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Healthcare Informatics Research

Health Informatics in Developing Countries: Going beyond Pilot Practices to Sustainable Implementations: A Review of the Current Challenges

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Objectives: Information technology is an essential tool to improve patient safety and the quality of care, and to reduce healthcare costs. There is a scarcity of large sustainable implementations in developing countries. The objective of this paper is to review the challenges faced by developing countries to achieve sustainable implementations in health informatics and possible ways to address them. **Methods:** In this non-systematic review of the literature, articles were searched using the keywords *medical informatics, developing countries, implementation,* and *challenges* in PubMed, LILACS, CINAHL, Scopus, and EMBASE. The authors, after reading the literature, reached a consensus to classify the challenges into six broad categories. **Results:** The authors describe the problems faced by developing countries arising from the lack of adequate infrastructure and the ways these can be bypassed; the fundamental need to develop nationwide e-Health agendas to achieve sustainable implementations; ways to overcome public uncertainty with respect to privacy and security; the difficulties shared with developed countries in achieving interoperability; the need for a trained workforce in health informatics and existing initiatives for its development; and strategies to achieve regional integration. **Conclusions:** Central to the success of any implementation in health informatics is knowledge of the challenges to be faced. This is even more important in developing countries, where uncertainty and instability are common. The authors hope this article will assist policy makers, healthcare managers, and project leaders to successfully plan their implementations and make them sustainable, avoiding unexpected barriers and making better use of their resources.

Keywords: Medical Informatics, Developing Countries, Public Health Informatics, Health Planning, Health Manpower

I. Introduction

In the last decade, the field of health informatics (HI) has grown worldwide [1]. The Institute of Medicine in the United States has declared that information technology (IT) is an essential tool to improve healthcare costs, patient safety and the quality and equity of care [2-4]. These benefits make HI particularly relevant for developing countries, where common difficulties faced by most of them, such as poor economics, political uncertainty, and the lack of cutting edge infrastructure, have hampered the quality of healthcare.

It has been shown that it is feasible to implement a broad spectrum of IT solutions in developing countries [5,6]. Al-

though success has been achieved in implementing pilots or isolated programs (mostly in mobile health or local Electronic Medical Records), large sustainable implementations at a country or regional level are less common [7-10].

This lack of sustainability and scalability prevents improvements in quality, efficiency, and equity outcomes. Thus, the potential benefits and the ultimate goal to achieve quality of care improvements through IT are not met, making sustainability a primary factor for its success [11].

According to Madani and Aronsky [12], when addressing the application of IT in healthcare, sustainability can be analyzed through the following factors: 1) effectiveness, measured by outcome variables, such as mortality, morbidity, safety, or quality of medical decision-making; 2) efficiency, including factors that affect resource allocation for the development and maintenance of systems, such as user training; 3) financial viability, including cost-effectiveness of applications and return-on-investment in the long-term; 4) reproducibility, such as integration and application in a variety of different settings; and 5) portability, measured by the ease of implementing and adapting concepts and approaches to other environments.

The benefits of achieving major sustainable implementations in HI have been hampered by several challenges common to most developing countries [13]. As the field matures and health information systems (HIS) become more relevant for healthcare, a review of the various factors affecting sustainability is needed [12].

II. Methods

Based on this reality, we conducted a non-systematic review of the literature. Articles were searched using the keywords *medical informatics, developing countries, implementation* and *challenges* in PubMed, LILACS, CINAHL, Scopus, and EMBASE.

The retrieved articles were classified by consensus rounds into six broad categories related to the challenges in achieving sustainable implementations in HI: 1) resource and infrastructure limitations; 2) development of health IT agendas; 3) overcoming uncertainty, ethics, and legal considerations; 4) lack of use of common interoperability standards; 5) lack of a skillfully trained workforce; and 6) regional integration.

This review article describes experiences published on the challenges and barriers faced by developing countries with possible ways to address them, in the hope of assisting policy makers, healthcare managers, and project leaders to anticipate the challenges they will face and help them overcome them early in their implementations.

III. Results

1. Resource and Infrastructure Limitations

There are many financial and structural hurdles that developing countries face when implementing sustainable e-Health programs. The infrastructure needed to support this kind of implementation is scarce and irregularly distributed. Examples of these difficulties are the lack of reliable electricity [14] and low-quality, expensive Internet access [15]. The situation is not the same in all developing countries. Disparities between different regions of the same country are common, and infrastructure can be very different when comparing private or public initiatives. These problems are most relevant in rural areas [16,17].

Developing countries have considerable structural deficits in their physical networks, due to high costs, geographic dispersion, and high percentages of the people living in rural areas. The possibility of using wireless networks and the widespread adoption of mobile phones help to ameliorate this issue. The penetration rates of mobile phones are increasing year after year in developing countries [7], providing opportunities to implement systems that require less resources in new and imaginative ways [18]. For these reasons, mobile health (part of a broader field known as telemedicine) is proving to be useful to avoid the lack of an adequate infrastructure [19]. Nevertheless, these solutions create new problems, such as fragmented information, and difficulties with project scalability.

Hardware acquisition is another difficult issue. Luckily, given the accuracy of Moore's law prediction [20], hardware costs are constantly falling; giving developing countries access to technologies that were previously unattainable. In addition, some governments are implementing initiatives intended to reduce the digital divide, through the distribution of low-cost, portable computers to children. Examples of these initiatives are the "Ceibal" program in Uruguay, which has recently distributed its millionth computer [21]; and the "Conectar Igualdad" program in Argentina, with more than 3,500,000 netbooks already distributed [22]. In Africa, Rwanda is the country with the largest number of laptops distributed to children, with 210,000 computers distributed by the end of 2012 [23].

In terms of software, the rise of the open-source movement is helping resource limited countries to implement HIS. Two well-known examples are PostgreSQL, a powerful open-source object-relational database system, with more than 15 years of experience, and a strong reputation for reliability, and OpenMRS, a software platform based on the data model of the Regenstrief Institute, which enables the design of

customized Electronic Health Records (EHRs) with no programming experience [24,25]. OpenMRS has been implemented in many developing countries in Africa, Asia, and Central and Latin America [9,26].

It is noteworthy that the direct costs of HI implementations can be large, which makes long-term commitments necessary to maintain them. It is common for these programs to rely on donor funding for the pilot stages [11], and when looking for opportunities to scale up, alternative sources of financing are needed. These can be difficult to obtain in resource constrained countries, where an e-Health agenda has to compete with more basic needs, like food, healthcare and education [7]. These infrastructure limitations in networks, hardware, and software must be considered before planning an e-Health project in developing countries [27].

2. Development of Health IT Agendas

A comprehensive nationwide e-Health agenda that contemplates most of the challenges we address in this review is vital [9]. The development of health IT agendas has been attracting increasing interest in recent years. The need for health IT application frameworks to better develop and sustain IT projects has been advocated by the United Nations, the World Health Organization (WHO), and other international organizations [28].

Worldwide, large amounts of health data are electronically collected, but information is scattered and is not useful for high-quality decision-making. Further development in HI will require the implementation of clear data standards in order to be of optimal value, and this situation demands a clear framework for understanding and moving forward on e-Health [29].

Many developed countries have advanced in the development of e-Health agendas: Canada, Australia, and Denmark among others [30-32]. In 2010, the Economic Commission for Latin America and the Caribbean (ECLAC), described the advances made and the difficulties encountered by five developed countries (Belgium, Sweden, Spain, United Kingdom, and Denmark) while implementing e-Health actions [33].

e-Health agendas have suffered from a lack of sufficient focus and targeted priorities in developing countries. Few of them have sufficiently strong and effective HIS to meet all their diverse needs. However, since 2008, more than 20 developing countries have been working on health information strategic plans, supported by the WHO's Health Metrics Network, a global partnership created in 2005, dedicated to assessing and strengthening national HIS [34].

In this sense, private initiatives could generate a positive impact in the disclosure of these programs. International so-

cieties could advance the generation of regional or national agendas that enable or facilitate the implementation of HI programs through economic incentives and professional training programs.

3. Overcoming Uncertainty, Ethics and Legal Considerations

Overcoming uncertainty represents a challenge in every new implementation. In the process of implementing an EHR, explicit and broad legal regulation is needed. Otherwise, resistance to adoption may be a barrier to overcome [35].

Ethical considerations must also be acknowledged at an early stage [36,37]. Patients enrolled in healthcare systems must trust those invested with the responsibility to safeguard their personal information [38,39]. These challenges are similar worldwide, but their consequences are less serious in developed countries, because their legal frameworks have better support for digital agendas [33].

Furthermore, security issues and legal accountability might represent a significant obstacle in the implementation process [40,41]. The high levels of legal uncertainty present in most developing countries could act in two antagonistic modes. On one side, the lack of legalization in the field could be an incentive to work more freely. On the other side, the lack of needed laws could delay the start of implementations, while countries wait for a framework to organize such programs. Still, in one way or another, the number of initiatives is lower than expected when compared to developed countries.

To manage these challenges, local health personnel need to acquire knowledge of legal frameworks and medical ethics. There is an urgent need to enhance the teaching of the discipline at both the undergraduate and postgraduate levels [42]. This teaching must accompany any efforts being made towards a sustainable implementation [43].

4. Lack of Use of Common Interoperability Standards

It is common for HIS to be fragmented, incomplete, inaccurate, and isolated, and this problem is even more explicit in developing countries. This leads to information silos, and the information contained inside them cannot be used for patient care or data analysis [44].

To overcome this problem, the effective use of standards is of cardinal importance [45]. The ability to exchange and use information between different systems (interoperability) is a fundamental requirement to accomplish healthcare goals [46]; the most important consequence of the lack of interoperability is the loss of the continuity of care among practitioners.

The WHO asked its member countries to adopt standards for effective information exchange between healthcare actors and e-Health implementations through a resolution in its

66th World Assembly [47].

Some of the aspects that need to be addressed to achieve effective interoperability are the correct and unambiguous identification of patients, improved cooperation among stakeholders to ensure the consistent application of standards across different domains, the use of data interchange standards to ensure syntactic interoperability, the application of semantic interoperability with the use of standard terminologies, and the use of quality measures to assure that data is accurate and relevant [45].

Most of the standards needed to create interoperable systems exist today, and are the same as those required in developed countries. The problem is that different groups select different standards for the same purposes. Governments and stakeholders must be aware of these issues and advance methods of reaching consensus on the common and consistent use of standards. International initiatives showing the benefits of defined standards could improve and accelerate the process to define these standards in developing regions. In the same way, international standard societies should help these countries in the process of implementing these interoperability programs by disseminating its standards and training staff.

5. Lack of a Trained Workforce

There is widespread agreement that an appropriately trained workforce is a critical dimension if sustained progress is to be achieved. There are too few well-trained medical informaticians, and they have an inadequate geographic distribution to meet the needs and expertise necessary for health IT implementations [42,48].

The general model to train the workforce needed emerged from the e-Capacity meeting in Bellagio in 2008, during which components of the educational strategy to train clinical informaticians and improve the level of informatics knowledge, skills, and attitudes in both formally and informally trained health workers were described [49].

Educational programs are emerging around the world. Different degrees of specialization are needed, from graduate education to shorter courses. One example is the American Medical Informatics Association's (AMIA's) 10 × 10 initiative, a program that aimed to train 10,000 professionals in HI by 2010 [50]. Since its introduction, AMIA has been working alongside local institutions in developing countries, such as Argentina and Singapore, to create an international version adapted to local needs [51,52].

Other initiatives include the Informatics Training for Global Health Program of the Fogarty International Center, US National Institutes of Health, that maintains eight partnerships between United States and international academic programs to expand informatics training in India, Latin America, and Africa [53] as well as the AMIA's Global Partnership Program, funded by the Bill and Melinda Gates Foundation, with the goals of promoting project-centric approaches to training in developing countries to expand the local capacity to continue programs in the future [54].

Another approach to this problem is the use of telemedicine and mobile devices to connect trained resources with the population in need. This is especially useful in rural areas located far from urban centers where the specialized workforce tends to live. One example is the experience in India of using mobile tools for the screening of retinopathy [55].

All of these actions are recognized as essential for advancing educational programs and implementing systems in ways that are compatible with local culture and healthcare needs, and should be coordinated with current efforts being made by the International Medical Informatics Association (IMIA) through education working groups [56].

6. Regional Integration

The US Office of the National Coordinator for Health Information Technology and the Institute of Medicine, recognizing the importance of integrating and sharing experiences, are committed to helping organizations share approaches to improve their likelihood of success. The flow of information needs to be nurtured to allow for the dissemination of potential patient safety issues, such as those involved in the implementation of HIS.

The communication of existing projects, as well as of past experiences has proven to be a challenge in developing countries [57]. Critical to the transition from a pilot project to a sustainable implementation is the sharing of resources, experiences, and lessons learned from other projects [16,27].

Traditionally, the communication of medical knowledge, research, and advances has been achieved by the publication of articles in scientific journals. Yet, this task also represents an obstacle in developing countries, and HI is not excluded. Publication and retrieval of HI scientific material can be facilitated quickly with relatively little expenditure when compared with other investments needed [58]. For example, the open-access approach to publishing helps authors in underdeveloped regions share information [57].

The IMIA, through its working group for development, has focused on this challenge, creating a global repository for all ongoing projects related to health IT, with the hope that it will fulfill the final goal of connecting all the actors working in HI solutions for developing countries. The site is still relatively new as it was introduced in July 2013, and manag-

Table 1. Recommendations for developing countries

Resource and infrastructure limitations	Use wireless networks and mobile phones, adopt open source software, and create programs to diminish the digital divide
Development of health IT agendas	Generate regional or national agendas that facilitate the implementation of informatization programs through economic incentives and professional training programs
Overcoming uncertainty, ethics and legal considerations	Create explicit and broad legal regulation to overcome resistance to adoption
Enhance the teaching of medical ethics at both undergraduate and postgraduate level
Lack of use of common interoperability standards	Advance methods for reaching consensus for the common and consistent use of standards
International standard societies should help in the process
Lack of a trained workforce	Implement educational programs or use partnerships with trusted institutions
Use telemedicine and mobile devices to connect the trained resources with the population in need
Regional integration	Communicate successful programs in the region, and share experiences on implementing programs and teaching resources

ing the input of data by project leaders has proven difficult mostly due to lack of knowledge of the tool [59]. Efforts to communicate successful programs in the region and to share experiences in implementing programs and teaching resources could have a big impact on the dissemination of these initiatives.

IV. Conclusions

Knowing the challenges to be faced is important for the success of any implementation in HI. This is especially relevant in developing countries where uncertainty and instability are very common.

We have reviewed the problems faced by developing countries arising from the lack of adequate infrastructure, and the ways these problems can be bypassed. The issues that must be addressed include: the fundamental need to develop nationwide e-Health agendas to achieve sustainable implementations; ways to overcome public uncertainty with respect to privacy and security; the difficulties shared with developed countries to achieve interoperability; the need for a trained workforce in HI and existing initiatives for its development; and strategies for achieving regional integration (see Table 1 for a summary of recommendations).

Even while this review has some limitations, such as the fact that it is not a systematic review, and difficulty in finding published papers related to the topic for all the countries in this group; the challenges and barriers seem to be common to most of them. More resources towards integration of the region may be necessary as well as programs to help incipient implementations through the sharing of experiences and workforce.

Although the challenges described in this article could be common to all the countries in this group, it is possible that they are not the only ones to be considered. Moreover, these challenges are discussed in relation to developing countries, where implementers must be aware of common barriers and difficulties that can strain efforts in all IT implementations.

We hope this article will assist policy makers, healthcare managers, and project leaders to successfully plan their implementations and make them sustainable, to avoid unexpected barriers as much as possible, and to make better use of their resources.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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