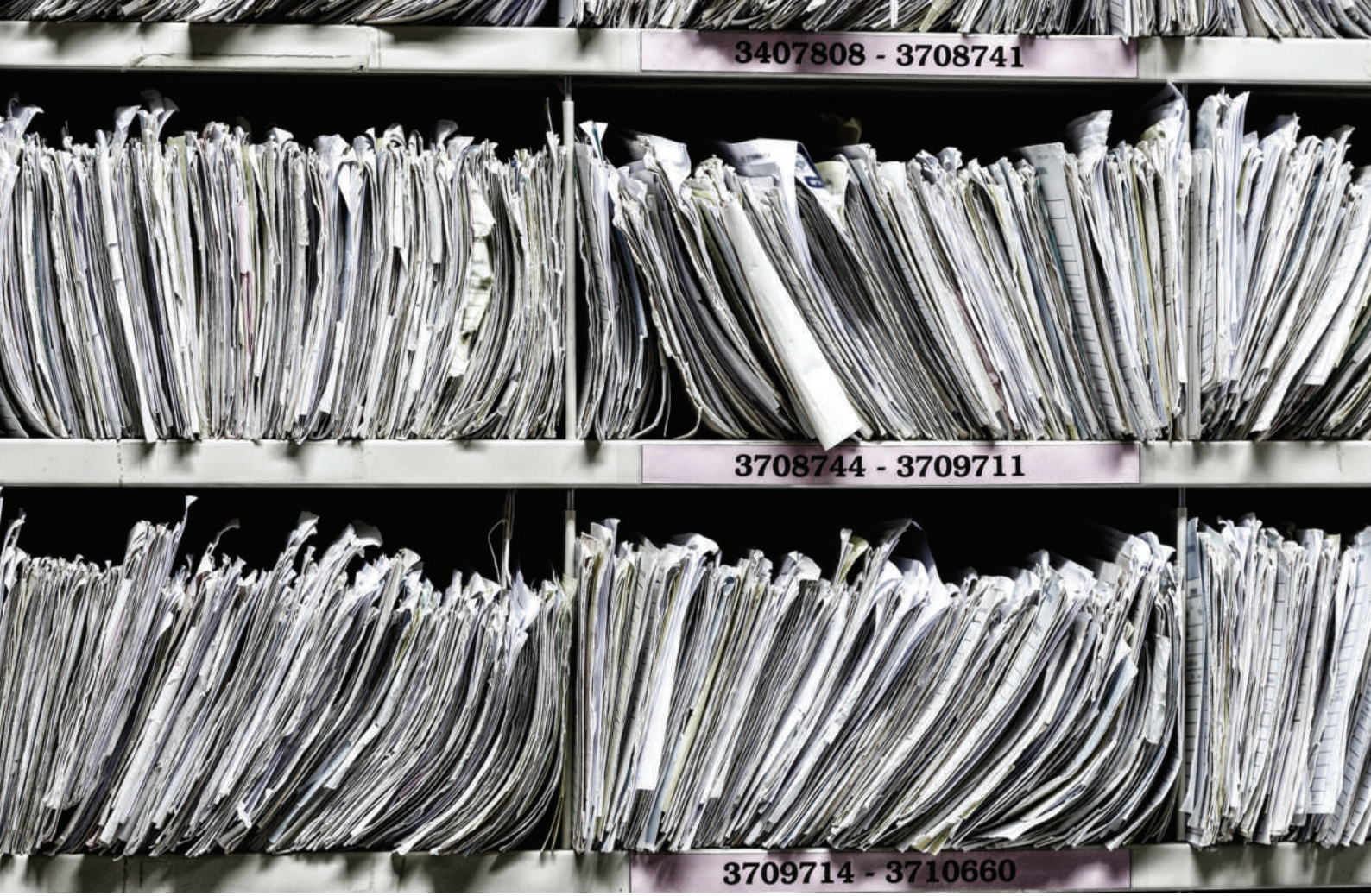

Electronic Health Records: A case study from Kenya

Background Paper

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BLAVATNIK SCHOOL OF GOVERNMENT
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Pathways for Prosperity Commission
Technology & Inclusive Development

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This paper is part of a series of background papers on technological change and inclusive development, bringing together evidence, ideas and research to feed into the commission's thinking. The views and positions expressed in this paper are those of the author and do not represent the commission.

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Introduction

Since the time of the 'Paris School' in early 19th century France, doctors have kept detailed clinical records to document each patient's medical history, tests ordered, the diagnosis reached, and any drugs that were prescribed or procedures performed. Traditionally, these records were maintained using paper filing systems but now, as the digital revolution has finally reached the practice of medicine, these paper files are being replaced by databases of digital records called Electronic Health Record (EHR) systems.

Adoption of EHR systems by hospitals and clinics has been driven by the belief that these systems can support the provision of efficient and high-quality care [1, 2]. In addition to acting as a store of medical information, EHR systems offer interactive features that can enhance care provision by providing additional support to healthcare workers. One such feature is a Clinical Decision Support System (CDSS) that can generate an alert, for example, to warn a doctor of potentially dangerous drug interactions when they create an electronic prescription [3].

As use of these systems has gained in popularity, EHRs have started to be used as a platform to support hospitals and healthcare systems to continuously learn and develop. In a 'learning health system' such as this, the data collected are analysed to identify areas in need of attention [4-6]. The hospital can then instigate a programme of quality improvement to target these specific areas and, in order to determine whether or not the new intervention was effective, the EHR data can be examined at a later date to see whether patient outcomes or clinical processes have been improved. Researchers are also beginning to use the learning health system concept to design cost-effective clinical trials, where the EHR system is used to randomise treatment allocation and collect follow-up data to determine the effect size of the treatment. Used in this way, EHR systems not only act as a digital copy of the record but also allow hospitals to conduct cost-effective research and quality improvement projects.

In high-income countries, the adoption of EHR systems has been stimulated by government schemes where healthcare providers have been compensated for the costs of ICT systems if they were able to demonstrate that the systems were used to improve care or increase efficiencies [7-9]. These incentive schemes have, in some cases, cost many billions of dollars and have had mixed results. Despite this, most hospitals and clinics in high-income countries now have an EHR system in place and are looking at the next level of innovation by leveraging the clinical data collected to improve care.

As high-income countries have adopted EHR systems over the last two decades, low- and middle-income countries (LMICs) have also seen increased use of EHR systems, although these have been introduced in different ways [1, 10].

Donor-funded projects linked to programmes that have targeted specific diseases such as HIV and tuberculosis (TB) have used open source EHR systems that have enabled better record-keeping, patient management, follow-up and stock control. In Kenya, the HIV programme introduced open source EHR systems in more than 600 clinics. One of the systems, KenyaEMR is a Kenya-specific distribution of the OpenMRS open source EHR system [11].

OpenMRS has also been used in other LMICs. In Rwanda, Partners in Health (PIH) have rolled out OpenMRS to hundreds of small healthcare facilities to collect data on HIV and TB treatment programmes. A new coalition of OpenMRS developers and implementers have recently established a new open source project called Bahmni™ that uses OpenMRS and several other open source tools to extend the core OpenMRS functionality to other areas, including hospital administration (Odoo), radiology (dcm4chee), and the hospital lab (OpenELIS). Bahmni has now been implemented in multiple countries across Asia and Africa including India, Nepal, Bangladesh, Pakistan, Zambia, Sierra Leone, South Africa and Uganda.

In Jamaica, an open source EHR system called GNU Health has been implemented by the Ministry of Health. GNU Health is a desktop application (unlike OpenMRS which runs through a web browser interface) and uses the Tryton open source Enterprise Resource Planning system as its base structure, allowing it to support administrative and back-end functions of a hospital or clinic in addition to clinical modules.

Another large-scale open source health information system used in 62 LMICs (including Kenya) is District Hospital Information Software 2 (DHIS2). This system collects aggregate data on a wide range of healthcare indicators (such as mortality rates and the number of cases of different diseases) from healthcare facilities across a country. It has also been used to support research projects and donor-funded healthcare initiatives.

In addition to the donor-funded systems like OpenMRS and DHIS2, our research group has recently conducted a survey that shows how hospital administrators in low-income countries such as Kenya have started to invest in new EHR systems directly to improve administrative efficiencies in their hospitals and increase financial accountability. In Kenya, these systems have largely been developed by local Kenyan companies with developers and support staff working closely with hospitals to meet specific needs. There is little published research on locally developed EHR systems outside of Kenya; our survey in Kenya, is one of the first in-depth investigations that included non-donor or government-backed systems.

To support these investments by individual hospitals, and to attempt to introduce a more coherent and standardised approach to EHR adoption, the Kenyan government has developed a series of reports and planning documents that outlined a vision for increased EHR use in public hospitals [12-15]. Following the development of these documents, the Ministry of Health decided to develop a new EHR system that would be compliant with the Ministry's standards, with guidelines that would be available for hospitals across the country.

To develop and implement a new EHR system without the type of large-scale government incentive programmes that have been implemented in high-income countries, the Kenyan government used the OpenMRS open source system that had been successfully rolled out in HIV and TB clinics several years earlier. By modifying the OpenMRS system to support the administrative and clinical requirements of a hospital system (rather than the smaller HIV/TB clinics it was designed for), the new system could build on the substantial investment by the President's Emergency Plan for AIDS Relief (PEPFAR) programmes and therefore reduce development costs. The new modifications

would enable hospital administrators to use a single system across all hospital functions, removing the need to purchase locally developed EHR systems that they had been using to provide patient administration, billing and lab services.

This case study describes the implementation of the new OpenMRS-based system called Afya (Swahili for 'health') Electronic Health Management System (AfyaEHMS) in Machakos County in Kenya.

Implementation in Machakos County

AfyaEHMS was first implemented in Machakos County in Kenya and later rolled out to different levels of healthcare facilities within other counties. Machakos County hospital was using an existing ICT system but were motivated to install a Ministry of Health-backed system in a bid to lower costs, improve system performance, and increase access to technical support.

Machakos County is one of Kenya's 47 counties, located just to the East of Nairobi County, and has a population of slightly over a million people. The county's health facilities can be grouped as District/ Mission Hospitals, Referral and Provincial Hospitals, Health Centres, Dispensaries, Private Hospitals, Private Clinics, Maternity Hospitals and Nursing Homes, and Special Treatment Centres. The referral hospital provides the highest level of care in the county and also serves as a referral facility for neighbouring counties. Health service delivery in Kenya is a devolved function from the central government and is therefore independently managed by each of the 47 counties [16].

Machakos County has 320 health facilities, 1,678 healthcare workers, and acts as a referral centre for Kitui, Makueni and Kajiado counties. The county has stated that it is committed to automating its 320 health facilities to boost revenue collection and enable retrieval and sharing of medical records and data for medical research [17]. Like many county hospitals in Kenya, the highest level of digitisation is at revenue collection points, administrative services and the Comprehensive Care Clinics (CCC) that offer services to HIV patients. Proprietary software is used for administrative services, while open source software is used for CCC services.

The county has invested heavily in systems (including a county asset management system, project management software, and central government systems) and infrastructure to support the provision of online services such as automated revenue collection. The Machakos County referral hospital had already implemented a medical billing system and was investigating digitising its paper health records systems. This process, however, had been faced with a number of challenges, including a lack of ICT policies within the county, low ICT budgets, and the lack of a training budget to equip ICT officers with the necessary skills to support the ICT investments [18]. The county had estimated the mobile network coverage to be 85% with good internet connectivity supported by the mobile network and fibre optic cable.

As the Machakos County implementation unfolded, our research team conducted interviews with a wide range of stakeholders, including the implementing consultants, Ministry of Health sponsors, and the ICT support staff, system users (clinicians, nurses, cashiers) and administrators in the hospitals where the system was being implemented. The evaluation tool was a pre-designed questionnaire with both multiple choice and open-ended questions.

Key factors and challenges of implementation

The results of our interviews revealed a number of significant challenges that the implementing team encountered, as described below. These challenges were largely the result of the limited time and resources available to the team. Many of the problems were common issues with implementing EHR systems that have been documented in high-income settings, but these were compounded by challenges unique to a low-income context.

For example, during the implementation of the EHR, rather than switching completely over to the new system, the manual paper file system ran in parallel. This led health workers to choose the paper system over the electronic system. The challenge was compounded by the feeling that the EHR was complex to use and health workers had not received adequate training. Also, there were workflow challenges that made the EHR incompatible with the clinical workflow, making it difficult to use the system effectively. These issues have been well-reported in the literature as problems with implementing EHR system in all settings. This reflects the need for adequate clinical buy-in and training prior to implementation.

However, we also heard stories that were more pertinent to a low-resource setting. In one facility, the fear of laptops being stolen halted EHR implementation, as the officer in charge was not confident in having portable devices at the facility. In another facility, the lack of electrical power for several weeks hindered the system implementation during that period. As we report below, these types of issues need unique solutions for a low-income context, such as enhanced security and reliable solar and back-up power supplies.

We used a framework created by Jawhari et al. [19] to summarise the key factors and challenges associated with the implementation into four categories: **Systems, People, Process**, and **Products**:

- **Systems** relate to infrastructure available, such as power and a reliable network.
- **People** relates to factors to do with users, such as their training and attitudes.
- **Process** relates to how the system is implemented, including the change management process and time of deployment.
- **Product** relates to the system itself and how it interoperates with other applications.

Table 1: Examples of descriptions and challenges of key factors in the AfyaEHMS implementation

	Description	Challenges
Systems	15 new laptops pre-loaded with Ubuntu Linux version 14.0 procured to be used in addition to the existing hardware Wired and wireless networks Laptops as client computers accessing a central server allowing for portability Two ICT staff to install and manage computer network and general troubleshooting of hardware issues Software support provided by an Indian software development company	Workstations insufficient; 30-35 computers needed to cover all the departments Laptops raised concerns of theft, leading to delay in deployment of equipment in some sites Inadequacies in infrastructure such as weak or missing Wi-Fi signal and poor 3G network made connecting to the internet difficult Lack of electric power in a site leading to delay in deployment Resolution of software issues were perceived to take too long
People	Training on system use completed at four (one Level 4 hospital and three Level 2 facilities) out of six target facilities Training completed at site of work ICT staff trained on system installation on the server	Low levels of computer literacy Reported high user workload Limited support staff Lack of clinical user buy-in
Process	System initially designed for clinicians and administrators to directly enter data	Shortage of staff and busy work schedules resulted in the use of data clerks to enter data from physical patient files
Products	AfyaEHMS modules deployed at initial implementation included: • Patient registration • Outpatient clinics • Inpatient • Laboratory • Pharmacy • Health records • Hospital inventory	Requests for additional functionality (more comprehensive symptom/diagnosis lists, an option to enter free text) Need to reduce number of steps required to achieve tasks (eg pharmacy and inventory modules) Finance module not as comprehensive as the pre-existing system

Key challenges

1. Large project scope

The initial project scope covered large hospitals and smaller health facilities at the same time. This wide scope of system implementation created challenges with the allocation of limited resources and personnel. To counter this, the scope of the system was scaled back to cover only primary healthcare facilities rather than larger hospitals and to just five additional counties following the roll-out in Machakos county (Baringo, Kilifi, Bungoma, Garissa, Turkana) with a target of 70 health centres where the system was aimed to be implemented.

Larger hospitals required that a robust finance module be put in place for an EHR to support the facility's administrative functions more meaningfully. However, the finance module was complex to develop, so the team focused on facilities that did not require faster implementation of the AfyaEHMS system and scaled roll-out to more (albeit smaller) healthcare facilities.

AfyaEHMS modules that were operation in the smaller health centres included:

- Patient registration
- Outpatient services
- Pharmacy
- Laboratory
- Maternity (to cover antenatal services and the mother and child health clinic).

2. System integration

Many smaller clinics in Kenya are funded through PEPFAR and other donor programmes. As described earlier, many of these use the OpenMRS system that AfyaEHMS is based on. Therefore, when the project was refocused to concentrate on smaller clinics, plans were made to more closely integrate and share data with the systems already in place, such as the KenyaEMR distribution of OpenMRS used in the CCCs.

As all facilities are required to report a range of healthcare indicators to the DHIS2 national reporting system, the implementing team also planned to develop a new reporting module that would generate a file that can be uploaded to DHIS2. Plans were also made to introduce internet access to facilitate automatic reporting of data to DHIS2.

3. Harnessing local talent to develop and support the system

To overcome the difficulties with support and development from external developers based in India, a Kenyan software development company was engaged. The implementer also put in place a plan to allow for a longer system handover and support over a period of six months. Other support strategies that were explored included the use of WhatsApp groups of system users and facility administrators to support implementations within the counties.

4. Stakeholder engagement

Because the system was to be implemented in various healthcare centres within the counties, the project manager made deliberate efforts to engage with the county leadership at an earlier stage of development. This change led to county administration teams being more supportive of the implementation and fostering more county-level buy-in to the project.

5. Use of scalable infrastructure

For an EHR to be effective, the appropriate infrastructure must be available to support the system. During the initial implementation, some health centres had electrical power outages for up to two weeks, bringing the implementation process to a complete halt. Therefore, to overcome this challenge, efforts were made to ensure that electrical power was available by using backup power generators and maintaining them in working condition.

The concern over laptop theft was countered using "zero clients" and a server. Zero clients are all-in-one computer terminals that occupy less space and are easier to roll out and maintain. The network was also set up using a Local Area Network (LAN) as opposed to a wireless network (which had proved unreliable in the past).

Discussion

The approach taken by the Kenyan Ministry of Health – developing and deploying an EHR system using existing open source software for use in public health facilities – is a novel way of overcoming the challenges of software costs in low-income countries. However, the implementation we studied in Machakos faced some of the common problems involved in implementing EHR systems that persist in both low and high-income countries. These challenges include clinical adoption, system complexity and usability challenges.

Evidence is building internationally that overcoming challenges with clinical adoption by doctors and nurses is a crucial step for successful implementation in both low and high-income countries [19-21]. For example, in a case study of EHR system implementation at a large hospital in India, Scholl and colleagues [22] found that management of different users' expectations was noted as an important aspect of the successful implementation. In addition, related work by Boonstra et al. [23] in the Netherlands also highlighted the need to identify key stakeholders who have different interests and abilities to influence the implementation process. These need to be managed and planned for at an early stage of system implementation. From the challenges arising with the implementation in Machakos County, users expected the new system to outperform the older system. Therefore, they were disappointed, especially when the financial module was not able to meet their needs.

User acceptance is hindered if clinicians view the implementation as an external project that is not relevant to them or the care they provide to patients, as was the case in this implementation. To prevent this, successful projects have used inclusive co-design or 'participatory design' at an early

stage. This ensures that end users can describe the issues they hope the system will help solve and have their ideas and suggestions included in the design and roll-out of the system [22, 24]. This, coupled with managing the scope of the system – for example, by gradually adding features to a system through Agile software development principles – could help to keep relevant stakeholders on board as the system is developed and deployed [25].

Research shows that, once the implementation is underway, clinical adoption can be supported by establishing a Community of Practice (COP). This can help to foster higher system utilisation through mentorship and interaction between developers and users through an online portal. COPs can be used to optimise features and for co-ordinating support with vendors. While some communities are self-organising, most will benefit from a dedicated facilitator or co-ordinator who helps the community focus on problems and develop solutions [26]. The constitution of a COP to support this implementation, as well as a help desk to help solve day-to-day issues, was discussed but required key personnel and funding to ensure its success.

Low-income countries are often characterised by few health workers and high workload; this setting was no different. To overcome the problem of high clinician workload, data clerks or scribes have been used to enter clinical data onto EHR systems in both low- and high-income countries [27-29]. While this allows facilities to obtain good electronic data without adding additional tasks to the health workers, finding the funds to support these new roles can be challenging in low-resource settings. Implementing paper-based structured data collection forms prior to conversion to digital systems have been shown to improve documentation and is a feasible option in a low-resource setting [30, 31].

Hospitals in both high- and low-resource settings are highly complex organisations that have multiple interactive agents [32]. This implies that a change management plan that considers all the actors and their views is key to any eHealth implementation [33]. The plan should consider existing workflows and organisational culture. Implementing any new technology requires considering the nature of hospital work, including the complex hierarchical organisation, staff workloads and their availability for training and participation in the implementation process. In our case study, the project team scaled back the implementation to smaller facilities, with a view to expand to more complex larger facilities later in the process once the initial issues had been addressed.

There is some evidence to support the approach described in this case study of using of well-known open source software as the basis for a national EHR where large-scale government funding is not available. The eSaude community is an example of a local community focused on the development and implementation of a Mozambican specific configuration of the OpenMRS medical record software and the integration into a national eHealth architecture [34]. Members of the community collaborate on eSaude and also contribute to the wider OpenMRS community. In turn, they receive mentorship for learning and developing the software. In this way, over-reliance on a single software vendor is reduced and users can receive important updates to their software in a timely fashion. Describing their experiences in exploring sustainability issues while implementing a tele-medicine project, Surana et al. (2008) identify this ability to tap into local support as a contribution to the principle of operational self-sufficiency that is key to implementing any ICT project [35].

However, low-income setting implementations also face challenges that are not overcome by the use of open source approaches to software development, such as the lack of electrical power, inadequate hardware and infrastructure. In our case study we saw that solutions specific to the setting were required. This included using multiple power sources to ensure availability of power if one source fails, making the system continuously available to support clinical care (an essential requirement if clinicians are going to move to digital systems from more reliable but less-sophisticated paper records).

Key policy recommendations

1. Human-centred design and implementation methodologies are as important as developing the technical capabilities of the system. Involve users and all relevant stakeholders at the beginning and incorporate their feedback to build system ownership.
2. Preliminary workflow analysis is essential to ensure that systems match clinical expectations. If necessary, adjust clinical processes prior to installing the EHR.
3. Implementing structured paper records prior to EHR implementation can make sure that end users acclimatise to the idea of incorporating comprehensive patient data collection into their workflow. This can ease the transition to digital systems.
4. Identify all users and their needs and prioritise key system deliverables with consensus.
5. Step-wise system installation or development may be more effective than trying to computerise an entire hospital in one go in a resource-limited setting. Lessons learned from departments can then be incorporated into development of new modules. It also allows for 'failing fast' and responding to issues in a timely manner.
6. The system implementers should have a close relationship and clear communication with developers and end-users.

Conclusions

We have described an implementation of an open source EHR in Kenya. It highlights the challenges faced by the implementing team and the solutions that were put in place. The process of implementing EHR systems is highly challenging in both low- and high-income settings. Open source software may give low-income settings an opportunity to reduce the costs of purchasing software. It can give the implementers access to an international community of developers and funders that may help to increase economies of scale and ongoing development.

However, the challenges present in all EHR implementation – such as user buy-in, system complexity and usability – persist with open source projects as much as they do with commercial system roll-outs. There may also be longer-term impacts on the development of the Kenya EHR industry if hospitals reduce their investment in systems provided by local commercial vendors in favour of

large-scale, donor-supported open source systems. Local vendors have been relatively successful in achieving adoption to date, particularly for administrative and financial systems in Kenyan hospitals. This means that careful consideration may be needed to determine whether these systems should be replaced by new national systems, or whether the two types of system could be integrated to allow both approaches to work together.

Future directions for Kenya and other low-resource settings could include: supporting the implementation of national standards and guidelines in commercial and open source projects; and increased support for the professionalisation of the digital health community.

The Kenya Health Informatics Association could be a key institution to support these developments, as well as providing access to research, support and resources from larger organisations such as the International Medical Informatics Association and the Health Information and Management Systems Society. Universities and government institutions in Kenya and other LMICs will also need to support professional development by providing undergraduate and postgraduate health informatics education and ongoing research into system design and implementation.

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