Use of Mobiles for Reducing Infant Mortality by Increasing Adherence to Vaccinations in a Low Resource Setting

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Abstract— **Infant mortality is inversely proportional to immunisation. In India, due to lack of awareness and knowledge about the benefits of immunisation, the infant mortality stands at 61%. With the need to reduce this high percentage, the use of technology has proved to be beneficial. The growing penetration of mobile technologies and the sending of alerts over mobile devices has helped extend the reach of healthcare services to resource limited settings. mHealth has numerous applications in child healthcare and one such mobile application that aims to address a long standing issue of high infant mortality rate is Child Immunisation Alert System (CIAS). This paper highlights the design and outcome of CIAS, which uses various communication modalities to send vaccine alerts to the parents for high vaccine adherence.**

Keywords-mhealth; child immunization; mobile health; vaccination; CIAS; infant mortality rate.

I. INTRODUCTION

Infant mortality has been inversely associated with the immunisation given to children [1][2]. In 2008, WHO estimated that 1.5 million deaths of children under the age of five were due to diseases that could have been prevented through vaccinations. In India, for the year 2012, the immunization coverage in the rural areas stood at 58.5% whereas the national average was 61% [3]. The major reasons for such dismal indicators are:

a) Lack of awareness: Majority of the mothers are not aware about the vaccines and its benefits [2][3].
b) Lack of knowledge: With the prevalence of traditional beliefs, people feel that their child should develop 'natural immunity'[4]
c) Lifestyle: Owing to frenetic lifestyles in an urban setting, parents tend to forget.

Numerous studies by healthcare providers indicate that technology enabled methods could be adopted to overcome the apprehensiveness of parents and prevent diseases from spreading [5]. For increasing awareness about vaccines, the use of mobile technology and text messages have achieved success in different parts of the world [6][7][8]. Given the scope and penetration of mobile technologies and its advantages in improving healthcare services, Child Immunization Alert System (CIAS), a mobile application was conceptualised to reduce infant mortality. For each registered child up to the age of five years, the application displays a set of immunisations along with its benefits, as recommended by India's Ministry of Health and Family Welfare (MoHFW). Alerts about the vaccines to be administered to the child are sent using either emails or SMS or push messaging (instant notifications). Key reasons for selecting these modalities are:

a) High penetration: In India, mobile communications services are amongst the cheapest in the world. As a result, in India, mobile phone's penetration is 70%+ and the market share of smartphones is increasing at a noteworthy rate [9].
b) Affordability: the three modalities for alerting users are cost effective and encourage higher adoption rates and speedier diffusion of the application.

This paper brings out the design of the system CIAS that was deployed in the Indian landscape. Section II of the paper describes the requirements taken from the doctors while designing CIAS. Section III, highlights the CIAS system design and its key components. Section IV, discusses the methodology adopted for deploying the mobile app CIAS. Section V, highlights the outcome of the CIAS system and discusses the feedback received from the users. Section VI, brings forth the future work to be done as part of CIAS and section VII concludes the paper.

II. USER REQUIREMENTS

The user requirements for preparing the functional specifications requirement (FRS) were gathered by having detailed discussions with 09 paediatricians from various healthcare delivery institutes in and around Chandigarh, India. The average experience of these medical experts was 11.77 years with a high of 28 years of experience and a low of 06 years of experience. The post-graduate work experience of the paediatricians was considered. Post discussions, the following user requirements were compiled: 1) it was felt that regular alerts along with the importance of vaccines be sent to the users by exploring maximum possible communication modalities available; 2) most of the clinicians highlighted the need to have a parallel web based system. This was required mainly to address the users who did not use smartphones but had access to internet for which the users are increasing at a significant rate [9]; 3) system to include sending of alerts for non-smart-phone users as the majority of the population uses such phones.

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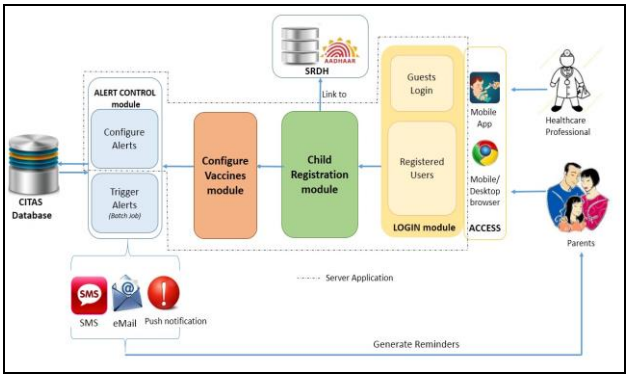

Figure 1. CIAS Architecture

User requirements lead to FRS, which were then transformed into CIAS system requirements and based on these, CIAS architecture was conceptualised (see Figure 1).

III. DESIGN

The application CIAS is designed based on open source technology. The key features of CIAS are:

A) Access:

CIAS has been designed both as a mobile application and a web based application. The data is stored in a web-based database for various advantages. These advantages include the provision of updated information, enabling real time alerts and easy retrieval of information anytime and anywhere. Also, for program managers, the collective data provides an effective source for some trend visualisations.

- The mobile application is developed on Android OS version 2.3 and provides upward compatibility [10]. Using the mobiles' internet connection (4G-LTE/ 3G/ 2G/ GPRS/ Wi-Fi), the child details including vaccine information is stored on the web server..
- The web based application has been designed using HTML5 as it helps to render the content according to the screen size of the device, which may be a mobile, tablet or a workstation [11].
- The database selected for CIAS is MS-SQL. To enable the exchange of information, web services were deployed. The web service was called in the mobile app and the mechanism for the exchange of data was established.
- For non-smart-phones users, the pull-SMS feature was introduced in which the user could text the name and date of birth of the child to a pre-defined number (51969) for receiving SMS-based alerts on their non-smart phones.

Apart from the parents, CIAS addresses the needs of field healthcare professionals who can type-in the details of the children born without having their parents need to register. This feature was enabled in concordance to the users' requirement.

B) Alert Control

The Alert Control mechanism comprises of two components: a) the alert type and b) the alert configurations.

- Alert type:
  i. SMS: The Mobile Service Delivery Gateway (MSDG) of the Government of India, was integrated with CIAS and is being utilised for sending free SMSes to the users [12].
  ii. Emails: Numerous studies have indicated that people who prefer emails feel that it provides a quick and convenient access to healthcare information [13]. Hence, this communication modality was also integrated in CIAS to send alerts.
  iii. Real time notifications: 'Push Messages' in Android makes use of Google Cloud Messaging service, which enables the sending of real-time notifications directly to the user [14].

- Alert Configuration: In CIAS, the users can select as per their convenience the different communication modalities for receiving alerts and also customise the periodicity of the alerts. The users can opt for either or a combination of sms, email and push notifications as the medium of receiving the alerts. Further, the alerts sent have been classified into three categories: *upcoming-vaccine, vaccine-due* and *vaccine-overdue*. Users can configure the upcoming vaccine alert according to their convenience. By default, alert for '*upcoming-vaccine'* is sent one-day ahead of the date of vaccination and alert for '*vaccine-due*' is generated on the day of vaccination. If the vaccination is not done on the due date then a one-time '*vaccine-overdue*' alert is sent the following day. In this case, the parent is prompted to provide the reason for the delay, as this would help to design suitable interventions to plug the gaps. Another configurable option is the schedule of vaccines. Though CIAS displays the schedule of the vaccines as recommended by MoHFW, however, in certain cases where the need is felt, the parents can alter/ configure the schedule of vaccines as recommended by their consulting doctor. All these configurations can be done on the mobile application, CIAS. Figure 2 shows the user interface for configuring the vaccination schedule.

All these alerts are sent through a *batch job* configured in the Task Scheduler, which calls a web service. This web service compiles the lists of alerts to be sent for that particular day from the database and then triggers the alerts.

C) *Linkage to State Resident Data Hub (SRDH)*

Unique Identification (UID) project is a biometric project being implemented by the Government of India, which uniquely identifies an Indian citizen and captures information such as their biometrics and demographic details [15]. For using UID, State

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Resident Data Hub (SRDH) is the application framework being created by UID Authority of India (UIDAI) having the resident's data for each state at the State Data Centres (SDCs). Linking of CIAS to SRDH would enable child's information to be mapped with the parents (UID) so that timely interventions could be designed.

IV. METHODOLOGY

The mobile app 'CIAS' has been developed indigenously by Centre for Development of Advanced Computing (C-DAC) at Mohali. The initial version of the mobile app CIAS, was released in December 2013 on the mGov mobile app store. mGov app store has been provisioned by the Government of India to provide various citizen centric mobile applications. This app store is available at apps.mgov.gov.in. CIAS was made available free of charge to the end users. Also, various camps were held in Post Graduate Institute of Medical Education and Research (PGIMER) Chandigarh, Civil Hospital, Mohali and dispensaries in Mohali district of Punjab state to create awareness amongst the citizens and encourage them to download and use the mobile app. Vaccinations in these hospitals are administered only on Wednesdays and Saturdays during the week, hence the camps were held accordingly. During the camp, interactions were held with the parents to increase the adoption of the CIAS mobile application. Based on the inputs, the application was enhanced with a user friendly and an intuitive interface using 'material design' technology. Figure 2 shows the user interface of the CIAS application.

V. RESULTS

CIAS was made available in December 2013, and by December 2014, the mobile app had been downloaded by 1314 users from the mGov store. Table 1 shows the count of SMS and emails sent as alerts to the users. Push notifications are managed by Google, hence, its count was not available. A look at the figures in the table indicate that users have opted for SMS as a preferred means for receiving vaccine alerts.

TABLE 1: COUNT OF ALERTS SENT

Sr. No.	Modality	Total sent
1	SMS	1641
2	Email	929
	TOTAL	2570

A feedback was taken from 134 randomly selected users. Their responses are shown in Table 2. The 3.74% of the users who did not get information on time, were inquired upon to get the reason. These specific users had opted for push notifications and did not receive those alerts because of intermittent internet connectivity. Hence, information could not be received on their mobile devices.

TABLE 2: USER FEEDBACK

No.	Question	Agree
1	CIAS is a useful service	94.02%
2	CIAS provided information on time and has helped improve vaccine adherence	96.26%
3	CIAS was easy to use	82.83%
4	I'm satisfied with the use of CIAS	78.35%

The data before the introduction of CIAS application could not be recorded as the mGov store does not have the option to register the users. Hence, the demographic details of the users also could not be obtained. Also, the feature 'overdue-alert' was introduce at a later stage and was not a mandatory field.

With the application being user-centric, the users highlighted the need to have local language support for deeper diffusion. Another feedback received, was the need of information of nearby hospitals where vaccinations could be administered. For this, CIAS was made context-aware and the list of hospitals was included based on the users' current location. A screen in Figure 2 shows the list of nearby hospitals. Also, in order to increase the penetration of CIAS amongst the public, the mobile application has also been published on the Google Play Store.

VI. FUTURE SCOPE OF WORK

The scalability of the CIAS system would need to be considered for a nation-wide deployment. Also, the integration of CIAS with the Mother and Child Tracking System (MCTS), a program of the Ministry of Health and Family Welfare, Government of India, would include detailed information about the pre-natal and post-natal care. The addition of voice based alerts in CIAS would enable speedier and deeper diffusion. Also, the inclusion of the child's growth and development patterns would make the system more comprehensive. Sending alerts for administering polio drops during the Indian Government's Pulse Polio Campaign, which is held twice a year, is also being considered.

With India having vast regional diversity, the CIAS system could be made multilingual. This would make the system more customised to the local requirements of the citizens and would help in bringing down the infant mortality rate.

VII. CONCLUSION

With the developing countries looking at a large infant mortality rate, the use of mobiles and associated technologies have certainly brought a positive change. With CIAS, it can be concluded that cost effective alerts, such as emails and SMS, can be introduced to provide timely vaccination alerts. However,for deeper penetration, the system needs to be made available across platforms. For the section of populace that still uses traditional

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phones, a web based system and pull-sms facility is provisioned. Also, efforts are being made on the localisation factors like support for regional languages, training, and empowerment of local experts to achieve speedier and deeper diffusion [8].

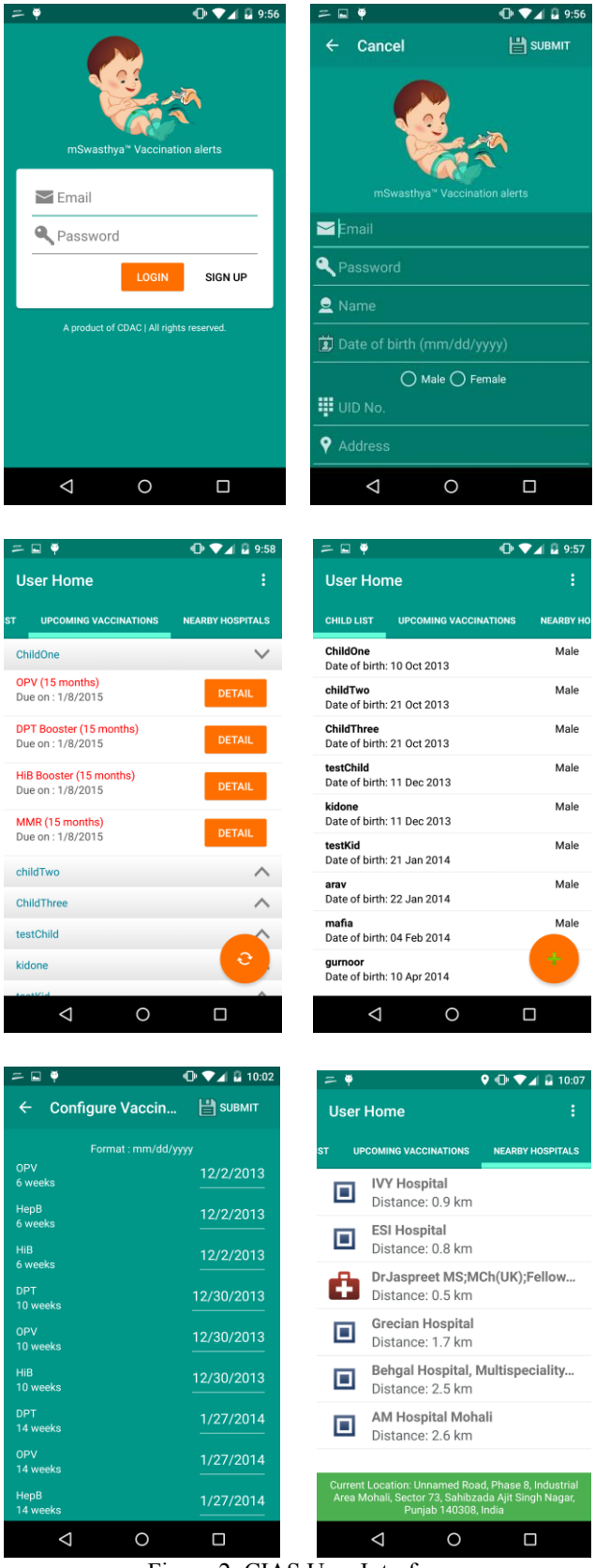

Figure 2. CIAS User Interface

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