

Evaluating success of mobile health projects in the developing world

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Abstract. Many mobile health (mHealth) projects, typically deploying pilot or small scale implementations, have been undertaken in developing world settings and reported with a widely varying range of claims being made on their effectiveness and benefits. As a result, there is little evidence for which aspects of such projects lead to successful outcomes. This paper describes a literature review of papers from PubMed undertaken to identify strong contributions to execution and evaluation of mHealth projects in developing world settings, and suggests a template for classifying the main success factors to assist with collating evidence in the future.

Keywords. Mobile health, cellular phone, developing countries, economics, evaluation studies, health impact assessment, telemedicine

Introduction

Despite the advancement of medical science, people in developing world countries receive inadequate healthcare services, which results in significantly lower life expectancy and quality of life. Some examples of these inadequacies include poor availability of and access to healthcare facilities, resource limitations on provision of treatment and medication, lack of sufficient trained healthcare personnel, and underserved public health programmes.

Mobile information and communication technology has been advanced significantly in the past 15 years to provide close to ubiquitous connectivity. A 2012 study [1] reported 5 billion mobile subscribers worldwide, of which more than 70% were located in low and middle income countries, and determined that 83% of the world's population was able to be reached by wireless services. The catalysing and leapfrog effects of this new telecommunications technology have been argued to support economic development in both the developing and developed world, and narrow the extent of economic separation between them [2].

There have been numerous reports on projects and programs delivering healthcare services in resource-limited areas using mobile technology e.g. [3]. There have also been various analyses of the potential for general development impacts through the

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upscaling of health services via mHealth e.g. [4]. These prolific examples of developments and deployments prompt us to ask: Can mobile health solutions improve healthcare services in developing countries with resource-limited health settings?

If we are to arrive at a positive answer for this question, some further sub-questions must be explored: What is the nature of the mobile health solution that leads to improvements? How is the mobile health solution created and delivered within the health services environment? What is the nature and extent of the health services improvements? What health benefits and health care cost impacts occur? What are what are the success factors and potential pitfalls in deploying mobile health solutions? This project was undertaken in order to investigate how these questions might be answered by deriving a structured approach from consideration of the clinical literature.

1. Background Materials

Prior contributions in the literature detailing success factors for mHealth projects in the developing world are scarce. In an early publication describing mHealth, Istepanian et al. [5] acknowledged the potential for applicability in that setting, but provided no framework for assuring success of implementations. Some guidance on success factors for Telehealth projects in developing world situations was provided by Wootton et al. [6], but concentrates on analysing issues concerning delivery of individual clinical services, in conventional Telehealth settings rather than mHealth. Latifi [7] presented a case for wide scale deployment of telemedicine services including those delivered by mobile technology, and indicated some contextual influences.

The evaluation of mHealth projects has received more attention in the literature but many publications are directed only at specific projects, and so the generality of any success factors reported is limited. Inadequate choices of parameters such as sample size and diversity, control of confounders, and length of trial period as well as a piecemeal approach to evaluation design and methodology, have led to a dearth of published material providing conclusive findings at high levels of evidence. Tomlinson et al. [8] argued that evaluation was a key aspect for achieving mHealth project success, due to its influence on clinical policy makers. Recently, Chib et al. [9] reported an analysis of 53 mHealth projects in developing world settings and concluded that a lack of evidence exists, due to various reasons including inadequate project design, preferences for technology driven projects without sustained clinical outcomes, and failure to extend projects beyond the pilot stage.

Expert analyses on development opportunities by international agencies and corporate consultants abound in the mobile technologies sector, but relatively few have specifically targeted mHealth. In a recent report by The Boston Consulting Group [1] describing the potential of mHealth based on knowledge acquired from over 500 mHealth projects worldwide, the main areas of opportunity for delivering clinical benefits were identified as:

- Health surveillance
- Information on disease prevention
- Patient monitoring & compliance
- Public wellness apps
- Remote data access
- Remote diagnostics

Another such report produced independently by The World Bank [2] identified a number of similar areas, including some non-clinical aspects such as education and accountability:

- Improving management and decision-making by health care professionals
- Real-time and location-based data gathering
- Provision of health care to remote and difficult-to-serve locations
- Fostering learning and knowledge exchange among health professionals
- Promoting Public Health
- Improving Accountability
- Self-management of patient health

Success factors and obstacles for the adoption of mHealth are also identified in some of these reports. For example, considerations of the experiences from past projects by The World Bank [2] and World Health Organization [4] concluded that the following reasons specific to the health ICT arena are strongly related to the failure of mHealth projects:

- Insufficient financial resources
- Lack of sustainable business models
- Privacy and security concerns
- Limited evidence
- Difficult coordination of stakeholders
- Interoperability issues

However, the aspects suggested to be addressed to ensure success are often generic to major ICT programmes and developing country projects and not specific to health ICT projects. For example, the following set of aims for mHealth projects to increase likelihood of success are listed in a United Nations Foundation report [3] on the potential of mHealth for the developing world, based on 51 mHealth case studies:

- Forge strong partnerships
- Be accessible
- Design with the end user in mind
- Build a long-term funding plan
- Set measurable goals
- Collaborate with other mHealth organizations

By comparison, the abovementioned World Health Organisation report [4] suggests more specific success factors associated with project management and change management:

- Avoid a one-size-fits-all approach
- Maintain flexibility
- Take standards and interoperability into account
- Track key success indicators for monitoring and evaluation
- Ensure quality and content of health information
- Enable public-private partnerships
- Offer training and take literacy into account
- Ensure the commitment of leaders

A report by Advanced Development for Africa [10], based on analysis of 9 widely representative case studies of mHealth projects in the developing world, offers numerous recommendations for successful project outcomes in the categories of

programmatic, operational, policy and global aspects, and identifies the following as success oriented best practices in project execution:

- Plan for scalability and sustainability from the beginning
- Assess real needs and required benefits within the local health landscape
- Identify existing initiatives and avoid duplication
- Educate and engage end-users during development, to support uptake
- Align with local health priorities and existing Health Information Systems
- Secure buy-in from healthcare authorities and partner with stakeholders
- Collaborate with local implementation partners
- Establish strategic partnerships to assist with scaleup
- Perform monitoring and assessment of impacts
- Maintain flexibility during implementation to address changing needs

In summary, it may be observed that many of the above recommendations intersect and are frequently more generally applicable to technology-based projects in the developing world, than merely to mHealth. This suggests that there may be more value in reviewing studies of mHealth projects in the developing world which appear in the clinical evidence literature, with a broader scope than was covered in the above stylized reports. By identifying strong contributions to execution and evaluation of such projects, we hope to suggest a template for classifying the main success factors, in order to assist with collating further evidence more systematically in the future.

2. Scoping the Evidence Base

The goal of this work was to collect representative instances (and grouped instances) of publications on mHealth projects (and the related health services) implemented in developing countries, and conduct analysis of these to identify factors leading those projects to deliver effective use of mobile technology in healthcare. The scope was confined to searching PubMed, as the primary source of clinical evidence through peer-reviewed publication, and limiting this to publications that have appeared since 2000, to ensure currency. Preference was to be given to publications reporting evaluation associated with the project, with explicit identification of the evaluation methodology.

Our initial approach to searching PubMed was to identify concepts within MeSH to help define search contexts which might map to publications of interest. This was not a simple task, because MeSH does not provide terms for qualitative concepts such as “success factors”, nor does it currently recognise “mHealth” (or “m-Health”). A scoping exercise was therefore undertaken to establish relevant MeSH terms to aid in the search. The three basic concepts in the statement of intention for this work were supplied as enquiry terms to a MeSH search: these were “mobile health”, “project evaluation” and “developing world”. None of these terms occurs directly in MeSH but some relevant primary terms were suggested by MeSH. Examining the paths to these terms from parent categories provided justification that they were relevant to the major concepts. Further examination of the paths revealed a number of secondary terms which were also clearly associated with the basic concepts. All the discovered terms and related paths are shown in Table 1.

Table 1. MeSH terms and paths related to the basic concepts of this work.

Basic Concept	Primary MeSH Terms	Primary MeSH Term Paths	Secondary MeSH Terms
Mobile Health	Cellular phone Telemedicine	Information Science Category / Information Science / Communications Media / Telecommunications / Telephone Information Science Category / Information Science / Communications Media / Telecommunications / Delivery of Health Care Health Care Category / Health Services Administration / Patient Care Management / Delivery of Health Care	Computers, handheld Medical Informatics Mobile applications Text messaging Wireless technology
Project Evaluation	Evaluation Studies Health Impact Assessment	Analytic, Diagnostic and Therapeutic Techniques and Equipment Category / Investigative Techniques Health Care Category / Health Care Quality, Access, and Evaluation / Quality of Health Care / Health Care Evaluation Mechanisms Analytic, Diagnostic and Therapeutic Techniques and Equipment Category / Investigative Techniques / Epidemiologic Methods / Data Collection Health Care Category / Health Care Economics and Organizations / Health Planning / Health Services Research / Health Care Surveys	Clinical Trials Epidemiologic Studies Feasibility Studies Intervention Studies Pilot Projects Program Evaluation Validation Studies
Developing World	Developing Countries Economics	Anthropology, Education, Sociology and Social Phenomena Category / Social Sciences / Internationality / International Cooperation Anthropology, Education, Sociology and Social Phenomena Category / Social Sciences Health Care Category / Health Care Economics and Organizations / Economics	Costs and Cost Analysis Economic Development Poverty Resource Allocation

All primary and secondary terms were combined in a PubMed search for publications satisfying the scope of the work, yielding a compound search string as follows:

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((((((("Evaluation Studies as Topic"[Mesh]) OR "Health Impact Assessment"[Mesh]) OR "Clinical Trials as Topic"[Mesh]) OR "Epidemiologic Studies"[Mesh]) OR "Feasibility Studies"[Mesh]) OR "Intervention Studies"[Mesh]) OR "Pilot Projects"[Mesh]) OR "Program Evaluation"[Mesh]) OR "Validation Studies as Topic"[Mesh]) AND (((((( "Mobile Applications"[Mesh]) OR "Text Messaging"[Mesh]) OR "Telemedicine"[Mesh]) OR "Cellular Phone"[Mesh]) OR "Mobile Applications"[Mesh]) OR "Text Messaging"[Mesh]) OR "Medical Informatics"[Mesh]) OR "Computers, Handheld"[Mesh]) AND (((("Developing Countries"[Mesh]) OR "Economics"[Mesh]) OR "Costs and Cost Analysis"[Mesh]) OR "Economic Development"[Mesh]) OR "Poverty"[Mesh]) OR "Resource Allocation"[Mesh]))
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Applying this search returned a list of 5476 publications, and applying each of the three AND-separated sections in turn returned lists in excess of 100,000 publications. Further analysis of those results would be well beyond the capacity of an individual. Inspection of the 5476 initial publications revealed that very few met our criteria for coverage of project execution and evaluation. The MeSH based search approach was therefore abandoned in favour of more general PubMed word searching, accepting that a smaller range of search words would be necessary. Nevertheless, this exercise was useful for determining topics that might occur in publications of interest.

3. Literature Search Methodology

To achieve our research goal by using PubMed word searches, a 3-step work plan was formed. Step 1 of the work plan was to refine a search strategy for finding appropriate publications. Step 2 of the work plan was to evaluate publications identified by the search strategy for their suitability for inclusion. Step 3 of the work plan was to perform analysis on the selected publications to extract success factor information.

To find publications of interest, an incremental sequence of search strings was applied, based on inclusion of the search word “m-Health” to be matched in the Title or Abstract fields of PubMed. The search strings and the resulting numbers of publications returned are shown in Table 2: note that a search for “m-Health” also matches with “mHealth”. It was decided that the basic concept “project evaluation” should be excluded from these searches, being the least reliable of the three basic concepts to be expressed directly in text. It was also decided to include the word “e-health” because numerous mHealth projects are badged as eHealth for convenience. However, it was observed that this increased the list size considerably and very many of the publications returned dealt with EHR systems. When it was found that the word “developing” constrained the search too strongly, it was dropped and subsequent searches concentrated on inclusion of words to address “mobile” aspects.

The final list chosen for Step 1 was aggregated from these searches. It is acknowledged that this list may not be a complete coverage of publications reporting mHealth projects in the developing world, but it was deemed large enough to provide a

set of representative example projects, while still being small enough to process the list entries manually for Step 2.

Table 2. Incremental PubMed search string results.

PubMed Search String	# Pubs
m-health[Title/Abstract]	187
(m-health[Title/Abstract]) OR (e-health[Title/Abstract])	1113
((m-health[Title/Abstract]) OR (e-health[Title/Abstract])) AND developing[Title/Abstract]	96
(mobile services[Title/Abstract]) OR (mobile computing[Title/Abstract])	183
(m-health[Title/Abstract]) OR (mobile health[Title/Abstract])	430
(m-health[Title/Abstract]) OR (mobile health[Title/Abstract]) OR (mobile services[Title/Abstract]) OR (mobile computing[Title/Abstract])	695

The inclusion evaluation process in Step 2 was designed to differentiate pertinent publications from extraneous ones. The main inclusion criterion was that the paper reported a mHealth project with some aspect of evaluation. For a publication to be included for detailed analysis, it had to offer clear descriptive content of the execution and evaluation of an mHealth project in a developing world setting, including detailed information on the type of mHealth technology used in the project, the scale at which it was applied, and any outcomes it delivered. The inclusion process was applied as a coarse-to-fine approach in two phases. In Phase 1, publications were judged based on their title and abstracts only; and in Phase 2, publications were judged based on their contents.

In Phase 1, the title of each of the 695 publications was read, to determine if it was clear that a project was being reported. Sometimes a publication title could determine directly whether it should be accepted, or rejected. If the title did not contain enough information to make that decision, then the abstract was read, and a decision was made from that information. After Phase 1, the 695 unique publications were classified into three groups: 543 rejected publications, 128 accepted publications, and 24 undecided publications. The 152 accepted and undecided publications were included in the rest of the review, because they were directly relevant to our study.

Despite efforts put into retrieving the publications, only 95 of the 152 publications were retrieved as the others were not available from the library network. Phase 2 of the inclusion process was applied only to the 95 retrieved publications. This time, each of the retrieved publication was read, and the inclusion decision was made based on the publication content. This resulted in 62 publications being excluded from further analysis, and detailed analysis was conducted on the remaining 33 publications.

4. Analysis of Publications

Each of the 33 publications was read in detail, and a critique was made in six categories: healthcare application areas, user acceptance issues, technology issues, government and organisation involvement, identified challenges, and desired characteristics. The categories were loosely derived from the main issues identified in the consideration of

background materials described in Section 1 above. These categories are described in more detail below, using examples from the 33 case studies.

4.1 mHealth application areas

mHealth systems cover a broad range of health services [11, 16, 24, 27, 30, 31, 33, 39], and they can be distinguished into the following areas:

- Health promotion, well-being education and chronic disease prevention such as lifestyle awareness, monitoring and assessment over mobile phone;
- Administrative support such as scheduling, billing, appointment booking and remote data collection;
- Decision support such as process patient information, diagnostic data management, medical reference, real-time information access;
- Clinical activities such as remote diagnosis and monitoring, reporting and lab test ordering;
- Education and research such as providing access to medicine and medical research;
- Disease and epidemic outbreak tracking and emergency care for natural disasters;
- Treatment support such as sending medication alerts, e-prescribing for repeat prescriptions, transmitting patient records and test results to clinicians, web access to database.

Specific clinical mHealth applications from developed world settings which may be applicable in some developing countries include management of diabetes, asthma, obesity, smoking cessation, stress, depression, mental health care, TB control, patient monitoring, and prenatal management [12, 14, 17, 26]. Out of these application areas, diabetes management has received the most attention. Most patient monitoring is focused on a specific type of health issue, such as cardiac conditions and mental disorders [22].

4.2 Technology issues

While increasingly many mHealth applications are released in the marketplace claiming to provide benefits to potential users, the literature shows the need for formal, standardised, systematic evaluation approaches to be applied to validate the claimed benefits [21, 23, 24, 26, 33, 36]. Most mHealth products are results of small-scale pilot projects that are not designed to demonstrate large-scale, long-term impacts. Their testing is therefore typically for feasibility rather than for validity in real clinical environments. Currently, there are more than 15,000 health-related apps (free and paid) on app stores. Due to the lack of evaluation standards, there is no study assessing and comparing the apps [17]. Overall, whether mHealth leads to better overall health outcomes will be unknown until rigorous, formal evaluations are defined.

In order to validate the claimed benefits and to allow direct comparison between similar products, repeatable systematic evaluation methods and gold standards need to be defined. The literature suggests that the following factors should be incorporated when defining evaluation methods. Firstly, among other quality measures, evaluation methods should include measures of user satisfaction and cost-effectiveness [18, 27]. Secondly, because mHealth products are built on technology that is rapidly evolving,

evaluations should also be long-term and continuous [21, 26]. Finally, the field of mHealth would be benefited greatly by establishing a mHealth evaluation registration like the one for clinical trials in the U.S. [23].

4.3 User acceptance issues

User acceptance is fundamentally important to the adoption of mHealth solutions. Users include both medical service providers and patients (customers). Although there is concern over healthcare workers' resistance to mHealth technology due to fear of job losses, the main question for medical service providers is how to integrate mHealth technology into their clinical practice and daily activities [24, 29]. The discussion in the rest of this section focuses on customers, who see costs and privacy as the two main challenges in adopting mHealth services.

Low costs promote usage; high costs can limit usage. Costs, including both hardware costs such as sophisticated phones and costs of using data network, have been a barrier [30, 33, 39]. A survey in China suggests that cost, presumably being passed on to the healthcare consumer, may potentially have an impact on the willingness to subscribe to pay-for-service mobile health programs [36]. Phone sharing is a way to keep costs down: in Ghana, the pricing structure for phone use makes this technique practical [21]. This, in turn, adds another complexity factor to mHealth privacy and data security.

Other barriers are related to mobile technology, such as small service coverage, screen sizes of mobile devices being too small, low quality of apps (e.g. app causes screen to freeze), malfunctioning equipment, limited battery power, limited memory, and quality of care received via a mobile device [12, 30, 31, 33, 35].

4.4 Identified challenges

It has been recognised that many mHealth barriers go beyond the complexity of the mobile technology itself and are related to broader health systems challenges in the practices of health personnel, the integration of new technology with existing information systems, sustainable funding and appropriate leadership to steer these shifts [27].

Confidentiality of information is a highly sensitive matter, as it is expressed as a concern appearing in every survey regardless of the communities [13, 16, 22, 24, 25, 26, 35]. In the U.S., migrant farm workers concern about confidentiality of information and trust of medical care centres. They fear being caught by law-enforcement agencies because of their immigration status [35]. Other vulnerable populations, such as those in HIV-prevalent areas, express concern about their health status being exposed.

Biomedical devices, especially for telemedicine and mobile health applications, should be sensitive to the issue of privacy in the same way as traditional healthcare services. Another common security issue that occurs with mobile devices is loss of the device due to theft or misplacement by the owner. Guidelines and laws on access rights to data, usage, and storage must be defined in order to promote mHealth.

Apart from privacy and security, connectivity and mobility are two challenges experienced by many users in developing countries. For connectivity, users worry about network reliabilities (which includes network failure and limited or inaccessible

to network) and coverage. Additionally, some remote areas also experience the problems of lacking electricity [22, 28, 32].

Mobility refers to frequent changes in phone numbers due to population movement. China Mobile, for example, reported that 71% of its customers frequently change their mobile phone numbers. Challenges therefore arise in keeping track of and providing medical care for the highly mobile population [15].

4.5 Government and organisational aspects

Government involvement and co-operations between governments and organisations are crucial, as study show that government support and sufficient funding are major factors behind successful deployment of mHealth in developing countries. There are varied levels of government involvement, and the general expectation is that governments should provide stewardship and leadership. These include building or improving network infrastructures, setting standards and guidelines for best practices, providing funding to organisations, industry and research, define strategies and policy, implementing public policies to decrease resistance to new technology, encouraging open standards-based technologies and workable approaches to interoperability, legislating laws to protect privacy and security; streamlining co-operations between local, regional and national governing bodies as well as academia and industries, evaluating mHealth products and healthcare service qualities, and enforcing standards compliance [15, 16, 19, 20, 22, 24, 27, 32, 33, 34].

Studies also found that there are factors that drive mHealth to success. These include socio-economic aspects and user acceptance of mHealth. It has been found that that socio-economic aspects, rather than technical aspects of mHealth, are a bigger influence on success. Technology must be affordable, reliable, acceptable to consumers and providers, easy to use and convenient and fitting in with existing lifestyles rather than demanding substantial changes in skills or existing practices [19, 33]. Systems do not work unless local staff have a real stake in the process from initial planning to full operation. It is also important to have strong, committed local leadership [18].

4.6 Desired characteristics

Experts are calling for a user-driven approach to adoption of mHealth. Patient-centric applications are easier to be adopted than technology-driven ones [33, 39]

It has been found that education was a positive and significant predictor as a complement to in-person doctor's office visit [37]. Short-term courses should be provided to both trainer and users, as sufficient training can improve acceptance of mHealth by society, patients, family physicians, specialists and administrators [19].

A concern shared by many patients in projects is the need for allowing communication between physicians in different institutions. A feature that facilitates this is to achieve 'one-patient; one-medical record', and health records should be accessible by both patients and carers [19, 22, 29]. It was found that the single most desired feature is that healthcare should be more patient-focused with personalisation of diagnosis and treatment for each patient [28, 29].

Other desirable features suggested for mHealth apps include the following:

- Personal health information to be transmitted via an unsecured network [28];
- Be reliable in resource-constrained settings [38];

- Be scalable to support home-based counseling and testing program [38];
- Be developed in an open-source methodology to lower the cost of future implementations [38];
- Work on a variety of handheld devices [38];
- Be implemented on a device that has built-in GPS [38];
- Seamlessly integrate with an open-source medical record system [38];
- Seamless transfer of information, integrated care, continuity of practice, extension to electronic health records, and links with existing healthcare processes [33];
- Tools to more rapidly and accurately assessed [13];
- The ability to better document and triage patients to additional services [13];
- mHealth devices should have higher precision, improved sampling frequency, fewer missing data values, greater convenience, and lower costs [26];
- The need for having a framework to ensure that projects align with national health objectives [40];
- Allow the use of photos for documenting physical findings [13].

5. Conclusion and Future Work

This paper has provided an analysis of literature on recent mHealth projects which have been evaluated sufficiently to provide relatively strong indications of success factors. While it was conducted with a defined methodology, it does not conform fully with the usual expectations of a 'systematic review', in that it has weaker inclusion criteria and does not analyse the evidence quantitatively. As a result of the review, a template for consideration of success factors in future project evaluations has been proposed. The template requires application in some new project settings to gain experience with more comprehensive evaluations of success factors, and to help develop it further.

A phenomenon of high interest in, but low usage of, mHealth apps has been observed in resource-limited settings [12]. This suggests that stakeholders (e.g. healthcare workers and patients) are not necessarily seeing mHealth as a substitute or as a complement to traditional healthcare services [37]. In fact, some people are concerned that use of technology would be detrimental to the human side of their interactions, and mHealth technology could be a threat to healthcare workers' job securities [13]. A deeper understanding of the relationship between healthcare workers and patients should therefore be gained before developing health programs.

Currently, most mHealth products have resulted from small scale projects, which do not show the social, organisational and cultural elements of successful implementation and adoption of information and communication technology [27]. Despite a vast number of available smartphone-based applications, very few comply with regulated/expert body guidelines [11]. In the US, the majority of cancer awareness and drug compliance apps require external, expert accredited peer-review. Selected mHealth apps need to be approved by the US Food and Drug Administration (FDA). In developing countries, the issues of treatment compliance and awareness have not been fully explored, and so there should be opportunities for future studies [22].

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