An IS contribution to the UN Millennium Development Goals: Next Generation Vaccination Management in the Developing World

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Abstract

More than 9.5 million people die in the developing world unnecessarily each year due not to a lack of medicine but due to poor information management. It is proposed that the IS Discipline could contribute to resolving this and similar global challenges by making a greater contribution to high impact and high visibility global issues such as the UN's Millennium Development Goals. In this paper we illustrate the potential for the IS Discipline to take a leading role in high impact issues by presenting an innovative design for a mainstream IS solution to an illustrative global healthcare issue through appropriate applications of mobile technologies, cloud computing, social networking and geolocation services.

Keywords

ICT for Improved Healthcare, IS Discipline Impact, Millennium Development Goals, Vaccination Management, Technology in the Developing World, m-Health

INTRODUCTION

As a discipline, Information Systems (IS) has been criticized for lacking focus on the transformational power of technology to address issues with high visibility (Agarwal and Lucas 2005). But what constitutes a high visibility issue? The United Nations has established eight goals as being of highest global priority. Known as the UN Millennium Development (UNMD) goals, these aim to: 1) reduce extreme poverty; 2) increase levels of primary education; 3) promote gender equality; 4) reduce child mortality; 5) improve maternal health; 6) combat disease, including HIV/AIDS, malaria and tuberculosis; 7) improve environmental sustainability; and 8) develop a global partnership for further development (UN 2010). The governments of 196 countries have accepted these goals formally as being high priority issues requiring urgent global action (ibid). By any measure, these goals can be considered as high visibility issues that should warrant the attention of the IS discipline. Exactly how and where the IS discipline could contribute, however, is not clear.

Three of the challenging UNMD goals (4, 5, and 6) focus on improving healthcare in the developing world, which shows the level of urgency and the high priority of healthcare related issues. A comprehensive analysis of the diversity of healthcare issues and consideration of IS-enabled solutions corresponding to each healthcare issue is beyond the scope of a single paper. Therefore, the scope of this paper is restricted to present analysis of a single healthcare case that illustrates the potential for a significant contribution by IS researchers. It is not the contention of the authors that lessons from a single illustrative case can be generalised across all healthcare issues – just that a single illustrative example may suffice to raise the levels of interest and awareness in researchers and to motivate them to engage with issues that require their active participation for resolution.

This paper aims to raise awareness in the scientific community and with IS professionals about how innovative applications of current technology may be applied appropriately to help address issues acknowledged as being of the highest priority for global attention: the UNMD goals. More importantly, this paper will focus on examining the potential for IS to make significant contributions to improving healthcare. The paper will focus on improving preventable diseases via vaccination management in developing nations by proposing formal analysis of an integrated information management and technology solution called MOBIVAX to cater for a range of healthcare challenges.

Despite major efforts little progress has been achieved in vaccine provision, each year 9.5 million people die from well-understood preventable diseases, nearly all live in developing countries (WHO2008, WHO and UNICEF 2008). In fact, the root of this problem stems not from a lack of vaccine availability but from poor vaccine and vaccination management as illustrated by the following issues: People travel large distances under difficult conditions to be vaccinated only to discover there is no vaccine available at that time; People forget to be immunised and to immunise their children; Doctors, health workers and administrators cannot predict or manage demand especially in crises or epidemics. A key challenge is the design of robust, innovative and ICT-

enabled technological information management solutions that can operate on rudimentary infrastructure available in developing countries.

MOBIVAX is an adaptive agent-oriented information system designed to use readily available mobile technologies, ubiquitous cloud computing and geolocation services to realise effective identity management, real-time data collection and control, and supply chain management, which in turn will improve vaccination management in remote and poor areas. To be more precise, MOBIVAX offers a wide range of functionality including patient alerts for vaccination when supplies are available at certain geographical locations, simple but necessary doctor-patient communication, patient vaccination tracking and monitoring, vaccination supply management, demand and supply prediction for improving a health systems, and the ability to anticipate physical requirements. Thus, MOBIVAX will generate new and considerable value in a high visibility application for the international community through the implementation of improved information management.

In this paper we describe: the potential for IS to be applied to assist global initiatives to improve healthcare; the state of the art in vaccination management; and the ongoing challenge of improving the prospects of millions of people who die each year from preventable diseases that may benefit from improved knowledge management. We highlight the obstacles to adoption and some strategies that can be used to overcome them. We propose MOBIVAX as a potential solution that relies on existing technology such as the large and growing availability of mobile phones and services in the developing world. A key feature of the MOBIVAX design is its flexibility in accommodating a wide variety of user skills, levels of literacy and technology capabilities, typically found in developing nations. The main design principle guiding our design choices is the need to accommodate the wide variety of mobile technologies, which are prevalent in the developing world from older-style, basic mobile phones to the latest, sophisticated phones that might be RFID-enabled or have GPS onboard. Even smart phones are making their way into communities in developing countries as their costs come down dramatically and they become more and more affordable for families to share (Wave 2009). These mobile phones also have considerable onboard capabilities for storage and to support communication with people who are illiterate using pictures and icons.

In the following sections we analyse the problem and its context, describe our research design, identify a set of requirements, provide a comparative analysis of existing state-of-the-art systems, describe the architecture and design of MOBIVAX in detail, identify some of the key challenges for adoption and strategies to address them, highlight the impact and benefits of MOBIVAX, and discuss the contribution to the IS Discipline.

UNDERSTANDING THE PROBLEM AND ITS CONTEXT

1. Infectious disease in developing countries is unacceptably high

Infectious diseases account for nearly 25% of all deaths worldwide (WHO 2003). Infectious diseases are now understood to be major causes of the poverty and economic underdevelopment that characterize the world's poorest countries. Development and deployment of new vaccines to prevent infectious diseases in developing countries have therefore become high priorities in the global health agenda (Sachs 2002, Clemens & Jodar 2005).

2. Vaccination can reduce death rate

Many infectious diseases prevalent in the developing world can be prevented by vaccination (WHO 2003). However, each year at least 2.5 million adults and 7 million children die from preventable diseases mainly due to lack of vaccination even though vaccines are readily available (WHO 2003). People in poor and remote regions find it difficult to manage the timing of crucial vaccinations. This problem is particularly acute in the poorest and most remote regions of the world, contributing factors to the high death rate in those areas and subsequent loss of productivity. The challenge is not the cost or even the availability of vaccines but the effective management of their delivery due to the complexity of vaccination management in the developing world e.g. low levels of education and systems to manage the supply and demand of vaccines.

3. Current efforts to solve this problem

In the past decade, several state-of-the-art mobile health (m-Health) applications have been deployed in developing countries to improve infectious disease treatment and management (See in Table 1). Most of them have made full use of mobile technologies, even sensor networks related technology such as RFID which is used to develop identification and real-time control systems in mobile contexts. Despite these achievements, key challenges remain which restrict their widespread deployment in developing countries. Some common shortcomings in m-Health systems are as follows:

- **Narrow attention and scope:** This issue is found particularly in problem scope, usage scope and the targeted users. The majority of existing systems concentrate on narrowly defined issues, which restrict the scope of applications in this complex context. As to the problem scope, they tend to focus only on the treatment and data collection of urgent infectious diseases outbreaks such as TB or HIV using

mobile technology, and some of them focus on functional areas like diagnosis only. Few applications can support vaccination management in real-time. For usage scope, most existing systems can only be applied at a national level rather than region or global level. Lastly, most of these applications target healthcare staff and wealthy patients not ordinary poor people.

- **Low level of mobility**: Although all of the applications on Table 1 are health applications that use mobile technology, none of them have realised universal mobility that allows people to obtain access to these services without geographical restriction.
- **Lack of alert mechanisms:** A basic function of mobile phones is message delivery. Although sending messages has been attempted, proactive message alerts have not been universally accepted and integrated into system designs (See Table 1).
- **Lack of doctor-patient communication:** No existing system supports direct doctor-patient communication for treatment initiation or follow-up.

Table 1. A Comparison of State-of-the-Art m-Health Applications

Feature	UHIN	MDOT	SiMpill	Microscopy	CelloPhone	EpiSurveyor	CORE Institute®
Problem targeted	TB	TB and HIV/AIDS treatment	TB and HIV/AIDS treatment	CellScope for Disease Diagnosis	blood count, diagnosis for a number of diseases	monitor which areas needed to be vaccinated, contain disease outbreak	monitor their own condition
Single integrated technology	Yes	Yes	No	No	No	Yes	No
Usage of Mobile technology	No	Video-based mobile phone	Mobile mechanism on pill bottle	external camera+ Special camera-based mobile phone	camera cell phone	Common cell phone	RFID skin patch sensors
Sensor network	No	No	No	No	No	No	Yes
Easy adoption	Yes	Yes	No	No	No	Yes	Yes
Government program promotion	No	No	No	No	No	No	No
Usage scope	National wide	National wide	Worldwide	worldwide	worldwide	national wide	worldwide
Targeted users	health worker	healthcare workers patients	healthcare workers patients	People who can use mobile phone	People who can use mobile phone	People who can use mobile phone	People who can use mobile phone
Real-time data collection	No	No	No	No	No	No	Yes
Identification	No	No	No	No	No	No	Yes
Message alerts mechanism	No	No	Yes	No	No	No	Yes
Simple Doctor-Patient Communication	No	No	No	No	No	No	No
Main function	1.Data collection 2.Deliver medical education	1. monitor patient adherence to medication 2. deliver text and video health messages	a pill bottle automatically delivers a message to a central server when opened	Disease diagnosis	Disease diagnosis	1.Track disease outbreaks 2.monitor drug supplies 3.manage vaccination programmes.	monitoring of temperature, blood pressure and other conditions

4. Why we need a better system

A new generation of vaccination management systems in developing countries will lead to the following significant benefits:

Social benefits: Ease the burden of limited health resources and improve the sustainability of development. People are increasingly impatient with the inability of health services to deliver. Few would disagree that health systems need to respond better – and faster – to the challenges of a changing world (WHO 2008).

Technology innovation: Significant value can be released through technology-enabled innovation. For example, innovation can help to overcome problems associated with communicating health and vaccine information to people in remote areas in need of the information.
Business/financial opportunity: New innovative systems have the potential to generate considerable value to the business world. M-Health and telemedicine represent an attractive opportunity for a range of value-add services in health but also other areas from bartering to banking. In Africa alone, there were 80 million new mobile phone subscribers in 2007 and by the first half of 2008 an additional 46 million were added[1]. The UN also predicted that cell-phone ownership will reach 5 billion in 2010 with the highest growth in developing countries (Gates foundation 2010). Rapid growth in deployment of mobile phone in developing countries will enable increased applications of mobile telemedicine in general, and mobile vaccine management in healthcare.
Mobile eGovernment: New innovation systems and platforms will accelerate the move to eGovernment services currently out of reach for remote and poor areas. Infrastructure can provide a bridge to deliver important guidelines and strategies ranging from new government support programs to global healthcare strategies.

RESEARCH DESIGN

This paper presents a technology-enabled solution relying on systemic integration between technology, functionality and costs in its design (Clark, et al., 2007). The research questions and hypotheses are developed primarily from scholarly works seeking to specify the focus and scope of the IS discipline (including. Benbasat and Zmud 2003, Weber 2003, Robey 2003, Hirschheim and Klein 2003, Galliers 2003, Descanctis 2004, Agarwal and Lucas 2005, and Sidorova et al. 2008 among others), as applied to the healthcare domain established in the preceding section. A series of research questions are proposed to assist in focusing the work.

Research Question 1: Can IS be applied beneficially to help resolve global issues of the highest visibility?
Research Question 2: If so; how can IS be applied beneficially to help resolve global issues of the highest visibility?
Research Question 3: If so; where can IS be applied beneficially to help resolve global issues of the highest visibility?
Research Question 4: How could the contribution of IS applications applied to resolve global issues of the highest visibility be evaluated?

These research questions are central to the IS discipline, a study of IS academic literature published between 1985 and 2006 shows that IS has maintained a relatively stable research identity that focuses on how IT systems are developed and how individuals, groups, organizations, and markets interact with IT (Sidorova et al. 2008). This paper focuses on how IT may interact with groups, organizations and markets on issues of high visibility and high impact. The research questions are addressed through formal analysis of the problem and its domain, and a detailed, objective description of IS' potential contribution to its resolution.

A COMPARISON OF EXISTING SYSTEMS AND TECHNOLOGIES

Vaccination management systems are tools for vaccine delivery, tracking, and data collection, supply chain management, and business intelligence. Most existing systems focus on specific issues in the vaccination management process/workflow e.g. person identification, or in meeting the demands of specific health problems, e.g. H1N1. By way of introduction we briefly describe three exemplars and then undertake a comparative analysis of them in Table 2.

1.Vaccine Management System (VACMAN[2]): is a tool for customizing, recording, transmitting, and managing vaccine data, which uses a database management system (DBMS) based on State, City, and Territorial Government and specific immunization programs called Projects. Only Projects designated by CDC (National Center for Immunization and Respiratory Diseases US Govt) are eligible to use VACMAN. It can be used to order, and optionally to track and record information relating to publicly funded (Vaccines For Children program (VFC), 317 Grant (G317), and state/other) vaccines.

2.Vaccine Management Business Improvement Project (VMBIP[3]): was one of the first "top-to-bottom" reviews of vaccine ordering and distribution, deriving from the requirements of vaccine management and inventory visibility needs under the Vaccines For Children (VFC) programs which dates back to 1994. It creates a streamlined approach to vaccine management and enables rapid responses to changes in vaccine supply and demand at the national, state, or local level. Major critical components include: centralized distribution, vaccine management technology system, funds management, and stockpile.

[1] http://www.ericsson.com/developer/sub/articles/other_articles/090924_mHealth
[2] Vaccine Management System (VACMAN), National Center for Immunization and Respiratory Diseases http://www.cdc.gov/vaccines/programs/vacman/ [viewed July 15, 2010]
[3] Vaccine Management Business Improvement Project (VMBIP), http://www.cdc.gov/vaccines/programs/vmbip/ [viewed July 15, 2010]

3. eMET[4]: is a solution for mobile H1N1 vaccine administration, released in 2009. It integrates patient-tracking software on a mobile platform to assist in the administration of the H1N1 vaccine due to its extremely high demand. It enables healthcare providers to effectively prepare for and manage mass H1N1 vaccine administration at locations such as hospitals, vaccination clinics or schools. With eMET, patients are provided with a bar-coded wrist band or other form of identification that includes vital information which is used to create an electronic medical record. The patient ID is entered into the eMET central database, creating a way for medical personnel to track and prioritize all patients, based on individual needs. The system automatically transmits all patient data scanned or entered into the mobile computer to the patient's record in the eMET database, ensuring that physicians have up-to-date information and can follow up with the patient as needed. It is also designed with easy-to-learn technology so all medical staff can quickly adapt to the system.

Table 2 summarizes the main features of these three state-of-the-art systems in vaccination management in terms of function, technology, services and authority requirements.

Table 2. A Summary of State-of-the-Art Vaccination Management Systems

Feature	**VACMAN**	**VMBIP**	**eMet**
Problem targeted	Order, optionally to track and record information of vaccines	Support rapid responses to changes in vaccine supply and demand	H1N1 vaccine administration
Services level	national	National	global
Vaccines alert services	No	No	No
Doctor-patient communication	No	No	No
Training & Education services	No	No	Yes
Supply chain management	No	Yes	Yes
Patient Vaccination Tracking and Monitoring	Yes/Optional	Yes	Yes/Optional
Demand and Supply Prediction	No	No	Yes/General level
Data collection	Yes, only for vaccines	Yes, only for vaccines	Yes, both vaccines and vaccination
Users targeted	Patients	Mainly children	Healthcare workers patients
Mobility	No	No	Yes/wristlets+ specialized mobile device
Geolocation	No	No	No
Data store and computing style	Online Database	Online Database	Distributed database
Single integrated technology	Yes	Yes	No
Sensor network	No	No	Yes
Government Program Promotional materials	No	No	No

From the perspective of functionality, eMet provides the most services, covering most of the required functions listed above, with the exception only of the alert and doctor-patient communication services. VACMAN mainly focuses on booking, tracking and recording information of vaccines, and VMBIP focuses on vaccine supply management during the vaccination process. However, two key requirements have been realised in the three applications.

eMet has technological advantages over its rival applications. It not only puts mobile devices and technologies into practice, but also uses a distributed database to provide data storage and processing in a mobile environment. These form the basis of its capability to support a sensor network. Despite eMet's merits, its use of wristlets may inhibit its general deployment due to the association of wristlets with HIV patients. It should be noted that the "Geolocation" feature is not provided by any of the three applications.

Services scope in the table includes service level and users targeted. Service level here refers to the level that the application can maximally reach. Due to the initial design purpose, VACMAN and VMBIP are all national projects in the US which can only improve vaccine management processes at the federal, state, and local levels.

[4] http://bit.ly/eMetV

In contrast, although eMet was developed in the US, its mobility features allow it to overcome geographical obstacles to provide services worldwide. In addition, targeted users in eMet include health staff and decision makers as well as patients, which increases its market potential.

Finally, in Table 2 important features related to authority requirements include Government Program Promotion and Demand and Supply Prediction. The Government Program Promotional materials feature is provided by any application and only eMet provides a general level demand and supply prediction feature – a critical omission that could be addressed by appropriate application of IS.

Key Service Requirements of Vaccination Management in Developing Countries

Analysis of m-Health applications ranging from infectious disease treatment (Table 1) and vaccine and vaccination management (Table 2), some typical issues associated with mobile vaccination (m-Vaccination) in developing countries can be identified.

Alert service: Healthcare workers and the general population in developing countries would benefit from alerts for: immunization schedules, vaccination supply information for each medical centre, and recommendations and guidance from doctors under ordinary (e.g. measles) and exceptional (e.g. epidemic) circumstances. Alerts would assist the situation where people fail to have or to complete a vaccination program due to lack of awareness and as a result they cannot make informed decisions about their family's vaccination management.

Education and training service: In developing countries ordinary people need to have access to the latest healthcare knowledge and skills to improve the quality of life. On the other hand, an important reason that healthcare including vaccination is at a low level lies in the lack of professional healthcare staff. How to deliver timely and ease-to-follow education and training to local healthcare staff is another worthy goal. This would create an opportunity to develop a healthcare learning ecosystem based on practical vaccination management.

Tracking and monitoring service: The capability to maintain up-to-date patient vaccination data is crucial to provide appropriate and safe medical treatment. This information is also valuable for government authorities and the World Health Organization for strategic planning and management.

Localization service: This requirement serves both patients and health sector workers. People in need of vaccination must be informed of locations (and directions to those locations) that possess the vaccines they currently need. In addition, in case of emergency, national and international health organisations also require effective ways to locate and assist people at risk quickly.

Data collection service: Data related issues are core to the design of information systems. Data collection in developing countries is a bottleneck in vaccination management. Data must be collected, processed, stored and retrieved in real-time, accurately, safely, securely, efficiently and in cost effective and privacy protecting ways.

Real-time control service: Some requirements listed above will be closely related to real-time control, such as tracking, monitoring, and localization. This service enables healthcare staff and decision makers to obtain the latest information without the need for face-to-face interaction. It will play a key role in addressing and managing emergency situations such as the outbreak of disease and to identify those at risk.

Integrated technologies: Ease of deployment and use by poorly educated users will be play a crucial role in attaining the necessary level of widespread adoption. The vaccination system must be flexible enough to be able to be implemented on the current infrastructure available in different countries rather than rely on the need to develop new and sophisticated technology.

High level of mobility: Two points need to be considered in this issue. One is the mobility of service delivery that focuses on how to deliver healthcare services to the areas no matter how isolated or hard they are to reach. The second is the mobility of data stores and computing power, which focuses on how to process distributed data more effectively and efficiently.

Universality of usage: The system is to be used by all kinds of people (children, adults and seniors), people with special needs (patients, people with low literacy), healthcare staff and policy makers.

Decision-making support: One criterion for successful vaccination management is the extent to which it can help patients, heath workers and health administrators make more effective and more timely decisions. Vaccination management is an area where high quality information and prediction capabilities based on IS can not only lead to better decision making but it can save millions of lives. Real-time access to patient data will also create an environment in which policy makers can best decide where and how to spend their limited resources (Wave 2009).

We now show how these key service requirements for vaccination management might be addressed and implemented in an innovative Information System - MOBIVAX.

MOBIVAX: REQUIREMENTS, ARCHITECTURE AND DESIGN

MOBIVAX is an adaptive agent-oriented system for a standard mobile phone which can realise identity management, real-time control, data collection and prediction for vaccination management in remote areas. It relies on existing technology deployed in an innovative way.

Requirements

The goal is to develop a new breed of vaccination management systems with key requirements that include low cost, adaptability, and mobility. There is a wide variety of infrastructure already in place in the developing world and MOBIVAX is designed to offer several levels of service; core, basic through to high determined by the sophistication of the technical infrastructure available. Core services include identification management, vaccine alerts, and information about the availability of vaccines. These services improve as the capability of the technology available is enhanced. If the mobile phone that a person or family has access to is Radio-frequency identification (RFID) enabled then more robust Identity Management is supported, if it possesses GPS capabilities then the geolocation services that notifying patients of a new supplies of relevant vaccines can be pushed instead of relying on user pull. Extensive use of cloud computing can be used to improve mobility and protection of data and reduce the cost of data storage, processing, analytics and prediction (Yang and Tate 2009).

MOBIVAX four main features are:

1. ***Mobile Identity Management*:** Core service requires a mobile phone number only, basic and above requires RFID enabled mobile phones. Currently, a number of m-Health applications have realised smart identification and tracking with the help of RFID labels or tags, which are identified by a Unique Identification Number (UIN). For example, eMet in the US and Hospital Patient Management Systems (HPMS) in Australia (Chowdhury & Khosla 2007) are two typical examples in this regard. However, RFID wristlets are not secure and are easy to damage and lose, and as a result they are not suitable for deployment in developing countries. Wristlet also generate a social stigma as they have been associated with AIDS treatments. RFID-enabled mobile phones, on the other hand, offer enormous scope for high performance identity management particularly for illiterate users who cannot write their identity details. RFID-enabled mobile phones can be used as both a RFID-reader and receiver.
2. ***Alert Services:*** This can be basically achieved using a common mobile phone. MOBIVAX has proactive capabilities and can automatically alert people that it is time for their vaccinations and to inform them where the vaccine they need is currently available. Health workers and administrators can also alert people to the availability of new vaccines or new health services.
3. ***Real-time Data Collection and Supply Chain Management:*** MOBIVAX supports inventory management at the initial stage and will eventually integrate supply chain management into its wireless infrastructure. Data collected through the client can be directly sent through a RFID-enabled mobile phone or device, or be stored in the cloud provisionally then transferred it to the required position when needed.
4. ***Geolocation services:*** As far as we know, geolocation services are an innovative feature in MOBIVAX. These services will be mainly applied in tracking and localizing people and health sector workers. Users can be guided to unfamiliar places for vaccination to increase the possibility of immunization. For health sector workers, when outbreaks and health threats occur, geolocation services will help them respond more effectively and efficiently in emergency situations.

Architecture and Functionality Design

All the functions involved in MOBIVAX designed in three layered architecture as illustrated in Figure 1 below.

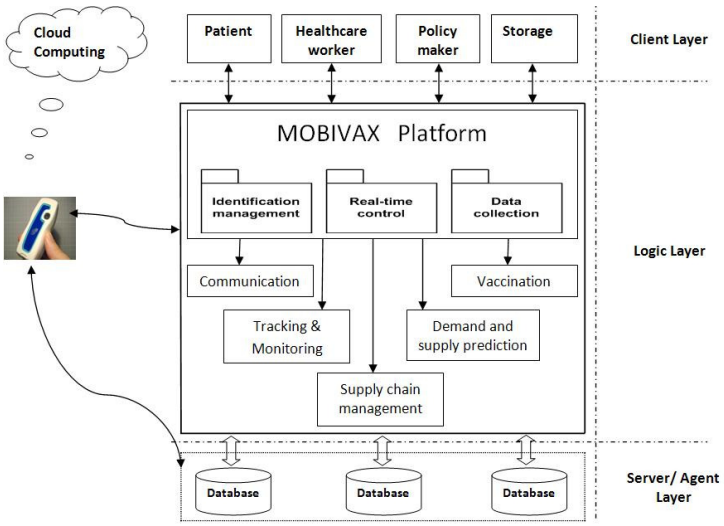

Figure 1: MOBIVAX Architecture and Design

The key functions of MOBIVAX are divided into identification management, real-time control and data collection, and analytics and prediction, which support the following main function components:

1.Doctor-Patient Communication

This component is responsible for communication and collaboration between patients and healthcare staff in terms of making appointments, vaccination alerting, general queries, vaccination ordering and feedback.

For the alert service, MOBIVAX will use a sensor network or a person to initiate proactive messages through a message server to a mobile phone. Alert services have been designed for the following scenarios:

- When new vaccines that patients need arrive, alerts can be automatically sent to the appropriate number of people, and confirmation of appointments received via mobile phone. Each available vaccine can be matched with a patient ahead of time.
- In cases where vaccines can be ordered directly by patients, alerts regarding supplies can be broadcast.
- When new types of vaccines for specific patients are available.
- When vaccines are discovered to be faulty or damaged and appointments need to be cancelled.
- Health workers can alert patients to new information after the vaccination as follow-up.

2.Patient Vaccination Tracking and Monitoring

Patient tracking and monitoring are related to real-time control and mobile phone tracking. Examples of tracking in the vaccination process include:

- Patients go to the right clinic at the right time - geolocation is used to find the place to be vaccinated after the alert is received.
- Patients register through mobile phone numbers or RFID-enabled mobile phone.
- Doctors obtain the relevant vaccines and patient records are updated.

3.Vaccination Supply Management

This function includes vaccine inventory management and vaccination available management. At the highest level, RFID-enabled mobile phones can automatically monitor and update vaccine and vaccination data through RFID and cloud computing technologies (Yang and Tate 2009). Two typical processes are:

- When new vaccine arrives, RFID-enabled mobile phones can obtain detailed information of the new batch of vaccines and update the database with their availability.
- When patients are vaccinated, patient information including the information about their vaccines are recorded through RFID-enabled mobile phones. If faulty vaccines are found, alert services are triggered.

4.Demand and Supply Prediction

This function will be specifically used by decision makers in the healthcare and government stakeholders to improve tactical and strategic planning and management of the vaccination process.

ADOPTION, IMPACT AND EVALUATION

To successfully adopt and implement the proposal, three key factors will play a crucial role: mobile phone penetration in developing countries, technology design and integration, and training for usage.

***Mobile phone penetration*:** Foreseeable high mobile phone penetration in developing world will be a significant advantage to the successful adoption and implementation of MOBIVAX. According to the UN's prediction that cell-phone ownership will reach 5 billion in 2010, with most growth in the developing world. This extraordinary penetration of mobile phones and connectivity offers an unprecedented and profound opportunity to access vast populations, including those previously hard-to-reach populations in rural areas (Gates Foundation 2010). Mobile telephony has become increasingly commonplace in the developing world and this trend will bring high degrees of ownership in those areas in the near future – see Table 3 below.

Table 3: Mobile Phone Penetration trend in developing world

Area	Population (billion)	Cell phone users (billion)	Ownership rate	Growth rate (per year)
India	1.2	0.427	35.5%	33.5%
China	1.3	0.547	42.1%	36.0%
Africa	0.98	0.371	37.8%	27.9%
Total	3.48	1.35		

***Technology design and integration challenge*:** RFID-enabled mobile phones have been applied in several applications and have proven their potential in practice, but questions around how to integrate cloud computing into a wireless infrastructure remain.
***Training for usage*:** is also critical to successful implementation with two situational contingencies influencing the effect of training on adoption and successful implementation: the complexity of technology and task interdependence (Sharma and Yetton 2007), where complexity and interdependence are both high.

Initial evaluation of these proposed contributions needs to address the outcome targets set by the UN. MD Goal 4 has the target to reduce the under-five mortality rate by 2/3rds between 1990 – 2015 (MDG 2010, p 26); MD Goal 5 has the target to reduce the maternal mortality ratio by 2/3rds between 1990 – 2015; and MD Goal 6 has the target to combat disease by halting the spread of specific diseases including HIV/AIDS (2 million deaths in 2008 – MDG p. 40); tuberculosis (1.8 million deaths in 2008 – MDG p. 51); and malaria (863,000 deaths in 2008 – MDG p. 46). Progress towards these targets has been significant: immunizations with retroviral and other interventions against measles, malaria, tuberculosis, and HIV have reduced child deaths from 12.5 million in 1990 to 8.8 million in 2008 (MDG p. 4), but more needs to be done. The growth in access to modern technology opens up greater opportunities for IS contributions. Mobile telephony continues to expand in the developing world such that by the end of 2008, cellular subscriptions per 100 people had reached 50% (MDG, p. 4).

Associated metrics for evaluation include the social impact and the impact of technology. The social impact aims to ease the burden of limited resources in developing countries and to reduce the suffering and death arising from preventable disease. The technological impact considers the development of mobile medicine and the supply chain management in difficult and remote areas.

An interim objective is to develop a standard platform for vaccination management. The long-term goal will be to develop a wireless infrastructure to allow interoperability among different m-Health applications. At an operational level, a balanced scorecard approach may be applied to integrate assessments of benefits from operational, financial, social and environmental perspectives (Kaplan and Norton 1992, Figge et al. 2002).

CONCLUSION AND DISCUSSION

In response to calls for the IS discipline to make a greater contribution to high visibility, high impact issues (e.g., Agarwal and Lucas, 2005) this paper aims to raise awareness in the scientific community and with IS professionals about how innovative applications of current technology may be applied appropriately to help address issues acknowledged as being of the highest priority for global attention: the UNMD goals. Selecting a specific issue to illustrate the potential contribution by IS, we have analysed the state and significance of vaccination management in the developing world and provided a comparative study of existing state-of-the-art information systems. We identified the key features needed to address the challenge of improving vaccination management and proposed an innovative system, MOBIVAX, that utilizes existing technology in innovative ways to satisfy the requirements. Since the system uses only currently available infrastructure it provides simplicity and low cost implementations with the capability to adapt as existing infrastructure is expanded to utilise technologies such as RFID-enabled and smart mobile phones.

In this paper we also have provided evidence to support four of our research hypotheses, namely 1a, 2, 3, and 4. Our contentions were that: IS can be applied beneficially to make a significant contribution to the resolution of global issues of the highest visibility; IS can be used to design a flexible, mobile, efficient cost effective innovative vaccination management system using existing infrastructure; and innovative IS systems can deliver substantial benefits by transforming the quality of life for millions of people globally.

The proposed IS design is limited in that it remains conceptual at this stage, but the conceptual framework and implementation, it is suggested, is adequate to illustrate how IS has the potential capability to address high visibility issues with global impact.

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