USE AND IMPACTS OF E-HEALTH WITHIN COMMUNITY HEALTH FACILITIES IN DEVELOPING COUNTRIES: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This paper reports on a systematic review of the evidence into the use and impacts of e-health in community-based healthcare facilities within developing countries. Thirteen studies met our inclusion criteria. Use was influenced by infrastructural challenges, user experience, system performance problems and lack of perceived usefulness. The majority of impact studies focus on effectiveness outcomes with studies providing promising evidence for the contribution of e-health to quality of care. However, more limited attention has been placed on the impacts of e-health on equity, access and efficiency. We conclude with suggestions for future research.

Keywords: e-Health; Community Health; Primary Healthcare; Quality of Care

1 Introduction

Community health facilities (CHFs) play an important role in the architecture of healthcare delivery systems and are positioned at the centre of primary healthcare re-engineering efforts in many developing countries (Coovadia et al., 2009; Kruk et al., 2010; Macinko et al., 2009). Even within developed country contexts, community health facilities have been described as "safety-nets" for vulnerable populations (Shi and Stevens, 2007). These facilities include community health centres, clinics, health posts and stations, and are staffed varyingly by physicians, nurses and community health workers. In developing countries, properly functioning CHFs can increase accessibility of healthcare by functioning as the first point of access for outpatient services. They perform promotive and preventative health services as well as specialist community-based services for HIV/AIDS care, TB care and maternal and child care. They may also offer limited midwifery and casualty services and coordinate the efforts of outreach teams operating in the community. As part of a network of facilities, CHFs play an important role in referring patients to more specialist hospital services as well as linking patients with other service providers e.g. social services, and acute or long-term care facilities.

However, front-line healthcare facilities in developing countries are often plagued by numerous problems. CHFs in developing country contexts are often under-resourced, suffer from poor provider skills that can lead to low levels of adherence to guidelines, incorrect diagnoses and high error rates, often lack functional equipment and are reproached for poor facilities management and problems in drug supply and availability of medicines (Travis et al., 2004). They are also associated with long wait times and patients often complain about the poor attitude of health workers (Streatfield et al., 2008).

Information and communication technologies (ICT) have been advocated as important interventions capable of addressing many of the problems and challenges in community-based primary healthcare

delivery. Some ICT or e-health applications such as electronic health records, diagnostics and imaging, clinician decision support and electronic prescribing technologies offer support to the front-lines of health delivery, whilst others such as patient tracking, appointment scheduling, and inventory and facilities management systems support the operations of healthcare facilities. However, empirical evidence of the benefits of such e-health technologies for CHFs in developing countries is still evolving. The design and implementation of these systems into developing country contexts is often undertaken with an expectation for benefits such as improved quality and continuity of care, improved patient tracking and follow up, improved administration and monitoring of treatment programs, improved patient safety, better clinical decision making, improved performance of health workers and improved workflow, reduced costs, and better data availability and quality (Blaya et al., 2010; Chen and Akay, 2011; Fraser et al., 2005; Kamadjeu et al, 2005; Luna et al., 2014; Ruxwana et al., 2010; Siika et al., 2005; Williams and Boren, 2008). However, as with all IT implementations, translation of theoretical benefits into realized outcomes in practice is difficult and subject to numerous contextual factors. Thus even when e-health technologies are successfully installed, the use of these technologies is often beset by challenges that if not understood and overcome can limit the potential of these technologies to influence CHF performance. There is a need to identify common issues across settings that can predict successful use of e-health by CHFs in developing countries.

The lack of readily available evidence on the impacts of e-health on healthcare delivery and patient outcomes is hampering efforts to develop national e-health strategies and to scale up the diffusion of e-health more widely. Such evidence is particularly important in under-resourced settings struggling with competing demands on health system budgets to improve physical facilities, increase the number of health workers, and introduce competing interventions. On the other hand, if these technologies can be associated with improved performance outcomes, they can be more effectively integrated into initiatives designed to strengthen the health systems of developing countries.

Thus it is necessary to improve understanding of the benefits and challenges surrounding the use of these systems in actual CHF practice. The purpose of this paper is to undertake a systematic review of the evidence on the use and impacts of health information technologies (e-health) in community-based primary healthcare facilities within developing countries. The next section of this paper outlines our systematic review protocol followed by presentation of results, discussion and conclusions.

2 Review Protocol

2.1 Search Strategy and Study Selection

A search of English language articles in EBSCO Academic Complete, MEDLINE, CINAHL, PubMed, ScienceDirect, IEEE, ACM, and the AIS e-library was conducted. Our choice of databases was informed both by recent guidelines on systematic reviews for e-health research (e.g. Bahaadinbeigy et al., 2010) as well as a desire to ensure that we adequately covered contributions from informatics and ICT disciplines. Our search terms were based on the following concepts with appropriate synonyms: 1) e-health or information technology or ICT; 2) community health centre or primary care or clinic; and 3) developing countries. Because we were interested in reported findings from empirical studies, we also included search terms to reflect methodological considerations such as survey, experimental, research question or interview. None of the searches was restricted by date range. The search was supplemented with articles identified in reference lists as well as searching the table of contents of selected journals.

The search yielded 265 results after removal of duplicates. Figure 1 illustrates the selection process. One author carried out a review of titles and abstracts. Inclusion criteria included 1) quantitative or qualitative empirical studies into the use and/or impacts of e-health technologies within community healthcare facilities; 2) in a developing country context. Exclusion criteria included articles which 1) only described e-health technology solutions or implementations but did not undertake an evaluation

of use or impacts of these interventions; 2) did not involve health workers; 3) described intentions to implement, but not actual implementation experiences or outcomes; 4) described attitudes toward potential adoption and use, but not actual experiences of users.

The two lead authors then assessed the full-text of remaining articles for inclusion and any disagreements were resolved by discussion. Papers were excluded for reasons such as:

- does not meet study definition for a community-based primary care facility (CHF);
- empirical work not carried out in CHFs in developing country contexts;
- describes e-health intervention or proof of concept but provides no observations or provides only preliminary anecdotal observations or no description of methodology;
- presents requirements for e-health implementations but no evaluation of an actual implementation;
- review article with no empirical findings;
- provides a protocol or framework for evaluation but no results;
- examines potential for use but not actual use;
- examines an e-health technology such as telemedicine from hospital rather than community clinic perspective;
- examines an e-health for impacts on health worker education and training;
- technology not used in a CHF setting e.g. mobile technologies used in the field;
- evaluates the qualities of the technology solution rather than its impacts or use;
- discusses lessons learned only from the e-health implementer (technologists) perspective;
- discusses the design principles for an e-health solution;
- uses the data form an e-health system for analysis of health programme outcome or public health trends.

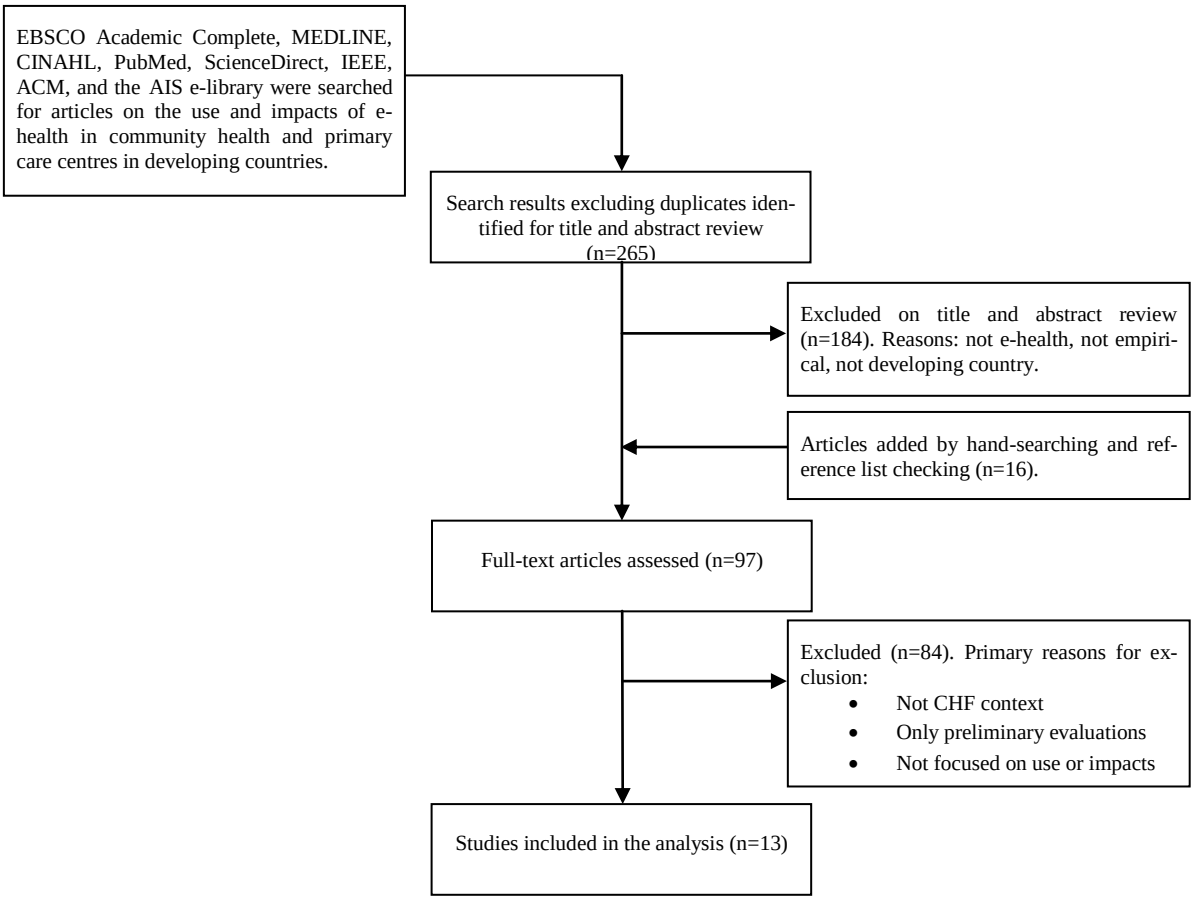

Figure 1. Systematic review process.

Thirteen (13) articles met criteria for inclusion. A review (abstraction) template was developed to facilitate analysis of the articles. One author independently reviewed each of the included studies with a second author re-reviewing each study as a verification step. Key variables recorded during this step included country, type of e-health system, focus on use or impacts, study purpose, study design, and main findings.

The 13 included studies are profiled in Table 1. The majority of the studies were carried out in Africa but studies in Latin America and Asia also met inclusion criteria. A large range of methods were employed with surveys being the most common method, although a number of experimental methods were also used. Consistent with the challenges facing developing countries in HIV/AIDS care and maternal and child health, we observed a strong focus on these two areas of care. The most common e-health technology examined was the electronic medical record (EMR).

Year of Publication	
<2010	4
2010	2
2011	1
2012	3
2013	2
2014	1
Country	
Brazil	1
Kenya	2
Nepal	1
Nigeria	1
Peru	1
South Africa	2
Thailand	1
Tanzania	1
Uganda	3
Health Specialty of Facility	
HIV/AIDS care	5
Maternal and child health	4
Primary healthcare	3
Tuberculosis (TB)	1
Type of e-Health Technology	
Electronic medical record (EMR)	7
Clinical decision support	3
Facility administration	1
Non-specific health IT application	2
Study Methods *	
Survey	4
Experimental (control trial)	3
Experimental (pre-post test)	2
Observation	2
Qualitative	2
Secondary data e.g. computer logs	2
Time-motion	2
* may sum to more than 13 due to use of mixed-method designs	

Table 1. Included studies (n=13).

3 Results

3.1 Types and Features of e-Health Systems

Half the included studies examined EMR systems. There was a mix of proprietary and open-source EMR technologies under study. Were et al. (2010a, b; 2011) for example examined the OpenMRS ® open-source EMR system whilst other studies focused on proprietary bespoke systems (e.g. Watkinson-Powell and Lee, 2012). Castelnuovo et al. (2012) examined a custom-made EMR built on a Microsoft® platform. The open-source implementations allowed some researchers to develop system modules as part of the research study. For example, Were et al. (2011) developed a patient-specific clinical summary module that was evaluated for its impacts on CD4 testing. One study examined a mobile facility admin tool (Ezenwa and Brooks, 2013).

While some systems relied on the use of data entry clerks (Were et al., 2010a, 2011), others focused on provider-based entry (Castelnuovo et al., 2012; Holanda et al., 2012). Castelnuovo et al. described provider-based entry as a potentially important EMR feature to reduce the rate of errors in data capture that may occur when data entry clerks are involved, as well as to provide real time validation of data, and to automate capture of drug prescriptions.

Clinical decision support systems were the focus of three studies. As one example, Horner et al. (2013) custom built their application using Microsoft® technologies for the purposes of the research project. The requirements for the decision support system were defined with the assistance of medical experts and the system included a rule base and knowledge base.

3.2 Use of e-Health Systems

Four studies on e-health usage met our inclusion criteria as most studies examining e-health use considered only the potential for use or were based on preliminary observations following pilot projects. Kijsanayotin et al. (2009) examined the factors influencing health IT acceptance and use within community health centres (CHCs) in Thailand. The research model was underpinned by the unified theory of acceptance and use of technology (UTAUT). A cross-sectional survey of a national sample of 1607 CHCs was carried out. Public health administrative officers within the surveyed CHCs were the study respondents. Performance expectancy was found to be the strongest factor predicting usage intentions (β=0.43, $p<0.001$). Actual usage was influenced by past experience (β=0.33, $p<0.001$), facilitating conditions (β=0.24, $p<0.001$) and intentions to use (β=.13, $p<0.001$). Actual usage was measured as a composite of usage frequency, use for care and routine reporting, use for management and administration, and use for communication and collaboration. The model explained 27% of the variance in actual usage behaviours. The study showed that health workers in CHCs exhibited relatively high degrees of acceptance and usage, and showed that the work-related benefits of e-health systems must be perceivable, identifiable and substantial to promote their acceptance and use.

Ezenwa and Brooks (2013) studied the use of a mobile ICT solution to aid the capture of health data on key maternal and child indicators, which could then be forwarded to a central server for updating national records. They used an actor-network theory (ANT) lens and carried out semi-structured interviews with health workers at primary care facilities. They found users had a generally low level of interest in the use of the e-health tool due to lack of incentives for taking up new reporting roles. Moreover, the top down implementation approach saw health workers having little input into the process. This was seen to result in poor understanding of the vision and benefits of introducing the technology and how efforts were resulting in broader contributions to maternal and child care. Other challenges surrounded infrastructure such as data lost during transmission and concerns over financial sustainability. They concluded that to realise the full potential of e-health use, initiators must align interests and communicate vision and relevance at the primary facility level.

Blignaut et al. (2001) recognized that health workers in developing country contexts may have low levels of computer usage experience. They used data from computer logs to examine the time needed for data capturing during a consultation by health workers (nursing staff) with low levels of computer experience. They found that capturing a complete patient record (with an average of 20 data units) is not possible for inexperienced computer users if workloads require more than 45 patients to be seen during a six-hour period. They also found that at least 400 consultations with a system are required before providers have enough experience and can be expected to enter 20 data units per consultation. The average service provider requires 1600 consultations with the system to break even with their performance on a manual paper-based system. They concluded therefore that only after about 3-4 months of experience can the service providers capture the optimum number of data units without having to forfeit patient attention. Findings suggest that a number of months of usage experience might be required by CHFs in developing countries before routine use of e-health can occur and benefits evaluated.

Holanda et al. (2012) surveyed satisfaction of physicians with a mandatory EMR system in use within community health centres in Brazil. 99 physicians participated in the survey. 81.4% found the system was not fast enough, 86.7% often experienced technical failure and 81.8% believed it was faster to document on paper. There was also clear dissatisfaction with support by more than half the respondents, and 47.5% were not satisfied with the system overall. Overall satisfaction was more likely for more experienced users ($p<0.01$) and those who believed EMRs are generally better than paper ($p<0.001$). They also reported that use of the system and its functions were associated more with younger female physicians who see less than 16 patients per half-day and allow more than 15 minutes on average per consultation. Holanda et al. (2012) argued that a slow EMR that is frequently out of service would erode the trust need by users of such systems and seem to be strong barriers for higher use.

3.3 Impacts of e-Health Systems

For characterizing impacts, we used Kruk and Freedman's (2008) framework for health systems performance in developing countries. Their framework identifies the three major dimensions of health system performance as effectiveness, equity and efficiency. In their framework, effectiveness is concerned with both access to care and quality of care, efficiency is concerned with maximizing the value of health system resources with a focus on costs, productivity and administrative efficiency, whilst equity is concerned with access and quality for disadvantaged groups together with participation (i.e. perception of inclusion or exclusion from the health system). Given our focus on community-based facilities within developing country contexts, all studies have an element of equity (e.g. focused on efficacy of care for disadvantaged groups). However, none of the studies explicitly focused on impact on equity.

Table 2 classifies each of the included studies in terms of the performance dimensions considered. Two authors independently classified each study into the four areas of impact depicted in Table 2 and consensus was achieved. As Table 2 demonstrates, the majority of the papers focussed on effectiveness in terms of the quality of care, with access to care considered in only one of the papers (Oluoch et al., 2014).

3.3.1 Effectiveness (Access to Care)

Indicators of access to care include availability, utilization and timeliness (Kruk & Freedman 2008). Availability was not addressed in the studies reviewed. Oluoch et al. (2014) studied the impact of EMR introduction on 17 previously paper-based rural health facilities in Kenya. Their study used a retrospective pre-post EMR study to assess the impact of introducing an EMR-based system for HIV patient data management on initiation of ART among eligible patients (access: utilization), timely initiation of ART (access: timeliness), and time to CD4 T-cell count test after initiation (quality of care: continuity). Use of the EMR led to a 22% increase in the odds of eligible patients initiating ART. Prior

	Effectiveness (Access)	Effectiveness (Quality)	Efficiency	Equity
Castelnuovo et al. (2012)		X	X	
Choi et al. (2004)		X		
DeRenzi et al. (2008)		X		
Horner et al. (2013)		X		
Oluoch et al. (2014)	X	X		
Watkinson-Powell and Lee (2012)			X	
Were et al. (2010a)		X	X	
Were et al. (2010b)			X	
Were et al. (2011)		X		

Table 2. Summary of articles evaluating impacts on health system performance.

to EMR introduction 20.3% of eligible patients did not go on to receive ART, this was reduced to 15.1% post EMR introduction (χ=33.5, $p<0.01$). There was a 7% reduction in length of time between eligibility assessment to ART initiation but this was not statistically significant. This may be attributed to time for preparation of patients for ART (pre-initiation counselling to improve patient compliance) and patient's own readiness to initiate ART. Time to conduct a CD4 test was also not significantly reduced by EMR implementation. This may be countered through improving knowledge of healthcare workers and improving access to CD4 T-cell count testing equipment. Based on these findings, the authors conclude that whilst EMR can improve the quality of care in resource-limited settings through placing eligible patients on ART treatment, timely initiation of ART is influenced by non-EMR factors.

3.3.2 Effectiveness (Quality of Care)

According to Kruk & Freedman (2008), safety, efficacy and continuity are important indicators of quality. Safety issues such as fatality rates were not addressed in the papers reviewed. Measures of efficacy and continuity are considered, largely with regards to reduction of errors and health worker compliance with guidelines.

Horner et al. (2013) examine the influence of a computerised decision support system (DSS) on PHC staff compliance with use of maternity care protocols (quality: efficacy) in a semi-rural township in South Africa. Through reviewing data input accuracy of patient records before and after the intervention they were able to record an overall increase in compliance from 85.1% to 89.3%. This increase was not statistically significant, but significant improvements over a paper-based checklist were found with respect to compliance at booking of first visit ($p<0.05$), compliance for patients younger than 18 ($p<0.01$), and compliance for patients booking after week 20 ($p<0.01$). The authors conclude that the system performed well for the most important category of first booking.

Were et al. (2011) also assessed the effectiveness of a computerised DSS with regards to improving health worker adherence to accepted CD4 testing guidelines in an urban clinic in Kenya. They argue that improved clinician compliance leads to improved quality of care (quality: efficacy). They carried out a controlled trial of a DSS that provided patient-specific care suggestions and just-in-time clinical summary reports. One study clinic was provided with reminders and summaries, whilst one was not. Order rates for overdue CD4 tests were significantly higher ($p<0.0001$) in the intervention clinic (53%) in comparison to the control clinic (38%). (This figure increases to 63% after adjusting for reminders that were inadvertently not printed in the intervention clinic due to issues with the clinic printer or computer). The intervention clinic increased the compliance with CD4 test ordering from 42% to 63% with the provision of reminders (compared to 8% increase ($p=0.51$) in the control clinic).

This improvement in ordering of follow up tests demonstrates an improvement in continuity (quality: continuity) according to Kruk and Freedman's (2008) framework.

DeRenzi et al. (2008) considered issues of compliance with Integrated Management of Childhood Illness (IMCI) protocols by clinicians in a rural dispensary in Tanzania. They assessed an e-IMCI prototype consisting of question and answer screens regarding symptoms and danger signs of child illnesses. They carried out pre- and post-trial observations of clinical care session to assess whether e-IMCI reduced errors in following IMCI protocols (quality: efficacy). Use of the prototype led to a significant improvement ($p<0.01$) with compliance with investigations required by IMCI (84.7% compliance) as compared to traditional practice (61% compliance). Use of the prototype was almost as fast as the traditional practice, where the chart book was rarely referenced and clinicians tended to rely on memory (both about 12.5 minutes). Thus, the use of the e-IMCI reduced unintentional deviations from IMCI, leading to improved care.

An indirect increase in efficacy is also demonstrated in Castelnuovo et al. (2012) through the reduction in error rates for ART information after the introduction of an EMR system to an infectious diseases clinic in urban Uganda. The authors retrospectively assessed four variables by comparing the rate of errors from paper-based forms and notes with errors in the clinic database after EMR introduction for 100 random patients. They also administered a qualitative questionnaire to 36 healthcare providers and 55 clients. Across the four variables, total error decreased from 66.5% to 2.1% for ART infections, 51.9% to 3.5% for ART toxicity, 82.8% to 12.5% for reasons for ART interruption and 94.1% to 0.9% for reasons for ART switch (all $p<0.0001$). Thus, the EMR significantly improved quality of data by reducing missing and incorrect information.

Qualitative survey results from clinicians suggested that the quality of care had improved (quality: efficacy) through the use of the EMR as had their satisfaction with data quality (efficiency: administrative efficiency) with 81% favourable responses regarding accessing patient information and 83% favourable responses regarding automation of regular tasks. Patient satisfaction with regards to timing and effectiveness was also demonstrated through the qualitative survey of clients. Patient satisfaction is also considered an important indicator of effectiveness according to Kruk and Freedman (2008).

Choi et al. (2004) assessed the impact of a nurse-order entry EMR system on error rates (quality: efficacy) for medication changes prescribed for tuberculosis patients in Peru. They conducted a controlled trial at two sites, finding that error rates reduced significantly at the test site ($p=0.0075$) while the rates remained static in the control site. Timeliness of data entry of medication changes was the largest source of error. The study suggests that further errors could be reduced if the EMR was linked to the pharmacy system.

3.3.3 Efficiency

Adequacy of funding, costs and productivity, and administrative efficiency are the categories attributed to efficiency by Kruk and Freedman (2008). Funding issues are not addressed in the papers reviewed. The main efficiency focus covered in the literature is productivity (Watkinson-Powell and Lee 2012; Were et al. 2010a; Were et al. 2010b), with some additional focus on administrative efficiency (Castelnuovo et al. 2012; Were et al. 2010a; Were et al. 2010b).

Watkinson-Powell and Lee (2012) focus on productivity issues and consider the impact of EMRs on consultation length and clinician time spent interacting with patients. Through observation of auxiliary nurse midwives at a Nepalese health post, the authors were able to conclude that there was no significant impact of the EMR on consultation length or time spent interacting with patients (efficiency: productivity), although the EMR did save considerable time with monthly report creation. Watkinson-Powell and Lee (2012) surmise that a change in work practices is required; staff need to establish a practice of referring to past patient records before the benefits of the EMR functionality are realised.

Were et al. (2010a) focus largely on productivity improvements resulting from the introduction of an EMR to a HIV/AIDS specialty clinic in Uganda. They used a time-motion study of 100 established

HIV-positive patients presenting for routine visits to assess changes to the number of patients per day, time spent with patients in direct care versus miscellaneous activities, and length of patient visits (efficiency: productivity). They also carried out a survey of provider attitude to 22 providers to assess provider attitude towards clinical summaries (efficiency: administrative efficiency) plus a minor (one survey question) assessment of provider attitude to reduction of errors in care (quality: efficacy). After implementation, there was no significant change to number of patients per day. However, providers spent significantly more time in direct care of patients (an increase from 2.3 minutes to 2.9 minutes). The length of patient visits was reduced by 11.5 minutes per visit. Patients spent significantly more time interacting with non-clinical and pharmacy staff post-implementation, but significantly less time waiting. Survey respondents were satisfied with the clinical summaries and felt that they were accurate and reduced mistakes in patient care. The authors conclude that by taking advantage of data stored in EMRs, efficiency and quality of care can be improved through clinical summaries, even in settings with limited resources.

Were et al. (2010b) also focus largely impacts of an EHR implementation on productivity in three urban (resource-poor) HIV clinics in Uganda. They assessed time in care of patients and number of patients per day (efficiency: productivity) through a time-motion study based on of 349 hours of patient observations of both new and returning patients. They also carried out a survey with 45 clinical providers in order to assess provider satisfaction with system (efficiency: administrative efficiency) plus a minor (one survey question) assessment of provider satisfaction with quality of care (quality: efficacy). Clinicians' time in direct and indirect care of patients was reduced from 60% to 43% after implementation. This was attributed to less time reading charts and writing orders and prescriptions. This resulted in saving 2.5 minutes of direct + indirect care per visit. 40% more time was spent on personal activities and 57% on miscellaneous work-related activities after EHR implementation. Numbers of patients per day increased from an average of 119 pre-implementation to 135 post-implementation. Mean patient duration with clinicians did not change significantly, whilst time spent with non-clinician staff fell by half and with pharmacy by 63%. However, waiting time for pharmacy (+11 mins) and other providers (+25 mins) increased significantly post-implementation ($p<0.001$). This may be due to computer inexperience of staff or perhaps due to bottlenecks created from the increase in patient numbers. Providers were highly satisfied with the EHR and support infrastructure and felt strongly that the EHR improved quality of care. The authors suggest that easing implementation of EHRs in resource limited settings through external support resources will increase provider productivity.

3.3.4 Equity

Whilst no studies addressed the impacts of e-health on equity, there was reference to issues specific to disadvantaged groups in the majority of studies in order to contextualise the research and the need for e-health solutions in developing country contexts. These issues included references to health providers' inexperience with computers and lack of computer literacy (Castelnuovo et al., 2012; Watkinson-Powell and Lee, 2012; Were et al., 2010b), limited infrastructure (Oluoch et al. 2014; Watkinson-Powell and Lee, 2012), lower-skilled health workers (Oluoch et al. 2014; Were et al., 2011), and inadequate funding (Oluoch et al. 2014). This may lead to suboptimal care compared to developed country settings (Were et al., 2011). Only one study explicitly addressed inequity as a justification for the need for e-health intervention (DeRenzi et al., 2008). However, no studies concluded on whether equity in the system had increased or decreased as a result of an e-health intervention, or compared different groups within the same population.

4 Discussion

We carried out a systematic review of the published literature into the use and impacts of e-health in community-based health facilities. We found a large number of studies that described e-health implementations however these studies did not evaluate the impacts of these interventions on healthcare delivery or study factors influencing the use of these technologies. Moreover, a large number of stud-

ies were found to focus only on potential for adoption and use rather than actual usage. Only 13 papers met our inclusion criteria. The small number of papers we were able to include reflects the limited diffusion of e-health within community-based facilities in developing country contexts. It also may reflect the type of use to which e-health technologies are being put e.g. an initial focus on data collection for reporting purposes rather than for patient care, which was the focus of our review.

The usage studies were also more likely to be underpinned by theory with one included study in the positivist tradition leveraging theory of UTAUT and one in the interpretivist tradition drawing on ANT. Common factors influencing use include user experience, infrastructural challenges, system performance problems, and lack of perceived usefulness or benefit.

The majority of studies examining impacts were focused on quality of care. Together the studies provide promising evidence for better compliance and reduced errors resulting from both EMR and CDSS e-health technologies. Whilst these effectiveness impacts are less contentious, efficiency impacts are varied. Reports of impacts on consultation times are mixed. Moreover, there appear to be some unintended consequences to the efficiency of the overall system following an EMR introduction (Were et al., 2010b) where time with physicians can decrease but waiting time can increase. If these consequences can be attributed to computer inexperience amongst users then such findings have important implications for how systems are introduced, and how users are supported and trained so as to develop the proficiencies needed for routine usage to occur and for overall performance of the care system to improve. Longer-term evaluations of impacts on consultation time would be useful, particularly once problems of user inexperience are overcome. Such studies would also do well to explain how use of systems improves efficiency e.g. by decreased documentation time. Without understanding the factors negatively impacting on initial efficiency or contributing to long-term improvements in efficiency, it is difficult to manage e-health implementations in a manner that ensures benefits materialize.

In the area of efficiency, we did not identify studies with a specific focus on how e-health technologies are impacting the costs of providing care. Studies are also needed into the total costs of e-health ownership for CHFs i.e. extending beyond initial implementation over the full life-cycle of operating and maintaining these systems.

There was little explicit focus amongst the reviewed studies on access or equity. Perhaps this is not surprising given that equity is largely a health system principle, and difficult to measure in evaluation studies (Braveman and Gruskin, 2003). However Eysenbach (2001) indicates that e-health has the potential to threaten equity by deepening the gap between 'haves' and 'have-nots'. Therefore, future studies would do well to address the gap in literature with regards to the impact of e-health interventions on equity. Such evidence is important to building stronger arguments of e-health's potential to address social exclusion of those members of the population whose only access to healthcare is through community-based health facilities. For example, future studies could usefully incorporate equity outcomes such as participation (Kruk and Freedman, 2008) or treatment probabilities (Musgrove, 1986) for disadvantaged groups.

Surprisingly, we did not find a strong focus on the impacts of e-health technologies on patient satisfaction in any of the studies, i.e. are patients more satisfied when e-health technologies are used by health workers in the patient encounter?, and do they generally hold more positive perceptions of facilities where e-health technologies are available? Evidence of the impacts of e-health usage on patient satisfaction in community-based facilities would be a useful avenue for future research studies.

4.1 Limitations

Certain limitations of our review should be recognized. Despite our comprehensive search, only 13 papers met our criteria for review. Our inclusion criteria limited our review to English language articles. This may have reduced our chances of finding other relevant studies. We restricted ourselves to articles identified in the published literature. Relevant unpublished articles may have been missed. During article screening, we came across studies that did not provide clear descriptions of the health

facilities under study or whether they were focused on primary care provision. We excluded studies where a determination could not be made, and this may have resulted in the exclusion of potentially relevant studies. There were few controlled trial studies found. We did not exclude any articles based on methodology and thus limitations in the methodologies of the reviewed studies may influence our conclusions. We restricted our review to published, peer-reviewed papers but did not exclude selected studies based on further appraisal of study quality. Despite these limitations, the studies yielded useful findings that we were able to summarize and have allowed us to present the current state of evidence into the use and impacts of e-health. The identified studies come from a number of different countries, reported on e-health within various CHF settings across HIV/AIDS care, maternal and child health and general primary care, considered different e-health technologies such as EMRs and CDSS, and examined different performance outcomes. Due to the heterogeneity of the articles identified, it was not possible to carry out a meta-analysis of the evidence on e-health's impacts. Moreover, because of the lack of available evidence on e-health use, we were unable to synthesize findings to identify common challenges to the use of e-health technologies in the frontlines of primary healthcare in developing countries.

5 Conclusion

We carried out a systematic review of available evidence and found a lack of coherent effort on the part of e-health researchers within developing country contexts to examine the use and impacts of e-health technologies within community-based primary care facilities. Specifically, we found that user experience was important for use, and that use was hampered by lack of perceived work-related benefits, poor understanding of vision and relevance, technical failures and infrastructural problems. The majority of impact studies focus on effectiveness outcomes such as compliance with guidelines, reduction in error rates and better data quality. This provides promising evidence for the contribution of e-health to quality of care in primary care settings. Evidence on efficiency and equity impacts is still emerging.

This review has helped us to identify several important directions for research in the field. Specifically, there is opportunity for (a) theoretically grounded studies of actual e-health use, (b) impact studies that include assessments of patient satisfaction, (c) studies explicitly focused on equity and access, and (d) longitudinal evaluations of e-health's efficiency impacts e.g. on costs, consultation times, waiting times, and health worker productivity. Future studies would do well to explicitly define and justify the health system performance dimensions and indicators selected for examination with reference to the Kruk and Freedman (2008) framework we have drawn upon. Their framework is also a useful tool for guiding future reviews and identifying gaps in literature.

Our findings are also useful for informing policy makers and healthcare practitioners on how community-based facilities can be improved through e-health so as to become more integral to the transformation of the health services system. National strategies for e-health are often developed around evidence specific to larger hospital settings. By examining evidence that is specific to e-health in community rather than hospital settings, we provide useful input for national e-health strategy processes. For example, e-health strategies could specifically refer to intended impacts of e-health for access, quality, efficiency and equity at the community healthcare level. Strategies should also include plans to address infrastructural problems as well as the computing experience, support and training of frontline health workers who will be e-health system users. Plans for long-term evaluation should also be included. Furthermore, our results should also be useful for health systems advocates looking to make community healthcare a strong focus for e-health practice and research.

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