Enhancing Immunization Healthcare Delivery through the Use of Information Communication Technologies

Agnes Semwanga Rwashana and Ddembe Willeese Williams

The role that Information Communication Technologies plays in improving the efficiencies and effectiveness of healthcare delivery and particularly immunization coverage through the use of information and communications technologies has been well established. The paper examines the effectiveness of current immunization systems and challenges, then goes on to examine broader views regarding the interplay of political, social, economic and technology forces that influence the level of immunization coverage. It is this inter-play of forces that makes the problem of immunization coverage complex and also affected by time delays to deliver some of the functions. The paper presents the challenges in the current immunization system and shows how information communication technologies can be used to enhance immunization coverage. The paper suggests a framework to capture the complex and dynamic nature of the immunization process, to enhance the understanding of the immunization health care problems and to generate insights that may increase the immunization coverage effectiveness.

1. Introduction

The role Information Communication Technologies (ICTs) play in improving the efficiencies and effectiveness of healthcare delivery has been well established in the more developed and industrialized parts of the world, however, the same is not true for developing countries in general. Traditional and new ICTs are being used to diffuse information to rural communities in developing countries (Gurstein, 2001). Developing countries lag behind in advances in information technologies over the internet, however, they are increasingly being used to increase the availability and quality of healthcare in remote areas, disseminate healthcare information to the public and provide knowledge to the healthcare professions (Musa, Meso and Mbarika, 2005).

The government of Uganda has designated ICT as a priority policy area and is committed to harnessing the ICT sector for national development (Scan-ICT Project, 2002). ICT role is generally low in the Ugandan healthcare environments, although most of the major hospitals and the medical schools use computers for administrative purposes, but only in limited ways. ICTs have greatly impacted the health sector and are increasingly being used to improve the administrative
efficiency of health systems. Service delivery in the health sector is still a challenge in many developing countries. Some of the issues that are faced by the health services include deficiencies in service delivery, growing gaps in facility and equipment upkeep, inequity of access to basic health services by the communities, inefficient allocation of scarce resources and lack of coordination among key stakeholders (Fraser and McGrath, 2000). The use of ICT technologies can increase the quality of health service delivery by providing reliable information and effective communication and efficient use of resources (Semwanga and Williams, 2006). The availability of information and communication techniques enables impoverished communities to access health care services which otherwise would be difficult under conventional healthcare systems.

2. Background

Preventable childhood diseases such as measles, polio and premature deaths still occur particularly in the developing countries due to low immunization coverage (WHO, 1999). In a study to evaluate new tendencies and strategies in international immunization, Martin and Marshall (2002) suggest that “failure to immunize the world’s children with life saving vaccines results in more than 3 million premature deaths annually”. According to Mbarika (2004), healthcare is one of the most fundamental needs for Sub-Saharan Africa. Various approaches have been applied to understand immunization coverage problems, however, there are still acknowledged deficiencies in these approaches and this has given rise to research efforts for alternative solutions including the need to adopt new technologies to address some of these problems. Primary healthcare has the role of monitoring of outbreaks and providing optimum continuous care for many diseases and is characterized by uncertainty, complexity, time delays and competitive stakeholder viewpoints. ICTs offer a platform for health education which plays a major role in the prevention of many diseases.

Definition of key Terms

To put this paper into context this section defines three key terms used in this research, namely immunization coverage, healthcare system, Information and technology Communications.

Immunization coverage can be defined as the proportion of a population that has been vaccinated against a given infection at a particular age (Edmunds et al., 2002). Infant immunization is done against childhood diseases such as: poliomyelitis, diphtheria, neonatal tetanus, measles, mumps, and congenital rubella. A target of at least 95% immunization coverage of children at 2 years of age is achieved in western countries, while about 60% is achieved in developing countries (WHO, 1999). Information is not always easy to obtain and some countries simply use immunization records or certificates held by schools or Health centers. If the number of children vaccinated in a district or country is not known, the number of doses administered, distributed or imported may be used to estimate the
number who received vaccine, however the problem is more difficult to solve for
immunizations given in multiple doses.

The second key term used is **healthcare system**, used to describe the organisation
of human, physical and financial resources in the provision of health services to
a given population. A healthcare system may include links between hospitals,
home care agencies, long term care facilities and people (physicians, nurses, social
workers, health care providers).

The third term, **Information Communication Technologies** is used to define
tools that facilitate communication, processing and transmission of information
and the sharing of knowledge by electronic means. This encompasses the full range
of electronic digital and analog ICTs, from radio and television to telephones (fixed
and mobile), computers, electronic-based media such as digital text and audio-video
recording, and the Internet, but excludes the non-electronic technologies.

The rest of the paper is presented in these sections: Section three, presents
compelling arguments why immunization system should adopt ICTs. Section
four highlights some of the cases of applications of ICT in rural areas. Section
five presents the research design pursued, while section six shows the key findings
from data collection and other authors. Section seven presents the status of ICT,
key challenges in healthcare, proposed ICT solution, benefits and challenges of
ICT adoption and diffusion.

3. Why Immunization System should adopt ICT

Healthcare services in developing countries such as Uganda, in particular
immunization services are provided through a decentralized system consisting of
geographically spread health centres, regional hospitals which are categorized into
health districts and health sub-districts with various roles as shown in figure 1
below:

**Fig 1. The Ugandan Immunization System**

As illustrated in figure 1, the development of health plans, policies
and service delivery are channelled from the national level through the
district, health sub-district, health centre right up to the community. The
decentralized health care system makes the management and
process of planning easier, however, this requires an effective feedback
system, supervision, monitoring and reporting if the goals of the system
are to be achieved.
Each health centre has its own immunization schedule and plans but it is desirable that the different health centres/hospitals offering immunization services work in a cooperative environment and be able to exchange data and information on service delivery. In order to improve the efficiency and effectiveness of immunization health services provided in such a distributed structure, it is vital that information is shared since it is a vital resource to the management of any organisation. Effective data collection and sharing of information can be enhanced through the application of information and communication technologies.

Health care services like any other business involve a lot of transactions such as importation and delivery of medicines; construction of hospitals and clinics; hiring and deploying staff; processing and payments of staff salaries. Other activities include the purchase and delivery of food for patients; collecting and analysing disease spread data in a country, and educating the community about good healthy living (Wasukira, Somerwel and Wendt, 2003). ICTs provide a competitive leverage to respond to the challenges of maintaining up-to-date immunization records (fully immunized and drop outs), tracking of facilities and vaccines, stock management, vehicle tracking and human resource management required by the immunization system.

4. Cases of ICT in Healthcare Delivery

The use of ICTs is rather limited in healthcare particularly in developing countries where healthcare systems are mainly used for storage and transportation of textual information using stand-alone computers. Some of the healthcare systems that have been developed include billing, financial systems, patient registration, computer based record systems and pharmacy systems. Most of lab equipment and radiology equipment are now computerized. Telemedicine which uses telecommunication and multimedia technologies is now increasingly used for remote consultation, diagnostics and examination of patients over the internet. As far as improving education in health is concerned, ICTs are being used for sharing documents, simulations, interactive environments and e-learning.

HealthNet one of the most widely implemented computer-based telecommunications systems in sub-Saharan Africa is being used in over 30 countries by around 10,000 healthcare workers to exchange ideas and provide medical solutions to various problems (Mbarika, 2004). HealthNet uses low earth orbit satellites and phonelines to provide email access system of local telecommunications sites used to provide low cost access to healthcare information in developing countries through a link to basic email (Kasozi and Nkuuhe, 2003). Users mainly physicians and medical workers connect to the network through local telephone nodes to access services such as physician collaborations (Mozambique, Tanzania, Uganda), data collection (Gambia), healthcare delivery (Ethiopia), research (Ghana), medical databases, consultation and referral scheduling, epidemic alerts and medical libraries.
Mozambique, a sub-Saharan Africa country, launched its first TeleMedicine project in 1998. A TeleMedicine link connecting two central hospitals was built based on existing terrestrial and satellite communications system using low cost equipment for transmission, exchange and visualization of images and radiographs (ITU, 1998). In Uganda hand-helds (EpiHandy) are being used by healthcare staff for communication (e-mail), studies and surveys, consultations and treatment guidelines (Kasozi and Nkuuhe, 2003).

SatelLife (Groves, 1996) uses low orbit communication satellites to link up doctors via the internet through “store and forward technology. SatelLife provides service to remote medical units through email and internet traffic as international telephone connections to capital cities in the developing world. Across Sub-Saharan Africa, the Internet is used to report daily cases of meningitis to monitor emerging epidemics. When threshold levels are reached, mass vaccination is required and the Internet is used to rapidly mobilize medical personnel and effectively coordinate laboratories and specialist services.

Nambaziira (2006) designed an online tool for ordering, distribution and monitoring of vaccines from the central stores to the various districts. Some of the functionalities included the capture and generation of reports for vaccine requisitions, supplies, issuances and disposals. Such a tool would be used in the monitoring of vaccines and that would reduce on the vaccine wastage thus minimizing the costs.

The above studies show that various technologies have been used to improve healthcare in remote areas although some of the challenges pertaining to healthcare are not adequately addressed. There is need to adopt systems that address some of these challenges and this can be done by undertaking a system such as provided by the systems dynamics methodology. In a study carried out to assess the application of information and communication technologies (ICT) in health information access and dissemination in Uganda, Omona and Ikoja (2006) suggest that there is need to support and promote ICT as the most effective tool for health information access and dissemination.

5. Research Methodology

In order to understand factors that influence immunization coverage and their relationships, survey research supported by semi-structured interviews were conducted to understand the intricate information flows, delays and other competitive challenges by use of ICTs. Data obtained from the study was analysed with SPSS statistical package. Influence diagrams representing the relationships between variables were developed using Vensim modelling software. Out of these key information and processes required for immunization coverage improvement were derived.
5.1 Research Questions

In order to assess how ICTs may be used to enhance the effectiveness and efficiency of the healthcare immunization system, several pertinent questions were considered:

1. What kind of data and information may be collected to understand the immunization coverage?
2. Which stakeholders provide data and use information for monitoring of the immunization system?
3. How should such an immunization system work?
4. What kind of ICTs may be used to deliver healthcare services?
5. How can these ICT tools and techniques be adopted to improve the management of the Ugandan immunization system?

It is these research questions that guided the research design. These experiences documented in the case studies and the cumulative knowledge were used to design a framework for enhancing immunization coverage.

5.2 Field Studies

Field studies were used to determine the full range of activities and challenges associated with immunization coverage and to examine the various acknowledged factors associated with the provision and utilization of immunization services were carried out. The study area Mukono District, lies in the Central region of Uganda comprises of four counties and has a good representation of both rural (83%) and urban population (17%) with a population density of 264 persons per sq. Km. Secondly, the people of Mukono district reside both on the islands (1 county) and the mainland (3 counties) and the population of Mukono consists of more than 18 tribes which would benefit the research by gathering cultural beliefs and opinions from the various tribes. The study was analytical; involving the various stakeholders who are important as far as the immunization system is concerned.

Mothers - In each county of the selected district, 200 mothers were interviewed. Multi-stage sampling method was used to select target sample size of 800 mothers. The sample size was determined as follows: Since many variables were being measured, a prevalence of 50 percent, which demands the largest sample size was used. At 95% confidence interval with the immunization coverage (p) of 70% and level of permissible error (e) as $e \leq 10\%$ the sample size $n$ was determined by the following equation:

$$n = \frac{z^2 p q}{e^2} \hspace{1cm} \text{Equation 1}$$

where $p=0.7$, $q=(1-0.7)=0.3$, $z = 1.96$ and $e = 0.1$
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\frac{(1.96)^2(0.7)(0.3)}{(0.1)^2} = 80.67136 \\
\text{.........Equation 2}
\]

Considering a non-response rate of 20% results in 100 respondents. A design effect consideration resulted into 200 (100 x 2) respondents for each county thus making the number of respondents in the four counties equal to 800. In each county, the planned number of interviews was at least 200 mothers. The interviews of the mothers were carried out consecutively until the completed number of interviews which was 800. A structured questionnaire was used to interview the mothers.

**Health Workers:** Three (03) private and five government (05) health facilities selected by simple random sampling from the district. Those that were selected included one (01) government hospital and one (01) private hospital and the rest were health centers and dispensaries. At each sampled health unit, two people were interviewed, one vaccinator and one Officer-in-Charge of vaccines bring the total of those interviewed to sixteen (16).

**Officials:** At the district level, several meetings with various officials from health services, administrative officials were held. Local community leaders, national officials as well as consultants with UNICEF were interviewed.

**6. Factors Associated with immunization coverage**

Findings from the field study as well as immunization studies of other researchers (Borooah, 2003; DISH, 2002; Drain *et al.*, 2003; WHO, 1999) are represented in the influence diagram (refer to Figure 2). Figure 2, illustrates the intricate and complex relationships among factors affecting immunization coverage from a parental participation perspective and a number of feedback loops which may help to explain different immunization coverage levels (Rwashana and Williams, 2006). It is this feedback structure that gives rise to complexity, nonlinearity, and time delays in Immunization coverage. Figure 2 shows that immunization coverage can be enhanced through improvement of the following :-

- Immunization awareness and knowledge which can be improved through health education, effective mobilisation and campaigns, literacy levels, increased sources of information and use of relevant methods and content,
- Level of trust in the health system which is built by having effective health centres with effective vaccines, sufficient well trained health workers (less waiting time for mothers), health education services.
- Availability of immunization centres which are easily accessible to the community. Systems for reporting and monitoring immunization activities
- Tracking number of children being immunized and the drop outs
- Vaccine inventory control and monitoring.
- Reporting and monitoring of immunization activities.
7. Status of ICT in Health

According to SCAN-ICT Project (2002), most governments health units have generally low ICT usage due to lack of basic ICT infrastructure. 80% of the Ugandan population is rural based with no electricity distribution thus constraining the diffusion of all forms of ICT. Internet connectivity and email usage in the health sector is still low compared to other sectors. Medical personnel most commonly use computers like accountants and secretaries. Until 1993, Uganda had a centralized health information system (HIS) which focused on morbidity and mortality reporting, with data flowing only from individual health units to the district and national level. A health management information system (HMIS) that emphasizes use of information at the point of collection is currently in use (Gladwin, Dixon and Wilson, 2003).

Immunization records, at the health unit level are done on paper registers and tally sheets by the health workers. The tally sheets are forwarded to the health district level for entry into a computerized database Health Management Information System (HMIS). Districts that have a computer and resources to maintain it, are provided with an easy spreadsheet based system for compiling monthly and annual reports. The reports from the districts are delivered to the headquarters either by hand, fax or by email. The national office has a LAN at the headquarters to enable health offices gain access to the HMIS products such as the ministry of health website. Future expansion includes development of a WAN, to provide connectivity to the rest of the districts.
7.1 Challenges with Immunization Healthcare Delivery

Some of the issues associated with the current system used for recording and retrieving information include the following:

1. Recording and capturing the data from the tally sheets into the computer is done at the district level which is very tedious, voluminous and often results into errors arising from poor handwriting thus causing a lot of delays in compilation.

2. It is difficult to trace the children who have not completed the immunization schedule status of each child since records are done using a one-off tally sheets.

3. Long time-delays for mothers resulting in recording of manual systems.

4. Lack of up-to-date reporting leads in inaccurate forecasts and targets, occasional stock outs and vaccine wastage at the various immunization centres which results into missed opportunities by the children.

5. Vaccines are estimated based on the district population and this results in wastages and stock outs since some of the births are not registered at the district.

6. Staff capturing the data lack competence in using the data capturing tools which results in slow processing and a lot of errors.

7. Poor management and lack of storage space of the paper files.

8. Insufficient monitoring and supervision of health centres.

7.2 Proposed ICT Solution

The ICT infrastructure enables the sharing the ICT capabilities which provide services for other systems of the organization (Broadbenta et al., 1999). For Broadbenta et al., (1999), these capabilities require the complex combination of the technical infrastructure (cabling infrastructure, hardware platform, base software platform), ICT shared services (as communications services), ICT applications (as WEB services), the human operators and the managerial expertise to guarantee reliable services (see figure 1).

The paper suggests the following ICT innovations (Figure 3) towards the improvement of immunization coverage:

**Child**: In the proposed system, a SMART card will be prepared for each child born. The card will have a chip card that can be swapped for record updates and the following details:

- Photograph of the child
- Child’s name, year of birth and sex
- Father’s name, address, telephone number
- Mother’s name, address, telephone number
- Location: Local council, village, parish, county, district
- Dates of immunization of the various vaccines

**Health Units**: The health units will have a SMART card writer which can update the immunization records. Stock and logistics updates and orders will be captured by using the handheld devices / Personal Digital Assistant (PDA). The
data is then uploaded onto the handheld device and sent to the district database through a fixed wireless terminal. Orders and updates of vaccines from the various health units is compiled to facilitate decision making processes at the district level. Reports on the performance of the various health units are generated and the data is then uploaded to the national database. Health workers will use the PDA to access immunization information (diseases, vaccines, side effects, immunization schedule, stock management) from the immunization content management system. PDA. Such information on a PDA when connected to the right video/audio output drivers could be shown using a TV monitor thus facilitating training and health education in the community.

**District level:** At the district level, data can be used to prepare forecasts, analysis and plans for the district. The reports generated can be used for monitoring and tracking of vaccines, children, health workers as well as preparing requisitions and facilitate distributions of vaccines to the various health sub districts and health units. The data from all the districts is compiled to obtain the national immunization performance. The data can then be used to generate national targets, imports of vaccines and supplies, management of staff and equipment as well as enhance decision making process for long term plans.

**National level:** An immunisation content management system that has all the information pertaining to immunisation (diseases, vaccines, schedules, side effects) and can be accessed by all districts and health units should be developed. A Health Management Information System linking all the health facilities at all community, district levels should be used for support and monitoring of immunization activities, planning, decision making, education and disease surveillance.

Fig 3: Proposed ICT Framework for the Immunization Services
7.3 Benefits Provided by ICT Adoption

Some of the benefits that would be provided by adoption of ICT services in the healthcare immunization system are:

1. Improved quality by reduction of variations in healthcare practices can significantly improve policy design effectiveness,

2. Improved sharing and dissemination of reliable information concerning vaccine administration, storage, side effects through online accessibility to the medical workers as well as the public improving their attitude towards immunization.

3. Timely reporting of disease outbreaks/epidemics will be made easier thus enabling timely interventions by the authorities.

4. Reduction in time delays for mothers due to reduced manual recording processes

5. Improved coordination and monitoring of immunization activities, facilities and equipment upkeep and allocation of scarce resources.

6. Improved overall administrative effectiveness of the immunization system which results in efficient use of resources both human and financial.

7.4 Challenges to adoption and diffusion of ICTs

Some of the challenges to adoption and diffusion of information technologies in remote areas for healthcare delivery include the following:-

a. Lack of telecommunication infrastructure and underdeveloped state of Internet Service Providers (ISP) which results in low internet penetration and insufficient bandwidth.

b. Lack of ICT awareness

c. Lack of relevant content which is essential to make ICT effective for the community thus presenting the need to repackage and develop local content.

d. Lack of skilled ICT personnel who are willing to live in remote areas, so there is need for capacity building and training

e. Cultural barriers include reluctance to adopt new technologies, language barriers and fear of SMART card technology which presents issues of confidentiality and privacy.

f. Political barriers such as unstable economic climate in the country.

g. Remote areas experience intermittent power supplies thus requiring other forms of power supply

h. High costs of installation and maintenance of ICTs

i. There is need to further enhance the enabling regulatory environment.
Conclusion and Future Studies

Simple, low cost techniques that are sustainable should be developed based on the following strategies for overcoming barriers to the successful integration of ICT into the delivery of immunization healthcare systems. First, the development use of standardised systems. Second, the government needs to provide political leadership to accelerate the adoption of electronic health systems and, third to create a public database that holds data at the community level, but is fed through the decision making structure to improve healthcare provision nationally and local level.

References


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