Title	Enhancing information quality as part of the disease surveillance system in Malawi, Africa: reflections on a mHealth intervention
Author(s)	Andersson, Bo; Wu, Tsung-Shu Joseph; O'Donoghue, John; Mastellos, Nikolaos; Thompson, Matthew; Hardy, Victoria; Ide, Nicole; Heavin, Ciara; O'Connor, Yvonne; Carlsson, Sven; Chirambo, Griphin Baxter; Lee, Hsin-yi
Publication date	2017
Original citation	Andersson, B., Wu, T., O'Donoghue, J., Mastellos, N., Thompson, M., Hardy, V., Ide, N., Heavin, C., O'Connor, Y., Carlsson, S., Chirambo, G., & Lee, H. (2017) 'Enhancing information quality as part of the disease surveillance system in Malawi, Africa: Reflections on a mHealth intervention', in Paspallis, N., Raspopoulos, M., Barry, C., Lang, M., Linger, H. and Schneider, C. (eds.) Information Systems Development: Advances in Methods, Tools and Management (ISD2017 Proceedings). Larnaca, Cyprus: University of Central Lancashire Cyprus. ISBN: 978-9963-2288-3-6. http://aisel.aisnet.org/isd2014/proceedings2017/General/4
Type of publication	Conference item
Link to publisher's version	https://aisel.aisnet.org/isd2014/proceedings2017/General/4/ http://isd2017.uclancyprus.ac.cy/ Access to the full text of the published version may require a subscription.
Rights	**© 2017, the Authors. This material is brought to you by the ISD 2017 Proceedings at AIS Electronic Library (AISeL).**
Item downloaded from	http://hdl.handle.net/10468/10524

Enhancing Information Quality as part of the disease surveillance system in Malawi, Africa: reflections on a mHealth intervention

Bo Andersson *bo.andersson@ics.lu.se*
Department of Informatics, Lund University School of Economics and Management
Lund, Sweden

Tsung-Shu Joseph Wu *wcsg@lukeinternational.no*
Department of Informatics, Oslo University
Oslo, Norway

John O' Donoghue *j.odonoghue@imperial.ac.uk*
Global eHealth Unit, Imperial College
London, UK

Nikolaos Mastellos *n.mastellos@imperial.ac.uk*
Global eHealth Unit, Department of Primary Care and Public Health, School of Public Health, Imperial College London
London, United Kingdom

Matthew Thompson *mjt@uw.edu*
Department of Family Medicine, University of Washington
Seattle, USA

Victoria Hardy *vhardy4@uw.edu*
Department of Family Medicine, University of Washington
Seattle, USA

Nicole Ide *iden8@uw.edu*
Department of Family Medicine, University of Washington
Seattle, USA

Ciara Heavin, *c.heavin@ucc.ie*
Cork University Business School, University College Cork
Cork, Ireland

Yvonne O' Connor *y.oconnor@ucc.ie*
Cork University Business School, University College Cork
Cork, Ireland

Sven Carlsson *sven.carlsson@ics.lu.se*
Department of Informatics, Lund University School of Economics and Management
Lund, Sweden

Griphin Baxter Chirambo *gbchirambo@yahoo.co.uk*
Department of Nursing and Midwifery, Mzuzu University
Mzuzu, Malawi

Hsin-yi Lee *hlee@lukeinternational.no*
Luke International Norway
Mzuzu, Malawi

Abstract

Public health surveillance and response to disease outbreaks is still a hurdle in many developing countries across sub-Saharan Africa. Pivotal in disease surveillance and response is the reliance on valid information, hence, the need for information which has high Information quality characteristics. A key issue with disease surveillance systems, stem from the diverse range of data sources with various levels of information quality that may affect the trustworthiness of the information. However, with the increasing diffusion of mobile phone technologies, there are opportunities to improve IQ. The aim of this study was to assess the information quality in data collected through a smartphone application the usefulness of such technologies in disease surveillance. Based on qualitative data from interviews, workshop and system specifications, it was found that information quality improves with the use of smartphone applications but aspects such as user competence, must be addressed to maximize the benefits of using mobile technologies for disease surveillance.

Keywords: Disease surveillance, eHealth, mHealth, Malawi, Africa, IDSR, IQ

1. Introduction

In sub-Saharan Africa countries such as Malawi, the timely management and accurate response to communicable diseases is still an overwhelming burden for the government. As a response to this burden, the use of computer-based information systems in the health care sector is considered a necessary means for improving efficiency and effectiveness of health care delivery [1-3, 20]. The implementation and use of computerized disease control and prevention programs succeed when resources are dedicated to detecting a targeted disease, obtaining laboratory confirmation of the disease, and using thresholds to initiate action at the district level [44].

A subset of healthcare information systems is “integrated disease surveillance and response systems” (IDSR), which constitute one strategy to manage responses to disease outbreaks. Indeed, the WHO requires their member states to optimize capacity for disease surveillance and response of both communicable and non-communicable diseases [41, 42, 44]. Disease surveillance in this context is interpreted as an “ongoing systematic collection, analysis and interpretation of health data essential for planning, implementation, and evaluation of public health practice, closely integrated with timely dissemination of these data to those who need to know” [2, 44]. Clearly a DSR will only deliver support to stakeholders if it is based on complete, timely, valid, and consistent information [47]; information can then be used to support healthcare related decisions and interventions (actions).

In the case of Malawi, there appear to be numerous opportunities to improve the IDSR system. The Malawi Ministry of Health (MoH) conducted an *ehealth situation analysis* focusing on health service delivery institutions within the health sector. It found that most health records were paper-based and manually managed. The manual handling makes surveillance challenging and integration even more problematic. Particular problems were identified with laboratory testing and medication supply chain logistics. For example, referral lab samples can take up to 21 days for results to be returned to a clinic. Regarding integration, the MoH noted that there are more than 20 different patient registers and more than 30 program specific reporting forms [46]. Hence, a considerable amount of information resides in uncoordinated information silos – both non-digital and digital information, with no standard regarding data management [18]. With paper-based patient registers, incomplete filling of records and illegible handwriting are known problems [30, 36]. In terms of ICT in particular, although the IDSR monthly reports are requires to be entered into the government owned district health information system 2 (DHIS2), the MoH has reported a lack of adequate ICT infrastructure, lack of maintenance of ICT equipments in health facilities, presence of multiple systems with no standards for integration and interoperability, lack of policies to support governance of the ICT infrastructure, major gaps in ICT knowledge and lack of sustainability strategies for implemented or proposed systems. With this points in mind, it is clear that existing IDSR systems have ample scope to improve. More specifically in the areas of complete, timely, valid, and consistent information i.e high information quality (IQ). IQ as a domain has been studied in several studies [4, 12, 16, 21, 25, 40], however studies on IQ in mobile systems and within health care is less developed.

Mobile technologies have gained momentum in healthcare in developing countries due to improvements in network coverage, cheaper network fees, and widespread penetration of mobile devices [6]. Several mobile health (mHealth) projects focusing on optimizing communication have been conducted in sub-Saharan Africa in particular, such as projects to improve communication between health workers in Malawi [24, 27], monitoring pregnancy and removing bottlenecks in communication regarding infants in Rwanda [29], and improving patient care in Uganda by communication between different healthcare actors [9]. Hence, it seems that mobile technologies have the potential to not only improve communication between health workers, but also enhance communication of complete, timely, valid, and consistent information which is pivotal for disease surveillance.

Developing countries, including Malawi, have witnessed a surge in the introduction of mHealth technologies to assist with the delivery of healthcare services at the point-of-care [37]. Many of these mHealth initiatives are supported for short periods of time (in the region of six months to four years) from international funding agencies [32], primarily for research purposes. As a result, many standalone disease-focused mHealth solutions (e.g. Malaria, Pneumonia) are designed, developed and, trialled/evaluated on the ground in these resource-poor settings (evident in a Malawian context) [23]. While this provides rich insights into the potential of mHealth in these regions, little consideration is given to the broader standardisation and exchange of health-related information [17]. Ultimately, this impacts disease surveillance in developing countries as a holistic repository of data/information is required to fully appreciate the status quo of diseases at any given time [10]. One of the central aspects to a holistic repository for disease surveillance monitoring and management is the need for intrinsic, contextual, representational and accessible information [13].

Despite encouraging reports of the use of mobile technologies, their role in improving disease surveillance in rural settings in countries such as Malawi is not known. An important question remains whether mobile applications can improve the information quality of data captured and feed into surveillance systems.

This study aimed to assess the information quality of data collected through a smartphone application in a field trial in Malawi, using the Wang and Strong 1996 framework on information quality, and explore the usefulness of such technologies in disease surveillance. The Supporting Life electronic Community Case Management application (SL eCCM App) was designed to be used by frontline community healthcare workers, known as Health Surveillance Assistants (HSAs) in Malawi [39].

The remainder of this paper is organised as follows: first, we present a framework based on information quality properties, followed by an account of methods for acquiring empirical data and mapping onto this framework. A description of the specific Malawi setting is presented in the subsequent methods section, followed by presentation and discussion of the results. Finally, a conclusion and reflections upon future research is provided.

2. Information Quality as theoretical lens

Disease surveillance systems relies like all ICT systems relay on high levels of information quality. Low information quality may result in a loss to organisations and to stakeholders. The costs are not solely economic. In the public sector they also include safety, health and well-being along with equal treatment of societies [12, 40]. In other words, if the information quality of the Malawian Health Information Systems is compromised, it will have effects on its end users, the patients.

In order to clarify IQ to ensure common understanding, IQ is both a concept and a function. The perspective “fitness for use” is pivotal and has become widely adopted in the literature within IQ [12, 40].

In order to improve IQ, Wang & Strong suggest first and foremost the need to understand what IQ means to the data consumers (who will use the data). The stakeholders in this case are members of the Malawi Ministry of Health and health staff at the zone, district, and community levels. High IQ can nurture more usages, more user satisfaction, and positive net benefits [11]. In contrast, low IQ could indicate dissatisfaction and negative net benefits. In the context of the Malawian Health Information Systems (HIS), the net benefits should mean improved health care in terms of cost, time, and health benefits to the population of Malawi as a whole [28].

The applied framework in this context is the framework developed by Wang and Strong [40], which has four main themes: the information (data) must be *accessible* to the data consumer, e.g. the data consumer knows how to retrieve the data, the data consumer must be able to *interpret* the information, e.g., the information is not represented in a foreign language, the information must be *relevant* to the data consumer, e.g., data are relevant and timely for use by the user in the decision-making process, and the data consumer must find the information *accurate,* e.g. the information is correct, objective and come from reputable sources.

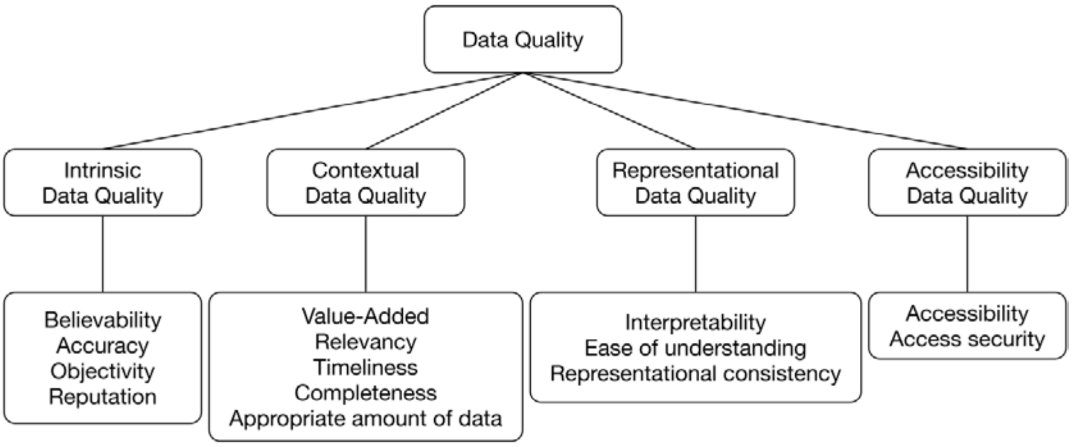

Figure 1. The Wang and Strong 1996 framework on Information Qualities. The framework makes out of four themes and fourteen constructs.

2.1. Clarification on Wang and Strong (1996) framework constructs

- Intrinsic
    - Believability - the extent to which information is regarded as true and credible
    - Accuracy - the quality or state of being correct or precise
    - Objectivity - the extent to which information is not biased
    - Reputation - the extent to which the source and content of information is highly regarded
- Contextual
    - Value added - the extent to which information is useful and beneficial
    - Relevancy - the extent to which information is applicable and helpful to the task at hand
    - Timeliness - the extent to which information is up-to-date for the task at hand
    - Completeness - the extent to which information required for the task at hand is not missing
    - Appropriate Amount - the extent to which the quantity of information is appropriate for the task
- Representational
    - Interpretability - the extent to which information is presented in appropriate languages, using commonly agreed symbols
    - Understandability - the extent to which information is easily comprehended
    - Consistent representation - The extent to which information is presented using the same format
- Accessibility
    - Accessibility - The extent to which information is readily retrievable

- Access security - The extent to which information is only accessible to authorized users

3. Methodological considerations

Data from this research comes from three main sources: *a mobile app*, *a workshop*, and *interviews*. A qualitative approach was selected as the objective was to get a richer picture of the phenomena at hand [26]. Data from the workshop and the interviews were triangulated with data from the app to improve the trustworthiness of the findings.

The *mobile app* is the Supporting LIFE App that is an implemented electronical community child management system (eCCM-system) [39] where information quality is examined. The mobile app was examined via technical specs, system architecture, database design and test usage.

The *workshop* was conducted in May 2016 in Lilongwe with stakeholders within Malawian Health Care system (see Figure 2). Main contributors were representatives from Epidemiology Department of the Ministry of Health, Norwegian Institute of Public Health, Baobab Health Trust, Ministry of Health IDSR team, I-TECH Malawi and Ministry of Health HIV/IDSR team. The format was round table discussions and white board mapping of constructs via a SCRUM Wall approach [34]. The topics revolved around aspects of information flow, digital and non-digital data/information, stakeholders within Malawian health care, organisational units, data producers and data consumers. The workshop was video recorded in order to facilitate analysis [33].

Interviews were conducted with health care staff in May 2016 at Area 18 Health Centre in Lilongwe. Participants were two HSAs, one OPD / ART clerk, and one District Environmental Health Officer. The interviews were semi-structured regarding surveillance and the perspective of complete, timely, valid, and consistent information. Notes were taken of these interviews. The purpose of the interviews was to apply additional observations on data creation and data consumption, hence the use of multiple perspectives [35, 38].

Analysis of data was conducted using qualitative data analysis (QDA) software, and data items were mapped onto the theoretical framework of information quality of Wang and Strong 1996. The analysis strategy was to investigate how the informants assessed the data/information in relation to constructs in the framework. Three levels of coherence with constructs were used, strong, moderate and weak. Strong if the informants implicitly assessed that a specific constructs property were aligned to the data/information derived from use of the mobile app. Moderate if there were implicit disparate or conflicting views on a specific constructs property. Weak if there were implicit agreement views on low adherence to a specific constructs property.

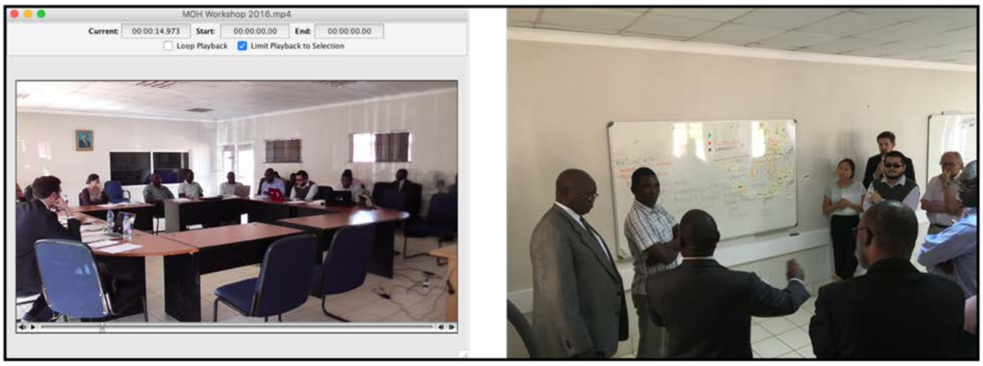

Figure 2. To the left, excerpt from the QDA software and the analysis of the workshop. To the right a photo from the SCRUM session.

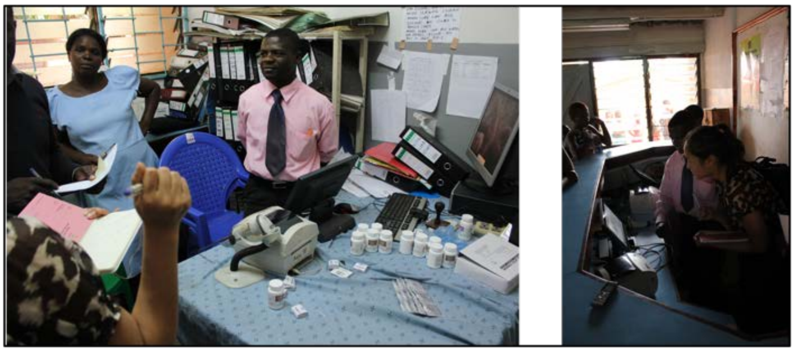

Figure 3. Health workers demonstrating and explaining computer assisted processes in health care at a clinical health center in Lilongwe.

4. Malawian settings

Malawi is a small, narrow, landlocked country in sub-Saharan Africa. It shares boundaries with Zambia in the west, Mozambique in the east, south, and south-west and Tanzania in the north. The proportion of Malawi's population residing in urban areas is estimated at 15.3%. Malawi is one of the most densely populated countries in Africa, the population was estimated to be 17 200 000 in 2015 and the density was estimated to 182 persons per square kilometre [18]. Despite considerable progress in reducing maternal and child mortality over the past few years, 460 women still die from pregnancy-related causes per 100,000 live births, and 64 children under 5 years of age die per 1000 live births. Malawi has approximately 2 doctors per 100,000 population, and the ratio of nurses to population in Malawi is also low: 37 per 100,000 compared with 70 per 100,000 in Zambia and 280 in Botswana and Namibia. In rural areas, Community Health Workers and Health Surveillance Assistants are the first—and often only—providers of health services. [8].

In 2014, an adapted version of WHO guidelines was developed; Technical Guidelines for Integrated Disease Surveillance and Response in Malawi. The Malawi government has agreed to follow WHO standards and applied a Zone-District division of health care areas. Nationally there are 5 zones, 29 districts and 1859 health facilities within communities/villages [46]. The village is the smallest administrative unit and each village is under a traditional village headman. A group village headmen oversees several villages [43, 45].

4.1. Health Care organizational structure

The Secretary for Health is the responsible officer in the Ministry and reports to the Minister. There are six directorates under the Secretary for Health: Preventive Health Services, Clinical Services, Nursing Services, Health Technical Support Services, Planning Services, Finance and Administration.

In each directorate, there are several deputy directors focusing on different areas within the directorate. Program officers, who are responsible for specific programmatic control activities, support the deputy directors. For example, the team in the Epidemiology Unit, under the Directorate of Preventive Health Services, conducts IDSR activities. At the Zonal level, the role of Zone offices is to provide technical support to District Health Management Teams (DMHT) in planning, delivering and monitoring of health services at district and central hospital levels. The office is comprised of Zonal Health Support Officer, Zonal Nursing Officer and other technical officers. At district level, the DHMT is led by the District Health Officer, who usually is a medical doctor. The DHMT comprises of District Health Officer, District Nursing Officer, District Environmental Officer, Health Services Administrator, District Medical Officer, Human Resource Management Officer and an accountant. The focal office for IDSR at district level is placed in the Environmental Health Section with DEHO providing overall direction

Regarding IDSR implementation and the Health Management Information System (HMIS) Officer is responsible for the IDSR monthly report entering to the DHIS2 in digital format.

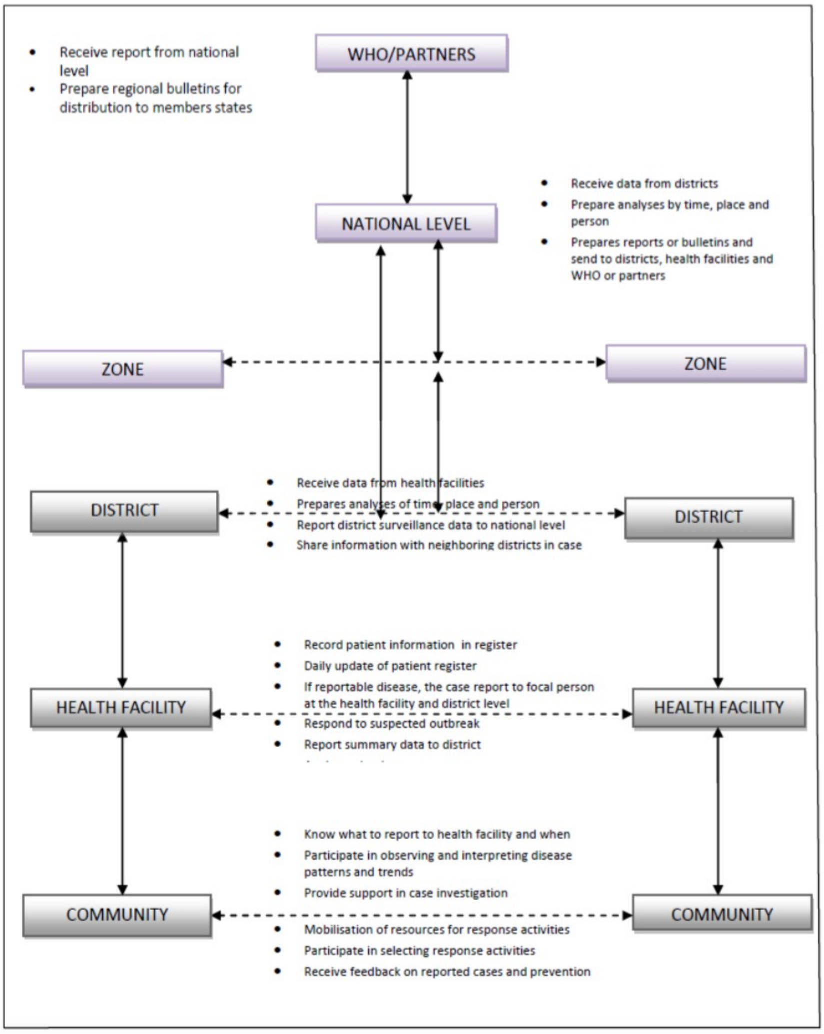

Figure 4. Idealized visualization of the information flow of health-related information, and responsibilities in Malawi. This information flow and organization is proposed by WHO and is partly implemented in Malawi.

At the primary health care level, the health centre management team is led by the officer in-charge of the health centre. The other members include nurses and Assistant Environmental Health Officers (AEHO). The AEHO acts as focal person for IDSR with support from the officer in-charge of the health centre.

4.2. Health Surveillance Assistants as "first line of defence"

One of the key actors in the health care sector in Malawi at the community level are HSAs. The approximately 9 000 HSAs are employed by the government and make up about 30% of the health workforce in the country [22]. They are assigned to a community where their duties include the assessment of children under-5 with acute infections and treating at home or referring those with complicated illnesses to a hospital or health centre for further treatment. An HSA receives 12 weeks of training and works across various health promotion and prevention activities for about 1 000 community members [14, 22]. Examples of the roles HSAs play in disease prevention are demonstrated in previous studies, showing involvement in immunization programs and anti-retroviral treatment for HIV [5, 19]. Therefore, "CHWs [Community Health Workers, including HSAs] are often seen as the most strategically placed cadre to increase equitable access to health care" [7, 15]. These HSAs are the workers designated to operate the Supporting LIFE Mobile app.

5. Supporting LIFE project

The overall objective of Supporting LIFE project is to combat mortality and morbidity among children in Malawi. It targets disease control in a multi-target intervention: Supporting LIFE provides local HSAs in Malawi with an electronic version of the Community Case Management (CCM) algorithm, adapted from WHO's guidelines for Integrated Management for Childhood Illness (IMCI) to Malawi context, that is used by frontline health workers, i.e. HSAs, to provide care for acutely unwell children under 5 years of age. The Supporting LIFE project developed an electronic version of the paper-based CCM algorithm, which was termed the SL eCCM App, and placed this on an Android based smart mobile phone. In both a feasibility study and a subsequent larger clinical trial, the effectiveness and acceptability of eCCM was evaluated in Malawi [39].

5.1. Supporting LIFE eCCM application.

The mobile hardware device selected to run the Supporting LIFE App is an android-based smartphone with the minimum specifications of 4.5 inch screen size, quad-core processor, 4 GB ROM, 1 GB RAM and Android version 4.1 or beyond [8].

It offers a computerised workflow of the paper based CCM flowchart. Information such as demographics, clinical information and clinical measurements are stored on the device. Clinical data is entered directly into the application via touchscreen technology, either by selecting the appropriate option or entering free text. Completion of all clinical questions and assessment items was mandatory on the application for the CCM clinical decision implemented. A mandatory workflow ensures that no questions are left unanswered [31]. The data is stored in a mySQL relational database in the cloud.

During the test period 100 HSAs was equipped with mobile devices and used the application in 3 500 patient examinations. Simultaneous 3 500 examinations were conducted with the standard paper based system, as a control group.

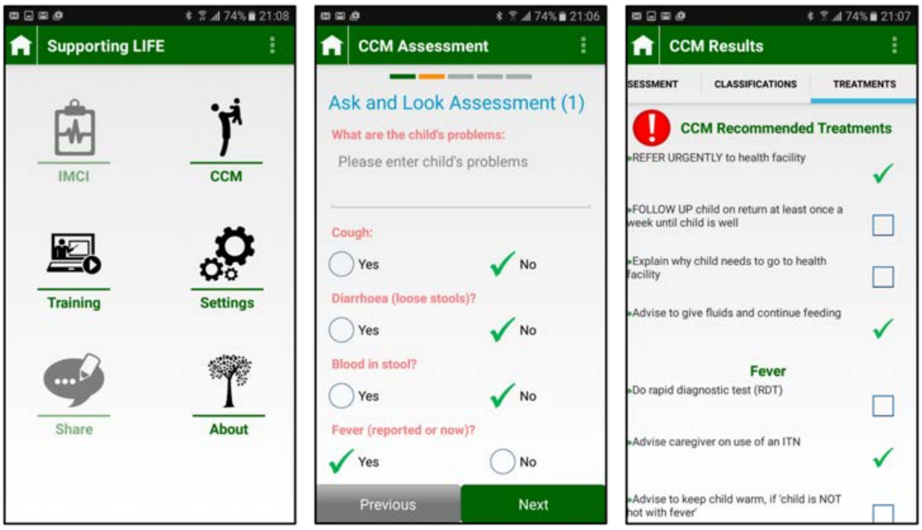

Figure 5. Sample screen shots from the eCCM application.

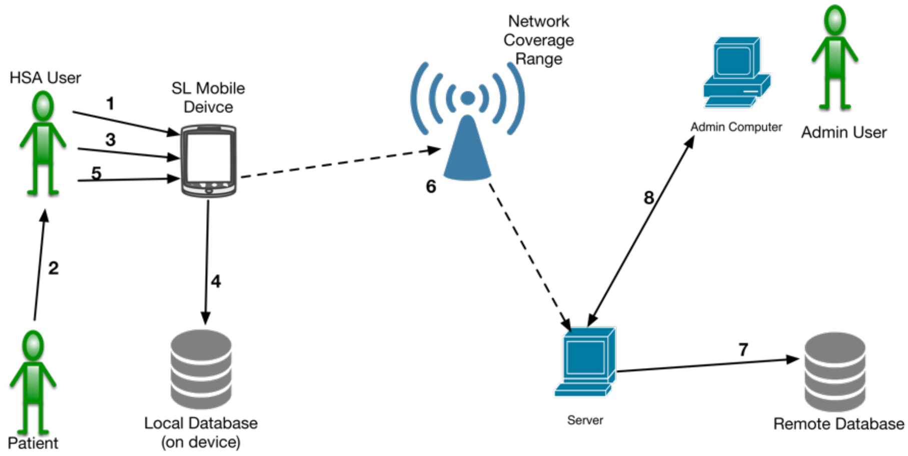

Figure 6. The implemented communication workflow in the system: 1- The HSA logs on to the app with username and password, 2 - patient is assessed, 3- the HSA fills in the CCM and treatment recommendations provided, 4-data is stored locally (on the mobile phone), 5- when appropriate, HSA synchronises the data and data is uploaded, 6- via mobile operators network the data is transmitted to the backend server, 7- backend server stores the data, 8- admin can access backend server and data if maintenance is required.

6. Results

The applied framework of IQ has four major themes: intrinsic, contextual, representational and accessibility (see figure 1). The informants' assessment on each of the fourteen construct is displayed in table 1 below.

Table 1. Summary of findings from empirical data.

	Construct in framework	**Assessment**	**Comments from informants**
Intrinsic	Believability	Moderate	Dependent on HSA competence/ credibility
	Accuracy	Moderate	Dependent on HSA competence/ credibility
	Objectivity	Moderate	Derived from CCM - however interpretation is still subjective
	Reputation	Moderate	Dependent on HSA competence/ credibility
Contextual	Value added	N/A	Cannot be evaluated with present case; a test case is needed
	Relevancy	Strong	Cannot be evaluated with present data
	Timeliness	Strong	Synchronisation offers timely data
	Completeness	Strong	Implemented mandatory fields forces the HSA to insert all data items
	Appropriate Amount	Strong	The workflow and data items corresponds to the CCM; few/none opportunities to add additional or superfluous data
Rep.	Interpretability	Strong	Derived from CCM, now alternative is possible
	Understandability	Strong	Same nomenclature as in CCM, values may be obscure, however no major issue, major improvement compared to paper based versions
	Consistent representation	Strong	Mandatory process and orchestrated input must ensure consistency, database design enforcing consistency
Ac	Accessibility	N/A	N/A
	Access security	N/A	N/A

Regarding the theme intrinsic quality, this is suggested to be dependent on the credibility in the HSA; if they are competent, the data is trustworthy. The findings indicate that there is a slight uncertainty from a data consumer perspective regarding the intrinsic quality, even with the use of computerised input. Hence, computerisation is not a guarantee by itself regarding intrinsic quality. The data producer ability to make correct judgment is pivotal and training and experience is key influencer in this theme.

Regarding contextual quality, those parts closest to automation - such as timeliness, completeness and appropriate amount - received strong assessment, and this was, from the authors' perspective, an expected outcome of computerisation, validated input [31][41] and synchronisation. Furthermore, the adherence to the CCM guidelines within the application supported the positive assessment of contextual quality.

Concerning representational quality, the information stored in the database was based on a process of capturing CCM-data. The process was extensively evaluated for adherence and as a consequence of this, coherence to representational quality theme was assessed as strong.

When it comes to accessibility quality, the investigated version of the eCCM system was not applicable as a testbed for accessibility quality, because no option or strategy for data retrieval has been developed. Hence, this version could not be evaluated for accessibility.

7. Discussion and Conclusions

It may seem obvious that direct synchronised information, information entered via mandatory input field, should improve IQ by itself. This is also supported by the findings, true. However, the concept of IQ and the applied framework highlights other aspects affecting the perceived IQ. Softer aspects such as the managerial trust in health care staff affected the overall impression of IQ. The application of the Wang and Strong framework illustrated aspects not obvious when designing the Supporting LIFE app. However, at large the IQ was improved with the use of the mobile application. If going the last mile in improving IQ the soft aspects as health care competence and trustworthiness must be addressed.

The application of the Wang and Strong (1996) framework is a retrospective analysis of the tested system, but the findings show that the IQ framework application is valuable, especially when applied early in the design process to capture aspects of importance.

Acknowledgement

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 305292

References

1. AbouZahr, C., Boerma, T.: Health information systems: the foundations of public health. Bulletin of the World Health Organization 83, 578-583 (2005)
2. Adokiya, M.N., Awoonor-Williams, J.K., Barau, I.Y., Beiersmann, C., Mueller, O.: Evaluation of the integrated disease surveillance and response system for infectious diseases control in northern Ghana. BMC Public Health 15, 1-11 (2015)
3. Backman, G., Hunt, P., Khosla, R., Jaramillo-Strouss, C., Fikre, B.M., Rumble, C., Pevalin, D., Páez, D.A., Pineda, M.A., Frisancho, A., Tarco, D., Motlagh, M., Farcasanu, D., Vladescu, C.: Health systems and the right to health: an assessment of 194 countries. Lancet (London, England) 372, 2047-2085 (2008)
4. Baškarada, S., Koronios, A.: A critical success factor framework for information quality management. Information Systems Management 31, 276-295 (2014)
5. Bemelmans, M., Van Den Akker, T., Ford, N., Philips, M., Zachariah, R., Harries, A., Schouten, E., Hermann, K., Mwagomba, B., Massaquoi, M.: Providing universal access to antiretroviral therapy in Thyolo, Malawi through task shifting and decentralization of HIV/AIDS care. Tropical Medicine & International Health 15, 1413-1420 (2010)

6. Betjeman, T.J., Soghoian, S.E., Foran, M.P.: mHealth in sub-Saharan Africa. International journal of telemedicine and applications 2013, 6 (2013)
7. Bhutta, Z.A., Lassi, Z.S., Pariyo, G., Huicho, L.: Global experience of community health workers for delivery of health related millennium development goals: a systematic review, country case studies, and recommendations for integration into national health systems. Global Health Workforce Alliance 1, 249-261 (2010)
8. Campbell, N., Schiffer, E., Buxbaum, A., McLean, E., Perry, C., Sullivan, T.M.: Taking knowledge for health the extra mile: participatory evaluation of a mobile phone intervention for community health workers in Malawi. Global Health, Science and Practice 2, 23-34 (2014)
9. Chang, L.W., Njie-Carr, V., Kalenge, S., Kelly, J.F., Bollinger, R.C., Alamo-Talisuna, S.: Perceptions and acceptability of mHealth interventions for improving patient care at a community-based HIV/AIDS clinic in Uganda: A mixed methods study. AIDS Care 25, 874-880 (2013)
10. Chapman, H.J.: Holistic Approach in Preventing Spread of Infectious Diseases: A Cuban Example. Perspectives in Public Health 136, 189-189 (2016)
11. DeLone William, H., McLean Ephraim, R.: The DeLone and McLean model of information systems success: A ten-year update. J. Manage. Inform. Syst. 19, 9-30 (2003)
12. English, L.: Information Quality Applied: Best Practices for Improving Business Information, Processes and Systems. Wiley Publishing (2009)
13. Espona, M.J.: Tracing Infectious Diseases in South America: An IQ Challenge. (2010)
14. Gilroy, K.E., Callaghan-Koru, J.A., Cardemil, C.V., Nsona, H., Amouzou, A., Mtimuni, A., Daelmans, B., Mgalula, L., Bryce, J.: Quality of sick child care delivered by Health Surveillance Assistants in Malawi. HEALTH POLICY AND PLANNING 28, 573-585 (2013)
15. Glenton, C., Colvin, C.J., Carlsen, B., Swartz, A., Lewin, S., Noyes, J., Rashidian, A.: Barriers and facilitators to the implementation of lay health worker programmes to improve access to maternal and child health: qualitative evidence synthesis. The Cochrane Library (2013)
16. Gorla, N., Somers, T.M., Wong, B.: Organizational impact of system quality, information quality, and service quality. Journal of Strategic Information Systems 19, 207-228 (2010)
17. Gutierrez, M., Moreno, R., Rebelo, M.: Information and Communication Technologies and Global Health Challenges. Global Health Informatics: How Information Technology Can Change Our Lives in a Globalized World 50 (2016)
18. Health, M.M.o.: Malawi Health Sector Strategic Plan 2011 - 2016. (2011)
19. Kadzandira, J.M., Chilowa, W.: The role of health surveillance assistants (HSAs) in the delivery of health services and immunisation in Malawi. University of Malawi, Centre for Social Research (2001)
20. Kanjo, C., Moyo, C., Galimoto, M., Braa, J., A., M.-P.: Towards Harmonisation of Health Information Systems
in Malawi: Challenges and Prospects. In: Proceedings of the IST for Africa. (Year)
21. Knight, S., Burn, J.: Developing a Framework for Assessing Information Quality on the World Wide Web. Informing Science Journal 8, (2005)
22. Kok, M.C., Dieleman, M., Broerse, J.E.W., Namakhoma, I., Chikaphupha, K., Nyirenda, L., Taegtmeyer, M., Theobald, S.: Health surveillance assistants as intermediates between the community and health sector in Malawi: exploring how relationships influence performance. BMC Health Services Research 16, 1-12 (2016)
23. Kulanga, C., Saforo, E., Ollis, S., Mitchell, M.: Integrating mHealth applications: Motivation, approach and outcomes. In: IST-Africa Week Conference, 2016, pp. 1-11. IEEE, (Year)
24. Lemay, N.V., Sullivan, T., Jumbe, B., Perry, C.P.: Reaching remote health workers in Malawi: Baseline assessment of a pilot mhealth intervention. Journal of Health Communication 17, 105-117 (2012)

25. Li, S., Lin, B.: Accessing information sharing and information quality in supply chain management. Decision Support Systems 42, (2006)
26. Lincoln, Y.S., Guba, E.G.: Naturalistic inquiry. Sage Publications, Inc, Newbury Park CA. (1985)
27. Mahmud, N., Rodriguez, J., Nesbit, J.: A text message - Based intervention to bridge the healthcare communication gap in the rural developing world. Technology and Health Care 18, 137-144 (2010)
28. Malawi, G.o.: National ICT Policy (2013)
29. Ngabo, F., Nguimfack, J., Nwaigwe, F., Mugeni, C., Muhoza, D., Wilson, D.R., Kalach, J., Gakuba, R., Karema, C., Binagwaho, A.: Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda. The Pan African Medical Journal 13, 31 (2012)
30. NMOH: IDSR in West Africa—Bridging the Gaps. Nigeria Ministry of Health (2010)
31. O'Connor, Y., Hardy, V., Thompson, M., Mastellos, N., Tran, T., O'Donoghue, J., Chirambo, G.B., Andersson, B., Carlsson, S., Heavin, C.: The importance of form field validation: Lessons learnt from a feasibility study of an mhealt application in Malawi, Africa. In: Proceedings of the Pacific Asia Conference on Information Systems (PACIS 2016). Pacific Asia Conference on Information Systems, (Year)
32. Oluoch, T., de KEIZER, N.F.: Evaluation of Health IT in Low-Income Countries. Studies in health technology and informatics 222, 324-335 (2016)
33. Penn-Edwards, S.: Visual Evidence in Qualitative Research: The Role of Videorecording. Qualitative Report 9, 266-277 (2004)
34. Robinson, H., Sharp, H.: Collaboration, Communication and Co-ordination in Agile Software Development Practice. In: Mistrík, I., van der Hoek, A., Grundy, J., Whitehead, J. (eds.) Collaborative Software Engineering, pp. 93-108. Springer, Berlin (2010)
35. Rubin, H.J., Rubin, I.S.: Qualitative interviewing : the art of hearing data. Thousand Oaks, CA : Sage, cop. 2005, 2. ed. (2005)
36. Rumisha, S.F., Mboera, L.E., Senkoro, K.P., Gueye, D., Mmbuji, P.K.: Monitoring and evaluation of integrated disease surveillance and response in selected districts in Tanzania. Tanzania health research bulletin 9, 1-11 (2007)
37. Sanner, T.A.: ICT4D Sustainability as Generativity. In: International Conference on Social Implications of Computers in Developing Countries, pp. 498-509. Springer, (Year)
38. Schultze, U., Avital, M.: Designing interviews to generate rich data for information systems research. Information and Organization 21, 1-16 (2011)
39. http://www.supportinglife.eu/
40. Wang, R.Y., Strong, D.M.: Beyond Accuracy: What Data Quality Means to Data Consumers. pp. 5. M. E. Sharpe (1996)
41. WHO: Integrated Disease Surveillance Quarterly Bulletin, 1 sept 2016. (2016)
42. WHO: International Health Regulations 2005, second edition. (2008)
43. WHO: Introduction to Country Context, Malawi. (2017)
44. WHO: World Health Organization and Centers for Disease Control and Prevention (2010). Technical Guidelines for Integrated Disease Surveillance and Response in the African Region, Brazzaville, Republic of Congo and Atlanta., (2010)
45. http://data.worldbank.org/country/Malawi
46. Wu, J., Mumba, S.: Implementation of an electronic Integrated Disease Surveillance and Response System. Baobab Health and Luke International (2016)
47. Zmud, R.W.: An empirical investigation of the dimensionality of the concept of information. Descision Sci. 9, 187-195 (1978)