instance, studies in Zimbabwe (Omar et al., 1994) and India (Dehury and Chatterjee, 2018) identified a widespread lack of understanding among health workers of the importance of the data being collected, which contributed to incomplete or low quality data. Dehury and Chatterjee (2018) suggested that improved education on the purpose and uses of the data, particularly among lower-level workers, may improve completeness (Dehury and Chatterjee, 2018). Frequent health worker error in classifying health conditions during documentation, as well as post-hoc recording were also described, resulting in inaccurate estimates of the prevalence of the condition in the population, and thus discouraging the use of the data (Cibulskis and Hiawalyer, 2002; Mosse and Sahay, 2003). Furthermore, other study reported falsification of data when there was a lack of supervision or feedback provided to lower level healthcare workers (Asah et al., 2017).

Behavioural factors also played an important role in data transmission issues, primarily due to poor staff motivation. Asah et al. (2017), for instance, found that data submission was commonly delayed when health workers were not paid on time (Asah et al., 2017), while Vidor et al. (2011) observed that, despite widespread computer and internet availability, many of the healthcare facilities in southern Brazil continued to prefer traditional communication methods and this led to delays in information feedback from the central levels to the municipalities (Vidor et al., 2011). In addition, the Brazil study found that over a sixth of the municipalities did not analyse their data, while a fifth analysed their data but did not use it for planning (Vidor et al., 2011). The authors attributed the lack of data analysis to the limited training and qualifications of health workers, combined with the belief that data should be selectively analysed at the central level. Such issue was also reflected by common mathematical errors, which hindered data processing and analysis (Omar et al., 1994). Lastly, at the dissemination stage, a study in Tanzania by Kimaro and Twaakyondo (2005) observed that health workers often had difficulties understanding the feedback provided to them from the central level on reports, leading to misunderstandings and delays for correcting mistakes (Kimaro and Twaakyondo, 2005).

Organisational determinants

Organisational and environmental challenges were the most common issues found to impede RHIS data use in the included studies, described by over half (62%, n=34) of articles. Of these challenges, the majority were related to resouce constraints, such as human and capital shortages, which hindered all steps of the data process. For instance, at the information needs stage, Pinchoff et al. (2016) found that it was not always possible to confirm diagnoses such as malaria, due to limited laboratory capacity in Zambia (Pinchoff et al., 2016). This resulted in delayed or

inaccurate reporting of data on the burden of diseases from health facilities, making it difficult to apply the information to inform decision-making (Pinchoff et al., 2016). Studies from Pakistan (Qazi et al., 2008), South Africa (Nicol et al., 2017), and Mozambique (Jani et al., 2006) also noted substantial human resource scarcities within health facilities, and clinicians in particular were severely overworked. This limited staff capacity to participate in the data collection, reporting and analysis process, impeding the usefulness of the RHIS. Furthermore, Yazdi-Feyzabadi et al. (2015) revealed that there was a general assumption amongst staff that RHIS data would only be used at the Ministry level in Iran, where decision-making occurred (Yazdi-Feyzabadi et al., 2015). Additional resource constraints, namely the lack of an adequate data storage system was another frequent challenge faced by health facilities at the data collection stage (Mboera et al., 2017; Ranasinghe et al., 2012). These studies also described the lack of dedicated and motivated staff for data management as a barrier to the data collection process.

Limited resources also emerged as a challenge to the transmission of RHIS data in many studies, with multiple authors reporting that a lack of transportation impeded the entry of manually collected data, particularly in settings in which poor computer and internet availability prevented electronic reporting' (Abajebel et al., 2011; Mpofu et al., 2014; Nutley et al., 2014; Yazdi-Feyzabadi et al., 2015; Scott and Gilson, 2017). Due to a lack of web-based technologies for recording data, for example, statistical forms completed at the point of service delivery in Iran must often be physically transferred to higher levels using vehicles, particularly in disadvantaged districts (Yazdi-Feyzabadi et al., 2015). One district health centre worker noted that this process can postpone data transfer, and thus use, and that in some cases, the data is simply lost, representing not only increased work for the healthcare workers but also a potential security issue (Yazdi-Feyzabadi et al., 2015).

At the data processing and analysis stage, equipment shortages and a lack of training provided to health personnel were identified as major barrier to RHIS data use by many authors. Low knowledge of data management, analysis and interpretation among staff was described in several studies (Qazi and Ali, 2009; Vidor et al., 2011; Ledikwe *et al.*, 2013; Shiferaw *et al.*, 2017). In Ethiopia, Shiferaw et al. (2017) found that 95% of RHIS health workers surveyed had not received training on data analysis or management, while more than half (53%) hadn't been trained on the use of the RHIS system itself (Shiferaw et al., 2017). The study identified a higher odds of good RHIS utilisation among health workers that had strong data analysis skills, suggesting that a lack of training inhibits RHIS use (Shiferaw et al., 2017). Indeed, the authors noted that inadequate monitoring and supervision procedures resulted in poor skills development and the misuse of resources by health workers, which in turn led to reduced availability and poor data quality, ultimately contributing to a weak management system (Qazi and Ali, 2009).

In addition to resource constraints, the dissemination of processed data was inhibited by unsystematic and non-institutionalised feedback from the ministry to the district-level, and a lack of inter- and intradepartmental coordination. As described by Seitio-Kgokgwe et al. (2015; 2016) in Botswana, for example, district managers frequently felt that the information generated at the health facility and the district levels should be sent back from the Ministry with feedback in order to facilitate corrective measures, however no such mechanisms were in place to ensure that the information was shared. Specifically, lack of coordination between various health systems level further limited use of RHIS data. In Pakistan, federal perception was that the RHIS was a provincial process, whereas at the district level, the managers felt indifferent due to lack of feedback (Qazi and Ali, 2009).

Strategies to mitigate challenges

In addition to challenges, 20 (33.3%) of the studies included in this review described strategies to improve the use of RHIS data, which are summarised in Table 3. As with challenges, strategies were organised according to the specific determinant they addressed: technical, behavioural, or organisational/environmental; and multiple determinants could be targeted within a single strategy.

[Table 3. Strategies described to improve data use in included studies]

Technical determinants

Technical challenges were targeted by two-fifths (n=8) of the RHIS interventions described in the included studies, the majority of which focused on indicator or register development, or the creation of tools. For instance, the introduction of simplified registers in Ghana to standardise data sources led to the consolidation of data collection from 27 register books to five (Awoonor-Williams et al., 2013; Mutale et al., 2013). It streamlined data collection and aggregation operations, as well as simplified feedback, allowing health workers to review their performance (Mutale et al., 2013). Additionally, to improve the analysis and dissemination of data at all levels of the health system in Papua New Guinea, Cibulskis et al. (2002) described their strategy of limiting indicators to an annual booklet containing only those that were considered highly important and were readily available for analysis (Cibulskis and Hiawalyer, 2002). This enabled provincial managers to prepare the annual report in advance and allow for feedback, which in turn helped increase reporting rates over a six year period (Cibulskis and Hiawalyer, 2002).

The development of various tools as a strategy to combat poor RHIS data use was described in five studies (25%), all of which yielded good results (Mutale et al., 2013; Nutley et al., 2013; Etamesor et al., 2018; Mengesha et al., 2018). In Nigeria, Etamesor et al. (2018) developed the DHIS2 Routine Immunization Dashboard Project, which aimed to improve routine immunization reports through identifying the health facilities that were falling short (Etamesor et al., 2018). The programme was successful at enhancing the completeness, timeliness, and availability of coverage data in health facilities across the country, allowing these data to be used to improve the immunization programme (Etamesor et al., 2018). Another study in Ethiopia implemented a mobile health management system to collect and store data in the cloud for immediate transmission to the RHIS, preventing information loss at the data transmission stage (Mengesha et al., 2018). Several strategies focused on improving RHIS data integration with community-level data, which also encouraged community coordinators to have ownership over the reporting and use of RHIS data (Mutale et al., 2013). Similarly, Nutley et al. (2013) described the development of a District Health Profile (DHP) tool in Kenya to integrate data from multiple sources, allowing staff to comprehensively review the data with auto-generated complex graphs by district to make informed decisions (Nutley et al., 2013). In addition to the tools described above, data quality assessment (DQA) strategies were also implemented in Rwanda (Gimbel et al., 2017), Mozambique (Gimbel et al., 2017), and Cote d'Ivoire (Nutley et al., 2013). Gimbel et al. (2017) found that in Mozambique, the addition of a mini data quality audit tool in health facilities allowed for district supervisors to assess the concordance between registries and facility forms, which led to a significant improvement in data availability (84% to 99%) and consistency (54% to 87%) (Gimbel et al., 2017). In Côte d'Ivoire, the introduction of a routine DQA tool: a self-administered tool intended to verify the quality of reported data and

improve data management and reporting systems; led to an almost 40% increase in data accuracy and a 20% increase in data completeness (Nutley et al., 2013).

Behavioural determinants

Strategies to address the behavioural challenges associated with RHIS data use were also common (35%, n=7) in the included studies, with most incorporating a staff education or training component in order to enhance skills among health workers (Cibulskis and Hiawalyer, 2002; Mosse and Sahay, 2003; Kimaro and Twaakyondo, 2005; Nutley et al., 2014; Ward et al., 2017; Etamesor et al., 2018; Nwankwo and Sambo, 2018). Several of these education interventions resulted in significant improvements, and Ward et al. (2017), for example, observed a marked improvement in staff capacity in Uganda following visits to health facilities by data improvement teams (Ward et al., 2017). The training took place over a five-day period and involved practical classroom workshops, deployments with rapid data quality and organisational assessments, and on-the-job learning (Ward et al., 2017). The study found improved knowledge among majority of district staff and better preparedness. Similarly, Nutley et al. (2014) described courses in data monitoring and evaluation, quality, and use, offered at national training institutions and universities, that enhanced staff capacity to use data (Nutley et al., 2014). Improved staff training contributed to an overall increase of discussion of RHIS analyses and decisions taken at the district and facility levels (Nutley et al., 2014).

On the other hand, a few studies (10%, n=2) did not find evidence of improved RHIS use following training. In Nigeria, health workers participated in a series of modules that covered key RHIS topics such as data quality, health facility recording and reporting, data analysis, presentation, information use, and feedback (Nwankwo and Sambo, 2018). In general, the

authors found no significant improvements in the accuracy, completeness, and timeliness of data, or in analysis and local use of information, following the training (Nwankwo and Sambo, 2018). Additionally, although Etamesor et al. (2018) observed marked improvements in rates of RHIS data completion and accuracy following training programmes that were tailored to health workers' experiences and responsibilities, the strategies implemented were multi-faceted and thus these positive changes could not be attributed directly to the training (Etamesor et al., 2018). A further three studies (15%, n=3) (Cibulskis and Hiawalyer, 2002; Mosse and Sahay, 2003; Kimaro and Twaakyondo, 2005) mentioned training staff on DHIS use, computer use, data handling, or data analysis as part of their interventions to improve RHIS use, but did not provide details on the outcomes of these interventions.

Along with training, data-use workshops were implemented in health facilities in an attempt to improve health workers' competence and motivation in Tanzania (Braa and Sahay, 2012). Braa et al. (2012) described quarterly week-long workshops, in which each district presented and assessed their own data using standardised analysis templates based on the Millennium Development Goals and local strategic plans (Braa and Sahay, 2012). Following each presentation, participants discussed and critiqued the data to identify common issues of data quality and health service performance, which promoted local involvement and improve quality. The workshops also provided opportunities for direct feedback on the revision of indicators and data sets, and increased problem-solving and computer skills among workers (Braa and Sahay, 2012).

Organisational determinants

Eight articles (40%) evaluated strategies to address the organisational and environmental challenges hindering RHIS use, including management support/changes, monitoring and evaluation cadre development, health management programme implementation, and ministry strengthening, all of which were largely successful. In Mozambique, for instance, Wagenaar et al. (2015) described the implementation of the Mozambique Population Health Implementation and Training Partnership (PHIT), which ranked health facilities by summary data concordance measures and provided supportive supervision and data training to those who placed at the bottom (Wagenaar et al., 2015). In Tajikistan, the Ministry of Health introduced infrastructural changes to divide RHIS responsibilities within district health management (Latifov and Sahay, 2013). Both programmes were found to foster improvements in data use processes, with the former resulting in a significant increase in data concordance (Wagenaar et al., 2015), and the latter yielding greater local RHIS data use, due to increased autonomy and budgetary control amongst local health workers and district managers (Latifov and Sahay, 2013).

Rather than management changes, several studies (15%, n=3) reported the development of special monitoring and evaluation positions as a strategy to improve data use, largely in response to the shortage of skilled health information personnel in some settings (Ledikwe et al., 2013; Mpofu et al., 2014; Nutley et al., 2014). In Botswana, for example, a new cadre of health workers known as Monitoring and Evaluation District Officers was introduced, providing on-the-job training and mentoring to recent university graduates, the majority of whom had no monitoring or evaluation experience (Ledikwe et al., 2013; Mpofu et al., 2014). The creation of this specialised cadre freed up other health workers to concentrate on clinical duties, while simultaneously enhancing the capacity to monitor and evaluate programmes within the districts through improved data quality, management and reporting, and increased use of health data for

surveillance and planning purposes (Mpofu et al., 2014). Similarly, in Côte d'Ivoire, a Director

of Monitoring and Evaluation position was created to ensure that decision making would be

prioritised (Nutley et al., 2014). Following the introduction of the role the use of data for

decision making at the district level rose from 40% to 70%, evidenced by PRISM assessments

completed pre- (2007) and post-intervention (2012) (Nutley et al., 2014).

In addition to the creation of a monitoring and evaluation director position, Nutley et al.

(2014) also developed a virtual leadership development programme to build a culture of data use

(Nutley et al., 2014). Although the effectiveness of the programme was unclear (Nutley et al.,

2014), a similar Standards-Based Management and Recognition (SBM-R) approach designed

specifically for health systems in resource-constrained settings was found to significantly

improve compliance and performance standards in over 30 LMICs (Necochea et al., 2015).

Furthermore, in order to facilitate comparisons between health facilities and identify data quality

issues, Moyo et al. (2016) introduced league tables, wherein facilities were ranked according to a

set of characteristics (Moyo et al., 2016). Such a process fostered transparency through visible

and accessible information, which led to improved information communication and sharing of

data, ultimately contributing to an enhanced understanding of the definition and interpretation of

indicators among data users and management of the district health teams (Moyo et al., 2016).

Similar strategies also enhanced the capacity for feedback, leading to the discovery of missing

data and outliers (Mutale et al., 2013).

Discussion

This systematic review explored the technical, behavioural, and organisational challenges that

affect the use of RHIS data in LMICs, as well as the strategies that have been implemented to

address them. Overall, we found that while there has been an increase in the number of studies

describing RHIS data use and its challenges in recent years, evidenced by the finding that over

half of the articles included in this review were published after 2014, the challenges described in

prior reviews by Hotchkiss et al. (2012) and Lippeveld et al. (2000) remain relevant and continue

to affect the use of RHIS data to this day. This suggests that little progress has been made in

overcoming common challenges impeding greater use of RHIS data in LMIC health systems

over the past decade. In line with this, of the studies identified in our review, there were twice

the number of articles that described challenges to the use of RHIS compared to studies that

described strategies to overcome them, indicating that the majority of research to date has

focused on the problems rather than the solutions.

Among the three types of determinants of RHIS data use described in the PRISM

framework: technical, behavioural, and organisational/environmental (Aqil et al., 2009;

MEASURE Evaluation, 2019); we also observed a disconnect between the frequency of types of

challenges described and of strategies developed to address them. For example, our review found

that technical challenges were the least commonly discussed in the literature, with less than a

third of the articles presenting technical challenges such as factors related to tools and

technology to manage RHIS performance. Despite this, strategies that incorporated technical

components were the most prevalent, many of which involved a focus on developing indicators,

registers and tools for data use improvement. Conversely, while more than half of studies

highlighted the organisational or environmental challenges associated with RHIS use, including

resource shortages, lack of training and management, and poor feedback between administrative

levels, just 13% of RHIS strategies targeted organisational determinants. Importantly, this

number represents an increase in studies targeting organisational determinants in recent years, indicating an expanded recognition of such issues (Hotchkiss et al., 2012).

Among studies that focused on strategies to address the challenges of RHIS data use, those that targeted behavioural determinants were less likely to report success than those that targeted the other determinants, despite aligning closely with the behavioural challenges described. This suggests that addressing the behavioural determinants of RHIS data use may not be an effective means of improvement, particularly when targeted in isolation. Indeed, as Aqil et al. (2009) emphasize, the determinants of RHIS use do not operate independently, but rather are all interconnected, and these relationships must be considered when developing strategies to address them (Aqil et al., 2009). The lack of staff motivation to use RHIS, for example, may be related to insufficient supervision and feedback from the administration (Aqil et al., 2009). Tools to assess the performance of RHISs, such as PRISM, also emphasizes a system-based approach to sustain improvement of RHIS data use (Thomas and Barry, 2018). As such, the connections between the behavioural, technical, and organisational/environmental determinants of RHIS data use should be investigated further, and comprehensive strategies to address the underlying challenges in combination should be developed if strategies to mitigate these challenges are to be successful.

This review has several limitations. First, we included English language articles only, and our literature search was limited to peer-reviewed articles in just four databases. As such, potentially relevant studies located in books, non-peer reviewed articles, reports, or grey literature were not considered. We also searched the literature using phrases that described health information systems in title and abstracts, thus limiting our reach to articles in which the phrases appeared selectively in the full-text. Additionally, we searched routine health information

systems and their variations, possibly missing relevant studies that may have used other key words to describe this data. Finally, given that two thirds of the included studies were conducted in countries located in sub-Saharan Africa, the results of this systematic review may not be generalizable to other contexts. That said, many of the challenges described in these studies are common to all resource-poor settings, including those outside of Africa, and thus the findings are still likely to be valuable.

Conclusions

In this study we identified common challenges that limit the use of RHIS data in LMICs at various stages of the health information system process, as well as summarised the effectiveness of strategies that have been implemented to improve data use and health service management. The findings of this review suggest that, despite substantial investments in RHISs in LMICs in recent years, a number of technical, behavioural, and organisation/environmental challenges continue to impede the use of this data in practice, and that strategies to address these challenges remain under-researched. There is therefore a need for additional studies, including those evaluating the effectiveness of broader, more comprehensive strategies targeting multiple determinants of RHIS data use in combination, in order to better understand how to overcome the identified challenges. Such knowledge is vital if the full potential of RHIS data is to be achieved in LMICs.

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Table 1. General characteristics of included studies

	n	Percent
Geographical region		
East Asia and Pacific	5	8.3
Latin America and the Caribbean	3	5.0
Middle East and North Africa	2	3.3
South Asia	9	15.0
Sub-Saharan Africa	40	66.7
Multiple Regions	1	1.7
Year of publication		
<2000	3	5.0
2000-2009	8	13.3
2010-2014	13	21.7
2015-2019	36	60.0
Types of study design		
Action research study	1	1.7
Case study	10	16.7
Case study and scoping review	1	1.7
Cross-sectional study	5	8.3
Descriptive study	6	10.0
Ecological study - longitudinal	2	3.3
Field experiment study	1	1.7
Intervention study with pre-post assessment	2	3.3
Mixed-methods study	16	26.7
Multi-case study	4	6.7
Pre-post study	1	1.7
Qualitative study	11	18.3
Description of challenges/strategies		
Challenges in using data from routine health information systems	55	91.7
Strategies to improve data use	20	33.3
Level of Health System		
National	5	8.3
Subnational	*35*	*58.3*
Provincial	4	6.7
District	26	43.3
Facility-Level	5	8.3
Mixed	*20*	*33.3*
National & Subnational (Provincial)	5	8.3
National & Subnational (District)	11	18.3
National & Subnational (Facility-Level)	4	6.7

Table 2. Common challenges identified in included studies

Data Process	Technical Determinants	Behavioural Determinants	Environment/Organizational Determinants
Information Needs	• Forms lack explicit information on disaggregation (e.g. sex) or definition • Different definitions of disaggregation in paper vs. electronic form • Data collection lack information on emerging diseases	• Misclassification of conditions by health workers • Incomplete data collection by health workers due to lack of recognition of data needs and purpose • Incorrect input from health workers' recollection	• Lack of diagnostic confirmation • Shortage of human resources • Lack of training for staff on recording data • Local needs for decision-making not included in study design
Data Collection	• Fragmentation of data due to use of different tools and reporting systems • Lack of integration with community level data	• Lack of supervisory feedback to prevent falsification of data	• Lack of system for data storage and dedicated staff for data management • Lack of or limited standardization of monitoring and supervision process on data
Data Transmission	• Inconsistency/low internet connectivity for data transmission and use of web-based tools • Data submitted in format difficult to access	• Delay in data submission; some occasions due to delay in salary • Resistance to electronic communication	• Lack of resources for data transmission from facility • Lack of transportation of manual data transmission and verification of data from district • Lack of or limited standardization of monitoring and supervision process on data
Data Processing/ Analysis	• Inaccurate population estimates for calculation of percentages and rates	• Common errors on simple mathematical computation • Infrequent data analysis	• Lack of training on data management analysis and interpretation • Lack of equipment to facilitate data analysis (e.g. computer) • Lack of or limited standardization of monitoring and supervision process on data

Dissemination of Processed Information	• Conflicting figures for same service across different reporting platform and survey	• Difficulty understanding feedback from central level	• Limited feedback from Ministry to district level
			• Limited dissemination of data
			• Lack of inter- and intradepartmental coordination on data sharing

Table 3. Strategies described to improve data use in included studies

Strategy	Study Description	Evidence of Improvement	Reference
Technical Determinant			
Development of indicators	Analysis and dissemination of data limited to annual booklet on family health indicators; of which data is available and considered important.	Publication prepared in advance; allowing for feedback. Feedback helped to increase reporting rates from 73% in 1994 to 85% in 1995 and to 93% in 2000.	(Cibulskis and Hiawalyer, 2002)
Tool creation / development	Dashboard development for regular review to identify problematic HF.	Led to increased improvement in completeness and accuracy of reports across country.	(Etamesor *et al.*, 2018)
	Implementation of mobile health management information system.	Data was collected then stored in the cloud for immediate transmission to HMIS. Helped with complete and accurate data (with build-in data validation).	(Mengesha *et al.*, 2018)
	District health profile (DHP) tool development: integrate data and enable staff.	Led to improved review and use of data, also increasing demand for additional data.	(Nutley, Mcnabb and Salentine, 2013)
	Connect project to integrate data using data capture tools.	Increase in review of community and HF data for feedback.	(Mutale *et al.*, 2013)
	Human Resources for Health Information System (HRHIS) staff training tool.	Generation of a report took the HRD less than 10 min after implementation, with the added feature of being able to sort the data by cadre, facility or health district.	(Driessen *et al.*, 2015)
Register development	Simplification of registers to ensure consistent supply.	Improved flow of information and supports integration of health service operations; streamlined reporting.	(Awoonor-Williams *et al.*, 2013; Mutale *et al.*, 2013)
Data quality assessment / audit tool	Data quality improvement strategy implemented in Zambia, Rwanda and Mozambique.	Improvement in data availability and consistency led to targeted resource allocation (Mozambique). Improved linkages between facility and community health programmes (Rwanda).	(Gimbel *et al.*, 2017)
	Data quality assessment system included data quality audits (DQAs) at national level and routine data quality assessments (RDGAs) at the regional level.	Accuracy: increase from 43 to 60% and 40 to 81% at the facility and district level. Completeness: increase from 43 to 65% and 80 to 98% at the facility and district level.	(Nutley *et al.*, 2014)
Behavioural Determinant			
Training / skill building of staff	HW provided with tools and training for data analysis; given a "health centre record" - a booklet designed to assess trends over time.	Not mentioned.	(Cibulskis and Hiawalyer, 2002)

	Data improvement teams visited health facilities to train staff in improving data.	Staff felt that visit by the teams helped them develop systems to enhance completeness and accuracy of data reported on the monthly HMIS report.	(Ward *et al.*, 2017)
	The trainings involved basic computer use, the DHIS, and data handling skills.	Not mentioned.	(Kimaro and Twaakyondo, 2005)
	Staff training to combat weaknesses in terms of data use, analysing, interpretation and presentation.	Discussion of RHIS analyses increased from 40% to 82% at the district level and 34% to 42% at facility level.	(Nutley *et al.*, 2014)
	Focus-based training on revised data tools and on daily responsibilities.	Since inception, there has been substantial improvement in completeness and accuracy of reports from health facilities.	(Etamesor *et al.*, 2018)
	Intervention covered overview of HMIS, data quality, HF HMIS recording and reporting system, analysis, presentation, information use, and feedback.	Improvements found in completeness, accuracy, timeliness, feedback, and use.	(Nwankwo and Sambo, 2018)
	Training of staff on the use of DHIS software.	None.	(Mosse and Sahay, 2003)
Data-use workshops	Each district presented and assessed their own data using standardized analysis templates from the Millennium Development Goals. Peers discussed and critiqued the presentations	Increased feeling of competence by workers, increased problem-solving skill. Improvement in computer skills. Ultimately improve health worker skills. 15% and 38% of facilities showed improvements in data completeness and timeliness, respectively.	(Braa and Sahay, 2012)
Organizational/Environmental Determinant			
Management support / changes	Facilities that had poor data quality received additional supportive supervision. Introduction of structural changes in district health management: dividing responsibilities.	Concordance improved significantly by an average of 1.04% per month from 2010-2011 and by 1.56% per month from 2011-2012. Improvements found in indicator duplicates, internet affordability, managerial control, capacity of staff.	(Wagenaar *et al.*, 2015) (Latifov and Sahay, 2013)
Monitoring & evaluation cadre development	Recent graduates recruited and provided with on-the-job training/mentoring to develop new cadre of health worker: District M&E officer.	Cadre improved health worker capacity to monitor and evaluate programmes within the districts; improved data quality, management, and reporting; increased use of health data for surveillance and planning purposes; and increased availability of time for other health workers to concentrate on clinical duties.	(Ledikwe *et al.*, 2013; Mpofu *et al.*, 2014)
Health management programme implementation	Creation of 'director of monitoring and evaluation' position to ensure M&E and data-based decision-making would be priority.	Information feedback after supervisory visits increased from 7% to 29% at the facility level.	(Nutley *et al.*, 2014)
	Standards-Based Management and Recognition (SBM-R) approach implemented in over 30 LMIC; model	Improved provider compliance and performance standards.	(Necochea *et al.*, 2015)

	designed to confront realities in health systems in resource-constrained settings.		
	To develop leadership of M&E systems; ministries participated in virtual leadership development programme.	Not mentioned.	(Nutley *et al.*, 2014)
	League table development: aimed to assist health management.	Compared HF within districts and exposed missing data and data gaps. Improved communication and sharing of data between DHMT.	(Moyo *et al.*, 2016)
Ministry strengthening	Strengthen HIS through innovated approaches to improve quality and use for resource allocation, monitoring and service delivery.	Improved feedback; discovery of missing data and outliers.	(Mutale *et al.*, 2013)

Appendix 1

Database search strategy

CONCEPT	KEYWORDS
Routine Health Information System	"routine health information system*" OR "routine health management information system*" OR "health management information system*" OR "health information system*"
Low- or Middle-Income Country	"Albania" OR "Algeria" OR "American Samoa" OR "Angola" OR "Armenia" OR "Azerbaijan" OR "Bangladesh" OR "Belarus" OR "Belize" OR "Benin" OR "Bhutan" OR "Bolivia" OR "Bosnia and Herzegovina" OR "Botswana" OR "Brazil" OR "Bulgaria" OR "Burkina Faso" OR "Burundi" OR "Cabo Verde" OR "Cambodia" OR "Cameroon" OR "Central African Republic" OR "Chad" OR "China" OR "Colombia" OR "Comoros" OR "Democratic Republic of Congo" OR "Republic of Congo" OR "Costa Rica" OR "Cote d'Ivoire" OR "Cuba" OR "Djibouti" OR "Dominica" OR "Dominican Republic" OR "Ecuador" OR "Egypt" OR "El Salvador" OR "Equatorial Guinea" OR "Eritrea" OR "Ethiopia" OR "Fiji" OR "Gabon" OR "Gambia" OR "Georgia" OR "Ghana" OR "Grenada" OR "Guatemala" OR "Guinea" OR "Guinea-Bissau" OR "Guyana" OR "Haiti" OR "Honduras" OR "India" OR "Indonesia" OR "Iran" OR "Iraq" OR "Jamaica" OR "Jordan" OR "Kazakhstan" OR "Kenya" OR "Kiribati" OR "North Korea" OR "Kosovo" OR "Kyrgyz Republic" OR "Lao PDR" OR "Lebanon" OR "Lesotho" OR "Liberia" OR "Libya" OR "Macedonia" OR "Madagascar" OR "Malawi" OR "Malaysia" OR "Maldives" OR "Mali" OR "Marshall Islands" OR "Mauritania" OR "Mauritius" OR "Mexico" OR "Micronesia" OR "Moldova" OR "Mongolia" OR "Montenegro" OR "Morocco" OR "Mozambique" OR "Myanmar" OR "Namibia" OR "Nauru" OR "Nepal" OR "Nicaragua" OR "Niger" OR "Nigeria" OR "Pakistan" OR "Papua New Guinea" OR "Paraguay" OR "Peru" OR "Philippines" OR "Romania" OR "Russian Federation" OR "Rwanda" OR "Samoa" OR "Sao Tome and Principe" OR "Senegal" OR "Serbia" OR "Sierra Leone" OR "Solomon Islands" OR "Somalia" OR "South Africa" OR "South Sudan" OR "Sri Lanka" OR "St. Lucia" OR "St. Vincent and the Grenadines" OR "Sudan" OR "Suriname" OR "Swaziland" OR "Syrian Arab Republic" OR "Tajikistan" OR "Tanzania" OR "Thailand" OR "Timor-Leste" OR "Togo" OR "Tonga" OR "Tunisia" OR "Turkey" OR "Turkmenistan" OR "Tuvalu" OR "Uganda" OR "Ukraine" OR "Uzbekistan" OR "Vanuatu" OR "Venezuela" OR "Vietnam" OR "West Bank and Gaza" OR "Yemen" OR "Zambia" OR "Zimbabwe"