Nutrition System – A mobile application for Pregnant woman

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme Master of Engineering in Computer Science and Engineering is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Approved by

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Abstract

Malnutrition has a devastating impact on the health and wellbeing of individuals and on the economic development of countries. In Bangladesh there is scarcity of proper nutrition information system that can provide appropriate nutrition messages based on different criteria of pregnant woman and infant while a primary or tertiary health workers could not provide the necessary service to them. This application can be easily used by any health workers in Bangladesh. Our health workers often forget to deliver the proper nutrition information to mothers. Such tool can be very useful to provide a proper way to deliver the specific nutrition messages to mothers based on their Ante-natal care (ANC), Post-natal care (PNC) state and also based on their infant age. The model of this application can provide the proper facilities of delivering nutrition messages to mothers by health workers. This system may need to analyse periodically in order to meet the changes of user requirement and apply appropriately.

Acknowledgement

I would first like to thank my supervisor Dr. Amitabha Chakrabarty, Assistant Professor of the Computer Science and Engineering Department at BRAC University. The door to Dr. Amitabha Chakrabarty's office was always open whenever I ran into a trouble spot or had a question about my project or writing. He consistently allowed this project to be my own work, but steered me in the right direction whenever he thought I needed it.

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List of Acronyms

ANC – Ante-natal care

PNC – Post-natal care

UHC - Universal health coverage

EDD – Estimated date of delivery

HHR – Health human resources

eHealth - Electronic health

mHealth – Mobile health

GOe – Global Observatory for eHealth

WHO - World Health Organization

Chapter 1

Introduction

The prevalence of malnutrition in Bangladesh is among the highest in the world. Millions of children and women suffer from one or more forms of malnutrition including low birth weight, wasting, stunting, underweight, Vitamin A deficiencies, iodine deficiency disorders and anemia. Today malnutrition not only affects individuals but its effects are passed from one generation to the next as malnourished mothers give birth to infants who struggle to develop and thrive. In this chapter we focus mainly on the nutrition problem in our country.

1.1 Background

Access to quality health services and associated costs are a threat to Bangladesh's current momentum for universal health coverage (UHC). The existing health system is largely (>60%) dependent on out-of-pocket payments [1]. Among many health system concerns, a serious lack and unequal distribution of qualified health human resources (HHR) [2] is a harsh reality. Furthermore, high population density and rapid urbanization is resulting in new and unfamiliar public health challenges [3]. Given the assumption that a combination of tools can better equip health care providers, enhance the quality of care and reduce existing disparities in health, electronic health (eHealth) and mobile health (mHealth) have rightly gained considerable attention as a potential tool for healthcare delivery. Globally, there is a close correlation between the concentration of qualified health workers (doctors, nurses, dentists and midwives together) and key health outcomes such as immunization coverage, primary health care outreach, and infant, under-5 and maternal survival. This is because "in health systems, workers function as gatekeepers and navigators for the effective, or wasteful application of all other resources such as drugs, vaccines and supplies" [4].

Mobile health, better known as mHealth is an emerging discipline for medical and public health practice. The Global Observatory for eHealth (GOe) of the World Health Organization (WHO) defined mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. mHealth applications include the use of mobile devices in

- Proper referral system
- Medical tele-consultations even from the most remote areas within the telecom network
- collection of clinical data for monitoring of patients' vital signs/test results real-time
- supporting treatment and medication compliance
- collecting community health data
- advising on health issues

- sending health alerts and reminders, and
- communicating between health-care workers

Mobile Health may catalyze the healthcare delivery model from a historical, episodic model into a tangible, patient-centric model. mHealth is being viewed increasingly by many as an important technology metaphor to achieve rich, robust patient engagement; ultimately, achieving a patient-centric paradigm change.

As mHealth expands access, availability and/or delivery like no other technology solution—health outcomes across the entire care continuum can be transformed. mHealth solutions hold the promise to provide new, innovative care access and delivery models that produce better outcomes, with reduced healthcare costs and innovative patient safety practices. To determine why mHealth is such an important Health Informatics topic today, a working mHealth context is necessary. Given the complexity and multiplicity of industry interests, there are as many definitional permutations as there may be organizations. As an emerging field, however, mHealth may be best defined as the access, provision and/or delivery of healthcare interactions—anywhere, anytime—facilitated by mobile and/or wireless technologies.

1.2 Motivation

Two billion people in the world suffer from malnutrition. Some 45% of deaths of children under five years of age are attributable to under-nutrition. Malnutrition is an underlying cause of death of 2.6 million children each year – a third of child deaths globally [5]. More than 165 million children under the age of five worldwide are affected by stunting. In some countries as many as half of all adolescent girls and women of child-bearing age are stunted, increasing the risk of poor fetal growth and low birth weight among their children. This project aim towards to health workers to give proper information of nutrition to mothers.

1.3 Problem statement

In Bangladesh, more than half the population suffers from malnutrition. Severe acute malnutrition affects 600,000 children, while close to 2 million children have moderate acute malnutrition. Stunting affects 40% of children under the age of five. A quarter of women are underweight and around 15% have short stature, which increases the risk of difficult childbirth and low-birth-weight infants. Half of all women suffer from anaemia, mostly nutritional in origin. Malnutrition is estimated to cost Bangladesh more than US$1bn every year in lost productivity. If a proper nutrition system can be introduced to these lower level facilities, there is a huge chance to change the situation dramatically.

1.4 Solution

This project aims to propose a prototypical implementation of a nutrition system that can be reduce maternal malnutrition as a determinant of birth weight and subsequent childhood nutritional status and guide the development of proper maternal and neonatal supplementation strategies.

1.5 Methodology

Design and implementation of an Android based mobile application for health workers to ensure that all pregnant women are getting the proper nutrition messages for them while they actually needed. This application provides a detail information regarding nutrition facility along with some other major information (i.e. LMP, contact number, address etc.). Android studio is used to develop this android application and Java language is used to program the application. We use SQLite database in order to store data for this android application. This Android application also has an online database system, to synchronize data among multiple users'/health workers in a certain area. To develop online data synchronization functionality, we use PHP scripting language for coding and and eclipse IDE is used for writing the code. MySQL database is used for storing the online data.

1.6 Outline of project

Figure 1 shows a quick overview of the report structure. To meet the objectives, a literature review was conducted, of which the results can be found in Chapter 2. The part of the literature review focuses on overall concept of e-health/ m-health and the factors that shape digital health scenario the second part focuses into software engineering challenges to develop a mobile application identified by current researches.

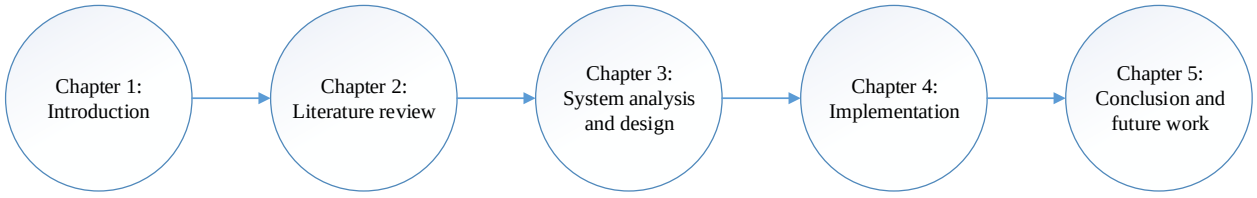

Fig 1.6.1: Report outline

Chapter 3 states the methodological approach to this paper. The functional and non-functional requirements, including the data model, system design of the proposed tool are introduced in Chapter 3. The implementation of the mobile application, user interface evolvement, is subject of Chapter 4. Chapter 5 concludes the report by discussing the findings and proposing future research endeavors in the area of mobile healthcare application.

Chapter 2

Literature Review

Mobile health, better known as mHealth is an emerging discipline for medical and public health practice. The Global Observatory for eHealth (GOe) of the World Health Organisation (WHO) defined mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. In this chapter we focus mainly on the health outcomes for using mobile health technologies in Bangladesh.

2.1 mHealth system (a brief overview)

mHealth (also written as m-health) is an abbreviation for mobile health, a term used for the practice of medicine and public health supported by mobile devices [11]. The term is most commonly used in reference to using mobile communication devices, such as mobile phones, tablet computers and PDAs, and wearable devices such as smart watches, for health services, information, and data collection [6]. The mHealth field has emerged as a sub-segment of eHealth, the use of information and communication technology (ICT), such as computers, mobile phones, communications satellite, patient monitors, etc., for health services and information [1]. mHealth applications include the use of mobile devices in collecting community and clinical health data, delivery of healthcare information to practitioners, researchers, and patients, real-time monitoring of patient vital signs, and direct provision of care (via mobile telemedicine) [2,3].

While mHealth certainly has application for industrialized nations, the field has emerged in recent years as largely an application for developing countries, stemming from the rapid rise of mobile phone penetration in low-income nations. The field, then, largely emerges as a means of providing greater access to larger segments of a population in developing countries, as well as improving the capacity of health systems in such countries to provide quality healthcare [7]. Within the mHealth space, projects operate with a variety of objectives, including increased access to healthcare and health-related information (particularly for hard-to-reach populations); improved ability to diagnoseand track diseases; timelier, more actionable public health information [8]; and expanded access to ongoing medical education and training for health workers [1].

According to an analyst firm, around 2.8 million patients worldwide were using a home monitoring service based on equipment with integrated connectivity at the end of 2012. The figure does not include patients that use monitoring devices connected to a PC or mobile phone. It only includes systems that rely on monitors with integrated connectivity or systems that use monitoring hubs with integrated cellular or fixed-line modems. It forecast that the number of home monitoring systems with

integrated communication capabilities will grow at a compound annual growth rate (CAGR) of 26.9 percent between 2011 and 2017 reaching 9.4 million connections globally by the end of the forecast period. The number of these devices that have integrated cellular connectivity increased from 0.73 million in 2011 to about 1.03 million in 2012, and is projected to grow at a CAGR of 46.3 percent to 7.10 million in 2017 [8].

A growing percentage of health-related smartphone apps are available, and some estimates predict 500 million patients will be using such apps by the year 2015 [9].

2.2 Health outcomes

The mHealth field operates on the premise that technology integration within the health sector has the great potential to promote a better health communication to achieve healthy lifestyles, improve decision-making by health professionals (and patients) and enhance healthcare quality by improving access to medical and health information and facilitating instantaneous communication in places where this was not previously possible [10]. It follows that the increased use of technology can help reduce health care costs by improving efficiencies in the health care system and promoting prevention through behaviour change communication (BCC). The mHealth field also houses the idea that there exists a powerful potential to advance clinical care and public health services by facilitating health professional practice and communication and reducing health disparities through the use of mobile technology.

Aponjon (MAMA Bangladesh) impact evaluation show that almost two-thirds (63%) of Aponjon primary clients who have completed the Aponjon service cycle from the time of registration up to the delivery of a child attended at least four antenatal care (ANC) visits. This represents a 37% increase over a 2011 national baseline of 26% attending four ANC visits. It is also important to note that 45% of the Aponjon subscribers went to a facility for delivery and 32% chose safe delivery at home. The survey results were also encouraging for subscribers in the 'new mother' category. 56% of new mothers did a postnatal care visit, 91% of new mothers fed colostrum after delivery, and 83% of new mothers practiced exclusive breast feeding. The immunization rate of BCG was 96%, and immunization rate of Pentavalet was 100%. The phone survey revealed that overall 93% of subscribers were satisfied with the service [10].

The growth of health-related apps and the availability of mobile device drives the growth of mHealth. In 2010, only about 4,000 health-related app available and now more than 20,000 health-related apps are available for mobile device. Revenues from remote patient monitoring services that use mobile networks will rise to $1.9 billion globally by 2014, according to Juniper Research's recent report in 2011.

Efforts are ongoing to explore how a broad range of technologies, and most recently mHealth technologies, can improve such health outcomes as well as generate cost savings within the health systems of low- and middle-income countries. In some ways, the potential of mHealth lies in its ability to offer opportunities for direct voice communication (of particular value in areas of poor literacy rates and limited local language-enable phones) and information transfer capabilities that previous technologies did not have. Overall, mobile communication technologies are tools that can be leveraged to support existing workflows within the health sector and between the health sector and the general public [20].

Within the mHealth space, projects operate with a variety of objectives, as stated by the UN Foundation and Vodafone Foundation's report on *mHealth for Development*:

- increased access to healthcare and health-related information (particularly for hard-to-reach populations)
- improved ability to diagnose and track diseases
- timelier, more actionable public health information
- expanded access to ongoing medical education and training for health workers [1].

2.3 Diagnostic support, treatment support, communication and training for healthcare workers

Diagnostic and treatment support systems are typically designed to provide healthcare workers in remote areas advice about diagnosis and treatment of patients. While some projects may provide mobile phone applications—such as a step-by-step medical decision tree system—to help healthcare workers diagnosis, other projects provide direct diagnosis to patients themselves. In such cases, known as telemedicine, patients might take a photograph of a wound or illness and allow a remote physician diagnose to help treat the medical problem. Both diagnosis and treatment support projects attempt to mitigate the cost and time of travel for patients located in remote areas [2].

mHealth projects within the communication and training for healthcare worker's subset involve connecting healthcare workers to sources of information through their mobile phone. This involves connecting healthcare workers to other healthcare workers, medical institutions, ministries of health, or other houses of medical information. Such projects additionally involve using mobile phones to better organize and target in-person training. Improved communication projects attempt to increase knowledge transfer amongst healthcare workers and improve patient outcomes through such programs as patient referral processes [1].

2.4 Disease surveillance, remote data collection, and epidemic outbreak tracking

Projects within this area operate to utilize mobile phones' ability to collect and transmit data quickly, cheaply, and relatively efficiently. Data concerning the location and levels of specific diseases can help medical systems or ministries of health or other organizations identify outbreaks and better target medical resources to areas of greatest need. Such projects can be particularly useful during emergencies, in order to identify where the greatest medical needs are within a country [2].

Policymakers and health providers at the national, district, and community level need accurate data in order to gauge the effectiveness of existing policies and programs and shape new ones. In the developing world, collecting field information is particularly difficult since many segments of the population are rarely able to visit a hospital, even in the case of severe illness. A lack of patient data creates an arduous environment in which policy makers can decide where and how to spend their (sometimes limited) resources. While some software within this area is specific to a particular content or area, other software can be adapted to any data collection purpose.

2.5 Emerging trends and areas of interest

Remote monitoring and treatment support allows for greater involvement in the continued care of patients. Recent studies seem to show also the efficacy of inducing positive and negative affective states, using smart phones [6]. Within environments of limited resources and beds—and subsequently a 'outpatient' culture—remote monitoring allows healthcare workers to better track patient conditions, medication regimen adherence, and follow-up scheduling. Such projects can operate through either one- or two-way communications systems. Remote monitoring has been used particularly in the area of medication adherence for AIDS, cardiovascular disease, chronic lung disease, diabetes [13], antenatal mental health, and tuberculosis. Technical process evaluations have confirmed the feasibility of deploying dynamically tailored, SMS-based interventions designed to provide ongoing behavioral reinforcement for persons living with HIV among others.

In conclusion, the use of the mobile phone technology (in combination with a web-based interface) in health care results in an increase in convenience and efficiency of data collection, transfer, storage and analysis management of data as compared with paper-based systems. Formal studies and preliminary project assessments demonstrate this improvement of efficiency of healthcare delivery by mobile technology. Nevertheless, mHealth should not be considered as a panacea for healthcare. Possible organizational issues include the ensuring of appropriate use and proper care of the handset, lost or stolen phones, and the important consideration of costs related to the purchase of equipment. There is

therefore a difficulty in comparison in weighing up mHealth interventions against other priority and evidence-based interventions.

2.6 Emerging trends and areas of interest

- Emergency response systems (e.g., road traffic accidents, emergency obstetric care).
- Human resources coordination, management, and supervision.
- Mobile synchronous (voice) and asynchronous (SMS) telemedicine diagnostic and decision support to remote clinicians.
- Clinician-focused, evidence-based formulary, database and decision support information available at the point-of-care.
- Pharmaceutical supply chain integrity and patient safety systems.
- Clinical care and remote patient monitoring.
- Health extension services.
- Health services monitoring and reporting.
- Health-related mLearning for the general public.
- Training and continuing professional development for health care workers.
- Health promotion and community mobilization.
- Support of long-term conditions, for example medication reminders and diabetes self-management.
- Peer-to-peer personal health management for telemedicine.
- Social mobilization for infectious disease prevention.
- Surgical follow-up, such as for major joint arthroplasty patients.
- Mobile social media for global health personnel.

Chapter 3

System Analysis and Design

Mobile health (mHealth) technology has been proposed to alleviate the lack of sufficient medical resources for personal healthcare. However, usage difficulties and compliance issues relating to this technology restrict the effect of mHealth system-supported self-management. In this project, a mHealth framework is introduced to overcome these drawbacks and improve the outcome of self-management.

3.1 Roles of the proposed application

Mobile phones have proven to be the best way of providing reliable access to information to people in low and mid income countries where other forms of communication perform poorly [16, 12]. As a result of the wide spread of mobile phones, there has been an increase in number of Mobile Application (M-Services) which are being used as a tool for disseminating different type information to people. Services of this nature are established to address informational challenges that are faced by people especially low income people. Because of this then, these projects must be sustained so that people can enjoy the benefits of it. Contrary to this, evidences show that most of M-Services are facing the challenge of cost of operating them, which in a direct way affects the sustainability of these services [6]. This section introduces the minimal requirements for the prototypical implementation of a mHealth nutrition app.

The provision of consistent and quality maternal and child health (MCH) services is a challenge for Bangladesh where most of the population lives in the rural setup. Health service delivery is constrained mainly by shortage of health professionals, meager resources, limited awareness among the society and bureaucratic procedures. Our health workers often forget to give proper nutrition messages to mothers. Low health service utilization of antenatal care (ANC), delivery services, and postnatal care (PNC) are believed to contribute for high maternal and child mortality rates. Innovative approach like mHealth based technological intervention believed to alleviate such challenges in countries like ours. However, currently, there are few evidences that demonstrate the impact of mHealth technology applications on the level of service utilization. This mobile application will be beneficial for improving malnutrition problems among mothers and their new born child by providing proper nutrition messages. Therefore, the objective our study is to assess the role of mobile phone equipped with voice call based software linking community health workers to mothers in rural Bangladesh. Following diagram shows the services and activities of the nutrition application.

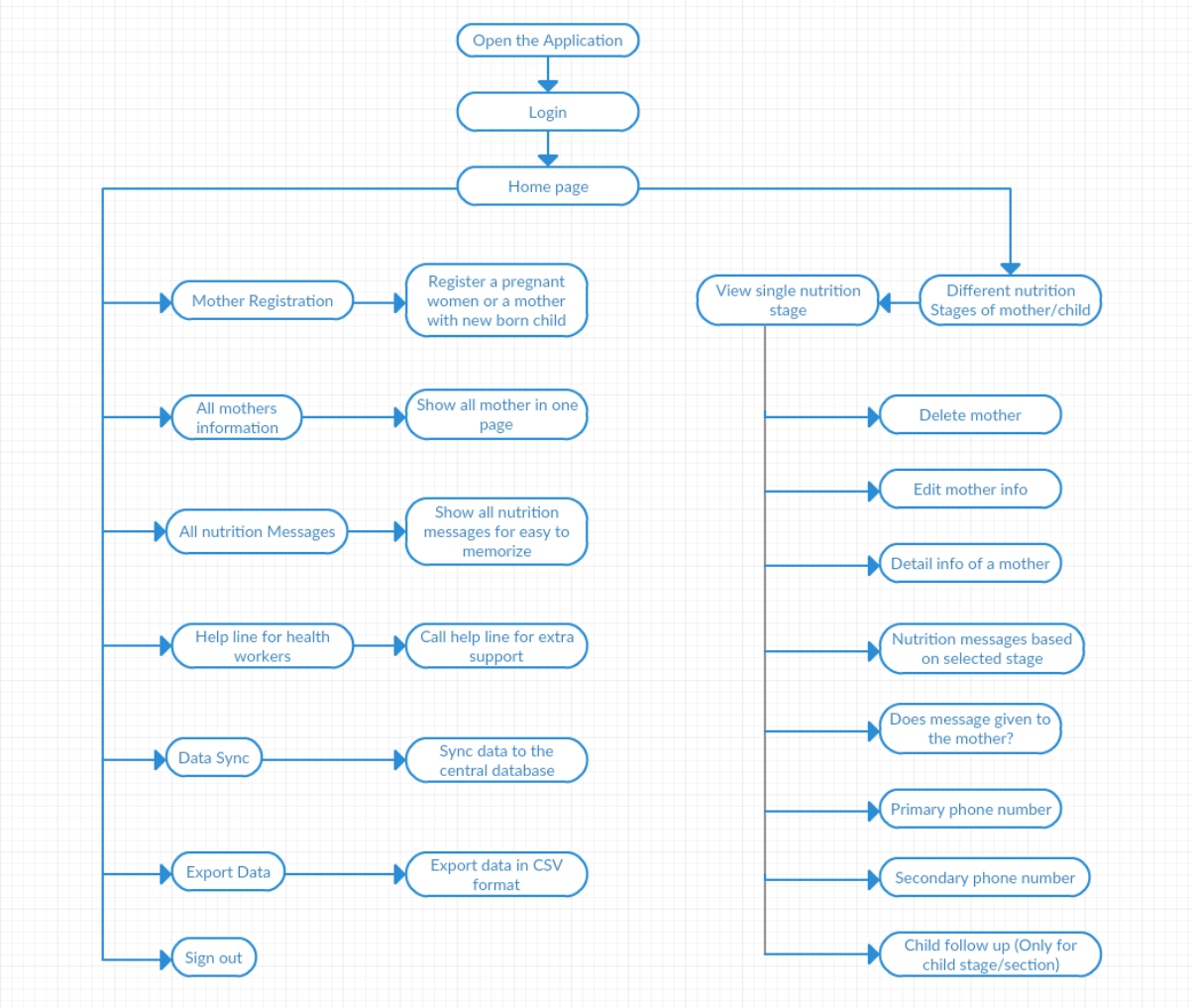

Fig 3.1.1: Basic flow diagram for nutrition application

As shown in Figure 3.1.1, this mobile application will be able to provide all the facilities to manage and deliver nutrition messages to mothers by user/health worker. For using this nutrition system user/health worker will login into the system by his/her user id and password. Using this application health worker can register a pregnant woman for delivering nutrition messages based on different stages of pregnancy and also for their new born child. While registering a mother user/health worker will collect some basic information about the mother like name of the mother, husband name, age of the mother, primary phone number, desire time for communicating to the mother, address, alternate mobile number, name of alternate mobile number holder, last date of menstruation (LMP) or estimated date of delivery (EDD) if she knew her EDD from a doctor. If the user/health worker insert last date of menstruation (LMP) date of the pregnant woman this app will automatically calculate the estimated date of delivery (EDD) for the mother. In mother registration section there is also an option for registering mother and their new born child together in case the mother is not

registered while she was pregnant. Based on the last date of menstruation (LMP) or estimated date of delivery (EDD) this application will calculate which nutrition is needed for them. For a registered mother this nutrition system will provide the following nutrition stages,

- Ante-natal Care (ANC)
    - 8 – 23 weeks of pregnancy
    - 24 – 31 weeks of pregnancy
    - 32 – 34 weeks of pregnancy
    - 35 – 36 weeks of pregnancy
- Delivery
- Post-natal Care (PNC)
- Child stage
    - 0 – 14 days' old
    - 6-month old
    - 9-month old

At each nutrition stage the user/health worker can communicate to a mother using voice call and deliver nutrition messages based on their nutrition stage. After the delivery of child, the user/health worker can register the new born child from the delivery stage. From child stage this nutrition system also provide a way to child follow up till one year. User/health worker can review all nutrition messages from home screen in one place in order to memorize them. This nutrition system provides an emergency contact number for user/health worker to get extra information from experts if needed. For synchronizing data to all devices this nutrition system maintains a central server on web. This central server will provide data that opens a broad way to research on malnutrition in Bangladesh for researchers. Our nutrition system can also export data in CSV format for further use.

3.2 Designing mobile applications

This chapter will help to understand when and how mobile applications are an appropriate solution, and the key design considerations for mobile applications. This includes learning about the components found in a mobile application; specific issues for mobile applications such as deployment, power usage, and synchronization; and the key patterns and technology considerations.

A mobile application will normally be structured as a multilayered application consisting of presentation, business, and data layers. When developing a mobile application, you may choose to develop a thin Web-based client or a rich client. If you are building a rich client, the business and data

services layers are likely to be located on the device itself. If you are building a thin client, all of the layers will be located on the server. Figure 2 illustrates common rich client mobile application architecture with components grouped by areas of concern.

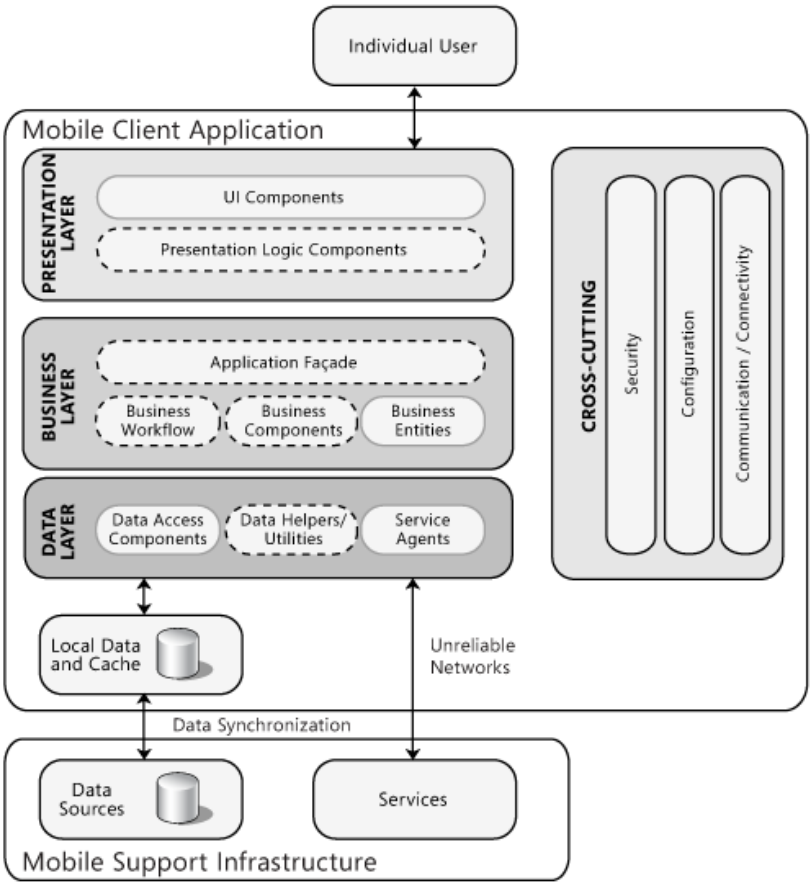

Fig 3.2.1: The typical structure of a mobile application

Before designing this application, figuring out the level of users is an important task. As this system have been proposed for everyone (from literate to illiterate) the user interface of this application need to design in a very simple way so that mass people can understand the application smoothly.

3.2.1 Presentation layer

In this referral application, presentation layer is the main focus goal. As the user needs the feedback as fast as possible with readable contents, so the presentation layer should be simple as possible. Following guidelines have been used to develop this user interface of this application.

- Design for a single window, full screen UI. If the device will be a single user device running only the main application, consider using kiosk mode. Keep in mind that Windows Mobile does not support a kiosk mode, so you will need to use Windows CE.

- Take into account the various screen sizes and orientations of your target devices when designing your application UI. Also, consider the limitations imposed by the small screen size, limited API, and reduced range of UI controls compared to desktop environments.
- Design for usability by supporting touchscreen or stylus-driven UI. Place menu bars and other controls at the bottom of the screen (expanding upwards when required) to prevent the user's hands from obscuring the display. Support touchscreen input by making buttons large enough, and lay out controls so that the UI is usable using a finger or stylus for input.
- Give the user visual indication of blocking operations; for example, an hourglass cursor.

3.2.2 Analysis & Design layer

Following guidelines have been used to develop the analysis and design layer of this application.

- Design asynchronous, threaded communication to improve performance and usability in occasionally connected scenarios. Limited bandwidth connections common on mobile devices can reduce performance and affect usability, especially if they block the user interface. Use appropriate communication protocols, and consider how the application will behave when multiple connection types are available. Consider allowing users to choose the connection to use, and to switch off communication to preserve battery life when appropriate.
- Designing an application that will run on a mobile phone, consider the effects of receiving a phone call during communication or program execution. Design the application to allow it to suspend and resume, or even exit the application.
- Protect communication over untrusted connections, such as Web services and other over the air methods. Consider using encryption and digital signatures for sensitive data, and ensure that data passed over a VPN is protected. However, consider the effects of communication security on performance and battery life.
- If application must access data from multiple sources, interoperate with other applications, or work while disconnected, consider using Web services for communication. Ensure you manage connections efficiently, especially in limited bandwidth communication scenarios.

3.2.3 Data layer

Data access on a mobile device is constrained by unreliable network connections and the hardware constraints of the device itself. When designing data access, consider how low bandwidth, high latency, and intermittent connectivity will affect your design. Consider the following guidelines when designing data access:

- Consider using a local device database that provides synchronization services, such as SQL Server Compact Edition. Only design a custom mechanism to synchronize data if the standard data synchronization features cannot meet your requirements.

- Program for data integrity. Files that remain open during device suspend and power failures may cause data integrity issues, especially when data is stored on a removable storage device. Include exception handling and retry logic to ensure that file operations succeed. To ensure data integrity in cases where the device loses power or connectivity, consider using transactions with SQL Server Mobile.
- Do not assume that removable storage will always be available, as a user can remove it at any time. Check for the existence of a removable storage device before writing to it or using FlushFileBuffers.
- If you use XML to store or transfer data, consider its overall size and impact on performance. XML increases both bandwidth and local storage requirements. Use compression algorithms or a non-XML transfer method.
- Minimize performance impact by designing for efficient database access and data processing. Consider the use of typed objects instead of data sets to reduce memory overhead and improve performance. If you are only reading and not writing data, utilize data readers. Avoid process intensive operation such as navigating through large data sets.

3.3 Database diagram

An entity–relationship model (ER model) describes inter-related things of interest in a specific domain of knowledge. An ER model is composed of entity types (which classify the things of interest) and specifies relationships that can exist between instances of those entity types.

In software engineering an ER model is commonly formed to represent things that a business needs to remember in order to perform business processes. Consequently, the ER model becomes an abstract data model that defines a data or information structure that can be implemented in a database, typically a relational database. An entity–relationship model is usually the result of systematic analysis to define and describe what is important to processes in an area of a business. It does not define the business processes; it only presents a business data schema in graphical form. It is usually drawn in a graphical form as boxes (entities) that are connected by lines (relationships) which express the associations and dependencies between entities.

From the below e-r diagram, Mother table contains information about registered mothers. The “ANC PNC msg” and the “Delivery and Child msg” table manages message delivery status for each state. Both table relate to the mother table using foreign key named “mother id”.

The “Child” table contains basic information about child like name of the child, sex, date of birth etc. Child table relate to the mother table using foreign key named “mother id”. The “Child follow up” table contains child home visit information. This table is relating to “Child” table using foreign key “child id”.

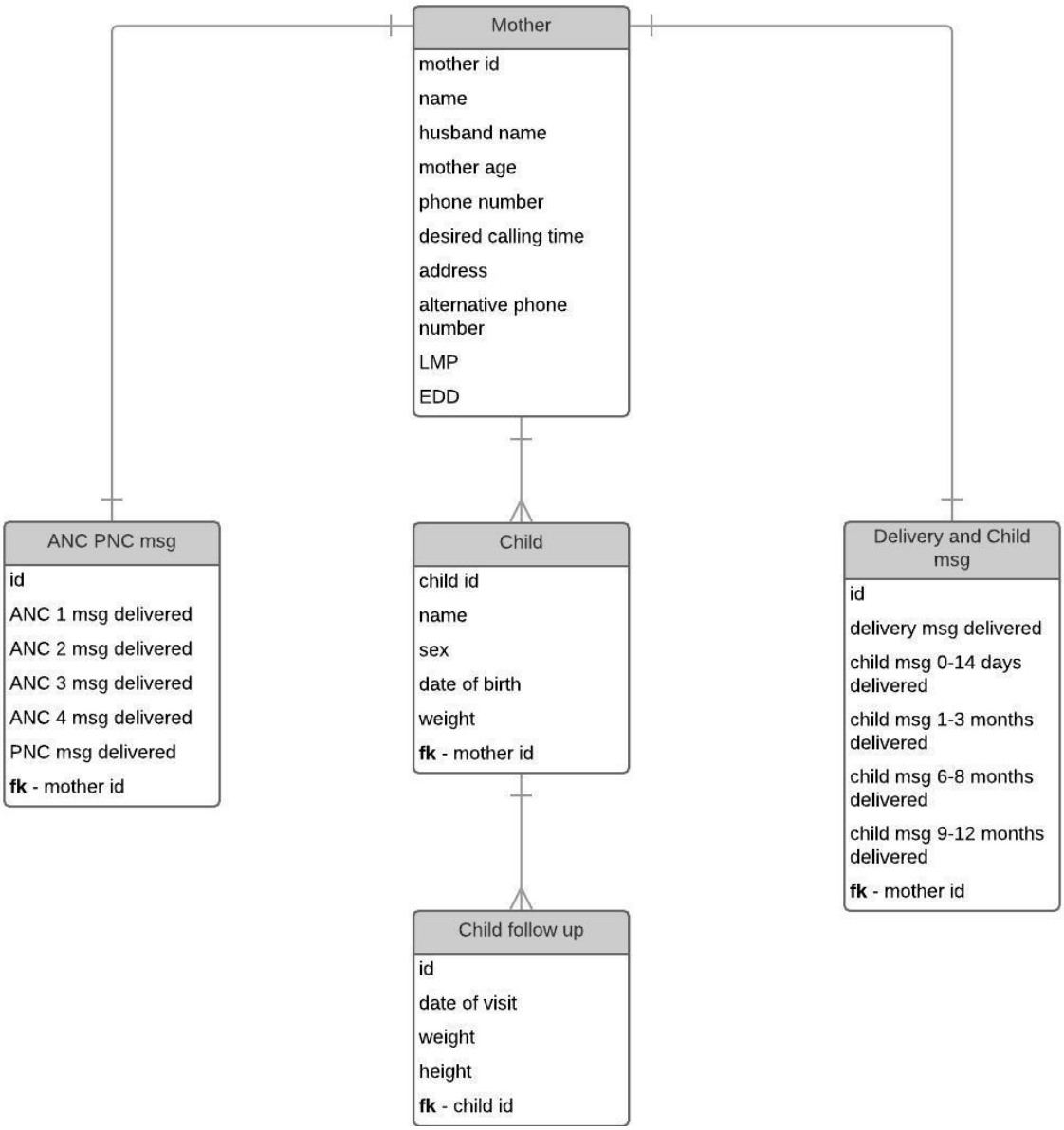

Fig 3.3.1: Entity relationship model

3.4 Use Case Diagram

Basic users of this Android application is health workers. The use case diagram of this application is shown in figure 3.4.1. In order to use this application user/health worker have to launch the application. After launching, this app will ask the user/health worker for login to the system. The application's home page will present to the user after a successful login. From this home page user/health worker can register a mother. For a registered mother this system is capable to show specific nutrition messages related to that mother. User/health worker will read the nutrition messages for a mother and then make a voice call to her cell phone to deliver the messages. After a successful

message delivery, the user will change the message delivery status for that mother. At the end of the day, user/health worker have to sync their data to the central database.

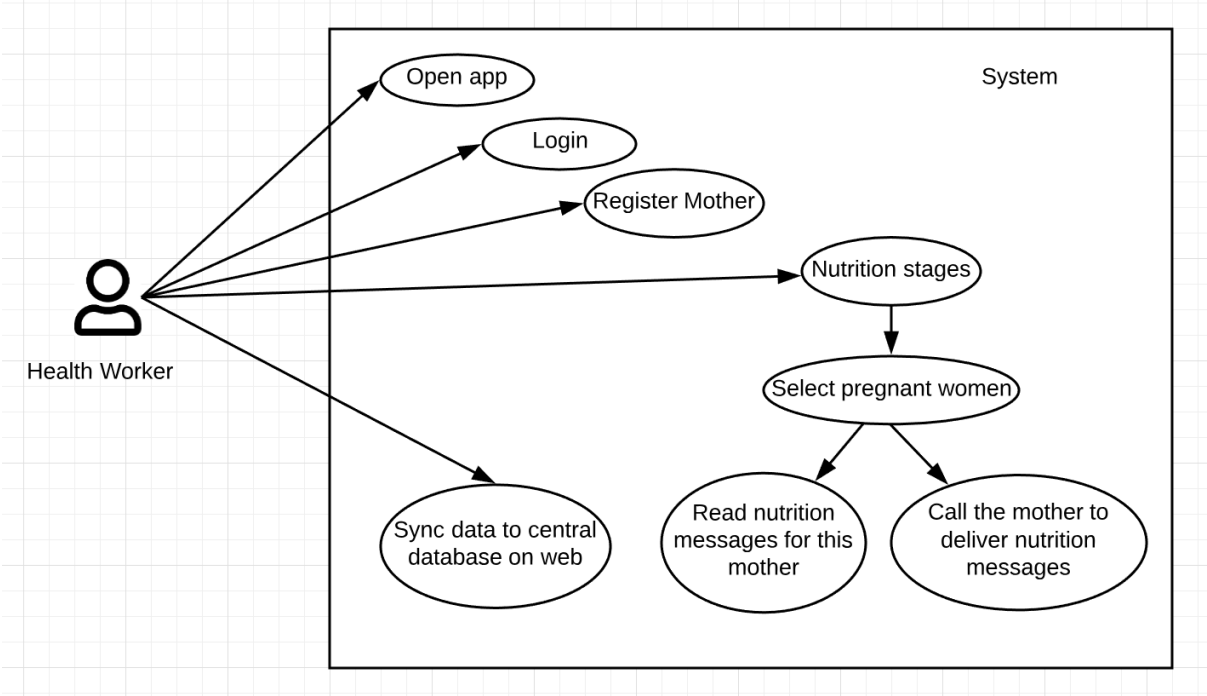

Fig 3.4.1: Entity relationship model

3.5 Platform used for developing nutrition application

As the role of mobile devices in people's lives expands even further, mobile app developers have become a driving force for software innovation. The question of "which platform to build an app for first" has been a popular one for the past five years. Often ideological or headline-focused, the platform wars may be over for now but the need to answer this particular question remains. To develop the nutrition care application Java has been used.

3.6 What is Android and why use Android?

Android is free and an open platform built on Linux. It is an open source solution for mobile devices offering a complete software stack including operating system, middleware, and key mobile applications. Apart from its speed, scalability, and performance, there are many other advantages of Android application development.

3.6.1 Open Source

The Android platform is open source which means the Android Software Development Kit (SDK) can be leveraged without having to worry about the licensing costs or royalty. Developers can interact

with the Android developer community for the forthcoming versions which they can incorporate into their Android app development projects. These benefits make Android a lucrative prospect for enterprises, device manufacturers and wireless operators alike, resulting in rapid development of the applications.

3.6.2 Customizable User interface

A user interface can either make or break your app. Android-based applications are highly customizable and easier to manage. Google is highly focused on making its user interface customizable to help developers create custom Android apps for business. Being an open source platform, it allows developers to turn their creative ideas into reality and build innovative and interactive apps. It offers a wide array of customization options. Even the data management functions and multimedia tools can be easily updated to the app.

3.6.3 Low Investment and High ROI

Android has a relatively low barrier to entry. Its Software Development Kit (SDK) is available for free to developers which significantly reduces the development costs. However, the app development costs can be bifurcated into three major parts: development, testing, and deployment. Developers are required to pay a one-time registration fee for application distribution. Thereafter, they can leverage any computer device to build and test the product on their smartphones, ensuring low investment and increased engagement among users. Ultimately, users get an interactive app and the enterprise gains higher return on investment.

3.6.4 Multiple Sales Channels

Unlike other mobile platforms, Android applications can be deployed in different ways. You do not have to rely on a single market to distribute your applications. Besides using Google Play Store and other third-party app marketplaces, you can create your own distribution and sales channels. You build it, you publish it. With your choice of promotional strategy, you can reach your end users through multiple channels.

3.6.4 Easy to Adopt

Android apps are scripted in Java programming language that leverages a rich set of libraries. Any developer familiar with Java can build Android applications easily. As per a developer survey, many

Java experts find it easier to write apps for Android as compared to programmers with command over other programming languages.

3.7 Development workflow basis

The workflow to develop an app for Android is conceptually the same as other app platforms. However, to efficiently build a well-designed app for Android, you need some specialized tools. The following list provides an overview of the process to build an Android app and includes links to some Android Studio tools you should use during each phase of development (Shown in Figure 3.7.1).

- Set up workspace
  - Install Android Studio and create a project.
- Write code for app
  - Android Studio includes a variety of tools and intelligence to help you work faster, write quality code, design a UI, and create resources for different device types.
- Build and run
  - During this phase, you build your project into a debuggable APK package that you can install and run on the emulator or an Android-powered device. For more information about how to run your code, see Build and Run Your App.
  - You can also begin customizing your build. For example, you can create build variants that produce different types of APKs from the same project, and shrink your code and resources to make your APK file smaller.
- Debug, profile, and test
  - This is the iterative phase in which you continue writing your app but with a focus on eliminating bugs and optimizing app performance. Of course, creating tests will help you in those endeavors.

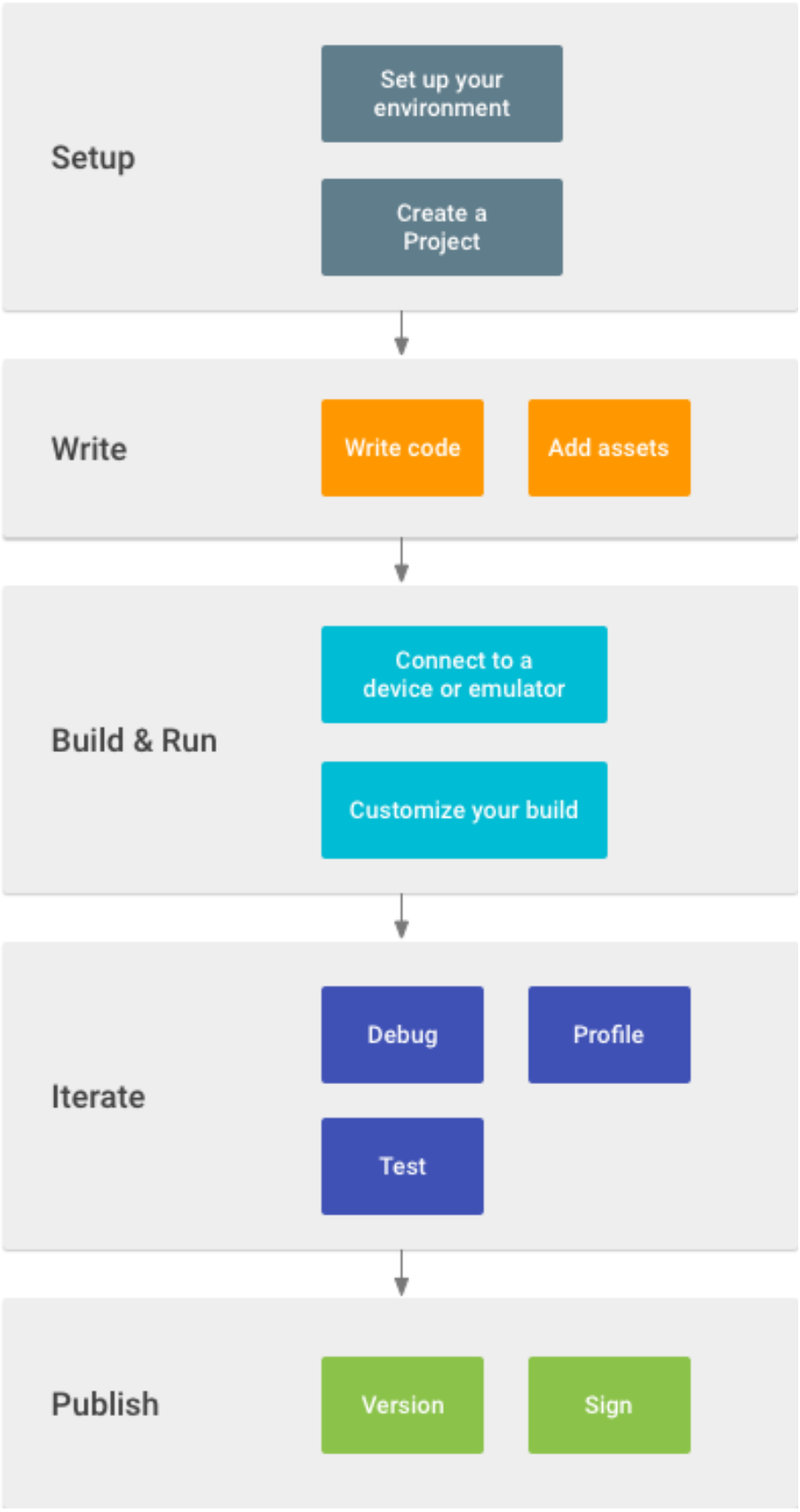

Fig 3.7.1: Development workflow

Chapter 4
Implementation

Telecommunications are the predominant technological platform for eHealth and mHealth based service delivery in the country. The provision of consistent and quality maternal and child health (MCH) services is a challenge for Bangladesh where most of the population lives in the rural setup. In this chapter we focus mainly on the implementation of our nutrition system.

4.1 Database used for mobile application

SQLite is a relational database management system contained in a C programming library. In contrast to many other database management systems, SQLite is not a client–server database engine. Rather, it is embedded into the end program. SQLite is a compact library. With all features enabled, the library size can be less than 500KiB, depending on the target platform and compiler optimization settings. (64-bit code is larger. And some compiler optimizations such as aggressive function inlining and loop unrolling can cause the object code to be much larger.) There is a trade-off between memory usage and speed. SQLite generally runs faster the more memory you give it. Nevertheless, performance is usually quite good even in low-memory environments. Depending on how it is used, SQLite can be faster than direct filesystem I/O. SQLite is ACID-compliant and implements most of the SQL standard, using a dynamically and weakly typed SQL syntax that does not guarantee the domain integrity. SQLite is a popular choice as embedded database software for local/client storage in application software such as web browsers. It is arguably the most widely deployed database engine, as it is used today by several widespread browsers, operating systems, and embedded systems (such as mobile phones), among others. SQLite has bindings to many programming languages.

4.2 User Interface

Since a user will typically interact visually with an Android application, it is important to design effective user interfaces for our users. In this section we give a brief overview of our nutrition system interface and how it works.

4.2.1 Facility type screen actual and mock-up (home page)

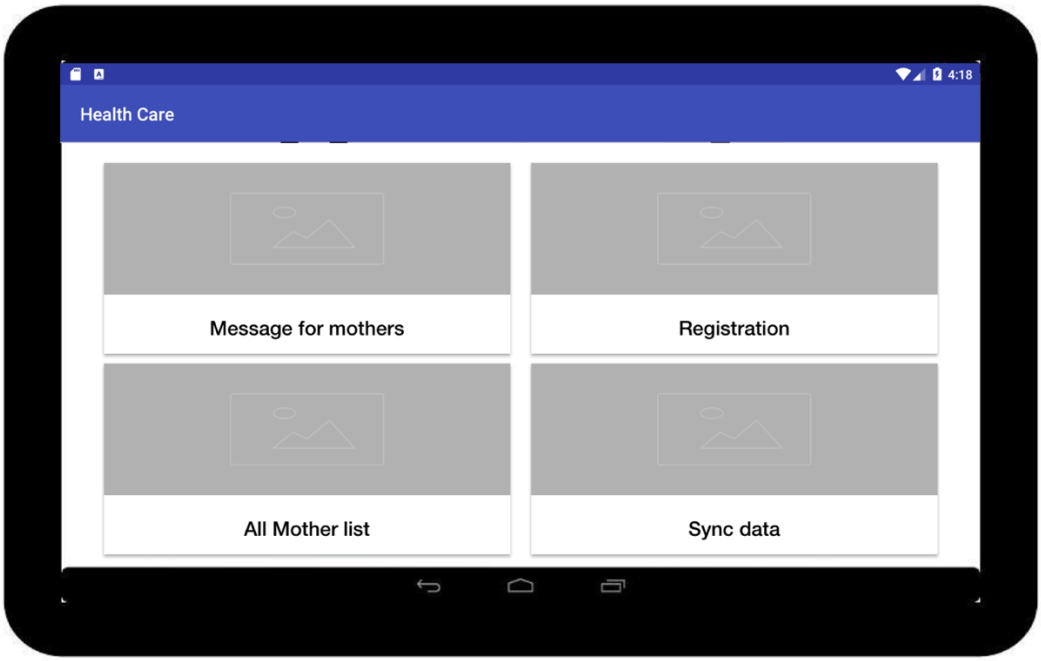

Fig 4.2.1.1: Home page (mock-up)

For generating a feeling for the application without having to write any code, the first version of the user interface was simply mocked-up using Sketch Mock-ups. Trying out the application as a simple PDF file with clickable buttons resulted in noticing and resolving a number of shortcomings depicted in Figure 4.2.1.1.

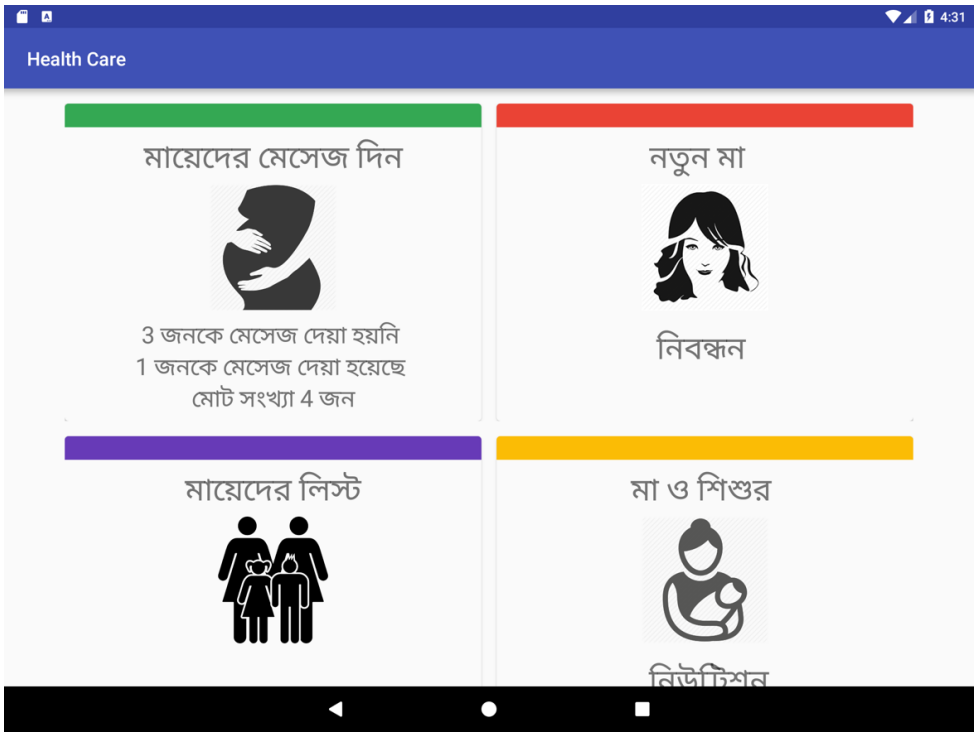

Fig 4.2.1.2: Home page (device)

Since the application targets novice users'/health workers with little to no experience on smartphone technologies, its user interface needed to be as intuitive and easy-to-use as possible. Therefore, a few different alternatives were reviewed that structured the content of the application differently. A few examples of this user-friendly restructuring can be seen in the Figure 4.2.1.2 and 4.2.1.3.

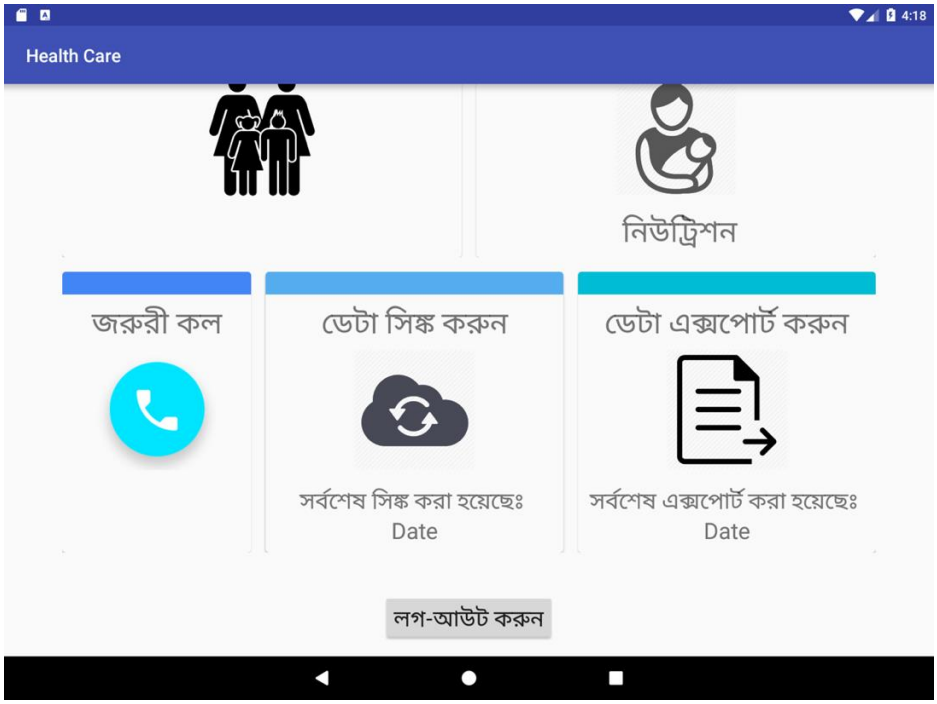

Fig 4.2.1.3: Homepage Cont. (device)

Each content of the home page (Figure 4.2.1.2 and Figure 4.2.1.3) represents the category of the facility provided by the application. If a user selects mother registration, application will redirect the user to a registration page where user can store few information about mother and register the mother.

Home page provides facilities for

- Registering mother
- Nutrition Stages
- Mothers List
- All Nutrition at a glance
- Emergency help line
- Sync data
- Export data

4.3.2 Mother Registration

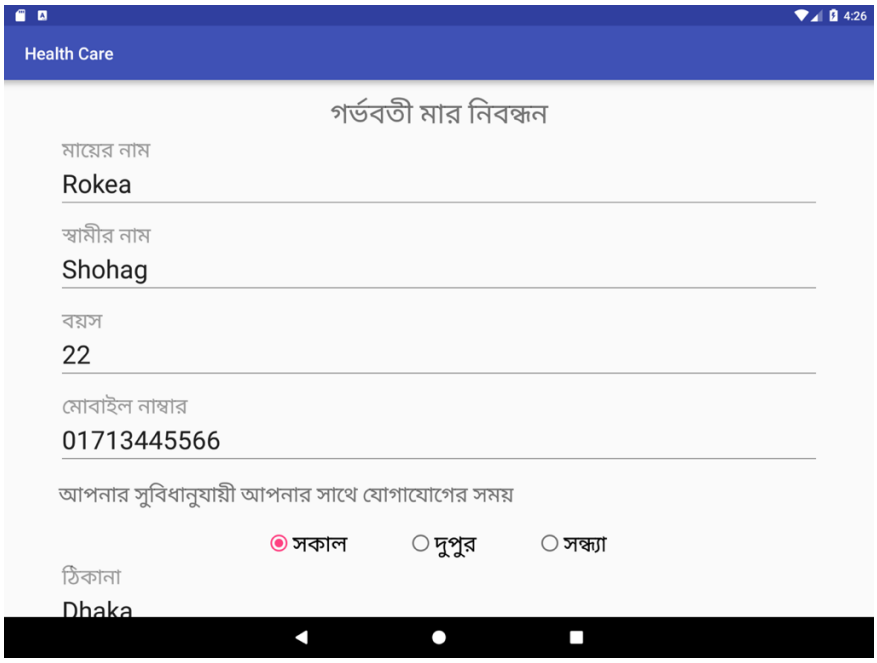

Fig 4.3.2.1: Mother registration

User/health worker can register a mother from this registration page. While registering a mother user/health worker will collect some basic information about the mother like name of the mother, husband name, age of the mother, primary phone number, desire time for communicating, address, alternate mobile number, name of alternate mobile number holder, last date of menstruation (LMP) or estimated date of delivery (EDD) if she knew her EDD from a doctor (Figure 4.3.2.1).

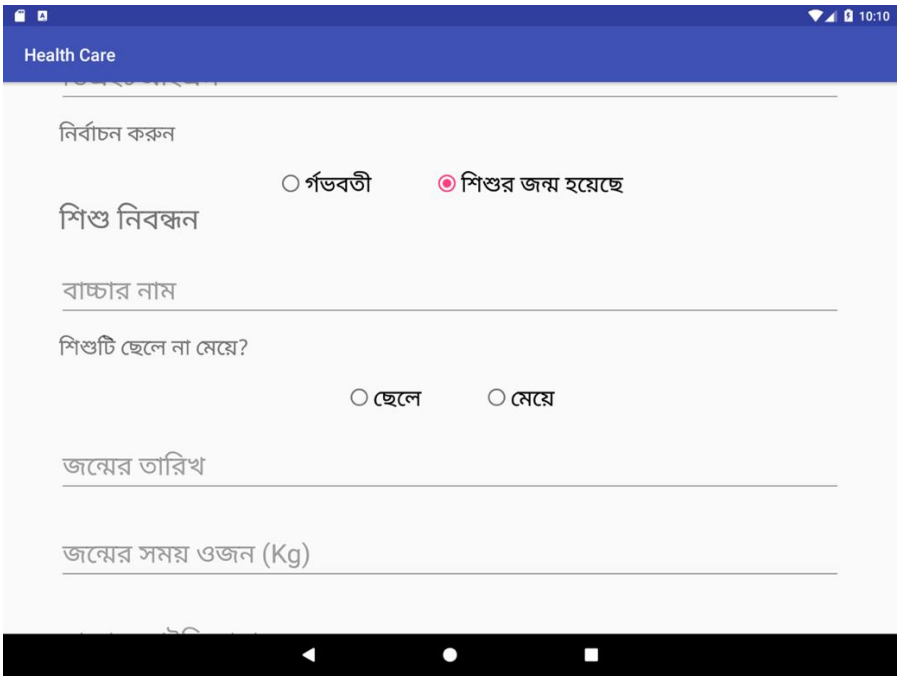

Fig 4.3.2.2: Mother registration with child

There is also an option for registering mother and their new born child together (Figure 4.3.2.2) in case the mother is not registered while she was pregnant. User/health worker will insert child name, sex, date of birth, weight at birth time etc. for registering child along with mother. If the user/health worker insert last date of menstruation (LMP) date of the pregnant woman this app will automatically calculate the estimated date of delivery (EDD) for the mother. Based on the last date of menstruation (LMP) or estimated date of delivery (EDD) this application will calculate which nutrition is needed for them.

4.3.3 Mothers and Child nutrition stages

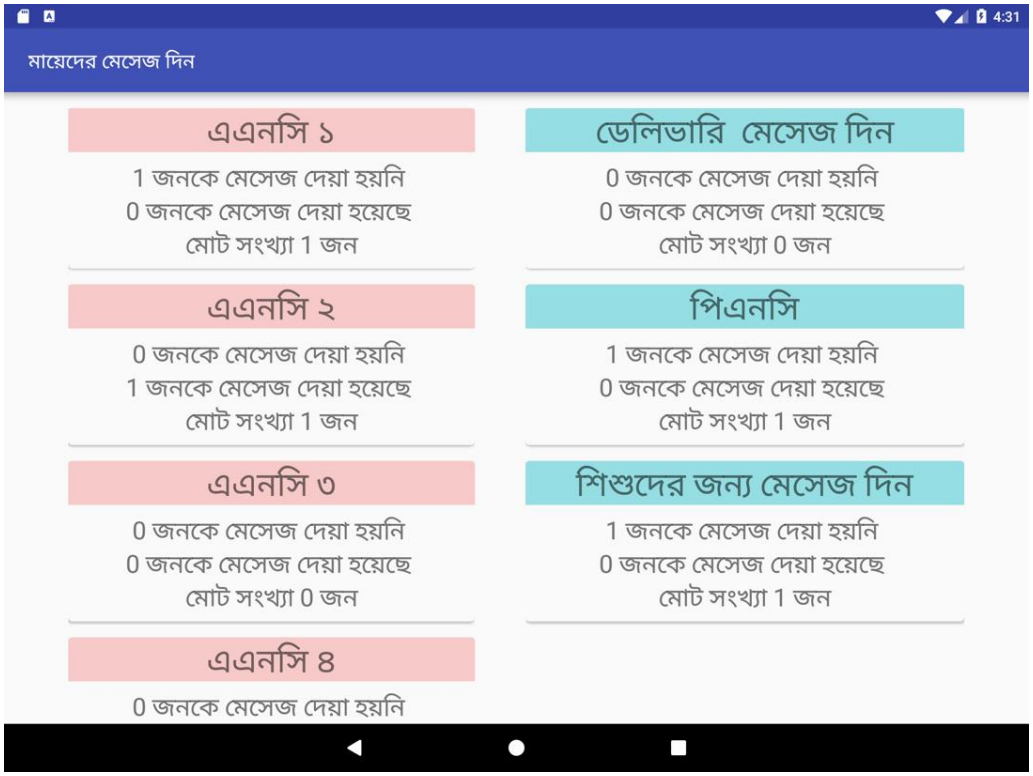

Fig 4.3.3.1: Different Nutrition stages

For a registered mother this nutrition system will provide the following nutrition stages (shown in Figure 4.3.3.1),

- **Ante-natal Care (ANC):** contains nutrition messages for different four different ANC stages.
    - ANC 1 (8 – 23 weeks of pregnancy)
    - ANC 2 (24 – 31 weeks of pregnancy)
    - ANC 3 (32 – 34 weeks of pregnancy)
    - ANC 4 (35 – 36 weeks of pregnancy)

- **Delivery:** this stage contains messages about delivery. After a successful delivery user/health worker can add new born child information at this stage.
- **Post-natal Care (PNC):** contains nutrition messages that should maintain post-delivery from 1 – 46 days.
- **Child stage:** contains nutrition messages for child of different ages. User/health worker will do child follow up at this stage.
    - 0 – 14 days' old
    - 6-month old
    - 9-month old

At each nutrition stage the user/health worker can shortly view how many mothers receive nutrition messages, how many mothers are pending to deliver the nutrition messages, and total number of mothers at that stage.

4.3.4 Detail page of a nutrition stage

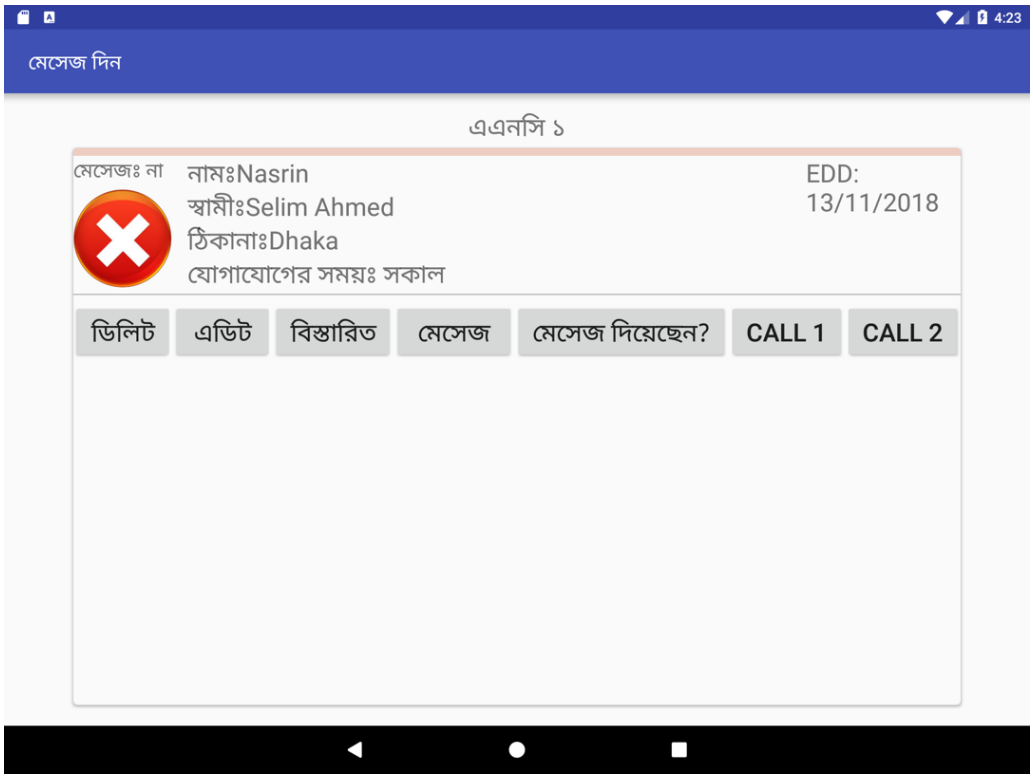

Fig 4.3.4.1: Detail page of ANC 1 Pregnancy stage

In this detail page (Figure 4.3.4.1) user/health worker can see a List of mothers. In the Figure 4.3.4.1 the list contains only one mother registered for this stage. Each list Item contains Thumbnail image, the name of the mother, her husband name, address, desired time for communication and EDD and

other features that is related to that mother. The Cross thumbnail image indicates that this does not receive nutrition messages for her ANC1 stage.

Mother details page provide features for a selected mother as follows,

- Edit mother details: edit mother information if needed
- Delete mother: delete mother if she died
- Details: show details information about the mother
- Messages: show nutrition stage related messages only
- Message delivery status: when a use/health worker deliver messages to the mother then s/he can will change the message delivery status to “yes”.
- Call 1: primary number for call
- Call 2: secondary number for call

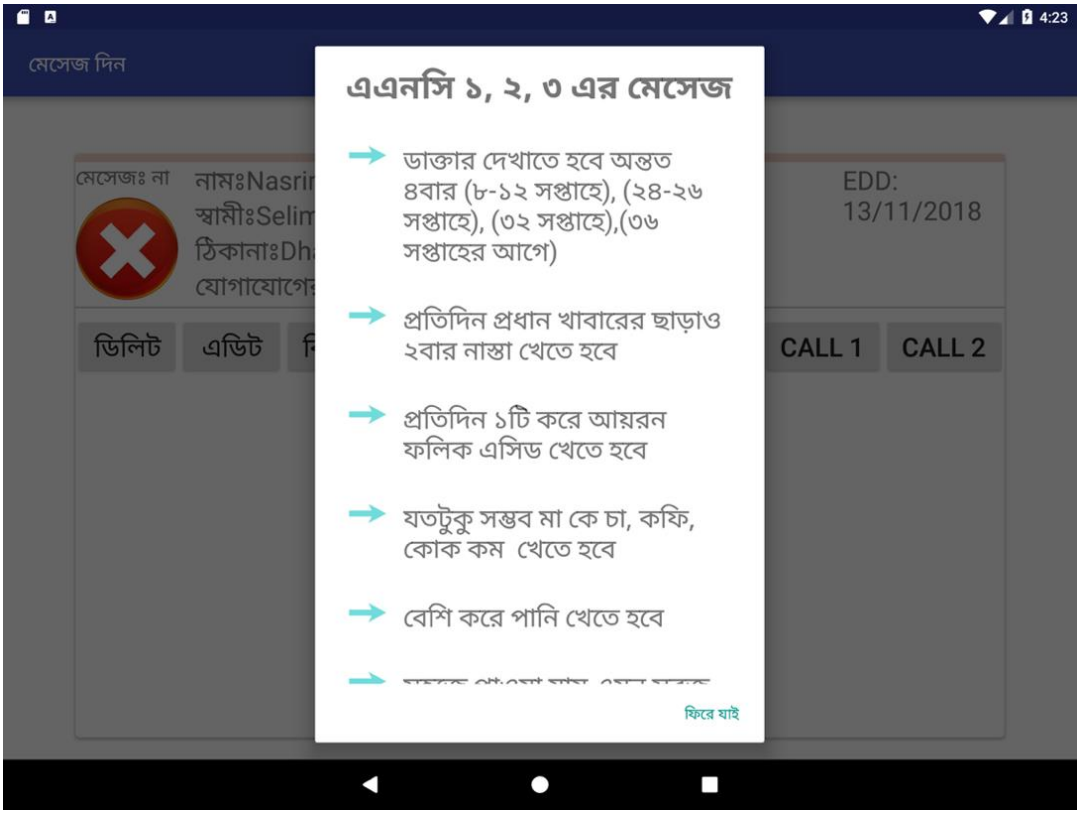

Fig 4.3.4.2: Nutrition Message

After click on the message (Shown in Figure 4.3.4.2) button a set of nutrition messages will show on the screen based on the nutrition stage. User/health worker will read this message and voice call the mother to deliver this nutrition message.

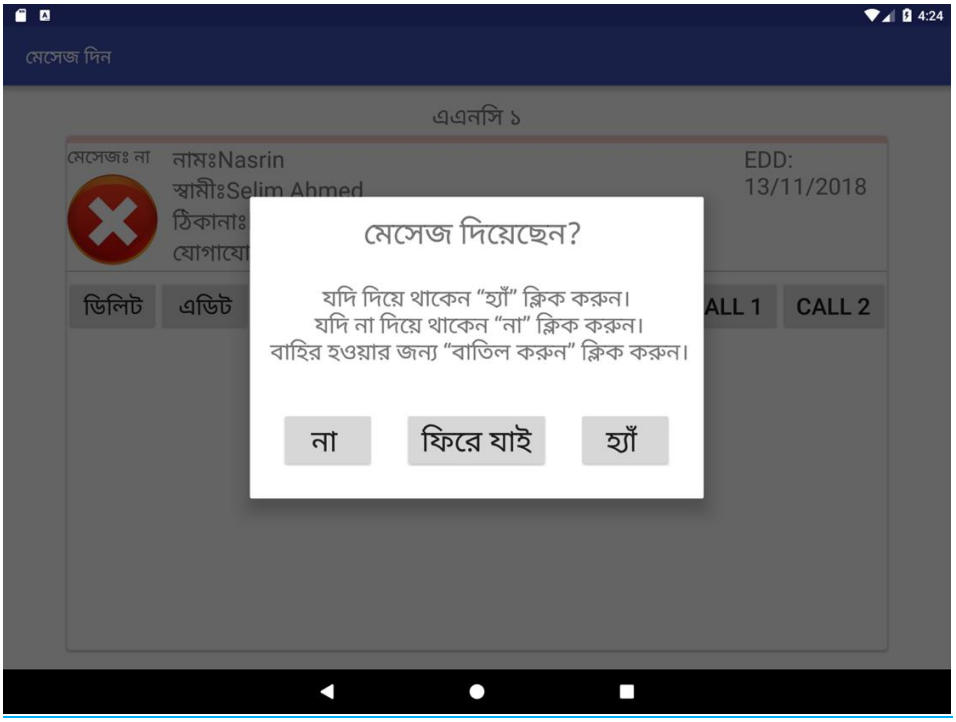

Fig 4.3.4.3: Change Message given status

After a successful message delivery to the mother user/health worker will click the message delivery status button to change the message delivery status (shown in Figure 4.3.4.3).

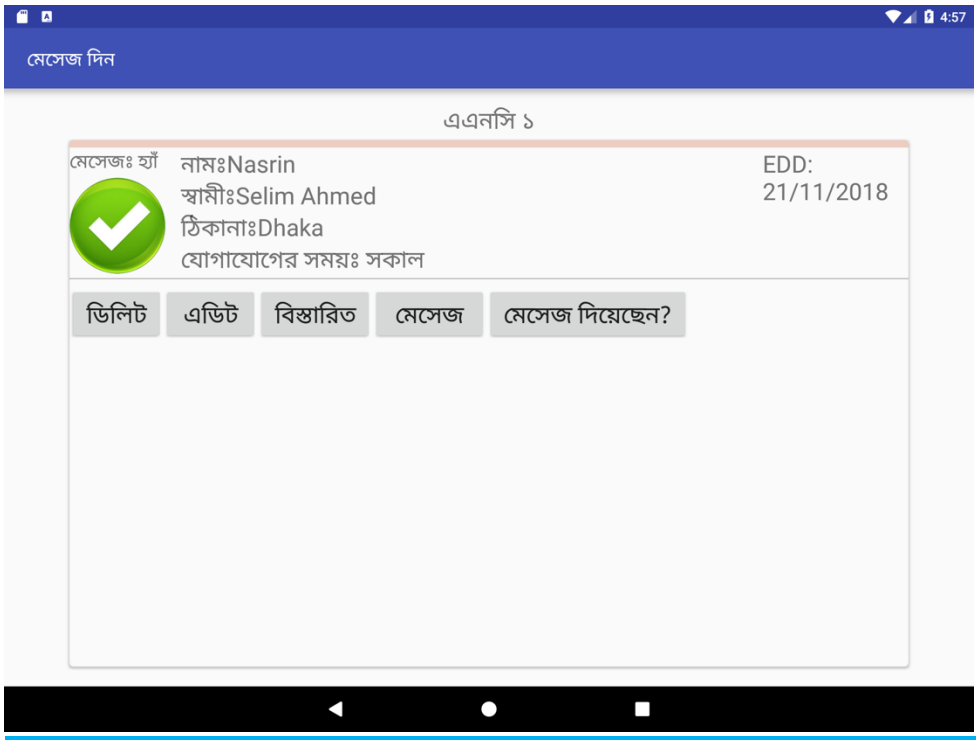

Fig 4.3.4.4: Detail page after message given to a mother

When user/health worker change the message delivery status to "Yes" mother detail page will look like the above picture (shown in Figure 4.3.4.4).

4.3.5 All nutrition at a glance

Fig 4.3.5.1: All Nutrition at a glance

User/health worker can memorize all nutrition messages from this page shown in Figure 4.3.5.1. This page contains all nutrition messages for pregnant woman and infant. This page is divided into two sections, the left clickable section contains nutrition messages for mother and the right clickable section contains nutrition messages for infant.

Fig 4.3.5.2: All nutrition messages for mothers

When user click on left side image of woman this nutrition system will show all nutrition information for a mother for all different nutrition stages at one place (shown in Figure 4.3.5.2).

Fig 4.3.5.3: All nutrition messages for new born child

When user click on right side image of child this nutrition system will show all nutrition information for a child for all different nutrition stages at one place for better memorization (shown in Figure 4.3.5.3).

4.4 Requirements to run the nutrition care system

The proposed mobile application can be run on any tablet android device that have minimum android SDK version 12. Any mobile processor along with 512 MB ram can run this application smoothly. A proper internet connection is needed to sync data from central database.

Chapter 5
Conclusion & Future Work

A healthy maternal dietary pattern, during the peri-conceptional period and throughout pregnancy, reduces the risk of maternal and infant complications, as well as longlife consequences. Dietary patterns with better micronutrient intakes (green leafy vegetables, fruits, whole-grain breads/cereals, oily fish etc.) positively influence the formation of a normal placenta at the beginning of pregnancy, fundamental later on in the developing fetus, thus decreasing the risk preeclampsia, premature delivery and abnormal fetal growth [4]. While undernutrition is mainly an issue of developing countries, malnutrition, due to poor quality diet, is becoming a global problem. Spreading the awareness of the importance of maternal nutrition before and during pregnancy and stimulating a cultural change in favour of a balanced healthy diet and high-quality foods consumption, is necessary for improving future global health.

This nutrition tool can be very useful to store information for pregnant woman and their infant, and provide the proper way to inform mothers for their nutrition messages based on their ANC, PNC state and also based on an infant age. The model of this application can easily provide the proper facilities of delivering nutrition messages to mothers by health workers.

Furthermore, a literature review was also conducted to identify what are the major software engineering challenges to develop and mobile application to solve healthcare problems. Four major issues that were identified are Creating Universal User Interfaces, Enabling Software Reuse across Mobile Platforms, Designing Context-Aware Mobile Applications, Balancing Agility and Uncertainty in Requirements.

Yet a prototype has been proposed in this report, a major work need to be done in order to branding this application. Facility owner and policy maker need to understand the proper requirement to implement this application. According WHO path toolkit [1], many projects fall just because policy maker and software engineer failed to understand the proper requirement. Before implementing this project in community level, need to discuss thoroughly with the people related with public health. It is also important to find out where are the barriers in community level to implement this application. There several technical problems may arise such as in production, there might be multiple servers required to update the data feed properly. As there are several live situations relate with project, we also need to ensure the quality of service. There is some quality work need to done correctly to provide the service to community level. It is very much necessary that in future an evaluation is conducted to find out potential shortcomings of the application both from software and hardware perspectives.

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