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mHealth: A Real Time Automated Measurement of Malnutrition

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ABSTRACT

Malnutrition is a formidable challenge faced by every country in the world. World Bank estimates that India is one of the highest ranking countries in the world for the number of children suffering from malnutrition. Although many steps have already been taken but scarcity of data, lack of uniformity in measuring malnutrition and non-reliability are major flaws. Many developing countries like India, still rely on paper for recording data, therefore inviting errors, delays and manipulation of the same. Hence, to minimize the scope of data manipulation, this paper attempts to develop an integrated framework for handling malnutrition data in India with minimum human intervention. The solutions will be derived on the basis of data observed/resulted in the field itself. For the same, mHealth, an android based mobile application was developed. This application is integrated with a weighing machine and connected wirelessly through Bluetooth. It is capable of collecting data in real time, measuring malnutrition and storing that data for future monitoring purposes. This will not only lead to operational efficiency but also nutrition allocation and will bring a sense of fairness for the children irrespective of their socio economic background. In the study, the overall state of malnutrition was found to be moderate as per the calculated z-score. However, it was observed that actual number of malnutrition cases in India was much larger than the reported cases.

Keywords: Android, Bluetooth, Malnutrition, Weighing Machine.

INTRODUCTION

According to International Food Policy Research Institute report (1), “one in three people is malnourished in one form or the other.” Malnutrition is manifested in various forms such as wasting (low weight for height), stunted growth (low weight for age), micronutrient deficiencies, obesity, high sugar or cholesterol content in blood. More than 150 countries of the world, in 2015, adopted the Sustainable Development Goal (SDG) to end all forms of malnutrition by the year, 2030. According to Global nutrition report (2), India is home to more than one-third of the world’s stunted children. India ranks 114 out of 132 countries, with stunting levels at 38.7%. Amongst south asian nations, it ranks with a Global Hunger Index (GHI) score of 29.0 ('serious situation'). This shows that malnutrition remains a significant global problem, particularly in developing countries like India. Malnutrition is not only a health hazard but also has various socio-economic implications (3). Compared to the well-nourished individuals, nutrition-deficient ones have a higher probability of catching infectious diseases such as tuberculosis and pneumonia, leading to a higher mortality rate. Further, nutrition-deficient individuals show less productivity at work (4). As an outcome, they remain in a low pay group and get trapped in under-nutrition circumstances generation after generation. The World Bank estimates that India loses 2-3% of GDP due to lower productivity (5). Malnutrition is a major cause that holds back our progress. It is an urgency which needs to be tackled with immediate effect. Although many steps have already been taken in this direction, scarcity of data, lack of uniformity in measuring malnutrition and non-reliability still persists. Many developing countries like India, even today, primarily rely on paper for recording data, thereby inviting errors, delays and manipulations of the same. As a solution, mobile electronic data capturing can help reduce these errors in monitoring the process to a large extent by reducing inefficiencies caused by insufficient and inaccessible documentation (6)(7).

With this backdrop, the paper suggests designing of an effective system to support malnutrition management in young children. We aim to develop an android application to handle and manage malnutrition in children under the age of six years with the following objectives:

a) To create a measuring system free from bias or adulteration.
b) To create a database, capable of storing the data in an organized manner which can be used for various applications in future.
c) Contributing to the movement *Free India of Malnutrition − Kuposhan Bharat Chhor do*.

Being an mHealth application, this will be a mobile based application which will leverage economical android devices. This application will target a) collection of data b) assessing the children's condition c) transferring it to the nearest *Anganwadi* centre and d) monitoring treatment thereafter. The paper also discusses the requirements of the mobile application and how it was designed. Potential users of this application would be health care providers, doctors, NGO workers, *Anganwadi* workers, volunteers, researchers, government departments and other individuals who are concerned with women and child development. Few of the existing applications were investigated in order to identify their strengths and weaknesses. An attempt has been made to incorporate those strengths and address those weaknesses while developing our application. Two of these applications are reviewed below.

a) 'WHO Anthro' a software application developed by WHO to help and assist in monitoring development and growth in children below five years of age, as per the new WHO Child Growth Standards published in 2006. The application is available in two versions: a mobile phone version and a PC version. WHO Anthro was primarily designed for mobile devices which used MS Windows Mobile 5.0 or MS Pocket PC 2003. The software has 3 modules that supported the following functionality:

- *Anthropometric calculator* − assessed child's nutritional status.
- *Individual Assessment* − tracked a child's development and growth over time.
- *Nutritional survey* − conducted nutritional surveys.

To determine the usability of the PC version of WHO Anthro, it was found that this application is obsolete and outdated and was available on the Windows mobile platform only. Also, this application did not support the reporting functionality, which is required for real time and transparent monitoring.

b) 'Mata Yashoda App' is an android application, developed by the Gujarat Government and launched in 2015 which aims at decreasing reporting time of *Anganwadis* to give more time to service rather than administrative work. However, the application is 'id login' based only for *Anganwadis* and not available for general public usage. Furthermore, all the features are in Gujarati language support only. Also, it does not support real time entry of weight which ceases to eliminate human interference.

RESEARCH METHODOLOGY

Many mobile applications related to health have been developed, but they cease to be a successful platform for gauging malnutrition effectively. The proposed mobile application will assist in data collection of child information in real time and save the information in the database. The application will take the child's information as an input to calculate the *z-score* (8)[1]. The application will then conduct a diagnostic exercise on the basis of calculated z-score (Table I) and report severity of malnutrition level, case by case, directly to the concerned ICDS supervisor of the area.

Table I: World Health Organisation growth reference for children aged 0-5 years

Z-Score Values	Classification
< -3	Severe malnutrition
>= -3 and < -2	Moderate malnutrition
>= -2 and < -1	Mild malnutrition
>= -1 and (Z < +1)	Normal weight
(+1 <= Z)	Over weight

[1]WHO(2011) defines a z-score as a " measure of how far the observed value is from the median value of the reference population divided by the standard deviation value of the reference population".

The application is capable of creating a weight measuring system which is free from bias or adulteration and has no human interference in measuring or recording the weight. Also, recording and interpretation of data in traditional way of record-keeping is maintained for an easy understanding. The detailed functional/operational requirements are shown in (Figure I).

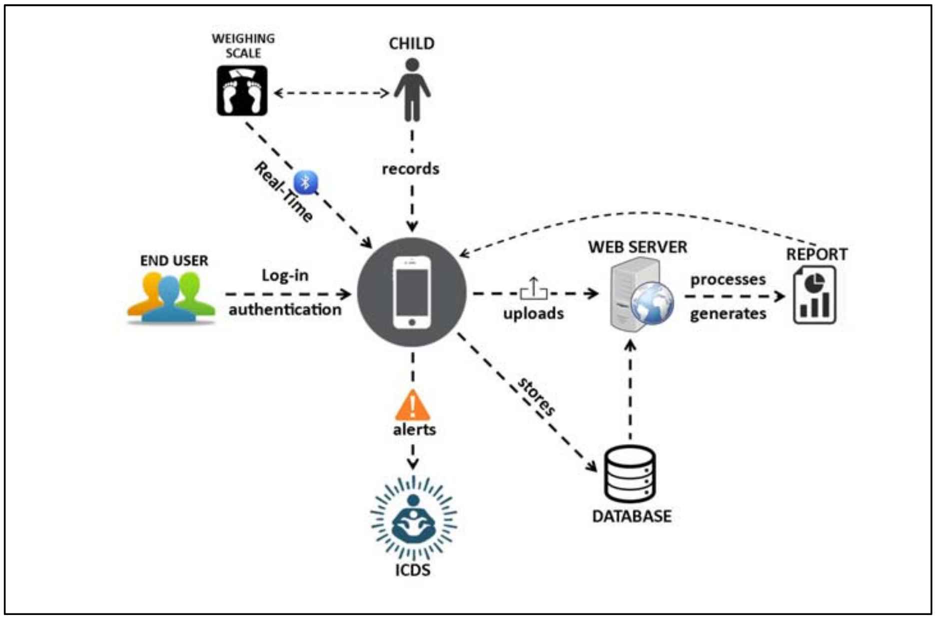

Figure I: Functional model of mHealth app

The functional requirements of the mHealth app is as follows:

1. *Login:* The user will be able to login to the application using his/her email address as his/her username and a unique password, which will be provided to the user.
2. *New entry:* The user will make a fresh entry into the system by capturing the child's biographical information and other necessary information required on the child details entry form.
3. *Updating of the existing entry:*
   a) *Get Weight:* The Bluetooth utility scans the nearby Bluetooth devices and automatically connects to the weighing machine. The weight of child is measured and it is detected by the mobile application.
   b) *Generate Report:* After a patient is identified, the user can enter the patient's current information and ascertain the patient's current nutritional status.
   c) *View reports:* The mobile application is also capable of able running queries and displaying reports on the basis of various criterion.
4. *Send alerts:* The application will automatically send reminder to the supervisors of the ICDS to inform in real time about the current status of severe malnutrition in a particular area.

5. *Synchronisation:* To achieve transparency*,* the data will be stored on a local database in a mobile phone in the beginning, however, on availability of active internet connection, the data will automatically sync to the central server.

Tools required to develop the proposed system:

1. ANDROID Software Development Kit: Android Studio Version 1.6 was used to develop Android applications. This SDK includes emulator, development tools and necessary libraries.

2. BLE (Bluetooth Low Energy) 4.0: It reduces the power consumption and cost as compared to classic Bluetooth. It is used for novel applications in the healthcare, fitness, security, beacons, etc.

3. SQLite: To store the data locally on android device SQLite was used and then entries were uploaded to the central server. Android comes with built-in SQLite database implementation.

4. MySQL and PHP and Apache: For the server side report generation, MySQL as database management system, PHP as scripting language and Apache as Web server were used.

5. Android REST Client using Volley**:** Volley is an HTTP library that was used for networking the SQLite database with the server for all kind of operations available including those predefined by the HTTP methods, GET, POST, PUT, DELETE and so on.

6. Google Charts: Google chart tools are free to use developer tools which were used for generating child progress graphs in the android application.

DATA COLLECTION

The National Capital Territory of Delhi is divided into nine districts, which are further divided into various projects by the ICDS (Integrated Child Development Services). Each project has anywhere around 100 to 180 *Anganwadis* sanctioned to it. On the basis of convenient sampling, the data for the study was collected from AWCs for a 3 month-time frame − March to June 2017, from 150 *Anganwadis* in various districts of Delhi; such as Sagarpur, Vasant Gaon, Kusumpur Pahari, Mochi Gaon, Moti Bagh in South West Delhi, Wazirpur in North West Delhi and Mohan Garden, Uttam Nagar in West Delhi among others. The data of children was collected from the daily attendance registers and the monthly progress reports maintained by the *Anganwadi* workers. The data collected included the name of the child, father's name, mother's name, address, date of birth, gender and weight of the child. The data from various AWCs was then entered into Excel sheets and compiled to assist in the process of application development. A sample input sheet is presented in (Figure II).

Data was then fed into the

	A	B	C	D	E	F	G
1	ID	CHILD NAME	DOB	MOTHERS NAME	FATHERS NAME	ADDRESS	M/F
2	WAZ/129/1	JOYA	10/5/2015	NEETU	DEEPAK	B420	F
3	WAZ/129/2	GIYA	11/8/2015	SAVITA	PANKAJ	B111 K	F
4	WAZ/129/5	LAKSHITA	12/17/2014	ANJU	MOHAN	B 68	F
5	WAZ/129/6	TWINKLE	9/12/2014	RUSHNU	MANISH	B 447	F
6	WAZ/129/7	KANISHKA	4/10/2014	DALI	GANESH	B 326	F
7	WAZ/129/8	MANNAT	7/27/2014	POOJA	PARVAZ	A 283	F
8	WAZ/129/9	SANNA	2/5/2014	ASHA	SAMAR	A 435	F
9	WAZ/129/10	PRIYANSHI	7/13/2013	TANNU	RAVISHANKAR	B 376	F
10	WAZ/129/11	MONICA	12/19/2013	PREETI	SANTOSH	B 413	F
11	WAZ/129/12	AVNI	5/10/2013	ROOPAM	KANISHK	B 326	F
12	WAZ/129/25	ROSHNI	11/29/2012	RINKI	MANJEET	B 284	F
13	WAZ/129/27	DEEKSHA	9/11/2011	MADHU	SATISH	A 425	F
14	WAZ/129/28	RADHIKA	11/4/2011	MEER	EMRAN	B 470	F
15	WAZ/129/29	ANANYA	9/15/2011	SANGEETA	MAHENDRA	B447	F
16	WAZ/129/30	PRIYANKA	1/5/2013	SUNITA	SURENDER	B 63	F
17	WAZ/129/3	AYUSH	10/8/2015	SAVITA	SUREKH	B 376	M
18	WAZ/129/4	BABY	2/29/2016	SEEMA	SACHIN	B 339	M
19	WAZ/129/13	SHIVNATH	12/29/2014	PRIYANKA	RAJESH	B 51	M
20	WAZ/129/14	PIYUSH	12/29/2014	SEEMA	VIKAS	A 301	M
21	WAZ/129/15	AARYAN	1/28/2014	ROOPAM	SATESH	B64	M
22	WAZ/129/16	ANSH	6/7/2014	POONAM	SANIM	B 311	M
23	WAZ/129/17	DEEPANSHU	6/28/2013	ANITA	SUNIL	B 348	M
24	WAZ/129/18	SHIVA	5/17/2013	RANEMA	VIDYAJEET	B 284	M
25	WAZ/129/19	VIVAN	8/2/2013	KOMAL	SANJU	B 380	M
26	WAZ/129/20	KARTIK	2/15/2015	PRIYA	KANTI	B 298	M
27	WAZ/129/21	HIMANK	4/11/2015	REENA	AJIT	B 386	M
28	WAZ/129/22	RONIT	1/1/2013	ROOPA	NEELKAMAL	B 404	M
29	WAZ/129/23	ASHISH	11/10/2011	SHAMILA	AJMAL	B 363	M
30	WAZ/129/24	KRISHNA	5/21/2011	USHA	RAMESH	B 68	M

AW_NO.(VARIABLE) (129) / AW_NO.(STATIC) (130) / AW_NO.(VARIABLE) (130)

Ready

Figure II: Input sheet

mHealth mobile app. Screenshots of the same are presented in (Figure III) and (Figure IV).

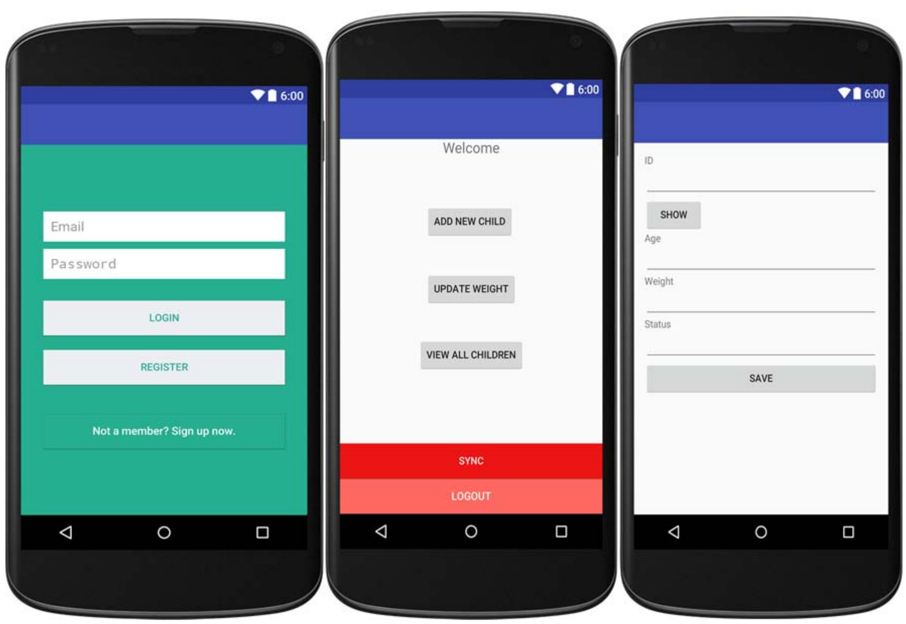

Figure III: Input form on mobile interface

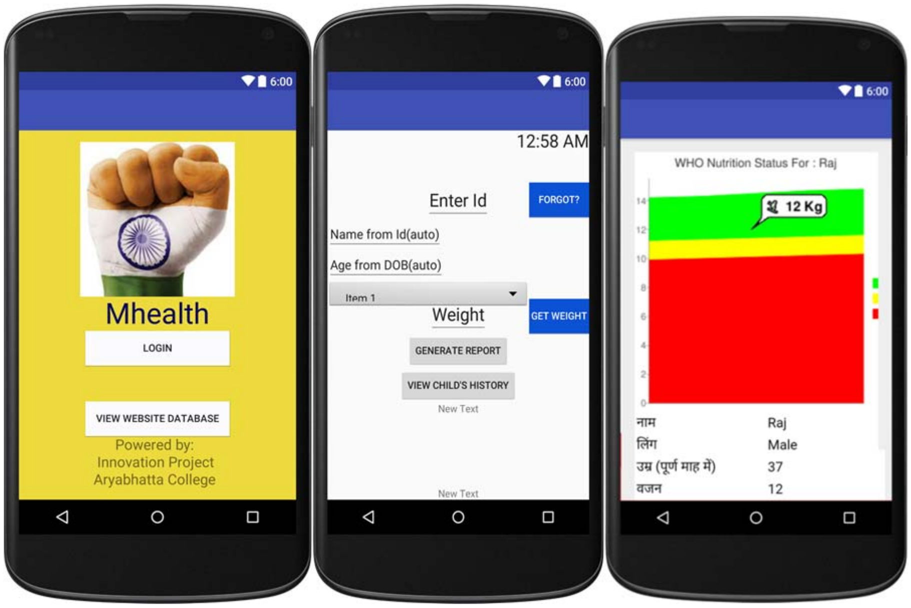

Figure IV: Login and output screen

RESULTS

Among the children below the age of five years, the z score value of the sample was calculated through mHealth app and the malnutrition level was found to be normal to moderate, ranging from -3.0 to +1.0 (refer Table II). The system helped to solve the problem of incorrect data entry. To solve the problem of incorrect data, our own database for storing information of children was created in the app. This data can not only be utilized to analyze problems such as malnutrition but also to monitor each child separately as each child is given a unique ID through our app. It was observed that there was no particular date of the month for measuring the weight data of the children. Absenteeism of children and sometimes even the users was observed and most of the *Anganwadis* did not have weight data. To overcome the issue of manipulation, a Bluetooth weighing machine was integrated with mHealth app which automatically feeds the weight to the app. This is an important achievement since data entry is not only prone to manipulation but also unintentional errors in data entry and faulty weighing machines. The mHealth app provided a digitally maintained database in a uniform format for better analysis. Plotting of graph for each child is a tedious task for *Anganwadi* workers. To solve this issue, an equation for the regression line or the line of best fit for the graph they were using was derived and integrated with mHealth app.

TABLE II: z-score output

Classification	Z – score values
Normal	-2.0 < z-score
Moderately malnourished	-3.0 < z- score < -2.0
Severely malnourished	z-score < -3.0

The z-score of the sample, bifurcated gender-wise, is shown graphically below in (Figure V) and (Figure VI).

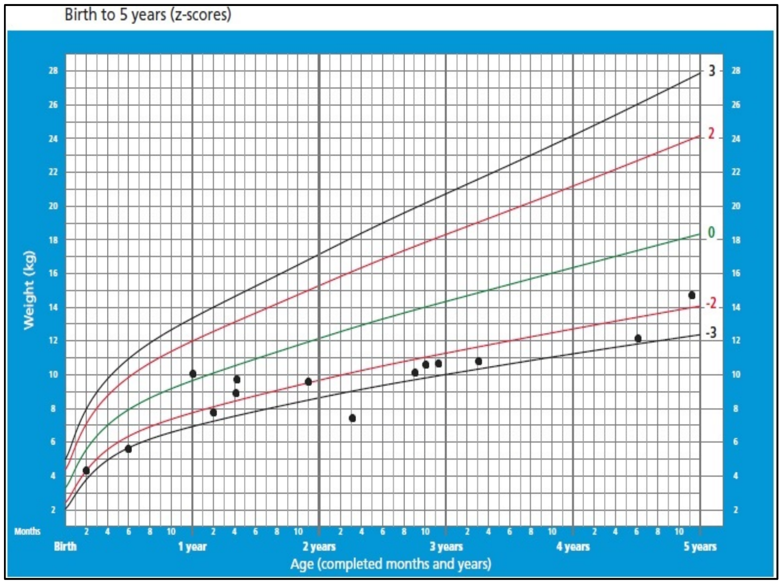

Figure V: Graphical representation of z-score values of Boys (< 5 years of age)

Figure VI: Graphical representation of z-score values of Girls (< 5 years of age)

LIMITATIONS AND SCOPE For FURTHER RESEARCH

During the study, we took note of some limitations that warrant examination and provides a further scope of research. Firstly, the sample size of the study was limited and restricted to only national capital territory of Delhi. The overall situation of malnutrition nation-wide, could provide an entirely different picture. It was found that number of malnutrition cases reported were much lesser than the actual cases. Also, the time lag between actual measurement and reporting of a case is very large and in most of the cases, malnutrition is not reported. Since this study has provided a platform for easy and error free data entry mechanism for malnutrition data, further studies can help in development of a cloud based centralized data repository system in the which could be accessible anytime and anywhere. Also, a real time monitoring system which provides solution on case to case basis can also be accommodated.

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