Design of Mobile Health Tools for Assessment of Health and Nutritional Status in Children

by
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Submitted to the Integrated Design and Management Program
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ABSTRACT

Introduction and Motivation:

In India, more than 700,000 accredited social health activists (ASHAs) are women selected and trained to work between members of their communities and the public health system. In spite of much advancement in screening tools and best practices in the healthcare system to date, service for members of the bottom of the pyramid remains largely unchanged.

ASHA workers need user friendly tools and job aids that would enable them to

- Conduct health-care screenings and consultations
- Educating communities on basic health-care practices
- Confidence to advise medical referrals for patients

Most of the existing solutions designed and deployed in the field ignore issues like context of rural/urban settings (language, living conditions), digital illiteracy, and portability.

Proposed Solution: Mobile Kit for Assessment of Child Health and Nutrition

In order to address the problem described above, the Mobile Technology Group, headed by Dr. Fletcher, is developing a smart phone based kit that will assist with the basic tasks that an ASHA health worker is required to perform. These measurements include:

- Baby's weight
- Baby's height
- Baby's thermal regulation (which is an indicator of health)
- Baby's cardiovascular health (heart rate, pulse oximetry)
- Middle Upper Arm Circumference (MUAC), which is an indicator of the nutritional status

The electronics and computer software for these tools is being implemented by another graduate student, Xavier Soriano. However, I am responsible for the product design, interaction design, and evaluation of the technology.

Primary Research Objectives:

1. To help design the non-invasive mobile based tools for assessing and health and nutritional status of children under 5 years to be used by community health workers in urban poor settlements of India
2. To test, evaluate and assess the ease of use of these tools by community health workers

Thesis Supervisor:

Dr. Richard Ribon Fletcher
Research Scientist
Head, Mobile Technology Group, MIT D-Lab

ACKNOWLEDGMENT

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I would like to thank the peers who were involved in this research project. Without their passionate participation and input, the project could not have been successfully conducted.

I am grateful to Steve Eppinger, Warren Seering, Andrew Macinnis, Melissa Parrillo, Lesley Perera, Robert Stoner and Georgina Campbell's guidance throughout the past two years and especially Professor Mathew S Kressy for his consistent mentorship and love.

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CONTENTS

CHAPTER I:
Introduction and Motivation

A. Public Health System and Challenges

Public health system is a system that is concerned with a community's health and wellbeing. It is an entity that contributes to the delivery of essential public health services within a jurisdiction. It is concerned with the factors affecting the promotion and maintenance of people's health. Many factors outside the health system influence people's health, such as poverty, education, infrastructure, and the broader social and political environment.

The public health system generally includes:

- Patients, families and communities
- Ministry of health
- Hospitals at state and district levels
- Healthcare providers – doctors and nurses
- Medical schools and research organizations
- Health and nutrition services organizations
- Public health organizations
- Community health workers
- Pharmaceutical companies
- Pharmacies/dispensaries
- Health financing bodies
- Economic and philanthropic organizations

The functions of public health services include health awareness, community health statistics recording and interpreting, assessment of community's health risks and health status, Diagnosis and investigation of health problems, healthcare planning and budgeting, Aid community partnerships, Develop and enforce laws, policies and plans for community wellbeing, Health service and infrastructure provision, Skill training for health care workforce, Design systems to evaluate health care services, Research and development, Financing and managing systems, Aid community partnerships, Develop and enforce laws, policies and plans for community wellbeing, Health service and infrastructure provision, Skill training for health care workforce, Design systems to evaluate health care services, Research and development, Financing and managing systems.

In most developing countries the public health care system consists of several tiers of service, ranging from the large hospital (Level 4 facility) to a simple 1 room health center (Level 1 facility). (see Fig 1)

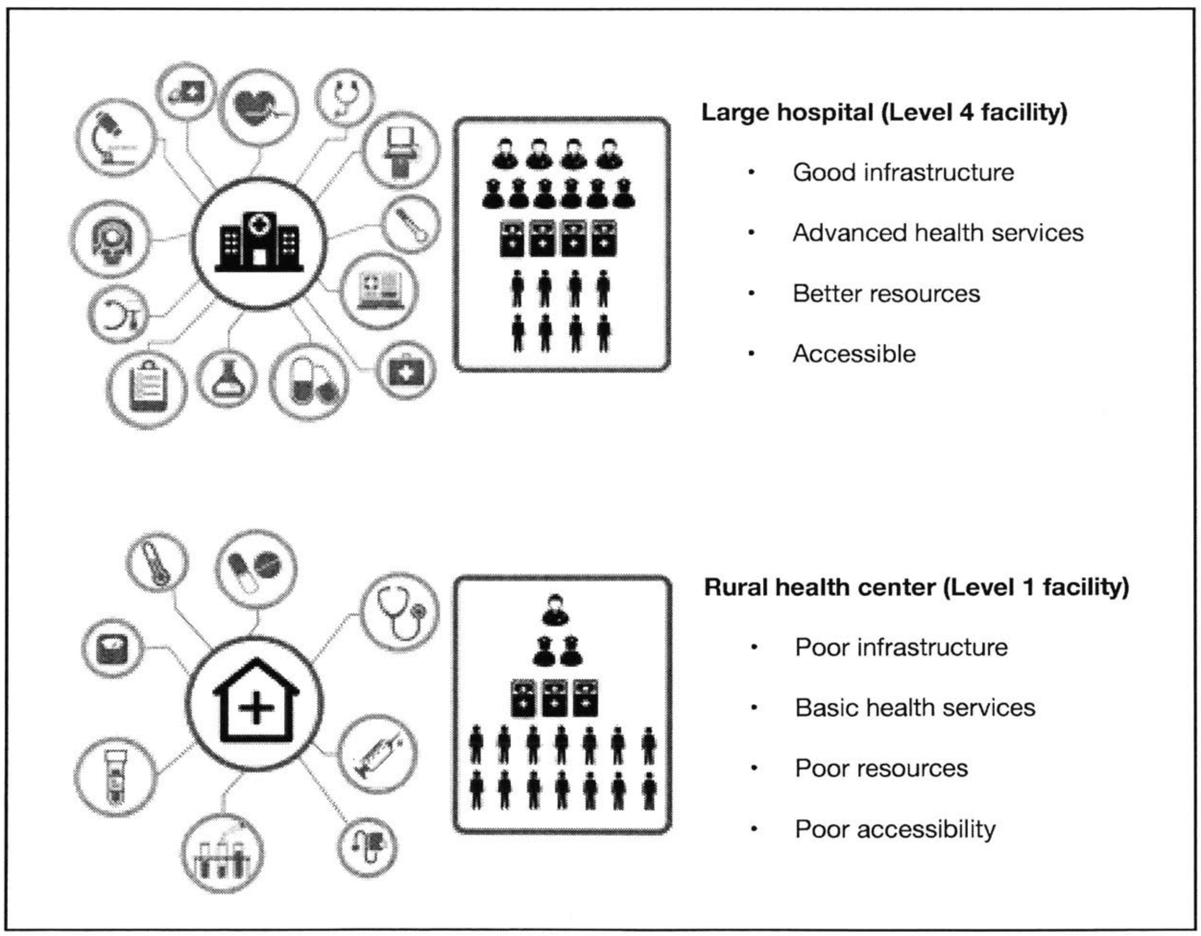


Fig 1: Tiers of hospital facilities in India [1]

1. Indian Public Health System and Challenges

India has a population of 1.2 billion people, whereof three quarters live in rural areas[1]. There are over 35,000 public hospitals across 29 states in India[2]. In 2005 the Government launched the National Rural Health Mission (NRHM), a health program in mission mode to improve the health system and the health status of the people, especially for those who live in the rural areas, and provide universal access to equitable, affordable, and quality healthcare. A component of NRHM at state level measures clinical output and performance indicators, and reports it regularly to the national level. This data helps the state and national health ministries to plan further programs based on the impact created.[1]

2.Structure and Organization

Under the Indian Constitution, each state is responsible for the functioning of its healthcare delivery system in which both public and private (for profit as well as nonprofit) players operate. The Central Government takes care of policy-making, planning, guiding, assisting, evaluating and coordinating the work of various provincial health authorities and providing funding to implement national programs.

The organization at the national level consists of the Union Ministry of Health and Family Welfare (MoHFW). In each State, the organization is under the State Department of Health and Family Welfare that is headed by a State Minister and with a Secretariat. The Indian public healthcare system consists of both Allopathy and AYUSH (Ayurveda, Yoga, Unani, Siddha and Homeopathy). In every state, each regional set-up covers 3–5 districts and operates under the

State Directorate of Health Services. The district level structure of health services is a link between the State and regional structure and the peripheral level structures such as Primary Healthcare (PHC) and Sub-Centre.[1]

3.Challenges in the Indian Public Healthcare System

1. Poor infrastructure and underutilization of existing resources
2. Shortage of specialists and doctors – There is only one doctor per 1,700 citizens in India.
3. Overcrowded hospitals – Poor patient management processes
4. Low skilled auxiliary staff and nurses
5. Poor access to hospitals: 70% healthcare infrastructure in is the urban areas
6. Poor awareness among people
7. Lack of preventative healthcare and early diagnosis

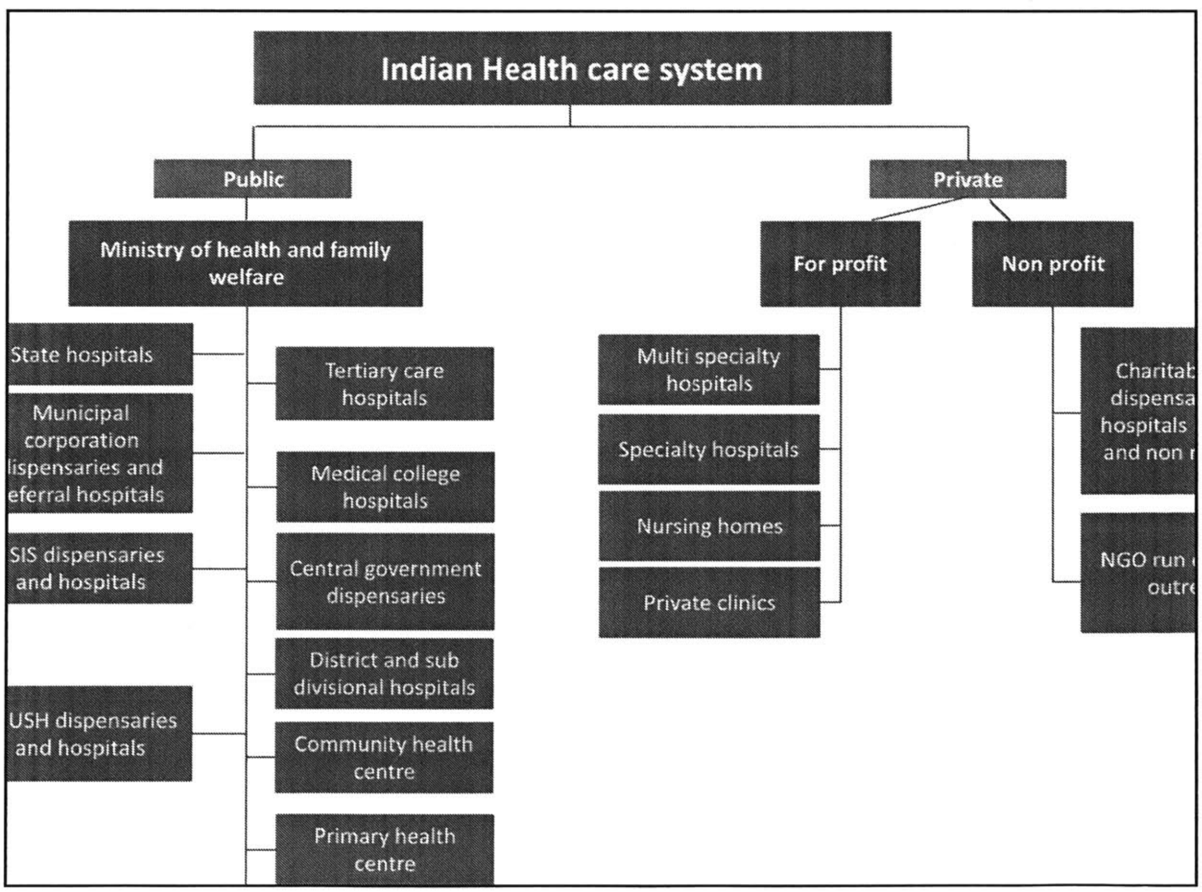


Fig 2: India health care system [1]

4. Three main delays in the Public Healthcare System

The three major delays that constitutes one of the major challenges in the public healthcare system are:

1. Delay in the deciding to seek appropriate medical help: Poor awareness and understanding of complications and risk factors, and financial implications are some of the key reasons for delay in seeking health care at the appropriate time. A delay in the recognition of a potentially severe condition will decrease the likelihood that appropriate care will be provided in a timely and effective fashion.

2. Delay in reaching the health care facility: Parts of India have a topology that makes access o healthcare facility difficult and travel time-consuming. This is worsened by poor roads and lack of proper infrastructure like public transport, also high cost of transportation. Effective care improves survival by decreasing the time to treatment.

3. Delay in receiving adequate healthcare: Even after a patient reaches a healthcare facility, due to poor facilities, inadequately trained medical staff and lack of medical supplies, coupled with a poor referral system causes delays in receiving good healthcare at the hospitals. Delay at this stage worsens patient outcome and their perception of the quality of health services and thus their willingness to avail medical help in the future.

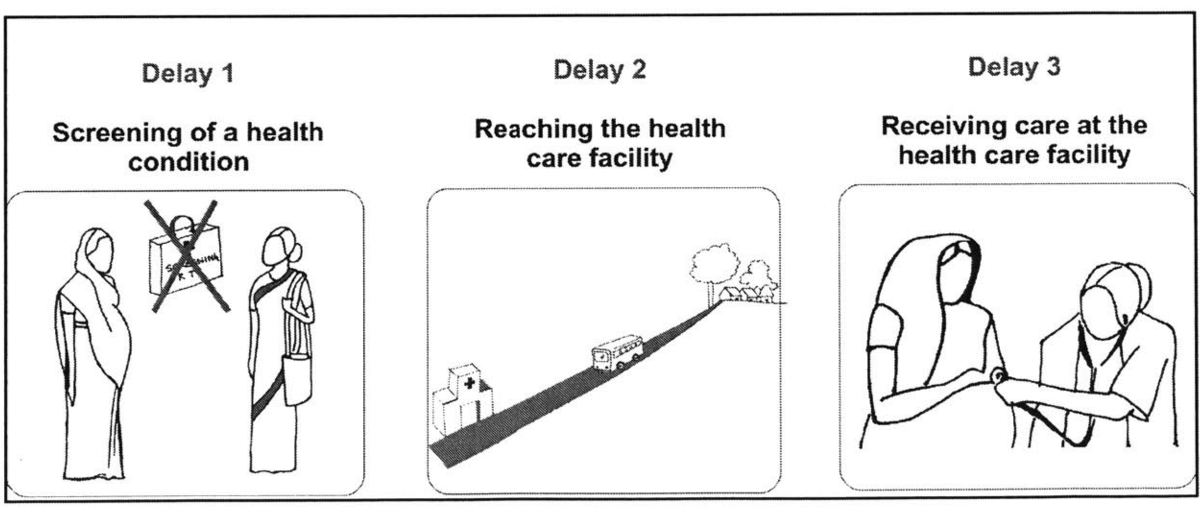


Fig 3: Three delays in the healthcare delivery system

Fig 4: Community health worker conducting preventive health camp for children below age 5 at a Balwadi

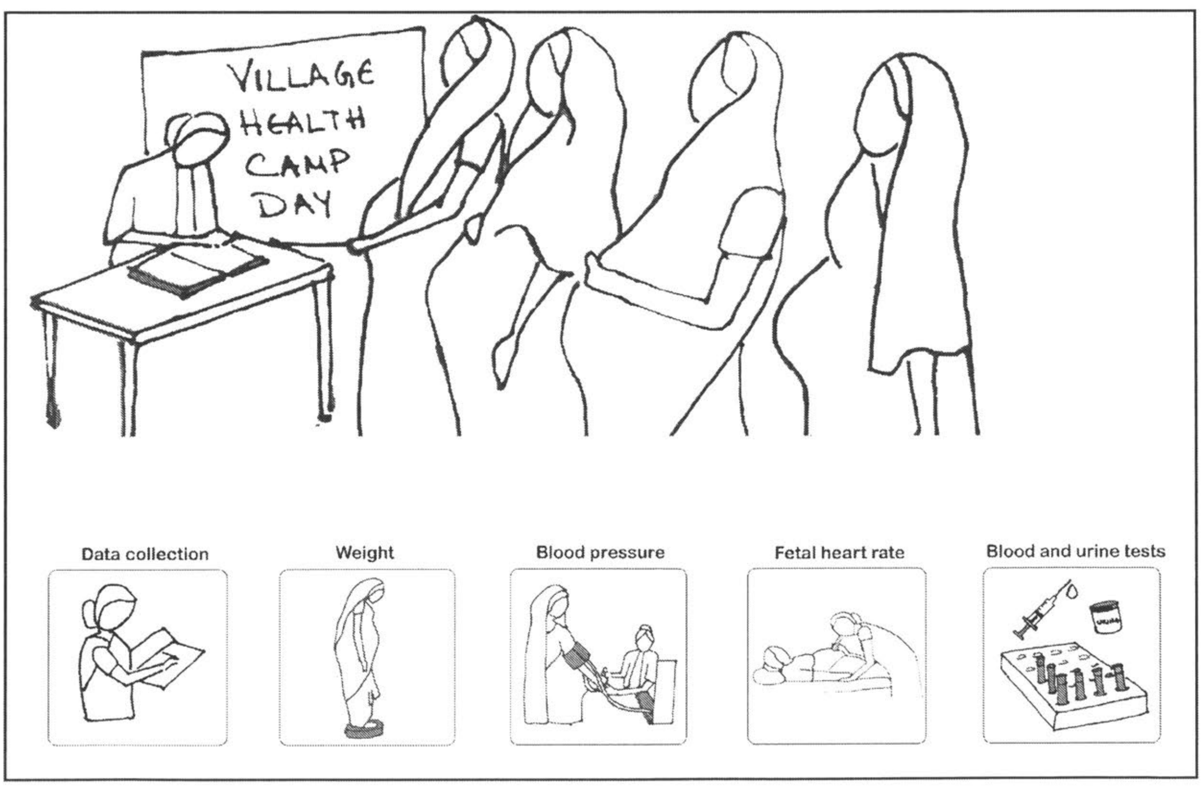


Fig 5: Preventive health checkups for pregnant women at the village health camp

B. Community Health Workers and ASHA program in India

In order to address these challenges in the public health acre system, the many developing countries, including India, have created a system of community health workers (CHW). The role of CHWs is to assist doctors and nurses in activities such as immunization and health promotion, and also act as social and cultural intermediaries strengthening the interface between the existing health system and the community. They facilitate community participation to address the socio-cultural barriers that lead to poor health.

Importance of preventive health care:

Preventive health care is a measure to identify and minimize the risk of disease, improve the course of an existing disease and screening for early detection of disease. Preventive health care is very important during pregnancy because if certain conditions are diagnosed during early stages of pregnancy, unnecessary complications can be avoided during and post child birth. Hence, preventive health check-ups help in bringing down morbidity and mortality rates, and the cost of medical emergencies.

ASHA worker

In India specifically, the government has created a health worker program called the ASHA program, which stands for Accredited Social Health Activist. ASHA program was introduced by the National Rural Health Mission (NRHM) in 2005. They are female cadres of India's community health worker programme.

The ASHA (Accredited Social Health Activist) programme is considered as being vital in achieving the goal of increasing community engagement with the health system and is one of the key components of the National Rural Health Mission (NRHM) that was launched in 2005 by Government of India. To complement the work of ANM, ASHA is selected from the community, a resident in the community, who is trained and deployed and supported to function in her own community to improve the health status of her area through securing people's access to health care services. She is the first port of call for any health related demands of deprived sections of the population, especially women and children, who find it difficult to access health services. She is a health activist in the community who creates awareness on health and its social determinants and mobilizes the community towards local health planning and increased utilization and accountability of the existing health services. She is a promoter of good health practices. She also provides a minimum package of curative care as appropriate and feasible for that level and makes timely referrals. She is a link worker for promoting universal immunization, referral for RCH, construction of household toilets, and other healthcare delivery programs Thus, without any formal medical training and limited academic education (most ASHAs have a 10th grade education), the ASHAs are given incredible responsibilities to look after the broad diverse array of health needs for the entire community. Unlike other health care staff ASHAs don't have any office or clinic, but simply go door-to-door, providing education, counseling, health screening, and referrals for both the young and old.

The National Health Mission in India offers several platforms for home-based newborn care (HBNC), and the presence of a trained ASHA (Accredited Social Health Activist) in the community is one of these primary platforms – particularly for families who don't live close to a large community hospital. ASHAs are considered as the main cadre of front-line workers to provide HBNC.

C. Current Problems and Challenges Faced by Health Workers

- **Lack of continuous and monthly income:** ASHAs work on contract and get a variable pay based on their performance. This does not motivate them to continue for a long time and hence the resources spend on training them remains underutilized.
- **Poor education and skills:** ASHAs are usually qualified until school (10th grade).

If there is no suitable literate candidate, a semi-literate woman with a formal education lower than eighth standard, may be selected.

- **Lack of tools and training to support their work:** Since ASHAs are contract workers, many hospitals do not trust them with screening kits and tools, and mentoring support that help them with their work.
- **Heavy work load:** One ASHA is assigned for 1000 people and she takes care of multitude of health problems. Hence, her work load is high, affecting her efficiency.
- **Safety issues:** Being women, ASHAs are limited in their movement and reach due to safety concerns. Especially during night time, they need a male member to accompany them and have to negotiate with family for performing her duty at night.
- **Socio-cultural issues and taboos:** For many family health issues, the ASHA has to talk to both the male and female members of the families. Being a woman, she faces a lot of resistance among male members and this greatly affects her performance.

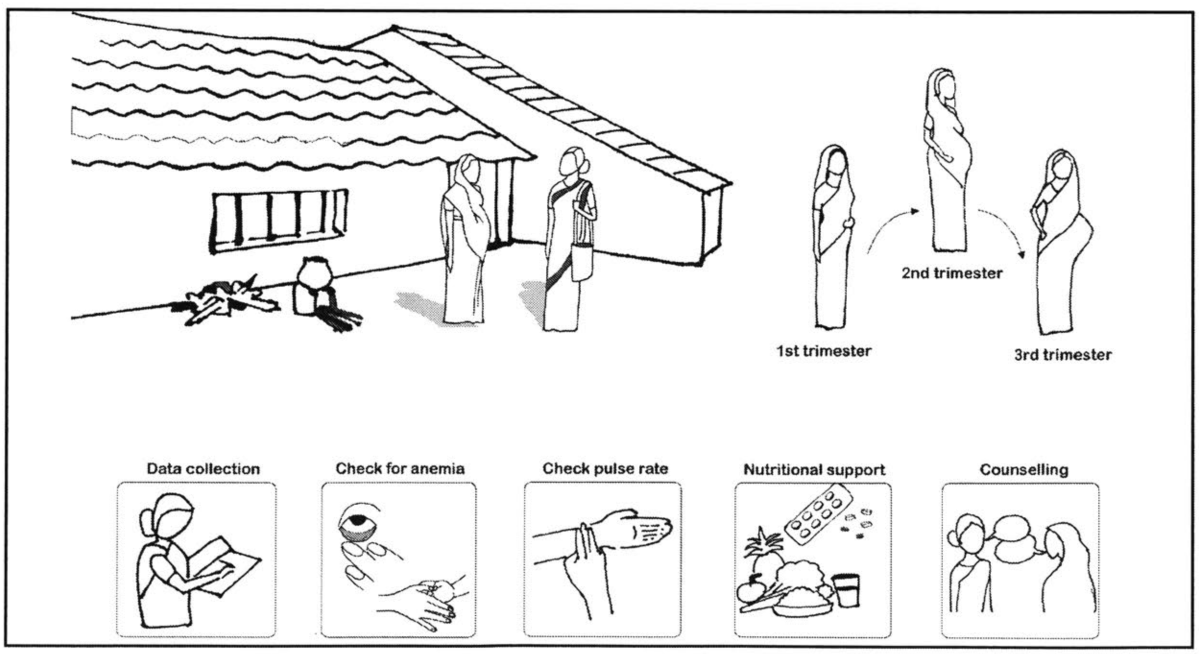


Fig 6: Routine activities during ASHA visits

Hierarchy in Public Health System for ASHAs

Central Government nominates a State Nodal Officer who ensures that resources are available to provide training support for ASHAs at district and block level. ASHAs are trained for a year for different health conditions. At the district level, there is a District Nodal officer who heads and supports the district community mobilizer, block community mobilizer and facilitators. The district medical officer at the PHCs and CHCs heads the ANMs and other health care workers, who in turn monitor and evaluate an ASHAs work.

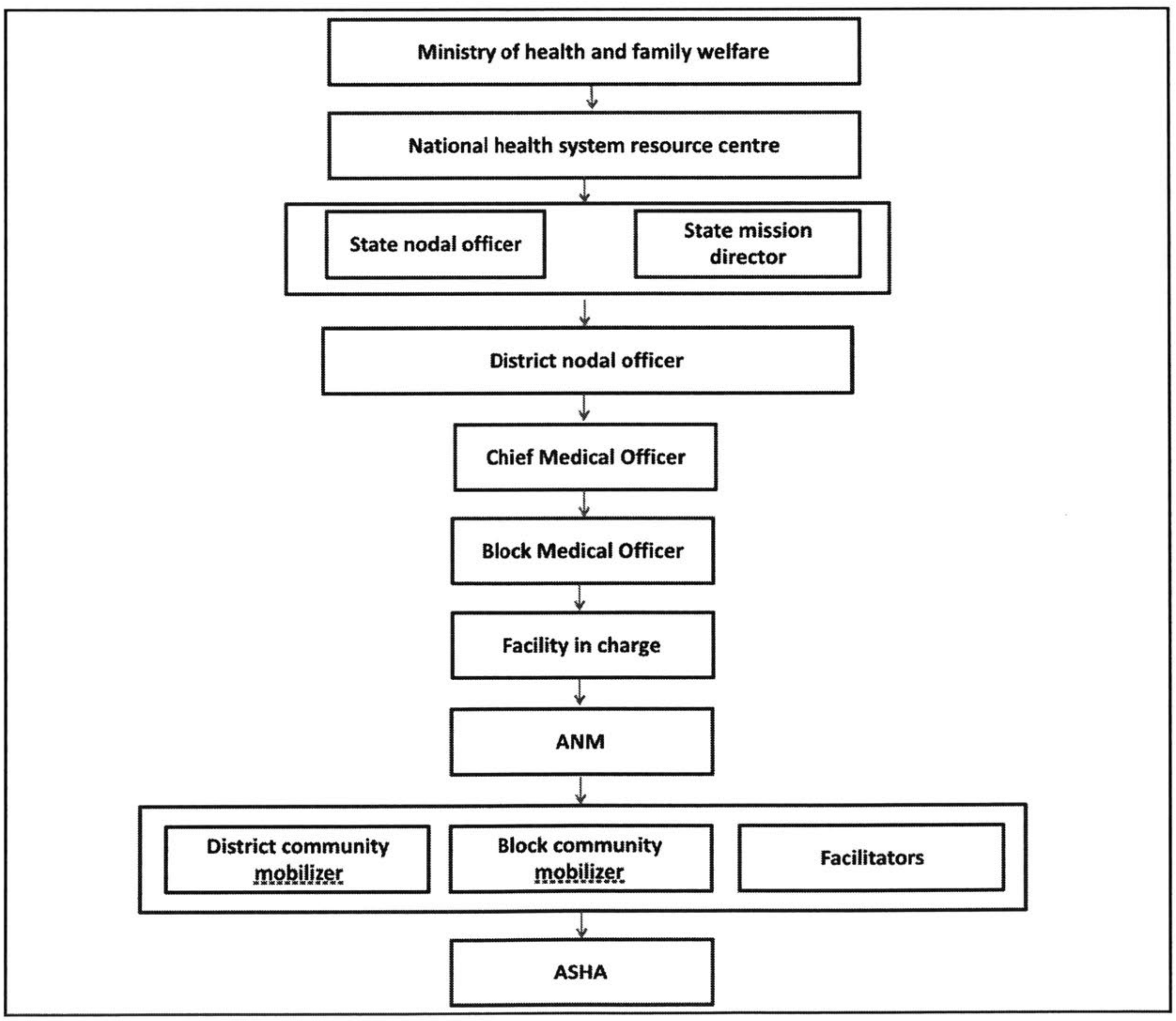


Fig 7: Hierarchy in the public health system for ASHAs[3]

CHAPTER 2: Proposed Solution: The Mobile ASHA Kit

A. Mobile Tools for Health Workers: A concept

In order to improve the current productivity and impact of ASHA health workers, our group at MIT D-Lab, headed by Dr. Rich Fletcher, has developed the concept of mobile-phone based tools to support health workers. Given the rapid increase in mobile phone adoption by even poor communities around the world, there has been great interest from many organizations to make use of this technology for public health applications. Unfortunately, however, the use of phones thus far has been primarily limited to its use as a data entry device, as a replacement for paper forms.

The concept developed by our group is to use mobile phones for more than just data entry, and use them as sensors and computers to automatically capture vital signs of the patient and automate much of the tasks that are done by the health workers.

Fig 8: App measuring baby malnutrition level using the ASHA kit from Mobile technology lab

B. Prior Work and Existing Solutions

A few groups around the world have begun to develop some next-generation tools to support community health workers. But many of these tools are too large and too cumbersome for practical use.

Care Mother kit

- Developed by Shantanu Pathak, Adithya Kulkarni and Anurag Meena from Care, Mumbai in India

Care Mother is a diagnostic kit + mobile application which can conduct 8 tests for pregnant women inorder to enable early identification of high risk pregnancies. This can avoid conditions like gestational diabetes, hyper tension, anemia, improper nutritional growth and fetal distress. The ASHA worker carries this kit along with her visits during her hand conducts these tests at the mother's home. The solution also enables electronic health recording.

At door care in rural region saves tests and traveling expenses for pregnant women. Further it reduces operating expenses of implementing agencies by decentralizing services through health workers and one click data management. [5]

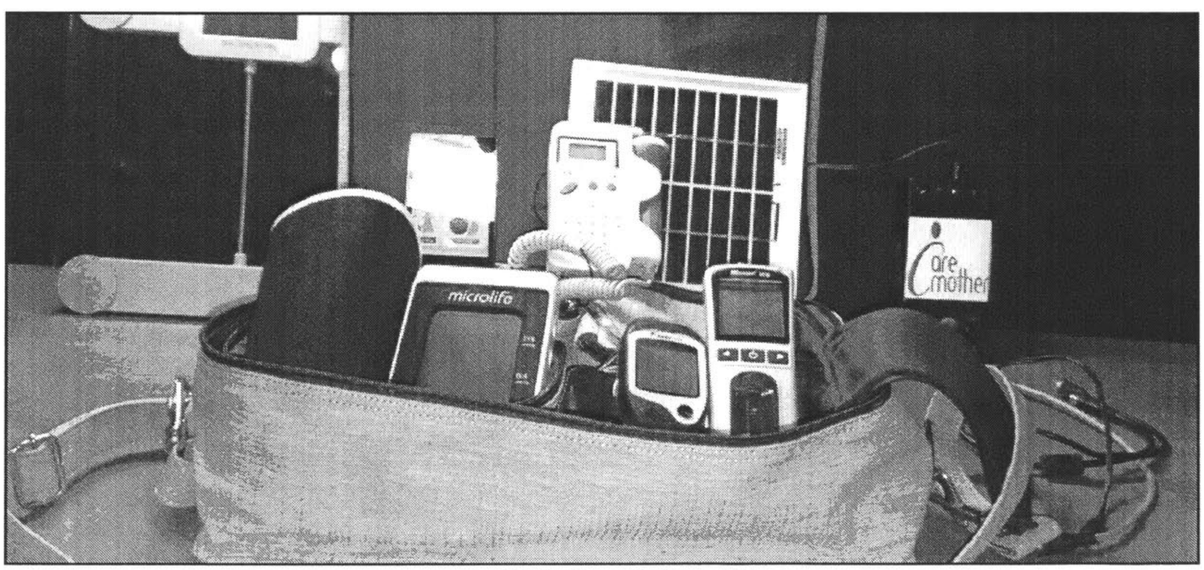


Fig 9: Care Mother kit [5]

The Swasthya Slate

- Developed at the Public Health Foundation of India by Dr. Karnav Kohol.

Swasthya Slate (Health Tablet) is an affordable bluetooth-enabled integrated diagnostic kit that works with an android based mobile system, to perform 33 diagnostics tests. Its purpose is to increase access to health care and health education in the country. The solution is able to record a patient's medical history, basic medical indicators, offer on-the-spot diagnosis on the basis of the information gathered. and even has decision support tools to enable users to deliver quality recommendations for achieving better health. Policy Makers can get real time data from portals and enhance data driven policy making. [3]

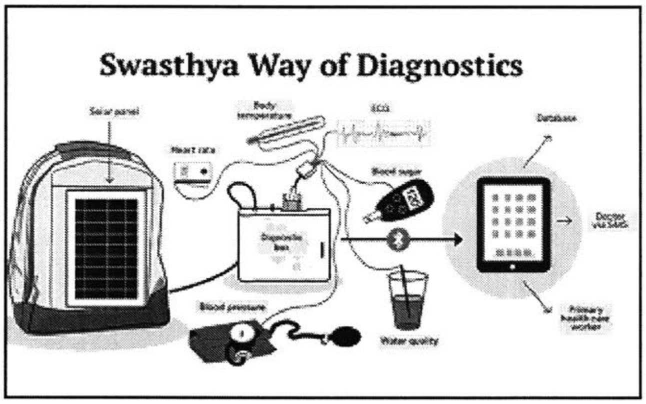


Fig10 : Working of Swasthya Slate[4]

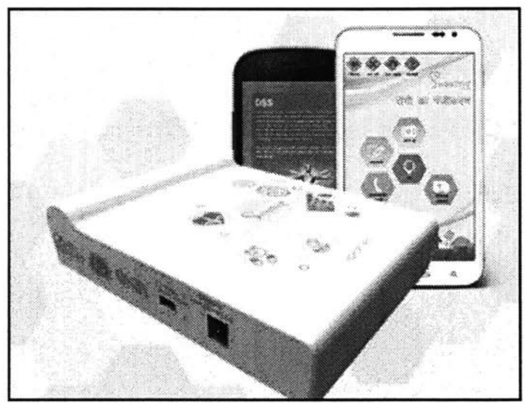


Fig11 : Swasthya Slate[3]

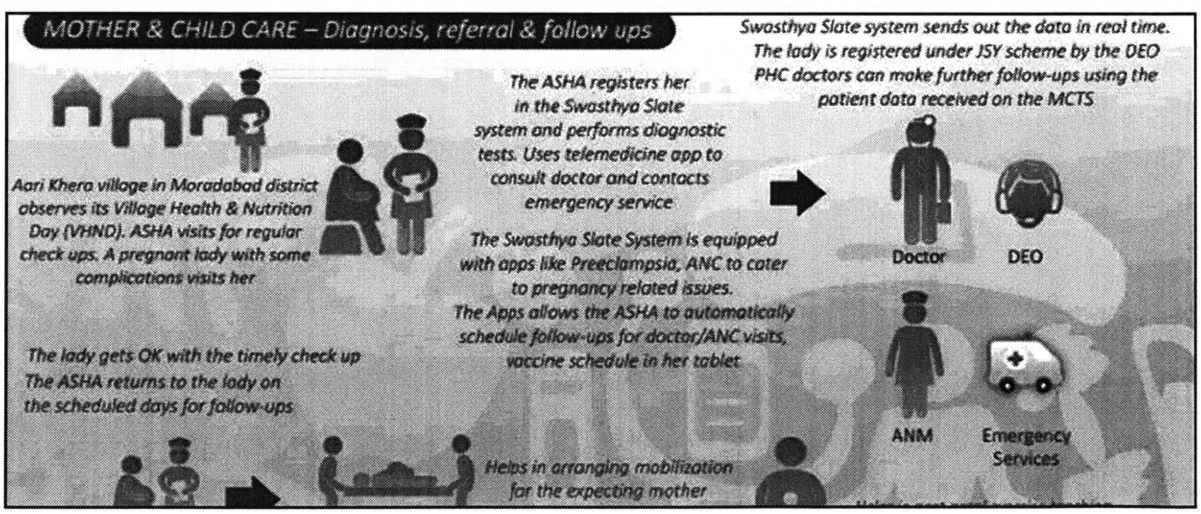


Fig 12: Swasthya Slate for mother and child care[3]

CommCare

- Developed by Dimagi, USA based software technology consultancy and software company

CommCare is a M-health solution to support ASHAs by facilitating better data collection, decision support, communications with clients and health centers, and access to educational training materials. In particular, Comm Care improves ASHAs' performance by tracking case management data in real time – the households they visit, the duration of these visits, the services provided during each visit, the quality of their decision-making (based on adherence to checklists and protocols), and the health outcomes of the households they serve.

The software includes registration forms, checklists, a tool for monitoring danger signs, and educational prompts with images and audio/video clips available in multiple languages. Comm Care has also been shown to increase the retention of health-related knowledge among ASHAs and to help them keep up with their scheduled visits. Ultimately Comm Care increases confidence among ASHAs and also improves engagement with clients. Comm Care Complements this community-based public health strategy by providing a mobile platform that can be used by CHWs and tailored to a diverse range of local needs and conditions.

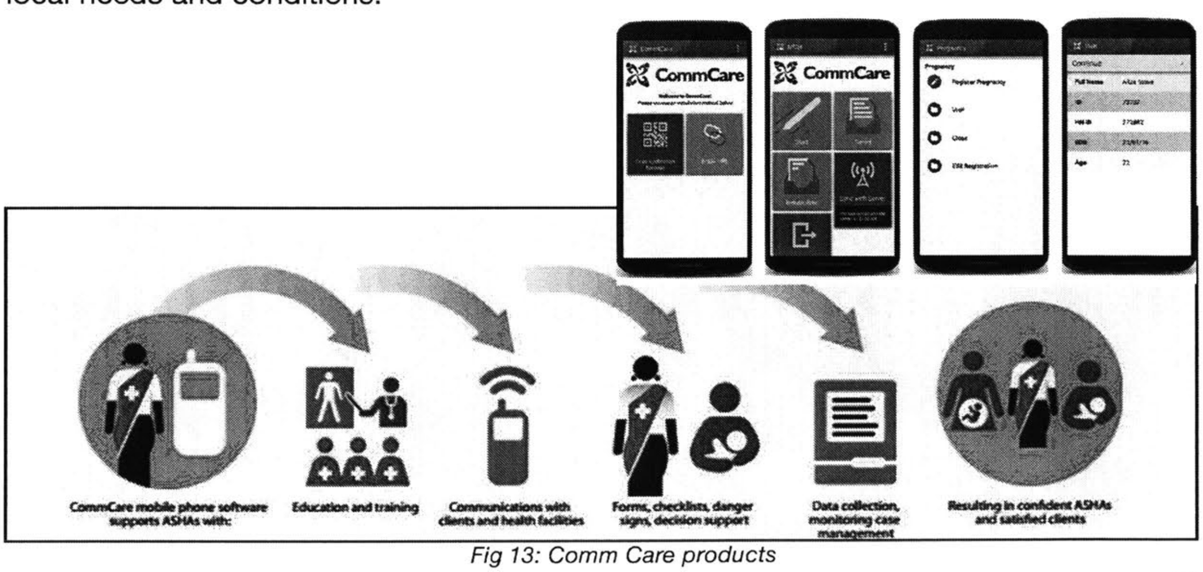


Fig 13: Comm Care products

ChildCount+

- Developed by Millennium Villages Project, Kenya

ChildCount+ is a mHealth platform aimed at empowering community health workers to improve child survival and maternal health. ChildCount uses SMS text messages to facilitate and coordinate the activities of community health care workers (CHWs). Using any standard phone, CHWs are able to use text messages to register patients and report their health status to a central web dashboard that provides a real-time view of the health of a community. Powerful messaging features help facilitate communication between the members of the health system and an automated alert system helps reduce gaps in treatment. It aims to:

- Register every child & pregnant woman - Create a "living" registry of all children under five and pregnant women in a community. Record all births, deaths and pregnancies.
- Routine nutrition screening every 90 Days - Monitor the nutrition of every child from 6 months to 5 years every 90 days. When a child with acute malnutrition is detected the program provides support based on community based management of acute malnutrition protocols.
- Treatment support for malaria, diarrhea and pneumonia – track and treat the three major preventable causes of death in children under 5. ChildCount+ manages clinic referrals and CHW follow-up visits.
- Complete immunization for all children - Track the immunization status and follow-up with defaulters to ensure that every child completes their immunization schedule.
- Comprehensive antenatal and post-natal care – Ensure that every pregnant woman attends at least 4 antenatal appointments and every child attends every childhood health appointment from 6 weeks to 18 months old.

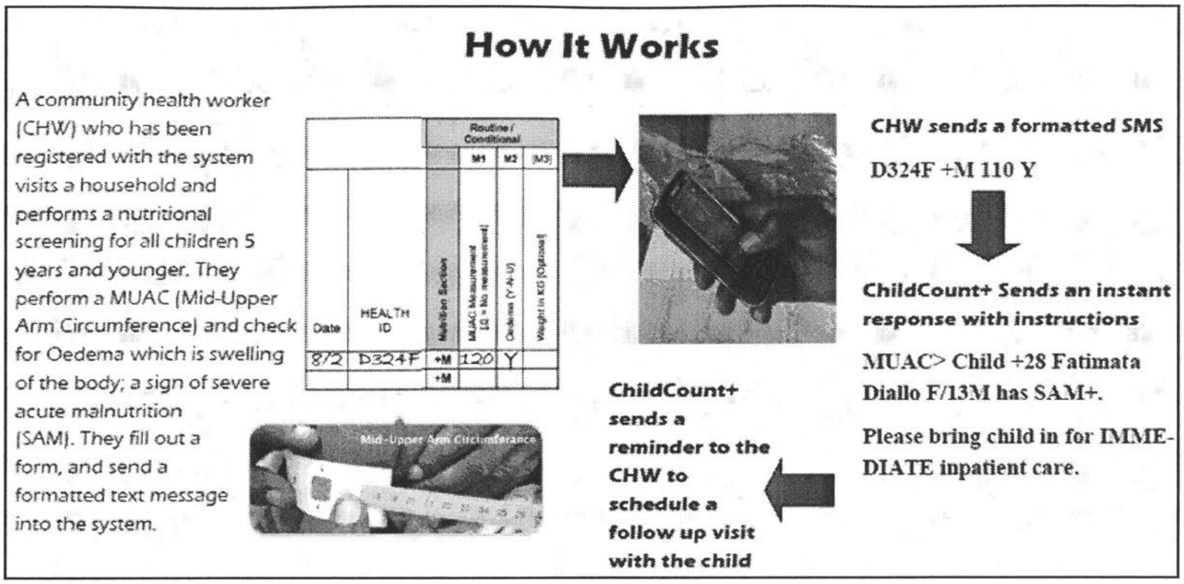


Fig 14: Child count uses MUAC to measure malnutrition for children

C. The MIT ASHA Kit

Background and rationale for developing the MIT ASHA Kit

The ASHA (Accredited Social Health Activist) program is considered as being vital in achieving the goal of increasing community engagement with the health system and is one of the key components of the National Rural Health Mission (NRHM) that was launched in 2005 by Government of India.

Home Based Newborn Care (HBNC) is a one of the key components of maternal, neonatal and child care under the National Health Mission (NHM) and the government of India. There is enough evidence that despite an increase in the institutional deliveries in India, a substantial proportion of neonatal deaths occur at home. Also the most vulnerable period of a newborns life is the period during the birth and the first week of life and three quarter of neonatal death occurs during this period. The remaining 25% of newborn deaths occur during the second to fourth week of life. Thus, HBNC is a critical component to preventing newborn deaths. The National Health Mission in India offers several platforms for home-based newborn care (HBNC), and the presence of a trained ASHA (Accredited Social Health Activist) in the community is one of these primary platforms – particularly for families who don't live close to a large community hospital. ASHAs are considered as the main cadre of front-line workers to provide HBNC.

Childhood malnutrition on the other hand, encompasses nutritional disorders that include stunting, underweight, wasting, severe acute malnutrition (SAM), and micro-nutrient deficiency disorders. It also includes overweight and obesity, at the other end of the nutritional spectrum. An estimated 50 million children under-5 years of age were wasted and 17 million severely wasted worldwide(an approximate prevalence of 7% and 3% respectively) in 2015. Half of all acutely malnourished children lived in South Asia and one quarter in sub-Saharan Africa. A child with SAM is 9 times more likely to die than a well nourished child. SAM is one of the top 3 nutrition-related causes of death in children younger than 5 years. Moderate and severe child malnutrition account for 40% to 50% of all deaths in children younger than 5 years.

Thus providing quality HBNC and screening of nutritional status children in the community has the potential for their timely referral to health center upon detection of any morbidity or malnourished status and also timely counseling for prevention of further deterioration. The MIT ASHA Kit has the potential to enable the ASHA workers to perform quality screening of these children and provide timely referral and counseling.

Description of mobile health tools for ASHA workers

The Mobile Technology Lab directed by Dr. Rich Fletcher at D- Lab has been developing several mobile tools that can be used to empower the community health workers (ASHA or Anganwadi workers). Some of these tools can be utilized to enhance the quality of care and decision making while assessing health and nutritional status of children under 5 and providing HBNC during home visits by ASHAs.

These tools include the following:

A) Baby blanket for measuring length of newborns and infants – Using a special woven pattern for the blanket, we use augmented reality to create a calibrated scale that will automatically measure the length of a baby placed on the blanket.

B) Mobile weight measurement – Using the augmented reality technology the team is developing a mobile phone app that can automatically capture the reading from a baby weighing scale. Using the phone camera, the special software automatically recognizes the scale and captures a reading. The phone software is able to recognize a pattern on the MUAC band, and it can automatically calculate the MUAC reading and store the value on the phone.

C) Measuring Mid-Upper Arm Circumference (MUAC) – MUAC is the standard measurement and a screening tool for measuring malnutrition in children under 5 years. Using augmented reality, this can also be automated and digitized. The phone software is able to recognize a pattern on the MUAC band, and it can automatically calculate the MUAC reading and store the value on the phone.

D) Photoplethysmography (PPG) – A PPG device, similar to a standard pulse oximeter, has been developed which can be clipped onto the child's hand or foot. This device connects to the mobile phone which records and analyzes the data. By analyzing the pulse waveform, several other parameters can be extracted, including stroke volume, and pulse oximetry.

E) Thermal camera – A special small camera attaches to the phone and is able to record the temperature readings from the baby or child. From the thermal image, it is possible to automatically record the temperature from several points on the baby's face and body. This information is used to assess the thermal regulation of the baby, and can also be used to detect inflammation or sepsis.

F) Billirubin measurement – A plastic strip containing a color scale is used to assess possible jaundice in young infants. Special software on the phone will take a photo of the bilirubin color scale and perform automatic color analysis to estimate the level of bilirubin.

D. Scope of the thesis

ASHA kit includes many tools as described in the MIT ASHA Kit as mentioned in section C of Chapter1 but that for the thesis I have helped in development of the following tools:

- Baby blanket for measuring length of newborns and infants
- Mobile weight measurement
- Measuring Mid-Upper Arm Circumference (MUAC)

The thesis primarily has two parts:

Part A : Design & Development

- Mechanical design of the tools
- Interaction design
- Graphic design
- Prototyping & Testing
- Designing the AR Target
- Validation of the tools

Part B : Materials for pilot study with Public Health Foundation of India, Delhi

- Training plan for the ASHAs
- Video for the products in use

The technical part (mobile programming) is being done by Xavier Soriano, and that his thesis will include a performance evaluation of the technology.

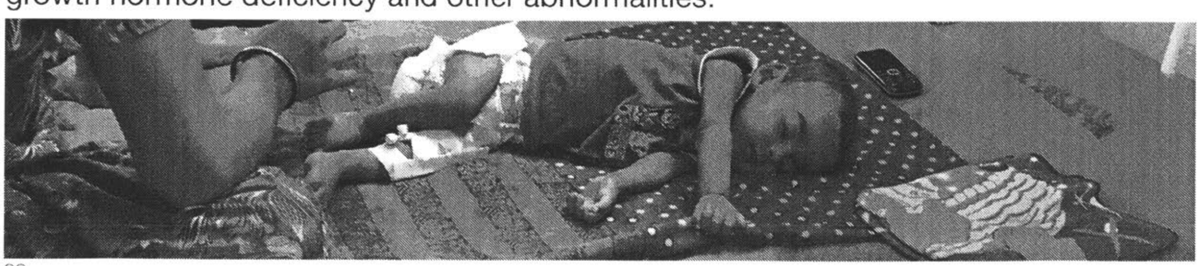
CHAPTER 3:
Design of Tool for Baby Height

A. Conventional Tools and Challenges

Measuring baby's height is one of the useful non-invasive methods and indicators for assessing their growth and wellbeing. By comparing this measurement over a period of time, helps determine baby's growth pattern and identify deviations from the norm and conditions like abnormal growth and obesity.

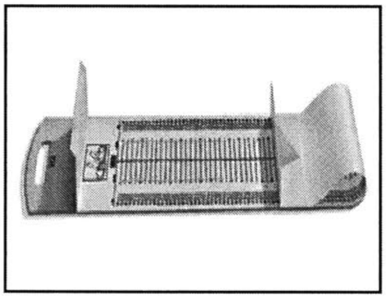
The two most commonly used height measurement tools for children up-to 24 months of age are height board and measuring tape. Up-to this age, baby's height should be measured without any clothes on them. Clothes, including a nappy, can distort the measurements. This also helps the health care professional assess child's body proportions. While measuring the baby's height with the height board, two health workers are needed to obtain an accurate measurement - one to support the baby's head and one to straighten their knees and ankles. Readings are then taken by the staff to the nearest millimeter. Post 24 months of age, height of the baby can be measured with them standing against a scale. The child should stand straight against the measuring device, looking straight ahead and measured to the nearest millimeter. Measuring height of a baby is comparatively more difficult because it is difficult to make them lie down and hold in the appropriate position.

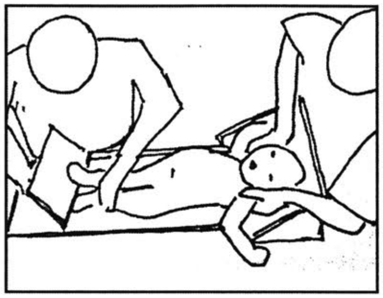
A referral or immediate action should be made if the length is greater than the 99.6th percentile or lower than 0.4th percentile. This covers at least half of all children with growth hormone deficiency and other abnormalities.



TOOLS	TOOL IN USE	CHALLENGES

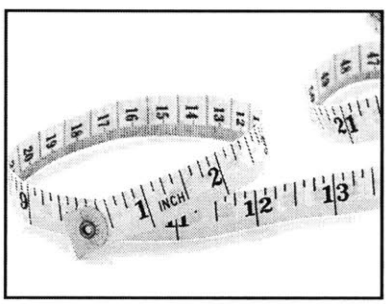
Infantometer also called Length board[9]

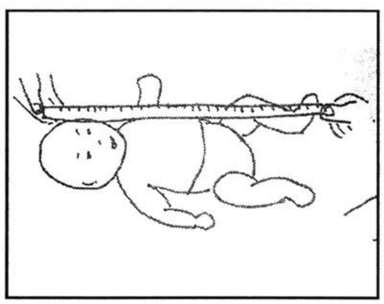




- Not easily portable
- Difficult to measure when the infant is moving
- Manual data recording
- Training required to interpret the data
- During winters placing the baby on a cold surface

Measurement tape[10]





- Difficult to measure precise readings
- Unreliable data
- Manual data recording
- Training required to interpret the data
- The edges of the measuring tape is not user friendly for the baby

B. MIT Baby Height Tool

The tool is a special designed pattern blanket along with an app which uses machine vision to measure the height of the baby. The app consists of two parts:

- Image recognition to identify a pattern and track the pattern.
- The augmented reality software displays and overlays the measurement which gives feedback to the user.

We are using augmented reality to create a calibrated scale that will automatically measure the length of a baby placed on the blanket.

The tool solves many challenges faced while using the conventional tools as mentioned in the section A. Most importantly it enables a community health worker to track the progress of the baby.

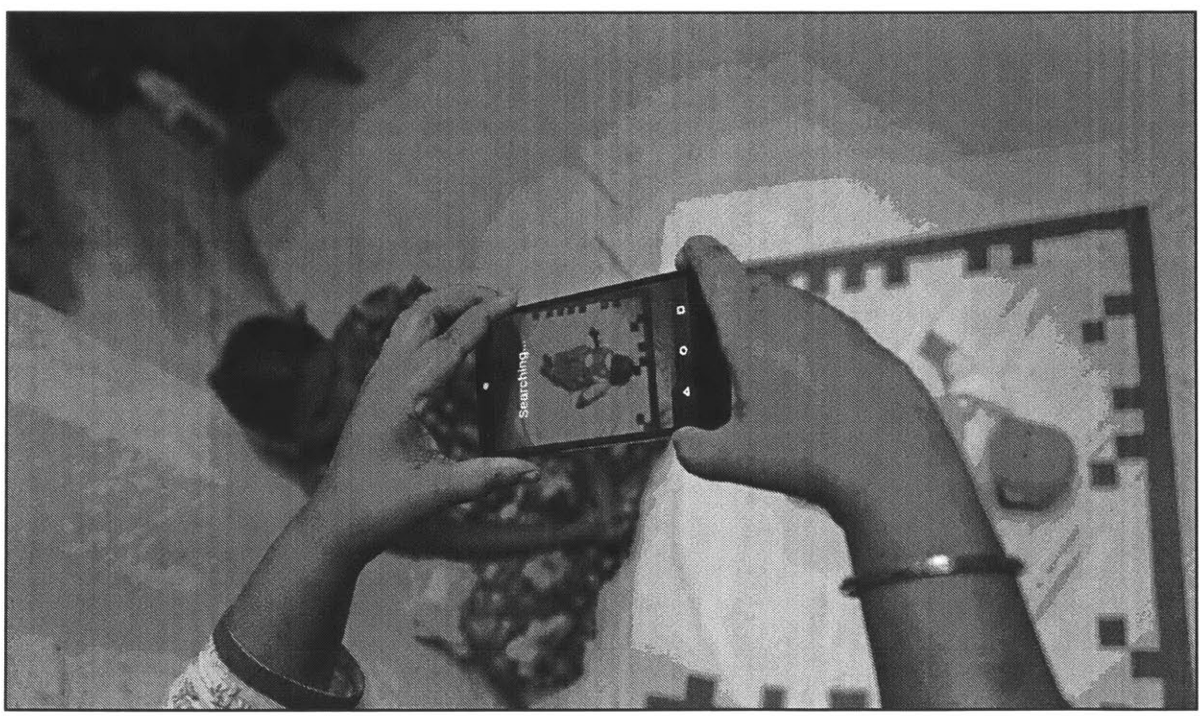


Fig 15: App measuring baby height using the ASHA kit from Mobile technology lab

C. Baby Height Tool Ideation

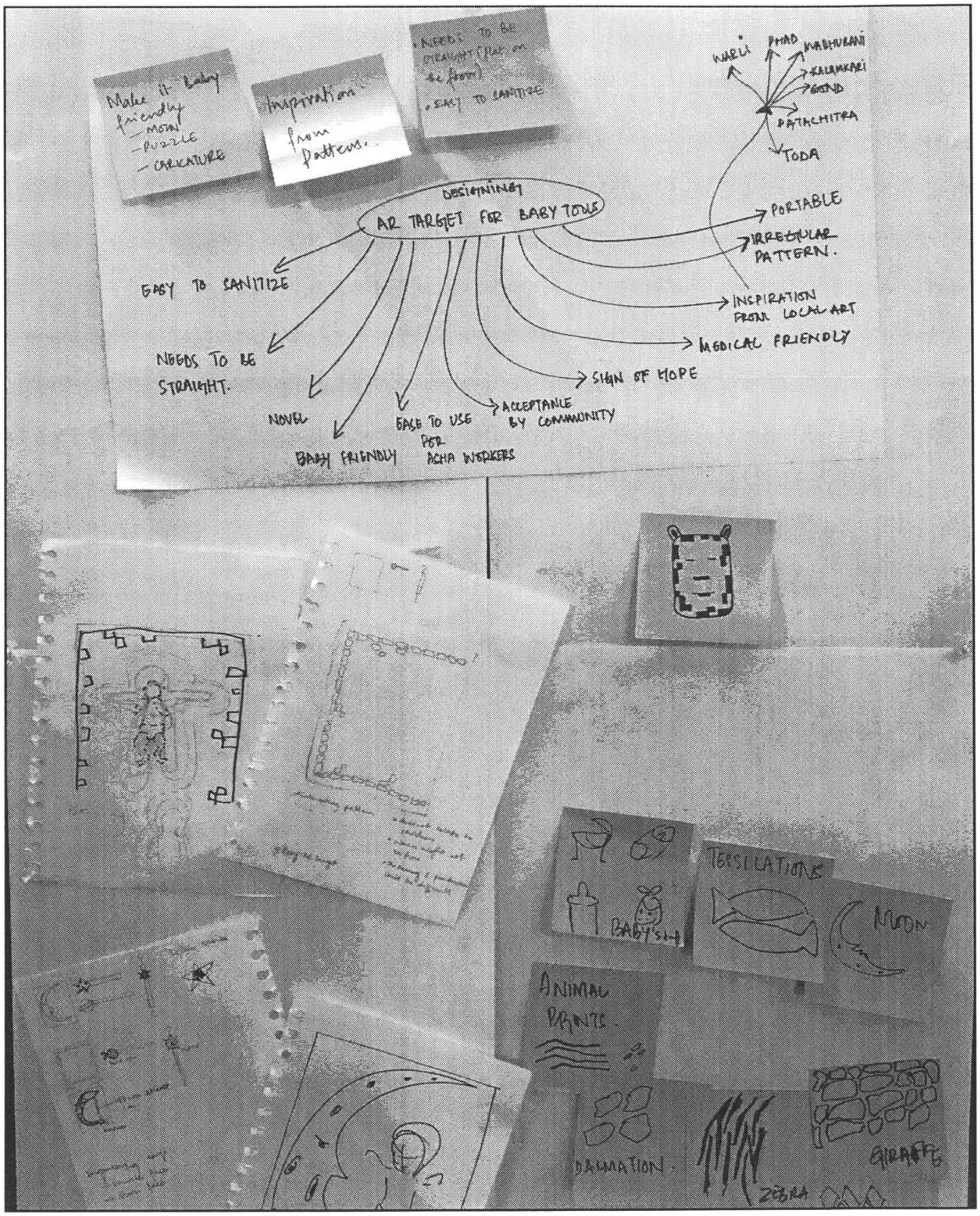
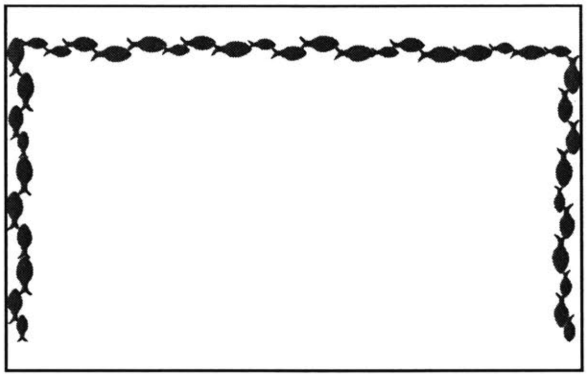
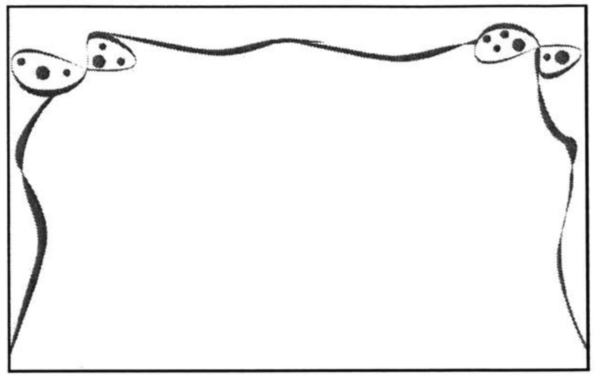
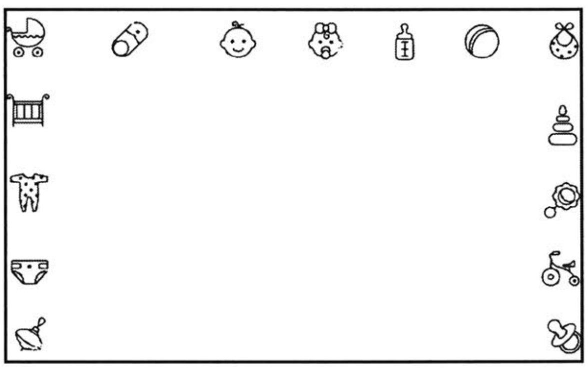


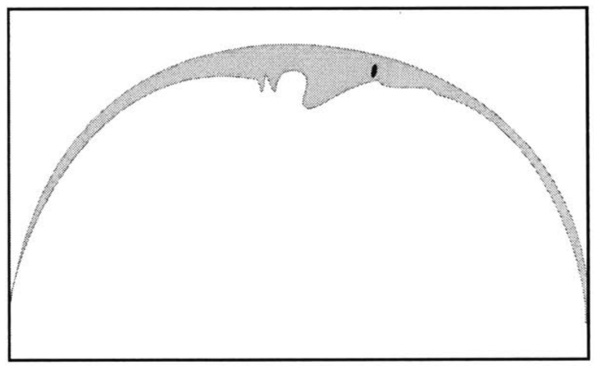
Fig 16: Ideation and mind-map to design the AR target for measuring baby height

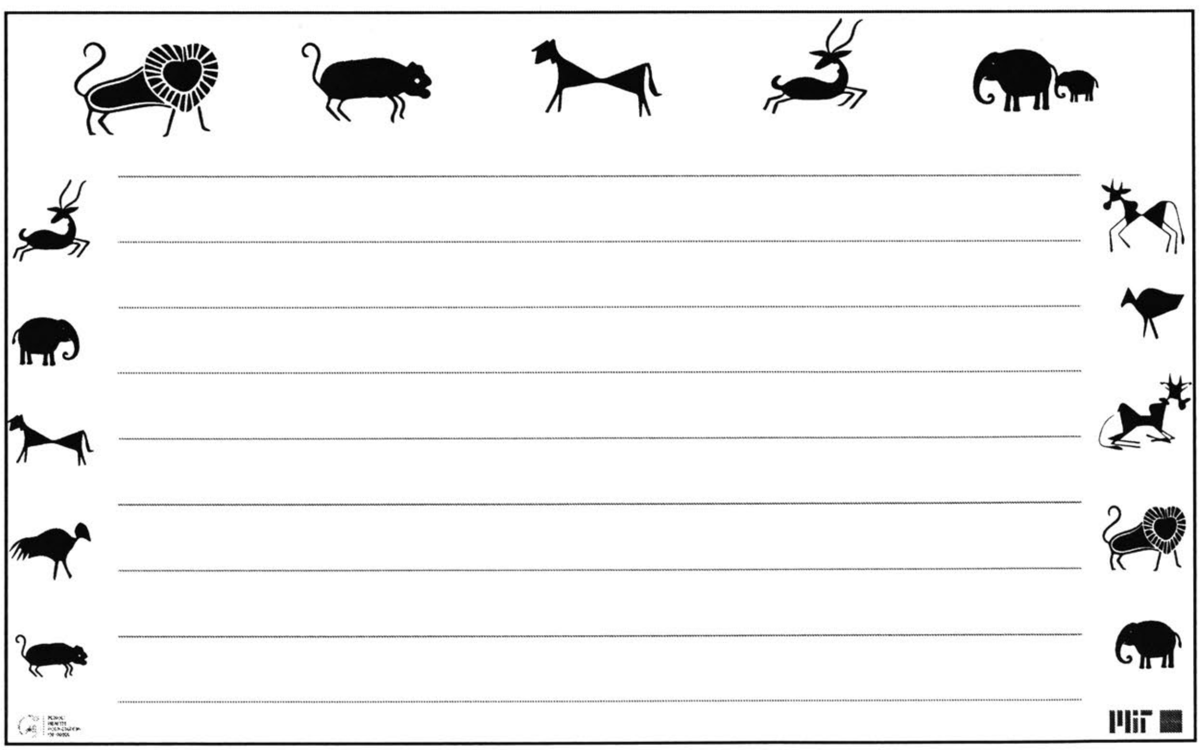
Augmented Reality Targets for the baby blanket











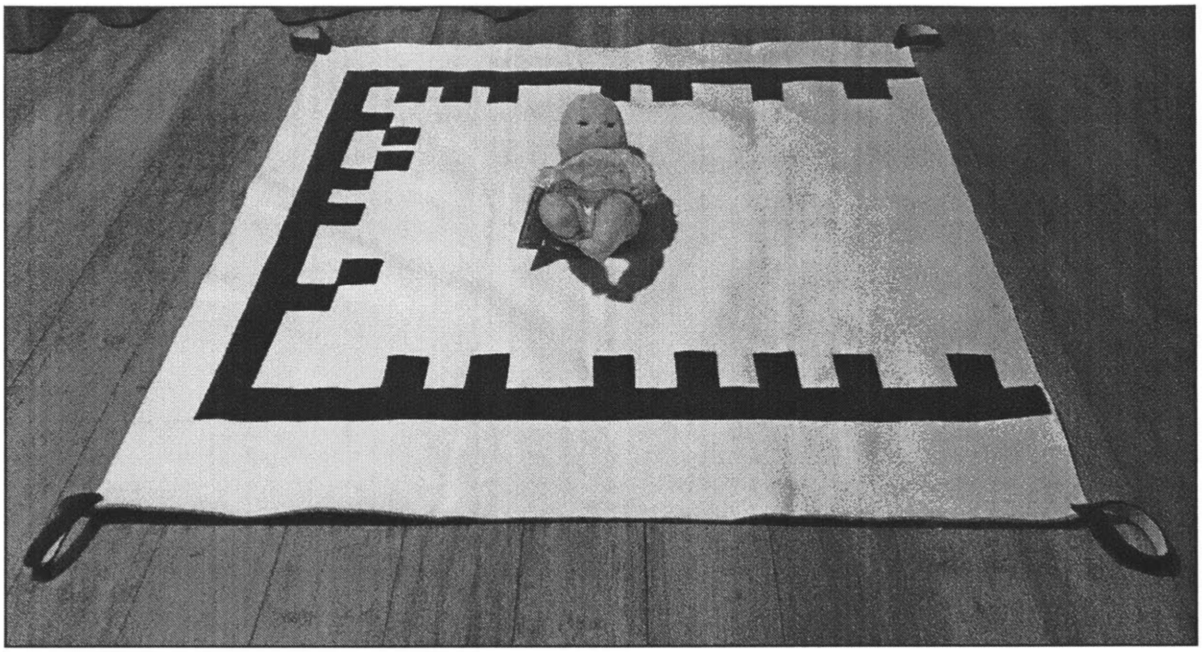


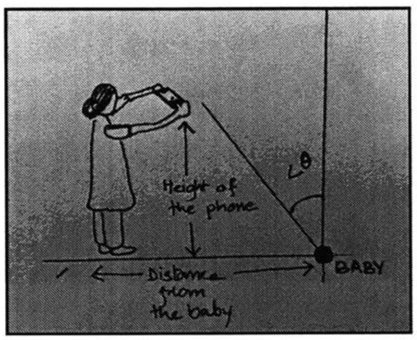
Fig 17: First iteration of the baby blanket using the augmented reality target

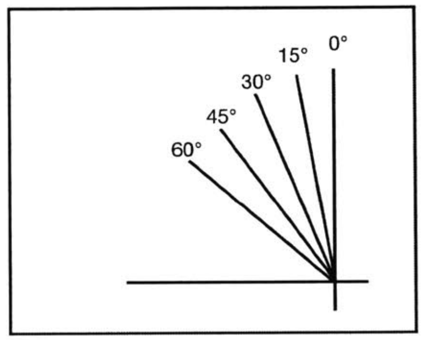
Fig 18: Testing the baby blanket and the augmented reality target

D. Tool Testing and Validation

The following tests were used for lab testing and validation:

1. Test for validating the application by holding the phone in different angles to check the reading on the app of the baby height compaired to the manual reading.





Patient id	∠ Angle	Distance from baby (cms)	Height of the phone (cms)	Manual baby's length 60.5 cms Reading from the app					Mean	Standard deviation
				1	2	3	4	5		
1	0	0	48.03	60.85	61.05	60.91	60.85	60.97	60.93	0.09
2	15	31	46.06	61.14	61.42	61.42	61.42	61.42	61.36	0.13
3	30	63	43.3	61.68	61.71	61.71	61.71	61.48	61.66	0.10
4	45	90	35.43	62.02	62	61.99	62.02	61.8	61.97	0.09
5	60	135	30.7	62.42	62.34	70.77	62.62	62.37	64.10	3.73

** Lighting level 550 lux constant

2. Test for validating the application in different light settings to check the reading on the app of the baby height compaired to the manual reading.

Patient id	Light level (lux) light meter facing ceiling	Light level (lux) light meter facing baby	Baby Sizes (manually measured height in cms)	Reading from the app					Mean	Standard deviation
				1	2	3	4	5		
1	25	14	35.5	36.22	38.37	38.28	38.28	38.57	37.94	0.97
2	50	38	35.5	36.74	36.34	37.14	36.57	36.68	36.69	0.29
3	100	84	35.5	37.34	37.6	37.6	37.42	36.85	37.36	0.31
4	500	360	35.5	35.71	35.68	35.51	35.71	35.65	35.65	0.08
5	25	14	51	49.25	52.25	53.42	52.51	53.19	52.12	1.68
6	50	38	51	55.42	55.71	54.97	56.28	54.08	55.29	0.83
7	100	84	51	51.42	52.57	52.28	52.28	51.17	51.94	0.61
8	500	360	51	52.97	53.42	53.42	53.22	53.42	53.29	0.20
9	25	14	60	62.28	62.85	67.74	62.85	63.11	63.76	2.24
10	50	38	60	62.85	63.14	63.54	62.14	62.37	62.81	0.57
11	100	84	60	62.28	70.57	62	62	62.28	63.83	3.77
12	500	360	60	60.6	60.85	60.57	60.57	60.57	60.63	0.12

3. Test for validating the application in comparing the reading on the app of the baby heights compared to the manual readings.

Blanket	Reading from the app					Mean	Standard deviation	Difference (manual reading - app reading colums 5)
Baby Sizes (manually measured height in cms)	1	2	3	4	5			
35.5	36.28	36.28	36.25	36	36.31	22.29	0.13	-0.78
39	40.97	40.88	40.88	41.14	41.14	36.22	0.13	-1.97
51	54.28	54.28	54.22	54.28	54.28	41.00	0.03	-3.28
21	22.37	23.45	23.45	21.02	21.14	49.56	1.19	-1.37
49	49.42	49.71	49.62	49.42	49.65	50.74	0.14	-0.42
50.8	50.85	50.85	50.57	50.74	50.68	51.46	0.12	-0.05
52	51.42	51.42	51.41	51.42	51.65	52.91	0.10	0.58
53	53.14	52.85	52.85	52.85	52.85	53.36	0.13	-0.14
53.8	53.42	53.39	53.42	53.45	53.14	54.20	0.13	0.38
54	54	54.28	54.28	54.17	54.28	54.27	0.12	0
54.8	55.14	55.14	55.14	55	55.14	55.11	0.06	-0.34
56.5	56.85	56.85	56.85	57.14	56.85	56.91	0.13	-0.35
57	57.42	57.25	57.28	57.42	57.42	57.36	0.09	-0.42
58	58	58.28	58	57.99	58	58.05	0.13	0
59.2	59.42	59.42	59.42	59.54	59.45	59.45	0.05	-0.22
60	60.57	60.28	61.14	60.28	60.28	60.51	0.37	-0.57
61	61.14	61.14	61.14	61.02	61.14	61.12	0.05	-0.14

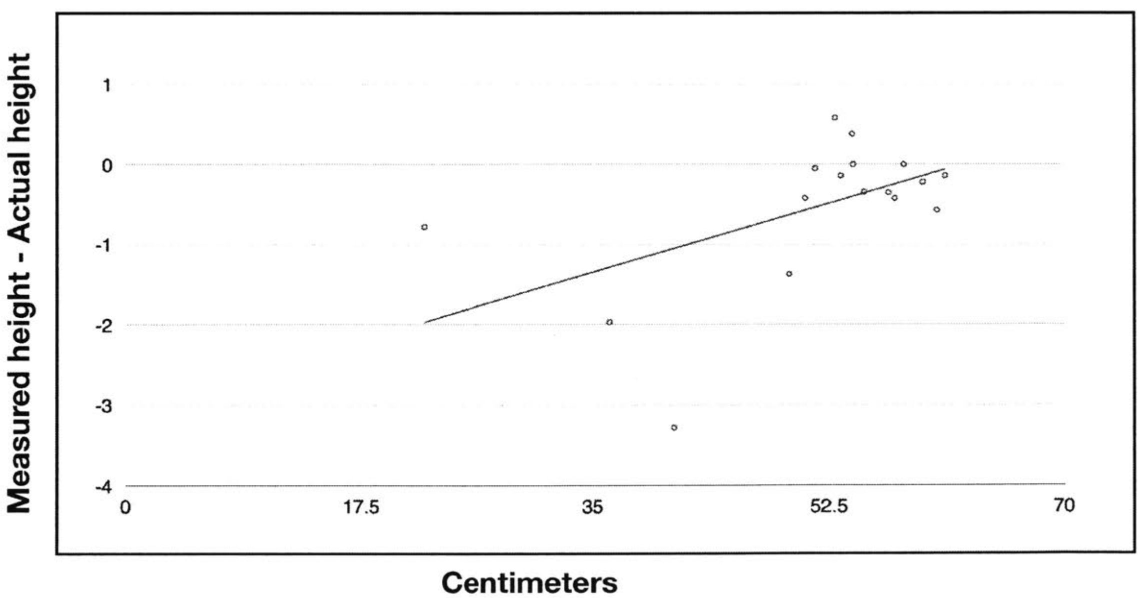


Fig 19: The Bland Altman plot to measure the variability in baby height

CHAPTER 4:
Design of Tool for Baby Weight

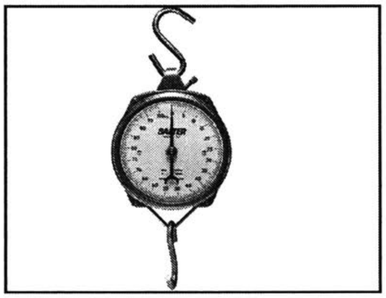
A. Conventional Tools and Challenges

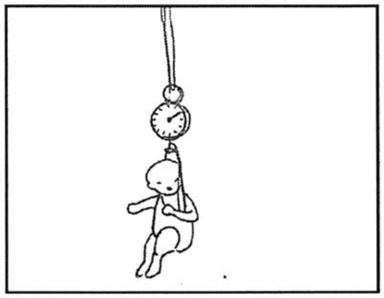
Weight is the most commonly checked growth parameter of the baby. It is also the most accurate and sensitive measurement of baby's growth. Interpretation of weight includes review of current and previous weight measurements, child's social and domestic environment and its food intake. By checking a child's weight regularly, its growth can be mapped and monitored. Thus, enabling the health care worker to see periods of no growth or weight loss and catch early signs of growth abnormalities.

Several tools are used to weight a child's weight like Salter scale, weighing scale and uniscale. The Salter scale is an analog, reliable and portable scale, which can weigh children weighing up to 25 kg. The scale has a hook which is used to hang the sling or pants in which the child is placed for weighing. The weighing scale is an analog or digital scale with provision to make the child lie down lie measuring its weight. With the uniscale, made by UNICEF, the mother can hold the child and stand on the scale. This scale can be re-set to zero when the person (mother) weighed is still standing on it. Thus, the child's weight alone appears on the scale.

TOOLS	TOOL IN USE	CHALLENGES

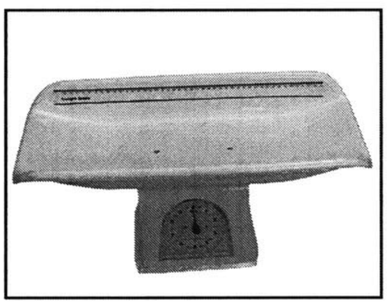
Salter scale[11]

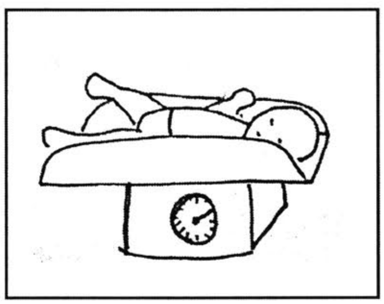




- Needs calibration
- Prone to errors
- Not easily portable
- Manual record keeping
- Training requited to interpret data

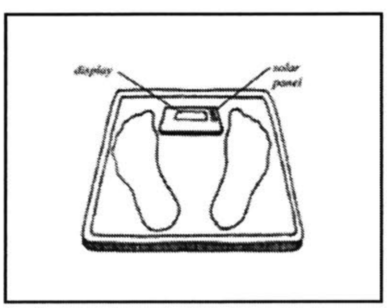
Weighing scale[12]

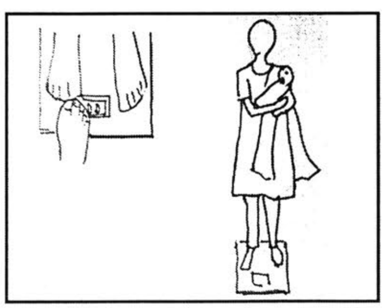




- Needs calibration
- Not easily portable
- Manual record keeping
- Training requited to interpret data

Uniscale[13]





- Needs calibration
- Not easily portable
- Manual record keeping
- Training requited to interpret data

B. MIT Baby weight Tool

The tool is a special designed sticker with a pattern along with an app which uses machine vision to measure the weight of the baby. The app consists of two parts:

- image recognition to identify a pattern and track the pattern.
- the augmented reality software displays and overlays the measurement which gives feedback to the user.

We are using augmented reality to create a calibrated scale that will automatically measure the weight of a baby placed on the weighing scale.

The tool solves many challenges faced while using the conventional tools as mentioned in the section A. Most importantly it enables a community health worker to track the progress of the baby.

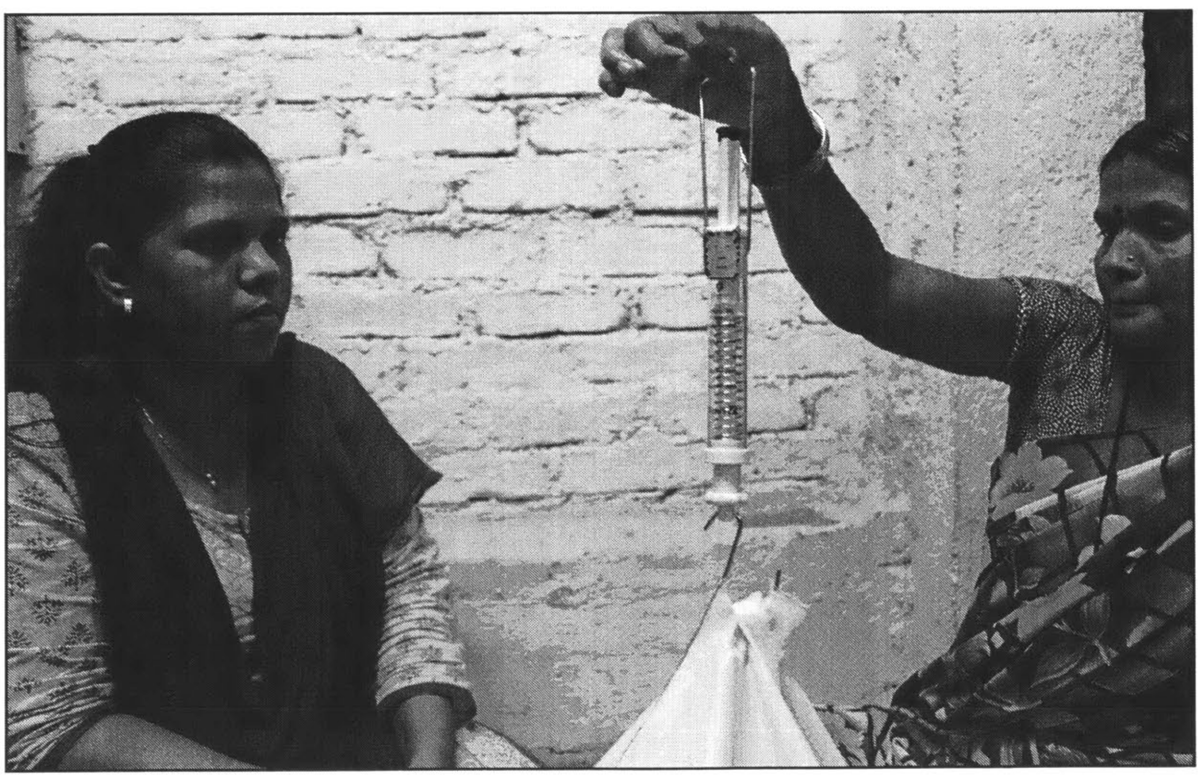


Fig 20: Asha worker taking the help of a mother to measure the baby weight

C. Baby Weight Tool Ideation

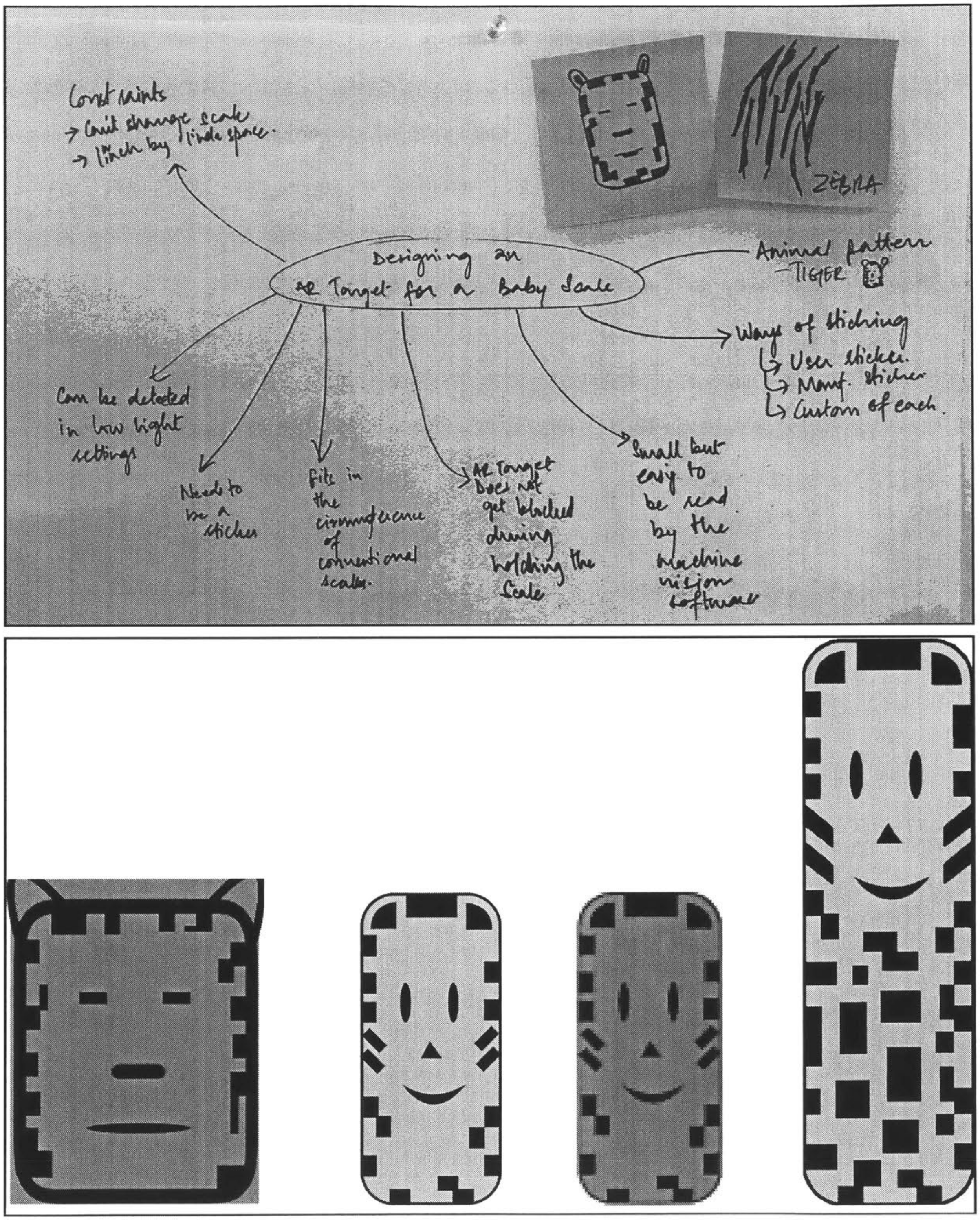


Fig 21: Iteration on augmented reality target for the weighing scale

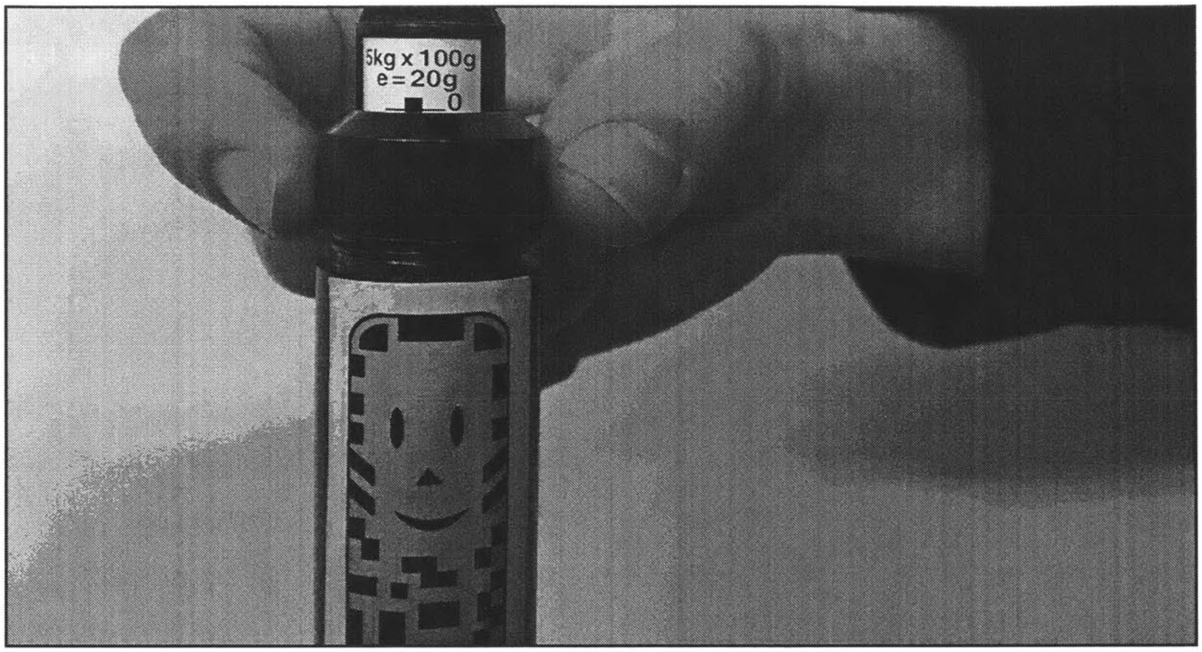


Fig 22: Image showing adjustment of the baby scale before measuring the weight

Fig 23: Testing the baby weighing scale and the augmented reality target

D. Tool Testing and Validation

1. Test for validating the application in different light settings to check the reading on the app of the baby weight compaired to the manual reading.

Patient id	Light level (lux) light meter facing ceiling	Light level (lux) light meter facing baby	Baby Sizes (manually measured height in cms)	Reading from the app					Mean	Standard deviation
				1	2	3	4	5		
1	25	14	35.5	36.22	38.37	38.28	38.28	38.57	37.94	0.97
2	50	38	35.5	36.74	36.34	37.14	36.57	36.68	36.69	0.29
3	100	84	35.5	37.34	37.6	37.6	37.42	36.85	37.36	0.31
4	500	360	35.5	35.71	35.68	35.51	35.71	35.65	35.65	0.08
5	25	14	51	49.25	52.25	53.42	52.51	53.19	52.12	1.68
6	50	38	51	55.42	55.71	54.97	56.28	54.08	55.29	0.83
7	100	84	51	51.42	52.57	52.28	52.28	51.17	51.94	0.61
8	500	360	51	52.97	53.42	53.42	53.22	53.42	53.29	0.20
9	25	14	60	62.28	62.85	67.74	62.85	63.11	63.76	2.24
10	50	38	60	62.85	63.14	63.54	62.14	62.37	62.81	0.57
11	100	84	60	62.28	70.57	62	62	62.28	63.83	3.77
12	500	360	60	60.6	60.85	60.57	60.57	60.57	60.63	0.12

3. Test for validating the application in comparing the reading on the app of the baby scale compared to the manual readings.

Scale	Reading from the app					Mean	Standard deviation	Difference (manual reading - app reading colums 5)
Baby Scale (manually measured weight in kgs)	1	2	3	4	5			
0.1	0.2	0.18	0.19	0.15	0.15	0.17	0.02	-0.1
0.2	0.21	0.26	0.25	0.26	0.26	0.25	0.02	-0.01
0.3	0.32	0.37	0.4	0.38	0.38	0.37	0.03	-0.02
0.4	0.45	0.47	0.5	0.46	0.46	0.47	0.02	-0.05
0.5	0.56	0.56	0.56	0.55	0.54	0.55	0.01	-0.06
0.6	0.64	0.64	0.65	0.63	0.66	0.64	0.01	-0.04
0.7	0.74	0.76	0.77	0.73	0.74	0.75	0.02	-0.04
0.8	0.72	0.73	0.76	0.86	0.83	0.78	0.06	0.08
0.9	0.83	0.86	0.88	0.8	1.02	0.88	0.08	0.07
1	1.06	0.96	1.01	1	0.98	1.00	0.04	-0.06
1.1	1.07	1.1	1.12	1.14	1.17	1.12	0.04	0.03
1.2	1.16	1.14	1.2	1.22	1.18	1.18	0.03	0.04
1.3	1.31	1.16	1.23	1.2	1.24	1.23	0.06	-0.01
1.4	1.44	1.4	1.39	1.46	1.41	1.42	0.03	-0.04
1.5	1.49	1.24	1.49	1.51	1.5	1.45	0.12	0.01
1.6	1.6	1.64	1.53	1.57	1.48	1.56	0.06	0
1.7	1.68	1.66	1.7	1.74	1.73	1.70	0.03	0.02
1.8	1.71	1.73	1.79	1.8	1.85	1.78	0.06	0.09
1.9	1.91	1.67	1.74	1.72	1.85	1.78	0.10	-0.01
2	1.9	1.88	2	1.87	1.9	1.91	0.05	0.1
2.1	2.01	2.14	2.21	2.08	2.17	2.12	0.08	0.09
2.2	2.24	2.19	2.1	2.15	2.17	2.17	0.05	-0.04
2.3	2.3	2.24	2.26	2.34	2.35	2.30	0.05	0
2.4	2.33	2.29	2.29	2.47	2.52	2.38	0.11	0.07
2.5	2.55	2.66	2.65	2.55	2.61	2.60	0.05	-0.05
2.6	2.68	2.63	2.63	2.5	2.72	2.63	0.08	-0.08
2.7	2.8	2.74	2.71	2.87	2.7	2.76	0.07	-0.1
2.8	2.79	2.83	2.8	2.76	2.81	2.80	0.03	0.01
2.9	2.91	2.92	2.96	2.81	2.86	2.89	0.06	-0.01
3	3.03	3.05	2.93	3.02	2.93	2.99	0.06	-0.03
3.1	3.11	3.08	3.03	3.03	3.05	3.06	0.03	-0.01
3.2	3.14	3.17	3.11	3.13	3.28	3.17	0.07	0.06
3.3	3.36	3.45	3.23	3.24	3.29	3.31	0.09	-0.06
3.4	3.31	3.37	3.45	3.3	3.33	3.35	0.06	0.09
3.5	3.43	3.5	3.53	3.47	3.39	3.46	0.06	0.07
3.6	3.61	3.64	3.56	3.51	3.55	3.57	0.05	-0.01
3.7	3.62	3.68	3.68	3.61	3.62	3.64	0.03	0.08
3.8	3.8	3.76	3.77	3.7	3.77	3.76	0.04	0
3.9	3.78	3.84	3.82	3.85	3.76	3.81	0.04	0.12
4	3.97	3.99	3.95	3.94	3.93	3.96	0.02	0.03
4.1	4.05	4.12	4.07	3.99	3.95	4.04	0.07	0.05
4.2	4.25	4.23	4.14	4.17	4.2	4.20	0.04	-0.05
4.3	4.4	4.2	4.28	4.38	4.26	4.30	0.08	-0.1
4.4	4.4	4.39	4.36	4.44	4.43	4.40	0.03	0
4.5	4.49	4.5	4.61	4.48	4.62	4.54	0.07	0.01
4.6	4.6	4.59	4.49	4.43	4.61	4.54	0.08	0
4.7	4.66	4.62	4.51	4.58	4.6	4.59	0.06	0.04
4.8	4.6	4.57	4.58	4.56	4.58	4.58	0.01	0.2
4.9	4.62	4.64	4.58	4.53	4.55	4.58	0.05	0.28

Bland Altman Plot

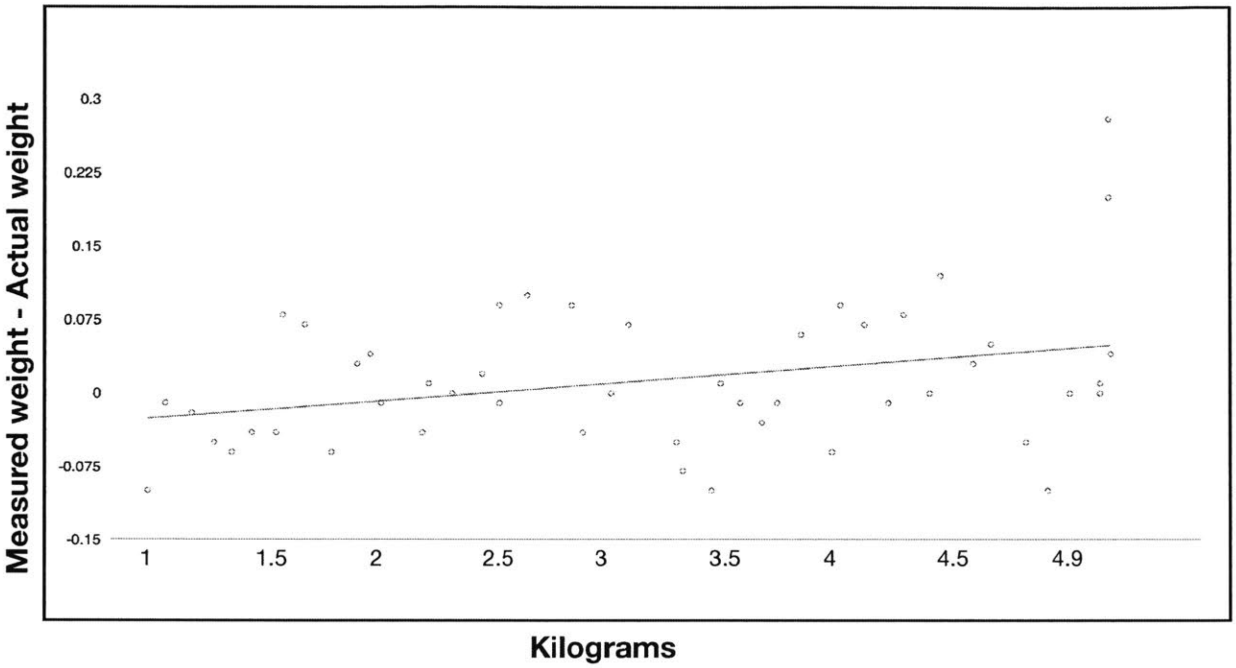


Fig 24: The Bland Altman plot to measure the variability in baby weight

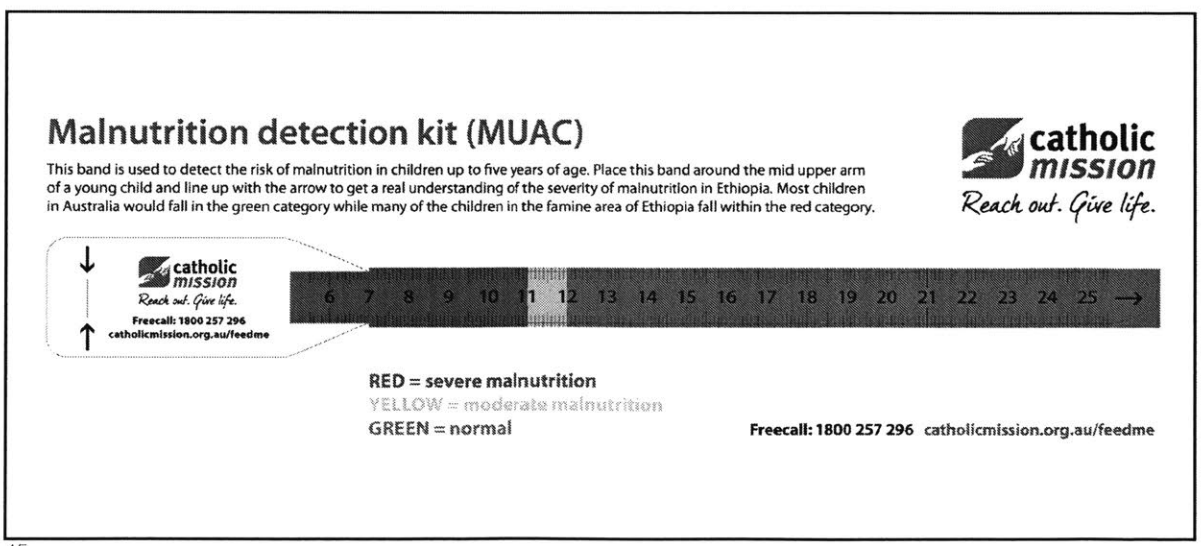
CHAPTER 5:
Design of Tool for Malnutrition

A. Conventional Tools and Challenges

Mid-Upper Arm Circumference (MUAC) tape is the most important tool for assessing child's nutrition status. It measures the circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow. In many studies, MUAC has been used to predict mortality in children and has been better than any other anthropometric indicator.

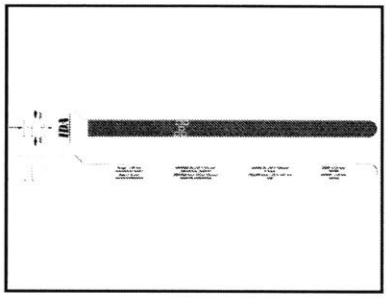
The MUAC tape is a simple and cheap tape made out of paper and also easy to perform by low skilled health care workers. It is less prone to errors, and an easy tool to train and interpret. MUAC take measures arm muscle and sub-cutaneous fat and they are important determinants of survival during starvation. This makes it a very sensitive and reliable tool for measuring malnutrition in children.

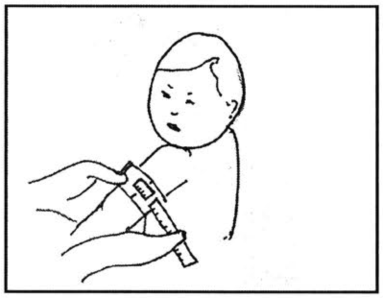
In places where the MUAC tape is not available, health care workers use a measuring tape to measure a child's upper arm circumference. This requires the health care workers to be trained for interpreting the measurement.



TOOLS	TOOL IN USE	CHALLENGES

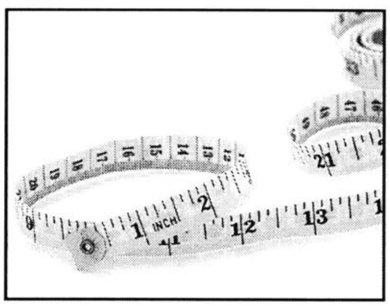
Mid-upperarm circumference (MUAC) tape[14]

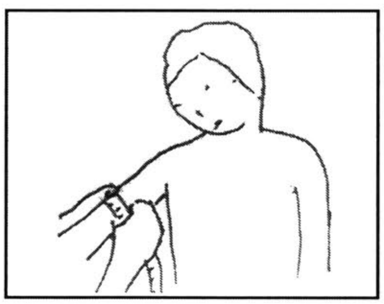




- Manual Data recording

Measuring tape[10]





- Manual data recording
- Training required to interpret the data

B. MIT MUAC Tool

The tool is a special designed pattern along with an app which uses machine vision to measure the malnutrition of the baby. The app consists of two parts:

- image recognition to identify a pattern and track the pattern.
- the augmented reality software displays and overlays the measurement which gives feedback to the user.

We are using augmented reality to create a calibrated scale that will automatically measure the malnutrition level of a baby by measuring the mid-upper arm circumference.

The tool solves many challenges faced while using the conventional tools as mentioned in the section A. Most importantly it enables a community health worker to track the progress of the baby.

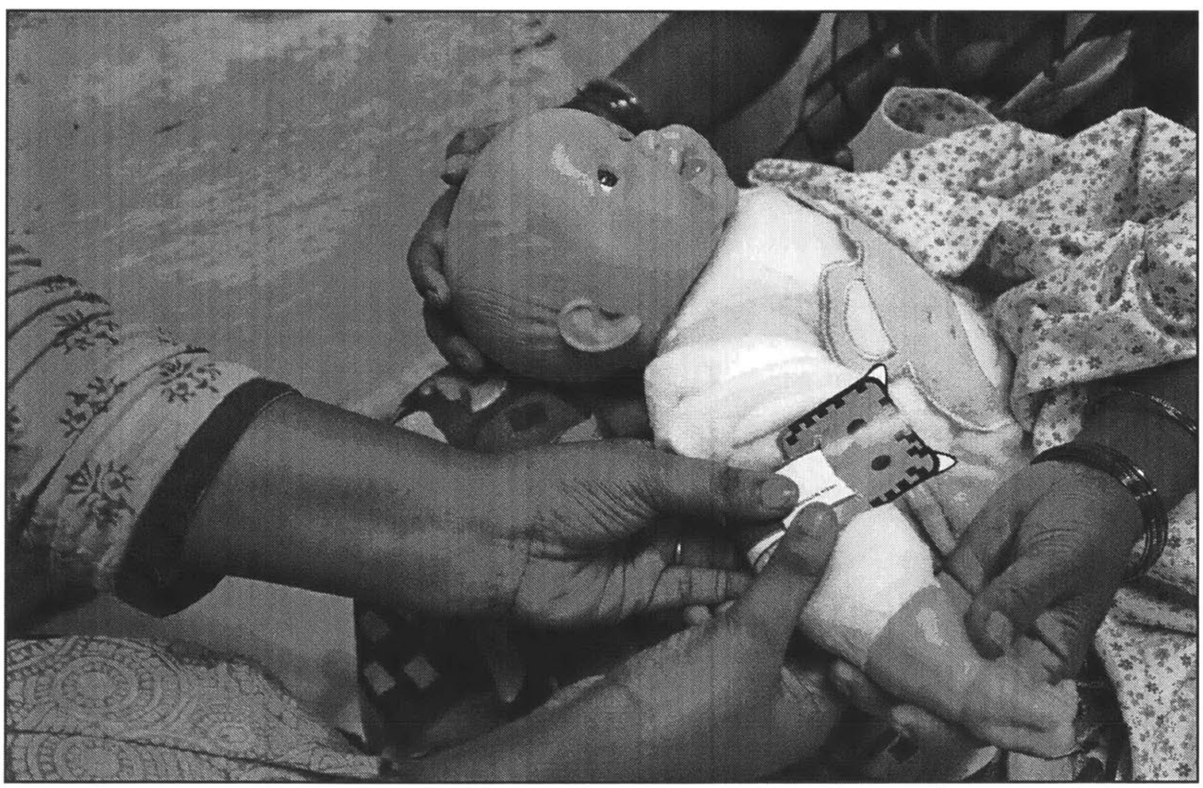


Fig 25: Testing the MUAC band and the augmented reality target

C. Baby Height Tool Design Process

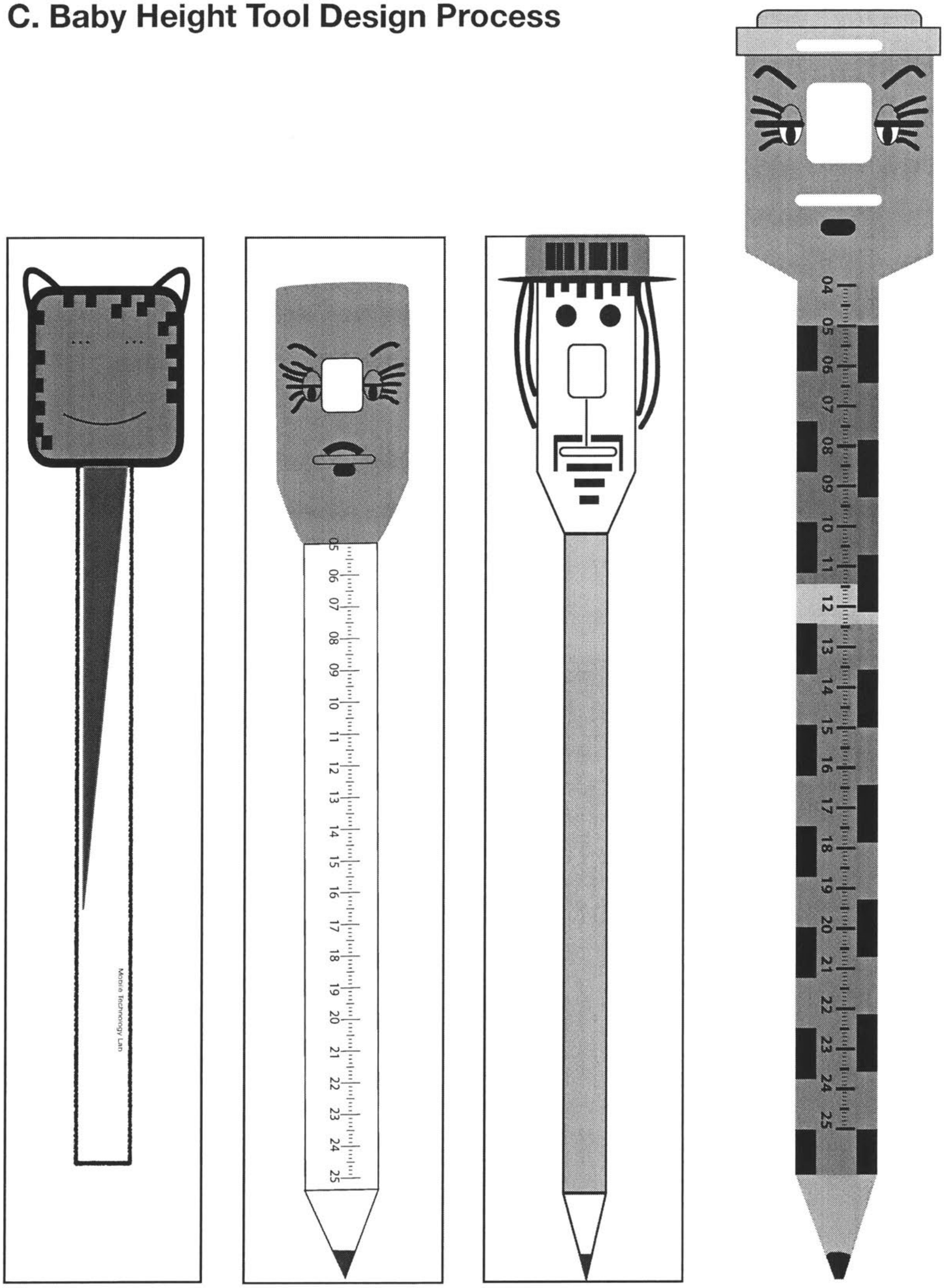


Fig 26: Iteration on augmented reality target for the MUAC band

D. Tool Testing and Validation

1. Test for validating the application in different light settings to check the reading on the app of the MUAC compared to the manual reading.

Patient id	(lux) light meter facing ceiling	(lux) light meter facing baby	MUAC (manually measured in cms)	Reading from the app 1	2	3	4	5	Mean	Standard deviation
1	25	14	11	not working	not working	not working	not working	not working	n/a	n/a
2	50	38	11	not working	not working	not working	not working	not working	n/a	n/a
3	100	84	11	22.51	27.9	7.74	22.91	7.76	17.76	9.38
4	500	360	11	10.77	10.7	10.64	10.72	9.43	10.45	0.57
5	25	14	13.5	8.02	not working	not working	not working	not working	n/a	n/a
6	50	38	13.5	not working	not working	not working	not working	not working	n/a	n/a
7	100	84	13.5	11.2	9.59	8.72	8.68	10.99	9.84	1.21
8	500	360	13.5	11.4	11.35	25	15.96	16.9	16.12	5.58
9	25	14	16.5	15.57	8.54	not working	not working	not working	12.06	4.97
10	50	38	16.5	15.02	not working	not working	not working	not working	n/a	n/a
11	100	84	16.5	15.46	15.5	15.49	31.01	9.09	17.31	8.14
12	500	360	16.5	15.44	15.5	15.51	12.47	15.07	14.80	1.31

2. Test for validating the application in comparing the reading on the app of the MUAC compared to the manual readings.

MUAC	Reading from the app					Mean	Standard deviation
MUAC (manually measured in cms)	1	2	3	4	5		
16.4	16.67	16.91	16.7	17.02	16.74	16.81	0.15
14.4	14.79	14.64	14.87	14.8	14.95	14.81	0.11
14.2	14.28	14.61	14.54	15	14.4	14.57	0.27
14	13.95	13.96	14.12	14.09	14.08	14.04	0.08
13.9	13.65	13.58	13.53	13.55	13.51	13.56	0.05
14.5	14.47	14.49	14.53	14.6	14.53	14.52	0.05
13.3	13.07	12.6	12.65	13.08	12.92	12.86	0.23
11.5	11.47	11.61	11.67	11.46	11.48	11.54	0.10
11.2	11.16	11.32	11.21	11.16	11.14	11.20	0.07
11	11.05	11.06	11.03	11.02	11.09	11.05	0.03
10.8	10.59	10.58	10.81	10.59	10.51	10.62	0.11
9.2	9.53	9.54	9.5	9.51	9.48	9.51	0.02
9	9.16	9.1	9.1	9.18	9.16	9.14	0.04
8.8	8.95	9	8.97	9.01	9.16	9.02	0.08

Bland Altman Plot

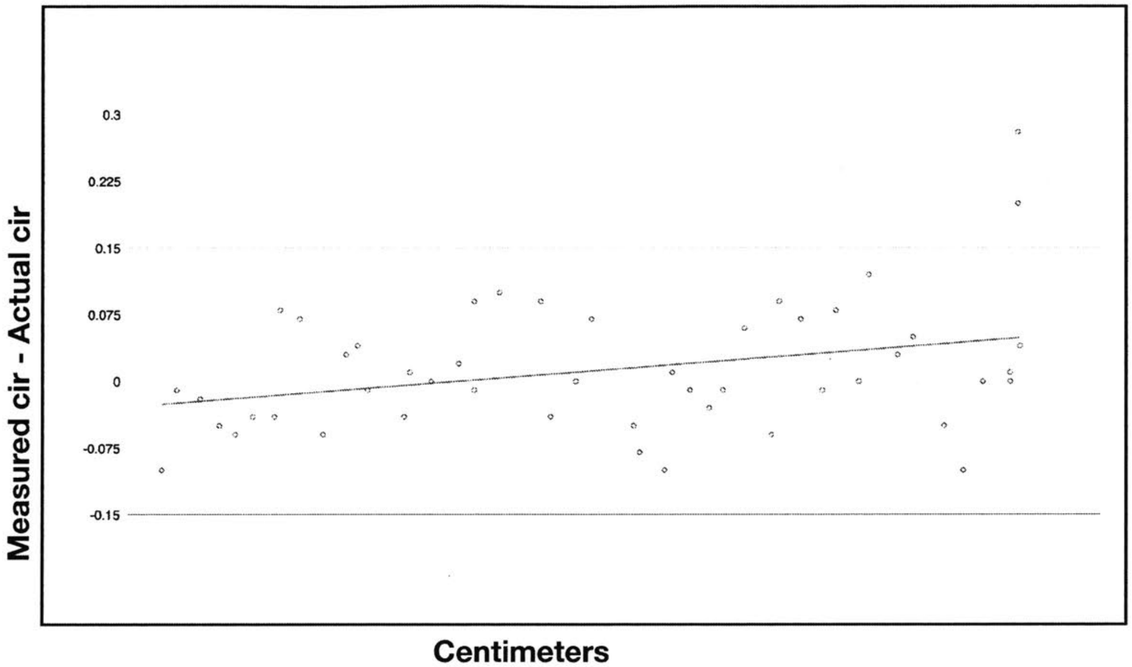


Fig 27: The Bland Altman plot to measure the variability in the MUAC band

CHAPTER 6: Monitoring and Evaluation

A. Theory of Change

Theory of change framework helps in thinking about a particular intervention will bring about results. It shows outcomes and preconditions to outlines the casual linkages in any intervention or programme between the short-term, intermediate and longer-term outcomes.

For the MIT ASHA Kit project it was vital to detail the frameworks of monitoring and evaluation starting with the theory of change activities and it leading to the following short-term and long-term outcomes.

1.ACTIVITIES

ASHA Education

- Supporting their day to day activities
- Imporved training
- Use of automated tools for health data collection
- Portable tools improve efficiency to
- Data Collection Procedure

Community Development

- Developing community infrastructure by enabling community health workers
- Providing health information and guidance
- Raising awareness for assessing nutritional and health status of newborns and children under the age of 5 years in the urban poor settlements

Digital Visibility & Literacy

- Usage of technology and mobile phones will build confidence
- Assessing skill of using digital technology in low resource settings

2.SHORT-TERM OUTCOMES

Enabling ASHAs with technology for advancement in screening tools and best practices in the healthcare system for low resource settings improving data collection and reporting

- Partner with community members and government to show the increased impact of accurate data collection
- Improved health data from communities in low resource setting
- Technology adoption by the government employees serving at the base of the pyramid of the Public Health System
- Improved ASHA and community trust and interaction
- Access to local data by government authorities in shorter time span
- Improved skill and employability
- Recognition of community health status by the government and increased visibility for social care
- Educating communities on basic health-care practices
- Conduct health-care screenings and consultations
- Increased confidence and independence in ASHAs

3.LONG-TERM OUTCOMES

- Confidence to advise medical referrals for patients by ASHAs
- Gender resilience
- Greater community engagement and acceptance of ASHAs
- Improved community wellbeing
- Improved data to influence policy

B. Logic Framework

A logic framework is used to depict program components so that the activities are matched to outcomes. Unlike the theory of change which gives the big picture and summarizes the project at the strategic level, the logic framework illustrates the implementation and understanding if the change process. The logic framework helps depict the components directly connected to the study or pilot.

INPUTS	ACTIVITIES	
What we invest	**What we do**	**Who we reach**
• Staff • Time • Money • Research findings • Materials • Technology • Equipment • Partners	• Conduct reserach • Conduct meetings • Training • Deliver knowledge and support • Develop products and resources • Bridge technology gap • Automate data collection through technology	• Participants in the study • Government organization • Locals in the Community • ASHA community • Clinical professionals • Global health professionals

OUTPUTS

What are the direct products of study activities
• 13 ASHAs trained • # services hours provided by ASHAs to the community • # of screenings conducted in a month • # of complete data collection from each participant • # change in the time of use of the app for data collection by ASHA and its deviation with increased usage • # Data of the health and nutritional status of children below 5 years participating in the study

OUTCOMES

Why this study: Short-term results	Why this study: Intermediate results	Why this study: Long-term results
Learning • Skills • Knowledge • Awareness • Perception about technology • Motivation • Adoption of technology • Attitudes	Action • Behaviour • Practice • Decision making • Policies • Social Action	Conditions • Health Information • Health • Economic • Social • Civic • Environmental (less carbon footprint)

CHAPTER 7:
Field Study in India

A. Asha Kit Feasibility Study with PHFI

Feasibility of using mobile health tools by ASHAs (Accredited Social Health Activists) for assessing nutritional and health status of newborns and children under the age of 5 years in the urban poor settlements of Delhi

1.Methodology

Study design: This will be an exploratory cross sectional study.

Study Procedure: Based on the various components of assessment of nutritional and health status, five components that are part of assessment of nutritional and health status of under 5 children and providing home based neonatal care provided by ASHAs have been selected. The team at MIT shall develop specific MHTs and handover to IIPH-Delhi, PHFI for field testing. After taking due permission from Delhi State Health Mission (DSHM), IIPH-Delhi, PHFI team shall be working with a group of 20-25 ASHA workers reporting to one Primary Urban Health Centre (PUHC) under DSHM, serving a population of approximately 40,000-50,000 people.

ASHA workers are already carrying out assessment of health and nutritional status of under 5 children and home based neonatal care in their designated population. A three days training followed by two-week period of hand holding will be provided to these ASHAs on using the mobile tools for part of health and nutritional status assessment. Following this, we shall assess the competency of ASHAs in using the MHTs. We shall also conduct interviews of the program implementers, decision makers and the medical offers in assessing the feasibility of using the MHTs as part of current ASHA kit.

Subject/participant selection: ASHA workers working under one purposively chosen Primary Urban Health Centre (PUHC) and the program implementers, decision makers and medical officers involved in the ASHA program.

Rationale for selecting ASHAs

- ASHA workers are the liaison between the public health system and the community. This study will help us analyze tools designed to enable them to make evidence based assessment of health and nutritional status and referrals of children suffering from malnutrition or other health conditions

Expected age range of participants

- Age range of ASHAs will be 21-50 years
- Number of participants: Around 20-25 ASHAs reporting to one Primary Urban Health Centre (PUHC) under DSHM, serving a population of approximately 40,000-50,000 people

Inclusion Criteria for ASHA workers:

a. Willingness to participate after signing informed consent.

Exclusion Criteria for ASHA Worker:

b. ASHA workers not willing to participate in the study

Rationale for selecting other stakeholders: The implementers, decision makers and medical officers shall be actually implementing these job aids in case they are found feasible at the field setting. Therefore opinions and perceptions of these key stakeholders will also be sought.

Methods Both quantitative and qualitative methods will be used. Quantitative methods will be used for assessing the competency of the ASHAs in using the MHTs for assessment of health and nutritional status. Qualitative methods like in-depth interviews will be used to capture perceptions of the ASHAs regarding the feasibility of using the MHTs in field set up.

Data collection: Quantitative data will be collected on the competency of ASHA in using the MHTs for assessment of health and nutritional status in children under 5 years. A checklist has been developed for this purpose (Study tools, Annex 3i).

For qualitative data, interview schedule will be used to assess the perception of ASHAs about the MHT and the factors that may act as barriers or facilitators (Study tools Annex 3ii)

Interview schedule will also be used to assess the perception of the program implementers, decision makers and the medical officers about feasibility of using the developed MHT as part of the current ASHA kit. (Study tool, annexure 3iii)

2.Protocol for taking measurements using MHTs

Using MHTs for taking anthropometric measurements and other physiological indicators

a. ASHA Preparation

The position of the ASHA should be comfortable in such a way that his/her back, elbow and forearm are supported, with legs uncrossed, feet flat on the floor, and there should be adequate lighting in the room. Children and guardians will be encouraged to remain silent for the entire duration of the procedure.

To control the factors that can cause changes in the stability of the children, the guardian should be present.

The ASHA should have washed and sanitized her hands

b.Data Collection Procedure in adults/children

One observer will hold the child in place with the test device. A reading will be taken on a smart-phone sequentially.

c. Resources for the study

- One smart-phone
- Baby Blanket for measuring length
- Connecting devices & accessories with the smart-phone
- Tape measure (to measure arm circumference)
- Stopwatch
- Weighing scales
- Forms and formats for recording observations

3.Device Assessment Procedures and Data Collection Procedures

A. Baby blanket for measuring height of newborns and infants – a special woven pattern for the blanket using augmented reality to create a calibrated scale for automatically measuring the length of an infant placed on the blanket.

Steps for measuring height of newborns and infants

1) Place the infant blanket provided on an even floor
2) Place the infant on the blanket between the guides (will be explained using a figure)
3) Move 20 inches away from the infant
4) Open the ASHA Kit app on the phone and align the camera to take a picture of the infant on the blanket.
5) The guides will appear on the screen followed by which the ASHA worker will need to take a picture.
6) Final observation will appear on the screen and will be captured in the form

B. Mobile weight measurement – a mobile app using augmented reality technology that can automatically capture the reading from a baby weighing scale.

Steps for doing mobile weight measurement

1) Remove the baby from any extra clothing
2) The baby should be wearing no diapers, if yes they need to be removed
3) Place the baby in the weighing scale and ask the guardian or the observer helping for the research study to hold the weighing scale
4) Move 15 inches away from the infant
5) Open the ASHA Kit app on the phone and align the camera to take a picture of he weighing scale.
6) The guides will appear on the screen followed by which the ASHA worker \ will need to take a picture.

C. Measuring Mid-Upper Arm Circumference (MUAC) – MUAC is the standard measurement used in the public health field for screening under-nutrition in under 5 children. The arm circumference can detect depletion in muscle tissue and energy stores in the form of subcutaneous fat. It is an absolute measure which varies little between the ages of 1-5 years and is sex independent also. It is simple, low cost and reliable and practical method. Using augmented reality, this can also be automated and digitized on a smart-phone.

Steps for taking the MUAC measurement of a child

1) Determine the mid-point between the elbow and the shoulder (acromion and olecranon)
2) Place the tape measure around the LEFT arm (the arm should be relaxed and hang down the side of the body).
3) Measure the MUAC while ensuring that the tape neither pinches the arm

nor is left loose.

4) Open the ASHA Kit app on the phone and align the camera to take a picture of the MUAC scale.

5) The guides will appear on the screen followed by which the ASHA worker will need to take a picture.

Web server: All of the data that is collected on the phones by the individual ASHA workers will be transmitted to a secure data server. If the phones do not have an active SIM card, this data transmission can be done using a designated Wi-Fi hot-spot. The data on the secure data server can be assessed by the DHSM and the study team via a special Internet web page.

4.Data Analysis

The qualitative data collected from the stakeholders will be transcribed verbatim in Hindi /English. The Hindi transcripts will be translated into English. Transcripts will be uploaded to a software Atlas ti 6.1 (Scientific Software Development, City West, Berlin) and coded line-by-line using detailed themes and sub-themes that will emerge from the data.

B. Interview Guide for ASHAs

1.In-depth interview guide for ASHAs

To assess the perception of ASHAs for using Mobile Health Tools (MHTs) as job aid in their day-to-day field activities:

Objectives of the in-depth interview with the ASHAs

- To capture the perception of ASHAs regarding the MHTs
- To assess the acceptability of using MHTs by ASHAs
- To assess the ease of use of these MHTs in field setup
- To identify facilitators and barriers in using MHTs in field set up
- To invite suggestions for improvement in the current MHTs for proposing additional components

PARTICIPANTS

  - Category : ASHA under a primary urban health center in any district of Delhi
  - Total number of IDI: till saturation

- Introduction
  - Personal Introduction
  - Introduction of the Study and Interview
  - Consent Process

Sign Post [Use any clues given in the introduction and sign post to next topic]

Background:

1. How will you describe your assigned community?

[Probe: population size, composition of people, socio-economic level, education Level, health and nutritional status]

2. How is your experience working as ASHA in your community?
3. How do you feel about your job responsibilities?

[Probe: related to the incentive received, amount of work]

4. Would you like to share your opinion and experience about the current job aids that you use for carrying out day to day job responsibilities?
   [Probe: ease of use, user friendliness, convenience]
5. What is your experience of using the current ASHA tool kit?
   [Probe: appropriateness, ease of use, inconvenience while carrying in field set up]
6. Are you satisfied with the current ASHA tool kit?
7. Do you feel the need of any additional component on the kit that would help you perform better in the field?

2.Training related questions:

8. How was your experience with the training on MHT?
   [Probe: Number of days/ mode of teaching / any written material provided/content or theme discussed in trainings/ practical use of that training usage of it in the field/ barriers faced during training /convenient timings/ recommendation for training, \ does the training make you feel competent enough]

9. Would you like to comment on the time period of training?
   [Probe: time availability, managing other field activities]

10. How long was the hand holding period post-training?
    [Probe: time period of hand-holding]

11. Do you have any suggestions regarding the training that would lead to smooth use of MHT?
    [Probe: More hands on activities]

Experience related to the use of MHTs:

12. How is your experience while using these MHTs as your job aids?

13. What did you like about using MHTs?

14. What are the difficulties/ challenges you faced while using MHT?

15. What are the difficulties you perceive in using these MHTs if they are included in the ASHA tool kit?
    [Probe: difficulty in using smart phone, handling of smart phone, sanitizing tools]

16. How does the community react when you use MHTs in the field?
    [Probe: community appreciates, is suspicious of]

17. Do you think these MHTs can be single handedly used in field set up?
    [Probe: may require any assistance]

18. Have you experienced any change in your routine performance after using MHTs?

Suggestions:

19. Do you have any suggestions regarding in current MHTs for making it more convenient and user friendly?

20. Would you like to share any further comments and suggestions regarding MHT?

Skills evaluation checklist for using the Mobile Health Tools (MHTs)

Purpose of skills evaluation checklist:

The skills evaluation checklist shall be used by research staff for assessing the competency of ASHAs for using MHTS as job aid. This checklist will serve as guide for the critical steps to be performed in a recommended sequence of standard practices while using MHTs.

1. Preparatory steps for using MHTs

	Yes (✓)	No (X)	Remarks
Please elaborate the steps before you carry out an anthropometric assessment by using MHTs			
Maintain a comfortable position as mentioned below: • Back, elbow and forearm should be supported • legs uncrossed • feet flat on the floor			
• Ensure adequate lighting in the room			
• Children and guardians should be encouraged to remain silent for the entire duration of the procedure			
• Ensure stability of the children with the cooperation of guardian.			
• Hands should be washed and sanitized before starting the procedure of taking anthropometric measurements			

2. Measuring length of newborns and infants by using baby blanket

Scenario: You are paying the routine home based newborn care visits. How will you measure the length of newborn female, aged 21 days by using baby blanket?

	Yes (✓)	No (X)	Remarks
Demonstrate the steps for measuring the length of newborn?			
Materials required (assesse should prompt) One smartphone Baby blanket for measuring length forms and formats for recording the observations			

• Place the infant blanket provided on an even floor			
• Adjust the infant maneuver by holding her knees together and press on them gently so her legs stick straight out			
• Move 20 inches away from the infant			
• Open the ASHA Kit app on the phone and align the camera to take a picture of the infant on the blanket.			
• Guides will appear on the screen followed by which the picture shall be taken			
• Final observation will appear on the screen			
• Record the newborn's observation in records			

3. Mobile weight measurement

Scenario: You are paying the routine home based newborn care visits. How will you take mobile weight measurement of a male child, aged 21 days?

	Yes (✓)	No (X)	Remarks
Demonstrate the steps for taking mobile weight measurement?			
Materials required (assesse should prompt) One smartphone Weighing scales forms and formats for recording the observations			
• Remove the baby from any extra clothing			
• The baby should be wearing no diapers, if yes they need to be removed			
• Place the baby in the weighing scale and ask the guardian or the observer helping for the research study to hold the weighing scale			
• Move 15 inches away from the infant			
• Open the ASHA Kit app on the phone and align the camera to take a picture of the weighing scale.			
• The guides will appear on the screen followed by which the ASHA worker will need to take a picture.			
• Record the newborn's observation in records			

4. Measuring Mid-Upper Arm Circumference (MUAC):

Scenario: You are doing nutritional assessment of children under five years of age in your assigned community. How will you take the Mid-Upper Arm Circumference (MUAC) measurement of a female child, aged 24 months using mobile health tools (MHTs)?

	Yes (✓)	No (X)	Remarks
Demonstrate the steps for measuring the Mid-Upper Arm Circumference (MUAC)			
• Determine the mid-point between the elbow and the shoulder (acromion and olecranon)			
Materials required (assesse should prompt) One smartphone tape measure (to measure arm circumference) forms and formats for recording the observations			
• Place the tape measure around the LEFT arm (the arm should be relaxed and hang down the side of the body).			
• Measure the MUAC while ensuring that the tape neither pinches the arm nor is left loose.			
• Open the ASHA Kit app on the phone and align the camera to take a picture of the MUAC scale.			
• The guides will appear on the screen followed by which the picture has to be clicked.			
• Record the child's observation in records			

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CHAPTER 8: Discussion and Conclusions

A. Lessons Learned to Date

Based on our design work and our observations in the field, the following are some potential areas of discussion and conclusions:

- Data collection. Data analytics is increasing gaining importance in the field of healthcare. Health experts (public and private) are seeking legitimate data – which is recorded properly and can be used for further analysis.
- Easy to carry. ASHA worker goes walking from one house to another and is already carrying a huge data recording book given by the hospital. So the portability aspect of our tools, plays an important role in increasing its acceptance among ASHA workers and thus its scaling.
- Data interpretation made easy. Currently, in order to monitor growth, ASHA has to plot the readings from weighing machine and height chart manually in the growth chart and then interpret that data. This requires time, training and precision. Quick and precise data. Measuring and manually taking readings in the current tools could be time consuming and prone to errors (machine calibration or manual). Also, ASHAs are over worked and the monotonous nature of recording the readings, may lead to errors.

If we can build a network on ASHA workers trained in mobile health, this could become a platform for other companies to launch or pilot their solutions.

Credible diagnostic data play an important role in tele health. An expert sitting in a remote location could analyze this data and provide consultation to the mothers.

ASHAs credibility would improve among families and they may be motivated to perform better if they are entrusted with new technology and the improvement in process of collecting families healthcare information

B. Future Opportunities

What will the future of healthcare workers roles be with access to mobile phones?

They could become health and wellness aggregators for the community – for information, health awareness, basic health screening, payment, shopping for health care products, tele health, etc This would improve access to better healthcare, and improve the quality of life and empower rural communities.

What is your perception about digital illiteracy & digital invisibility among the ASHA workers?

With the digital penetration in rural India, many ASHA workers own and use mobile phones. They learn to use them through their children who mostly belong to the millennial generation. They are connected to other ASHA workers in the neighboring villages on the phone and frequently share work related updates among themselves. They didn't use internet to search or learn about health care interventions. They still relied on training programs to learn new skills.

How does empowering ASHA workers with new technology change the perception of technology in the community?

ASHA workers are normal house wives with minimal educational qualification – just like any other woman in the village - turned into health activists. And because of the acquired knowledge in healthcare, they are perceived as opinion leaders. They have a strong rapport with the women in the community and have inspired many to join them. So if ASHA workers adopt new technology, others in the village– especially women – may want to use technology and it may seem more accessible to them. With technology, even men may want to become ASHA workers.

How does giving an ASHA worker a mobile phone connect her with the larger eco system of public health? How does this help the public and the government?

It would really help in easy and quick dissemination of credible information. This would in turn improve their efficiency and reduce the cost of training. Many training programs could be provided online. It could decentralize the system, thus making implementation of solutions faster given the bureaucracy and hierarchy in the public health system. It could act as a platform for ASHA workers to voice their queries to higher management and expect faster solutions. Monitoring and rewarding ASHA workers would become easier and more effective

How does technology intervention lead to improvement in job aid in the community?

Technology connects the community to the outer world. It makes opportunities more accessible to them. This could even help the ASHA workers have a career plan and venture into areas of their interest.

ADDITIONAL RESOURCES

- siteresources.worldbank.org/HEALTHNUTRITIONANDPOPULATION/Resources/281627-1154048816360/AnnexLHNPStrategyWhatisaHealthSystemApril242007.pdf
- www.who.int/bulletin/volumes/93/6/14-146571/en/
- www.nihfw.org/Doc/NCHRC-Publications/Operational%20Guidelines%20on%20Home%20Based%20Newborn%20Care%20(HBNC).pdf
- www.who.int/childgrowth/training/module_b_measuring_growth.pdf
- nipccd.nic.in/elearn/manual/egm.pdf
- motherchildnutrition.org/early-malnutrition-detection/detection-referral-children-with-acute-malnutrition/interpretation-of-muac-indicators.html
- World Health Organization, United Nations Childrens Fund. WHO child growth standards and the identification of severe acute malnutrition in infants and children. World Health Organization. 2009. Available from: http://apps.who.int/iris/bitstream/10665/44129/1/9789241598163_eng.pdf
- UNICEF/WHO/World Bank Group. Levels and Trends in Child malnutrition: UNICEF/WHO/World Bank Group joint child malnutrition estimates [Internet]. 2016. Available from: http://www.who.int/nutgrowthdb/jme_brochure2016.pdf?ua=1
- Ministry of health and family Welfare, Government of India. HOME BASED NEWBORN CARE: Operational Guidelines [Internet]. 2014. Available from: http://dshm.delhi.gov.in/pdf/guideline/Revised_HBNC_Operational_Guidelines_2014_English.pdf

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3. [3]www.swasthyaslate.org/flyer.pdf
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11. [11]www.averyweigh-tronix.com/en-IN/products/industrial-weighing-scales--applications/salter-india/
12. [12]zenuvo.in/ product_22.htm
13. [13]nipccd.nic.in/elearn/manual/egm.pdf
14. [14] motherchildnutrition.org/early-malnutrition-detection/detection-referral-children-with-acute-malnutrition/interpretation-of-muac-indicators.html

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