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Abstract

By encompassing the complete supporting infrastructure, from vaccine suppliers to vaccine recipients, this article proposes a new system model for Saudi Arabia's regular immunisation programme. There are methods to improve access, service quality, decision-making for administrative personnel and the enthusiasm of CHWs for completing the immunisation schedule via the use of this strategy. All of the new system's agents have graphical user interfaces, which are included in the system model design. There is a lack of access to vaccines in rural areas, as well as a lack of health personnel and an inconsistent vaccine supply chain that makes it difficult for people to be vaccinated. As a result, a more centralised outreach effort linked directly to district vaccine depots might bypass ineffective distribution pathways for vaccines and improve vaccination accessibility and quality. Using ICT, community health workers may urge families to finish vaccinations and educate them about planned vaccine outreach programmes. The existing Saudi Arabian vaccination system was analysed and evaluated using a qualitative analysis approach that included methodologies such as structured, semi-structured, observations, and literature reviews. This framework was developed using a DSRM in Design Science and ISO9241-110 usability metrics were used to assess the GUI of a web-based Android mobile application.

Keywords: Vaccination service delivery model, immunization, ICT, CHW, DSRM, DVS, VTC, CVS, HIS,IS,EPI,IPM,outreach

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Week 01

The Problem and its Setting

1.1 Introduction

The vaccination of children has been shown to have a negative correlation with infant mortality. WHO, UNICEF, and the World Bank projected that vaccine-preventable illnesses claimed the lives of 1.5 million children under the age of five between 2000 and 2008. Immunization is the most efficient technique for decreasing infectious disease burdens, and small pox has been eradicated globally thanks to immunisation and the limiting of its transmission (Andre et al. 2008). With a goal of making vaccines widely accessible and harnessing their full potential, the World Health Organization has undertaken an ambitious initiative for the period 2011-2020. Immunization plans have been adopted by many governments and other organisations to avert outbreaks of vaccine-preventable diseases." An example of this is a British law established in 1853 that required all British people to be vaccinated against smallpox, with consequences for non-compliance. Before enrolling in public schools in the United States, children must be vaccinated against common illnesses (Cole, J. P., & Swendiman, K. S, 2014). Opposing vaccination and other scientific interventions is anti-vaccinationists, a civil society group. According to others, immunizations do not work, the government is interfering too much in people's personal lives, or vaccines aren't safe enough (Wolfe & Sharp, 2004).

People are concerned about their children's safety. They take tremendous care in ensuring that their children are not infected with any disease. Anti-infective vaccines are one of the most effective ways to keep youngsters healthy." For vaccines to work, they must be administered on a certain schedule, and these schedules differ from adult to kid (Lance, E. R, 2005)

There is no doubt that Saudi Arabia is a case in point. Vaccine-preventable illnesses (VPDs) have been linked to lower rates of morbidity and death in Saudi Arabia since the country's national immunisation programme was implemented in 1980. The programme is coordinated at the national level by the Ministry of Health's (MOH) directorate for maternity and child health. The EPI case team is one of six case teams in the MCHN directorate, which aims to synchronise and coordinate the execution of numerous immunization-related projects. Working together with the Policy and Planning Directorate of the Ministry of Health, Pharmaceutical Fund and Supply Agency and Saudi Arabian Public Health Institute as well as the Food, Medicine and Healthcare Administration and Control Authority, the EPI case team is a global effort. from 42 percent in the 1990s to more than 88% in 2013 Saudi Arabia's administrative coverage has improved. Dropout rates and large regional variations were among the findings of the 2012 national vaccine coverage study.

rate. Additionally, same declines in performance were also recorded in administrative coverage. As of 2011 and 2012 (EPI's status in Saudi Arabia),

Through an analysis of the current state of vaccination services in Saudi Arabia, the challenges of providing quality vaccination services in low resource settings have been identified: bad traffic conditions, a lack of supplements, a heavy workload and low data transaction levels. Saudi Arabian vaccination services face these challenges. These issues are to blame for the present state of vaccinations in Saudi Arabia.

1.2. Statement of the problem

Saudi Arabia has been vaccinating its children for a long time now. However, the extent of coverage varies by region, with rural children in particular suffering the most. Health Data collecting components in public health systems must make extensive use of information and communication technologies. Health care providers, policymakers, and decision-makers all rely on timely and reliable data to enhance their services. Since mobile technology is rapidly developing in Saudi Arabia, its use in ICT may help close the country's information gap. We set out to address these two questions in our research.

1. In terms of planning and preparation, does the Saudi Arabia IPM prototype produce a considerable amount of information about how often each vaccine type is used?
2. Can the Saudi Arabia IPM prototype be utilised by health professionals providing vaccinations in the real community to update real-time data using their Android phone application??

Week 02

1.3. Objectives

1.3.1. General objective

It is the goal of this project to introduce the use of Android smart phones to enhance child immunisation services in Saudi Arabia using web-based mobile solutions. The current paradigm of child immunisation monitoring in Saudi Arabia will be shifted from a manual to a mobile system application in this scenario. Progress has been made in Saudi Arabia's efforts to increase the number of children vaccinated, yet discrepancies still remain across areas. The lack of timely vaccination of children in rural regions is hampered by a lack of information on both the supply and demand sides of the service equation. Health services may be improved and underserved people can be reached thanks to mobile health technology's fast advancements. Mobile health technology treatments have the potential to improve vaccination coverage and usability, however there is a paucity of evidence to support these claims (apps). The advantages of a mobile web-based system solution may be gleaned through a comparison of analogous systems. These benefits include increased portability and flexibility, improved distant connection and data transfer, reduced data input error rates, and high data quality.

1.3.2 Specific objectives

To accomplish its major goals, this research used the following methods.

- i. Understanding several connected concepts via a review of research on mobile-based child immunizations
- ii. In Saudi Arabian EPI health sectors, data is collected on the present ICT infrastructure, utilisation strategy, and efficiency.
- iii. exploring the advantages of web-based Android mobile systems & cloud hosting for Android devices
- iv. building a prototype (GUI) for a web-based android mobile framework for child vaccination in Saudi Arabia
- v. Using the ISO9421 usability standard to evaluate the system's overall usefulness

1.4. Significance of the study

1.4.1. To health workers

Health care workers (CHW) will be able to use their Android phones to keep track of children who have received vaccinations, as well as DVS and VTC to keep track of vaccine inventories and administrative staff to organise vaccination campaigns.

1.4.2. To parents/guardians

Parents or guardians are the most beneficial indirectly through their CHW to get a reliable vaccination service for their children

1.4.3. To future researchers

Other researchers can use this study as a base to improve and monitor child vaccination services using Android smart phones and add more features that make it more suitable according the environment they are going to apply it in.

Week 03

1.5. Scope

This research shows how to use an Android web-based mobile system that may be hosted on a cloud server to enhance and monitor the regular child vaccination services offered under EPI for Saudi Arabian children under the age of five. Health care providers may also benefit from this. To keep parents abreast of immunisation schedules and associated announcements, the system sends reminders and alerts to a mobile app. Nurses and CHWs are able to make updates to vaccination records on the go using their Android smartphones, and VTCs and DVS can keep track of immunizations in real time. The system offers inferences and conclusions for health professionals that may assist estimate immunisation frequencies and vaccine demand and prepare and plan for appropriate forthcoming immunizations, particularly for the management personnel in the health facilities. As a result of this, child mortality rates in Saudi Arabia may be reduced due to sustained child health.

1.5.1. Limitation

Only Saudi Arabia's EPI organisational structure, the country's economy, and the population's geographic distribution were taken into account while developing the system for immunising children under the age of five. In order to use the mobile IPM, you must have an Android phone or Chrome browser.

1.5.2. Delimitation

This research is confined to the Tigray region's child immunisation service for the purpose of data gathering. An ISO 9241 usability test serves as the only criterion for the system's assessment. And the prototype is only available in English.

1.5.3. Deliverables: Artifacts

Three deliverable artefacts related to the Saudi Arabian child immunisation service will be provided by the research prototype (EPI). These are some of the things:

1. A methodology for finding the relevant stakeholders in a systemic approach
2. An novel, comprehensive immunisation service delivery framework is provided through the use of process models and organisational structures.
3. User-friendly graphical user interfaces for mobile apps

Week 04

Review of Related Literature

1.1 EPI Target Disease and Vaccines

Six of the most prevalent vaccine-preventable illnesses have been included in the EPI, which has a major impact on children. Infectious diseases such as tetanus, diphtheria, whooping cough and poliomyelitis are also included. Other diseases were also included to the EPI programme based on the country's endemicity and resource availability. Among them are yellow fever and hepatitis, both of which may be deadly. The EPI now delivers eight vaccinations:

BCG (tuberculosis vaccine)

'Tuberculosis is caused by a bacterium (Mycobacterium Tuberculosis) That is Carried by almost 2 billion people. The Disease Killed More Than 3 Million People in 1995. It Usually Attacks The Lungs, But Other Parts of the Body, Including The Bones, Joints and Brain Can ALSO be affected "

Oral polio vaccine (OPV)

"Polio is caused by a virus. It is a crippling disease that can be Can Occur in Adults but it is Much Commoner in Children. WHO Aims to Eradicate Polio by The Year 2000".

Diphtheria-pertussis-tetanus (DPT) vaccine

"Diphtheria is Caused by a germ called corynebacterium diphtheriae. Major Epidemics Have Occurred in Eastern Europe and Central Asia Since The Late 1980s. Zones. It Tends To Be A Disease of the Colder Months and Of Temperate Climates. The Germ Produces A TOXIN That Can Harm Or Destroy Human Body Tissues and organs. One Type Of The Disease Affects The Pharynx and Other Parts of the Throat. Another Type, Commoner In The Tropics, Causes Ulcers On The Skin."

Hepatitis B vaccine (HepB) "

This Disease, Caused by The Hepatitis B Virus, Affects The Liver. People Usually Recover, But SOME Continue to Carry The Virus For Many Years and Can Spread The Infection to Others Throughout The Time That Uses Chronic Carriers. It is Estimated ".

Measles vaccine

" Measles Kills More Children Than Any Other Of The EPI Target Diseases. It is caused By a virus and is highly infectious, I., Very Easily Spread. IT is Constantly Present in some Populations and Occurs in Epidemic Proportions. In Conditions of Crowding and Poverty Where Large Numbers of Non- Immunized People are in close contact the stage is set for Measles Epidemics. The Disease Is More Severe in Infants and Adults Than in Children.

Yellow fever vaccine

" Yellow Fever, An Acute Disease of Short Duration, is caused by a virus. IT Occurs in Tropical and Subtropical Areas, Mainly in Sub- Saharan Africa and Central And Central South America, and Affects People of All Ages".

Homophile influenza type b and tetanus toxic (TT) vaccines. Under Saudi Arabia, there are now eight vaccine-preventable illnesses in the EPI programme. This is in addition to the six recognised EPI-program illnesses, namely Hep B and Hi (Belachew Etana, 2011)

2.2. Addressing Information Gaps in Developing Countries

For computers to really solve the information gaps in developing countries, information services need to be authored by non-programmers, distributed by resource-constrained organisations, consumed by minimally educated users and stay strong despite intermittency and connection. This is why we created Open

Data Kit (ODK), a set of tools that can be used by anybody to construct information and services for developing countries (Yaw Anokwa, Waylon Brunette; Adam Lerer; Clint Tseng; Gaetano Borriello)

In the last several years, there has been an increased emphasis on HIS as a critical component of functional health systems, particularly in developing nations. It has also been noted that better HIS is needed to monitor the MDGs, and numerous projects have been launched to address this issue. To help countries improve their national health information systems, the Health Metrics Network was formed in 2005. (HMN 2005). Although there are many international organisations supporting countries in their efforts to improve their health information systems (HIS), HMN has become a strong advocate for the creation of a national HIS that integrates data from various health services and programmes, as well as from various donor initiatives. The HMN programme has inspired several developing nations to improve and modernise their national HIS systems. Even in developed nations where health information systems (HIS) are widely available and well-supported by donor agencies, implementation has been hampered by a lack of coordination and a design-reality gap as well as by the lack of long-term sustainability (Kimaro and Nhampossa, 2005).

2.3. Advantages of MHealth Systems in Healthcare and Disadvantages.

The term mHealth (also known as m-health or mobile health) refers to the usage of mobile devices in the delivery of medical care and public health initiatives. When it comes to using mobile technology for health services and information, mobile health is the most widely used word (Cipresso, P., Serino, S., Villani, D., et al. ,2012).

Users of mHealth have the option to engage in health care operations from a distance; these users are usually important contributors to the collection and distribution of data on illnesses and health concerns. mHealth has the potential to improve health communication and healthcare quality by increasing access to medical and health information via advancements in mobile technology. The immunisation service might be more accessible if it could be run remotely and communicated with remotely. Instead of relying on a restricted number of health care facilities, mHealth might allow doctors to offer outreach services, such as vaccinations, from the comfort of their own homes. (Rui Xue, 2012)

Benefits of MHealth Systems in Healthcare

For consumers, a major benefit of mHealth is its convenience. Wearable devices and other mobile technology allow users to continuously track and manage certain health data without having to see their healthcare provider. There are also a plethora of apps to choose from: As of 2017, there were 325,000 mHealth apps available for download from app stores, according to digital health consulting firm research2guidance.

mHealth can also help bridge gaps in care by allowing patients to communicate with their physician or care team and vice versa without meeting face to face. Secure messaging, for example, allows physicians to alert parents when their child is out of surgery. It also allows healthcare providers to communicate with each other about patients -- for example, letting a nurse know when a patient has arrived for an appointment.

Some mobile health apps, such as the Apple Health App, can integrate with a patient's electronic health record, allowing users to access their health data on their iPhone or iPad.

Disadvantages of MHealth Systems in Healthcare

One disadvantage of mHealth apps is that their privacy policies may lag behind those of other apps. Even when privacy policies are present, users may not always read them, which can lead to a lack of understanding about how vendors or other parties use their health data. Additionally, not all mHealth apps are compliant with the Health Insurance Portability and Accountability Act (HIPAA), meaning there is no guarantee that a user's health information will be protected or that users will be notified if there is a data breach.

Another potential drawback of mHealth apps is that their information may not be accurate. Some apps claim to be able to measure blood pressure by having the user press their finger on a screen or camera, but there is little research to support this claim. Researchers from Johns Hopkins University School of Medicine tested one such app -- Instant Blood Pressure -- and found that the measurements "were highly inaccurate." It behooves users to read the descriptions for these apps carefully for explanations of how measurements are ascertained. This dilemma may cause frustration for providers as patients may think they are accurately managing and measuring their blood pressure and may not seek actual medical care. Users should also be aware that some apps may include a warning that the app is intended for entertainment or recreational use only.

2.4. Medical Data Mining Applications and its Uses

Patient care is the primary source of healthcare data. Privacy and legal considerations must be taken into account while mining medical records for information. It is vital to employ data mining in healthcare since the nature of medical data is incomplete due to variables such as age, family history, work environment, etc., which may affect the kind of tests and diagnostic procedures that a patient receives. There are now so many ailments to choose from that health care services like disease awareness are in high demand. There must be a cost-effective, non-invasive, and painless technique to identify the start of illness. It has been shown that missing values and databases created for financial or billing

purposes have a negative impact on the quality of medical data (Ichise, R., and Numao Learning, M., 2001).

Week 05

Large volumes of data regarding patients, hospital resources, illness diagnosis, electronic patient records and medical equipment are generated in the health care sector nowadays. This massive volume of data must be analysed in order to extract useful information that can be used to save money and make better decisions. Pre-processed data may now be mined for hidden patterns that might aid healthcare professionals in making clinical and administrative decisions, thanks to data mining techniques. However, in the end, it is up to the medical specialists to make the final call. (Gayathri. P, Dr. N. Jaisankar, 2015)

2.4.1. Data Mining in KDD process

Definitions of data mining and KDD process:

Data Mining is a step in the KDD process consisting of applying data analysis and discovery algorithms that, under acceptable computational efficiency limitations, produce a particular enumeration of patterns over the data (see Section 5 for more details).

Note that the space of patterns is often infinite, and the enumeration of patterns involves some form of search in this space. Practical computational constraints place severe limits on the subspace that can be explored by a data mining algorithm.

KDD Process is the process of using the database along with any required selection, preprocessing, subsampling, and transformations of it; to apply data mining methods (algorithms) to enumerate patterns from it; and to evaluate the products of datamining to identify the subset of the enumerated patterns deemed "knowledge".

Historically the notion of finding useful patterns in data has been given a variety of names including data mining, knowledge extraction, information discovery, information harvesting, data archaeology, and data pattern processing. The term data mining has been mostly used by statisticians, data analysts, and the management information systems (MIS) communities. Throughout this paper we use the term "pattern" to designate pattern or model extracted from the data.

It has also gained popularity in the database field.

The term KDD was coined at the first KDD workshop in 1989 (Piatetsky Shapiro

199t) to emphasize that "knowledge" is the end product of a data-driven discovery. It has been popularized in artificial intelligence and machine learning

An algorithmic approach to extracting patterns from pre-processed datasets might be referred to as data mining in the context of the KDD process (Fayyad, U., Piatetsky-Shapiro, G., and Smyth, P.,1996). Clinical choices such as diagnosis, prognosis prediction, and treatment may all be aided by the health care data mining application's helpful information. It may also aid in administrative decisions, such as health care coverage, staffing projections, and use of hospital resources. In the KDD process, data mining is seen as a key component. Organizing KDD involves the following steps:

1. Developing an understanding of the application domain and the relevant prior knowledge, and identifying the goal of the KDD process from the customer's viewpoint.

2. Creating a target data set: selecting a data set, or focusing on a subset of variables or data samples, on which discovery is to be performed.

3. Data cleaning and preprocessing: basic operations such as the removal of noise if appropriate, collecting the necessary information to model or account for noise, deciding on strategies for handling missing data fields, accounting for time sequence information and known changes.

4. Data reduction and projection: finding useful features to represent the data depending on the goal of the task. Using dimensionality reduction or transformation methods to reduce the effective number of variables under consideration or to find invariant representations for the data.

5. Matching the goals of the KDD process (step 1) to a particular data mining method: e.g., summarization, classification, regression, clustering, etc. Methods are described in Section 5.1, and in more detail in (Fayyad, Piatetsky-Shapiro, &

Smyth 1996).

6. Choosing the data mining algorithm(s): selecting method(s) to be used for searching for patterns in the data. This includes deciding which models and parameters may be appropriate (e.g. models for categorical data are different than models on vectors over the reals) and matching a particular data mining method with the overall criteria of the KDD process (e.g., the end-user may be more interested in understanding the model than its predictive capabilities- see Section 5.2).

7. Data mining: searching for patterns of interest in a particular representational form or a set of such representations: classification rules or trees, regression, clustering, and so forth. The user can significantly aid the data mining method by correctly performing the preceding steps.

8. Interpreting mined patterns, possibly return to any of steps 1-7 for further iteration. This step can also involve visualization of the extracted patterns/models, or visualization of the data given the extracted models.

9. Consolidating discovered knowledge: incorporating this knowledge into another system for further action, or simply documenting it and reporting it to interested parties. This also includes checking for and resolving potential conflicts with previously believed (or extracted) knowledge

2.5. Advantages of Cloud Hosting Service for Web Based Applications

In the case of a private cloud, or internal cloud, the data centre, proprietary network, or cloud infrastructure is managed purely for the benefit of the enterprise or government agency, which prefers to retain its data in a more regulated and safe environment (B. Furht, 2010). Outsourcing IT infrastructure management while maintaining tighter control over resource placement and administration is possible with the private cloud. This means that the prices are likely to be greater since there is less opportunity for economies of scale, and the resilience may be weaker because of the limited service resources available (Larry Ryan, 2012). In a private cloud, data and processes are handled inside the business without the limitations of network capacity, security exposures, and regulatory obligations that utilising public cloud services would imply (VenkateRao J. et.al. 2011). Security may be improved by limiting access to a single customer in a private cloud, but in a public cloud, all apps and data are housed in the same shared environment.

2.6. Related Work

There have been a number of ICT interventions designed to help rural populations deal with their health issues. In 2010, Rohit and Borriello (2010) devised a mobile phone-based system, FoneAstra (2010), enabling remote monitoring of vaccines' temperature and location. A vaccine cold-box is included into the system, which has a temperature sensor and is used to store vaccines in a temperature-controlled environment. As the temperature of the cold-box fluctuates over time, FoneAstra keeps track of it. In the event that it detects a temperature over a certain level, it will immediately send out an SMS message to notify the user. Additionally, the cell phone's Wi-Fi may be used to monitor the position of vaccinations in transit.

Electronic devices were used in a fall detection system built by Zhang, Wang, Liu, and Hou in 2006 to detect the fall. They made use of a smartphone that has a built-in accelerometer. A decision tree model analyses sensor data to determine whether a fall has occurred. Any time a fall is detected, a prompt appears asking the user to respond. An SMS alert is sent to a guardian if the user's body is injured and unable to reply. As a result, the injured person may be treated quickly.

Using a web-based approach, Anas, Alaa, Chulawadee, and Adib (2011) were able to send SMS messages to expectant moms informing them of the status of their pregnancy.

The Osama (2012) mobile phone SMS-based diabetes self-management system was created by a diabetic for diabetics. Real-time data may be sent to the patient's doctor, allowing for continuous monitoring of the patient's health in the present moment. Also, the doctor encourages patients to exercise and attend medical visits through text message or phone call.

With the use of two-way radios, ambulances, and bikes, the United Nations Foundation (2010) was able to reduce the death rate of women in Saudi Arabia by half as a consequence of its Rural Extended Services and Care for Ultimate Emergency Relief (RESCUER) programme. Sherwani et al. (2011) created Health Line, a speech-based health information system, for use by community health

workers in Pakistan's Sindh Province who have limited literacy skills. As a result, many of the community health workers were incapable or had difficulties reading. The system uses an instructor to guide the health workers in the field. In low resource situations in India, Saurav Gupta and D. K. Jain(2015) established a mobile vaccination service.

Also at Saudi Arabia's EPI centres, there are information gaps that need to be filled, and researchers believe mobile apps may best address these gaps. Prototype development is followed by cloud hosting of the application programme and central data administration.

