Home Based Child Growth and Health Monitoring Support System

Submitted in partial fulfillment of the requirements for the degree of

Master of Technology

in

Biomedical Engineering

by

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April 2018

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This is to certify that the thesis work entitled **"Home Based Child Growth and Health Monitoring Support System"** submitted by **Uwamahoro Raphael**, School of Electronics Engineering, Vellore Institute of Technology, for the award of the degree of *Master of Technology in Biomedical Engineering*, is a record of bonafide work carried out by him under my supervision, as per the VIT code of academic and research ethics.

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Place : Vellore

Date : 21 April 2018

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Approved by

Head of the Department

Department of Sensors and Biomedical Technology

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Declaration

I hereby declare that the thesis work entitled **"Home Based Child Growth and Health Monitoring Support System"** submitted by me, for the award of the degree of *Master of Technology in Biomedical Engineering* to Vellore Institute of Technology is a record of bonafide work carried out by me under the supervision of **Prof. Bhaskar Mohan Murari**.

I further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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Acknowledgment

It was not possible to complete this project without wisdom and healthy life. I thank Almighty God for his protection and blessings to carry and complete the project. The project would not have been well directed without guidance from my mentor. I would like to express sincere thanks to **Prof. Bhaskar Mohan Murari** for his encouragement, inspiration and important suggestion to endeavor brilliant performance of the project work. I am thankful to all faculties for their fundamentals in Biomedical Engineering and students in the school of SENSE for their help and motivation during my studies. I express thanking to health workers who provided feedback for the research project especially midwife **Benegusenga Charlotte** and **Miss Mugwaneza Mariette** for their role in questionnaire feedback from local health workers. I gratefully express thanking to my parents, my brother and sisters for their support and encouragement during my studies life.

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Abstract

Child growth and development represent essential life stage in human beings. Monitoring growth of children has been recommended as a simple, cheap and affordable method of detecting early growth and help in taking measure to overcome abnormal patterns of growth and health promotion. Inadequate controlled child health lead to several health inconvenient such as neonatal mortality, autism, delay growth and chronic diseases like heart, blood pressure, Respiratory diseases .As child grows, information survey of the early data provides effectiveness of health status of the child and the overall population in general. Moreover, there is no direct data management that can help as a referral for health care practitioner in the third world countries. The development of a community based support platform was implemented to help rural population to frequently evaluate the life progress of the people therein by use of child information. In this system, the anthropometric measurements will be determined to provide a growth status of child under surveillance. In this system, the Sleep Apnea detection has been interfaced with the system as a predictor of the risk of respiratory disorders in infant that can rise when no early control was made. For storage requirements, a Micro SD card Module was provided to hold the memory card and save all data while taking measurement. The arm circumference were measured with a standard deviation of 0.29, 0.40, 0.46, 0,37 and 0.30 for 5 measurements. The test results of the system has shown that the system can reduce the measurement error faced in rural areas, and can be interfaced with the health sectors for well being of the population. It is expected that the implementation of this system in rural area will overcome abnormal growth and related defects.

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List of Abbreviations

APLS	Antiphospholipid Antibody Syndrome
OSA	Obstractive Sleep Apnea
BMI	Body Mass Index
CDC	Centers for Diseases Control and Prevention
CSA	Central Sleep Apnea
NHENS	National Health and Examination Survey
MGRS	Multicenter Growth Reference Studies
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver Transceiver
WHO	World Health Organization

Chapter 1

Introduction

This section introduces the state of child health screening materials to figure out the future development, provides historical overview of anthropometry, prevalence of overweight and sleep apnea and health issues, and clarifies the problem that motivated to conduct this thesis work. The last part explain the intended views and work organization.

1.1 Background

Child growth refers to an increase of the physical parts of the body. Individual healthcare inconvenient management need is daily increasing. Child growth monitoring is affecting the life of people from infant to adulthood. For many years ago, more researches carried out on the child health has shown overall population health planning based on the children health status (McDowell et al. 2008). A typical mechanism of the growth assessment begins from birth where the head is assessed for brain development screening. In addition, the MUAC is used to screen malnutrition in children below 5 years of age. The measurement of the weight plays a significant role in screening obesity in children aged from 2 to 20 years. However, since the weight has some correlation with age and sex, World Health Organization (WHO), CDS and National Health and Examination Survey (NHENS) have developed reference standard of the growth chart. Growth chart were used from many years and a reduction in the disease severity was resulted due to early diagnosis (Garner et al. 2000). The excess weight has affected more population after the World War II .The earliest invention of the technology to screen the excess weight in combination with the height dated back in 1830s (Eknoyan 2007) and was internationally accredited by the WHO after different research analysis. However, the age and sex are to be considered while using Body Mass Index (BMI) in children. Thus the development of Body Mass Index (BMI) standard for adults and children with age and sex as main concerns. Under healthcare providers prospective, child health information management and monitoring has to be guaranteed. A number of strategies have been investigated. Today, home based medical services are of interest and can provide professional health satisfaction (McAllister et al. 2007). Due to the data acquisition issue, information management affect proper screening of children and their mother life (Guyon et al. 2016), in addition to the lack of standard reference data (Van Buuren et al. 2004) for proper screening. In 2011, the World Health Organization (WHO) (Organization et al. 2011), reported a global framework to be developed for screening the health of children and their mothers. Due to incapability of most countries to supply needed data for Health progress control , in (AbouZahr & Boerma 2005) developed a health Metric Information system that help to gather data on the global trend. The development of software based on the WHO and MGRS growth chart reference (Grote et al. 2008) has limited frequent visit to hospitals endocrinology services but due to change in life at different national levels, clinical decision rules should be investigated.

1.2 Motivation

As introduced above, untreated childhood are exposed to more chronic diseases and disabilities. The rate of death of underweight children on global trend in middle and low income population is rated at 130 million (Boutayeb & Boutayeb 2005). Home based medical devices for monitoring health of people therein may play a considerable role in healthcare industries. Child growth monitoring devices have become very popular to detect the real development of children and screen the life of the population in general. A poor management of the health of people especially children are leading to frequent growth and development related disorders. With the development of healthcare technology, people in any location of the globe require to play a role in the medical management of their life. From this understanding, child growth and health should periodically be monitored. In early method of children screening process, child health care givers or parents need to move and meet health care pediatricians after travelling many miles. Weight, height and MUAC are the popular data measured in detecting the growth protein. Most health sectors use hanging analog weight measuring balance and stadiometers for height measurement and tape-measure devices for MUAC, keep hand written material as storage and require to retype data in digital format when sharing is required. These methods are time consuming in addition to frequent error while recording measurement data. Moreover, developing countries face a lack of community healthcare workers that can perfectly analyze measured data. In addition, early research have frequently mentioned a correlation between the cardiovascular and respiratory defects in adults that are related to their status in childhood (McAllister et al. 2007, Freedman et al. 2001, Dietz 1998). The mentioned problem reveals to look for an improved system that provides time reduction, easy to manipulate offering saving techniques without hand written materials thus a reduction in errors due to poor data acquisition. The existing community healthcare workers are not familial to plot and analyze the growth chart after raw data collection from children individual. Moreover, the error made when taking anthropometric measurement is accompanied with interpretation error (Ulijaszek & Lourie 2005) and requires direct manipulation while assessing the nutritional status. This causes frequent visit to hospitals and health centers in growth promotion.

Following the collection of data, frequent physiological parameters defects leading to adulthood chronic diseases are detected using signaling devices with some noise that interrupt the sleep. To overcome this challenge, the development of IOT inspired us and provides a choice to integrate many devices as a single system. Unfortunately, most of sensors systems in biomedical application are wearable. That requires a special attention when collecting data from human body. It is of interest to overcome all of challenges by means of new technology design of non-wearable, non-invasive in human body in addition to their ability to offer easy data exchange among healthcare workers and medical service providers.

1.3 Research aim and objectives

1.3.1 Aim

The main intention of this dissertation is to develop a community based child growth and health monitoring platform that provides a growth and health status for children with data saving capability.

1.3.2 Objectives

The goal of this research is to investigate the health inconvenient due to poor health management and provide solutions. One aimed objective is to develop a framework to guide the childcare giver and parents to know the growth status and provides the future growth, developmental predict medication in case of abnormality without traveling to hospitals and health centers. The second objective is to provide an algorithm to assess and classifies the child growth status. In the third objective, we intended to design a system that predicts the primary medication for the child. Due to the growth status, the system will provide a guide to the healthcare provider or the system user to prescribe the required intervention for continuous well being of the child. The fourth objective is to develop a health monitoring system for third world communities. Unlike traditional health monitoring system based on the growth, the desired system will not require and hand writing material. The fifth objective is to integrate the physiological parameters data collection system with the anthropometric data in a single file for periodic reference and update as measurements are taken. The respiratory apnoea will be detected based on the saved data. In order to impact the long term health management of the population based on the community health, systematic management of the children health status will help the policy plan of the entire population under national level, will help to provide public healthcare settings that will improve the health quality.

1.4 Thesis outline

The work in this dissertation is arranged in 5 chapters starting from the Introduction. Chapter 2 deals with the early work done on the use of anthropometry to screen the child health. Chapter 3 presents the design methods used and outline the implementation of the proposed system. Chapter 4 provides results and discussion of the work and future plan of designed medical devices in developing countries. Chapter 5 conclude the work and provides future research plan of the work.

Chapter 2

Literature Review

This section reviews the work early carried out in child growth assessment and health monitoring and emphasizes on anthropometric data collection methods. It also provides a literacy relating the growth and physiological parameters from birth to adulthood which focuses on early respiratory apnea monitoring detection techniques.

2.1 Anthropometry

The physical behavior of human body changes from birth and is detected by anthropometric measurements. Endeavour screening of human measurement using anthropometric data dated in the later 1769 by a French Georges Cuvier (1769-1832). His research focused the comparison of human to other primates while standing on any location on the globe. The literature of anthropometry stands for the measurement of the human body features. Current stature, body weight, arm circumference and skin folds are broadly collected for assessing growth, body adiposity and reference data. The measurement of weight and stature will be provided for analysis of the child growth referred to international growth standards. Body composition study conducted by (Wells & Fewtrell 2006) has shown that the use of anthropometry evaluates the nutrition in young children and adults? fat adiposity has shown a risk of chronic diseases related to excess weight. This section reviews some prominent researches done on the use of the anthropometric measurement in the human progress and emphasizes the children growth.

2.2 Early anthropometric Measurement methods

Long established anthropometric measurement are carried out by expertized and trained anthropometrist based on the use of available instruments. Measuring tape for recording the body height, circumference and curvature were popular devices. Irrespective of the trained anthropometrist, frequent measurement errors appear during existing measurement techniques, thus continuous training of anthropometrists by Multicenter Growth Reference Studies (MGRS) to minimize random errors (de Onis et al. 2004), where imprecision and reading error are common errors.

2.2.1 Height measurement

Currently, available tools require the examiner to use hand written materials to record data while the subject stand on the wall or a graduated material for height measurement as seen from Fig. 2.1, whereas the weight measurement is taken by hanging analog weighting balance with a spring as shown in Fig. 2.3. The process is time consuming and may require more than one person for data recording. To facilitate medical sectors to provide meaningful and trustable measurement, improved design should be introduced.

2.2.2 Weight measurement system

In analog weight measuring balances, the user mostly take one reading. Novel fabrication technology of cheap and affordable devices can prevent this challenge .Automatic measurement methods are provided with multiple measurement and output the results on the display. Digital weight measurement methods provides two benefits where this research focuses. The first deals with a technique how the information from the subject under examination can be stored and retrieved when required. This is done by using digital measurement devices and is achieved by providing measuring

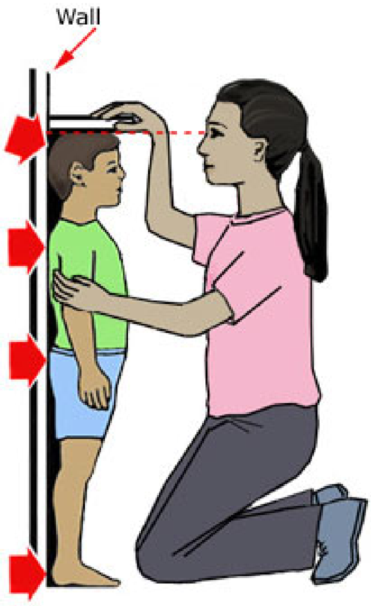

Figure 2.1: Height measuring system

Figure 2.2: Graduated stadiometers

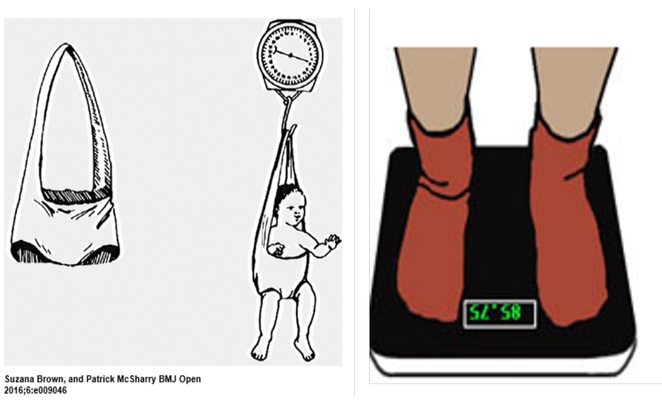

Figure 2.3: Weight measurement

devices with storage attributes.

2.2.3 Weight for age

The weight for age is used to estimate the current status of child?s weight. During emergency drug dosage, the weight of the child estimate is a simple method to use. The challenges come when validating which formula to use in developed and developing countries. APLS formula (1) courtesy has shown that the use of the weight estimation will vary depending on the region of the globe and was confirmed to be used in Trinidad and research continued and reveals (Luscombe et al. 2011) to analyze the validity of the weight for age estimation in a large population and has shown that weight for age estimation by Luscombe should continue to be used in large population. The main drawback of these theorems are based on specific regions and are limited to be globally used. The APLS and Luscombe formulae are respectively estimated as:

$$Wa = 2 \times \ (age\ (year)\ +\ 4) \tag{2.1}$$

$$Wa\ (Kg) = 3 \times \ (age\ (year)\ +\ 7) \tag{2.2}$$

2.2.4 Weight for-height

In malnutrition assessment, the term weight for height is a characteristics of the children to not gain sufficient weight for his age and is termed as wasting due to frequent or chronic diseases .

2.2.5 Body mass index

Body Mass Index is defined to quantify the individual?s body fat by considering the persons height and weight. BMI is mathematically the ratio of body weight (in Kilogram) to the Square of its height (in meters).

$$BMI = \frac{Weight\ (Kg)}{(Height\ (m))^2} \tag{2.3}$$

The inspiration of BMI dated back in 1830s by a physician Adolph Quetelet studies leading to a conclusion that human weight increases as the square of the height from birth to puberty and was termed the Quetelet Index. In 1990, (Henry et al. 1990) proved that anthropometry has been used as screening means of nutritional status in children from developing countries and has been used for the assessment of human survival by using BMI as an indication to health function. After the World War II, the weight and cardiovascular diseases become frequent; thus the Quetelet index has confirmed to serve as an index to relate the body weight and has been adopted by the World Health Organization as a determinant tool of obesity in 1995 after (Eknoyan 2007) has termed it Body Mass Index (BMI). From then, in 2005, (Ulijaszek & Mascie-Taylor 2005), proved that anthropometric measurements can estimate the nutrition rate in children (Ulijaszek & Lourie 2005). In their study, it was proved that there was no particular attention payed on the risk of underweight category and health relationship. Later in 2007, the BMI has been used as a screening means of male under risk of obesity (Eknoyan 2007). A part from the child growth, anthropometry is used in science and technology to examine genetical behavior and to design of devices that offer the human to effectively perform his BMI is not limited to application in different health examination. In developed countries, BMI was used to examine the relationship between motors and physical fitness (Sharma et al. 2011) through experimental analysis conducted on school going children which has shown that children with low BMI level have a high level of healthy motor fitness .The risk of adult coronary heart defects was confirmed by (Freedman et al. 2001, Baker et al. 2007),in their study during which the BMI was investigated and the longitudinal correlation was examined in adult lipids. Their study was conducted on 2617 children aged from two to seventeen and were retested for lipid in adults from 18 to 37 years old to determine if the BMI in childhood relates to adult lipid quantity. The findings of the research has shown that obese child remain obese in adulthood. In adolescent,

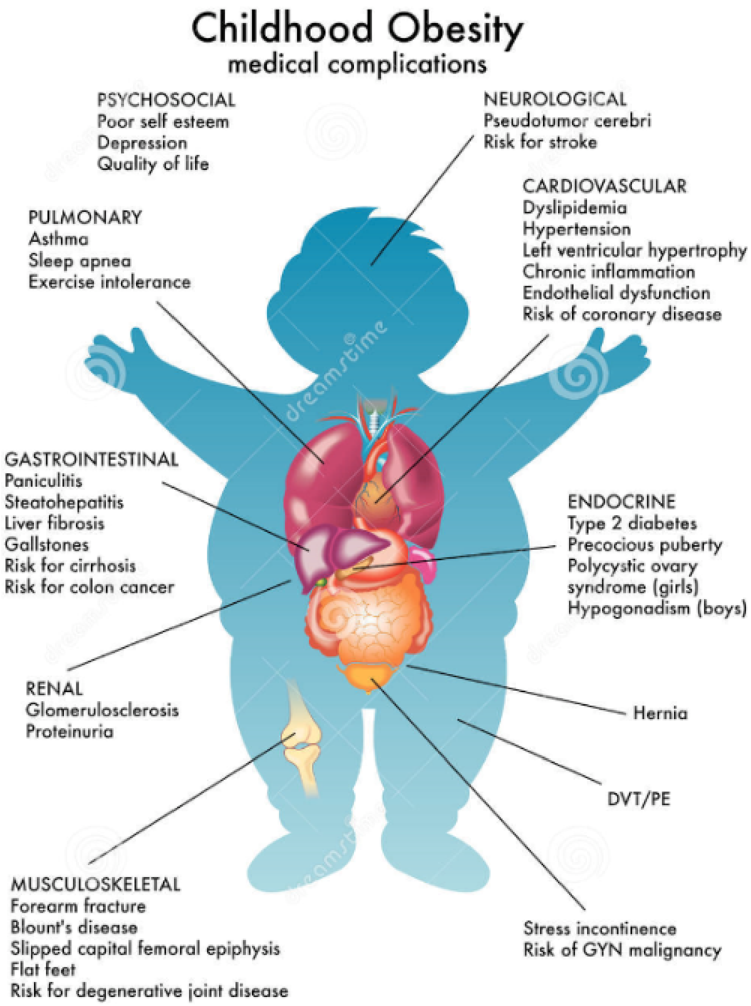

Figure 2.4: Medical Complication of childhood obesity

children who were obese develop a risk of neurological and orthopedical conditions and the may develop adult diseases and premature death .Obesity has been examined from weight for age, triceps skin folds, but all of these measurement did not yield exact results. BMI was one of methods used to examine obesity where children with BMI greater than 85th to 95th were under risk of developing various medical complication including gastrointestinal , apnea and elevated intracranial pressure (Must & Strauss 1999).

They are many technology that apply in determining BMI. Honade (2013) has determined BMI using MATLAB. The technique requires additional process and interface with a computer. Thus the automated BMI calculation with age and gender dependence, community healthcare givers and parents can determine the life of child and kids without specialist health specialist intervention.

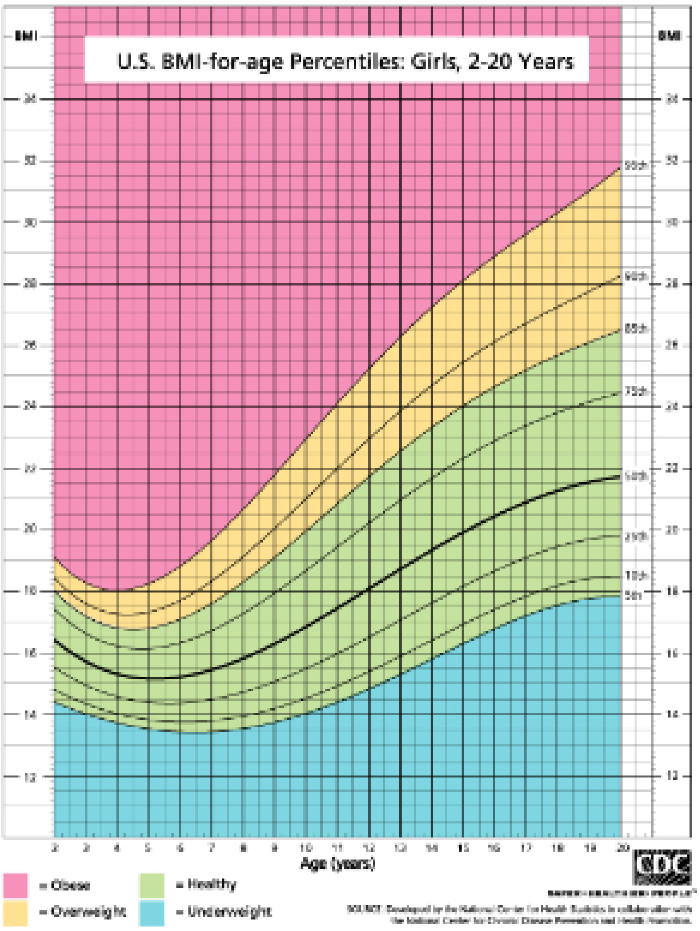

Figure 2.5: Body Mass Index for-age girls standard from CDC

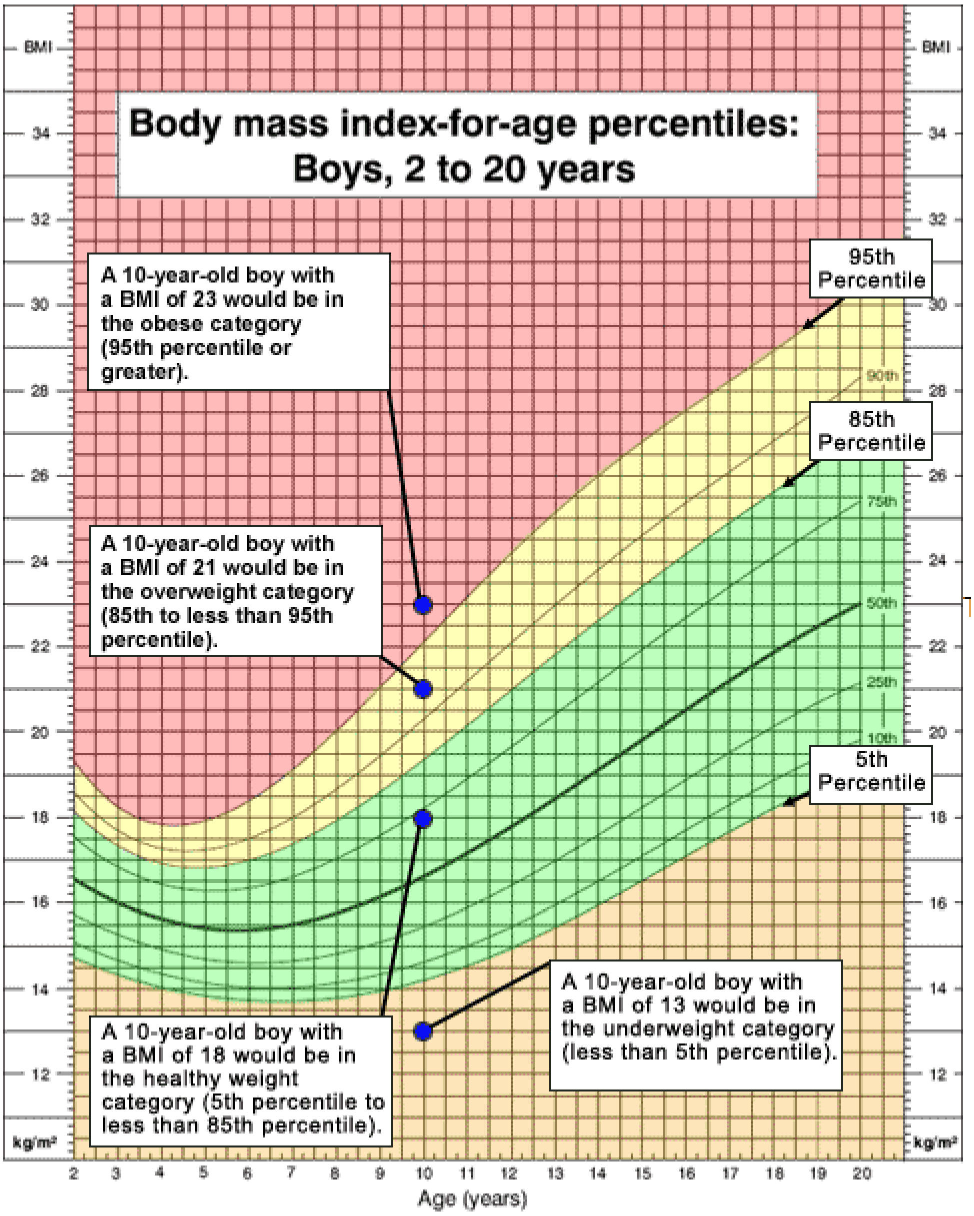

Figure 2.6: Body Mass Index for age percentiles boys standard from CDC

Classes	Percentile Ranking	Weight status
1	Lesser than 5^{th} percentile	Underweight
2	From 5^{th} percentile to lesser than 85^{th} percentile	Health weight
3	From 85^{th} percentile to lesser than 95^{th} percentile	Overweight
4	Equal or greater than 95^{th} percentile	Obese

Table 2.1: BMI and weight classification based on CDC chart

2.2.6 Classification of weight status and BMI

The standard for Body Mass Index are age independent in adults. Same cut off value can apply for both male and female. The international classification of the Body Mass index in children take into account the age and the gender (Dinsdale et al. 2011). Based on the percentile ranking, the Table 2.1 classifies the weight of children based on their Body Mass Index.

2.2.7 Middle Upper Arm Circumference

The arm circumference helps to pediatricians to examine the nutritional status of the children. It was shown by the WHO that severe malnourished children lead to severe risk of diseases and mortality. In 2005, malnutrition was tested in hospitalized children in Kenya and were assessed for inpatient death and MUAC was confirmed as a screening tool to be based on to screen malnutrition and the risk of mortality (Berkley et al. 2005). The research participants were 12 to 59 months admitted in hospital in rural Kenya. Non stretchable measuring tape were used. The research concluded that MUAC is a trustable anthropometric measuring tool in family based assessment. In addition following research have confirmed the use of MUAC to screen growth rate of children where the food insecurity and various disasters are frequent. Mramba et al. (2017) have developed reference MUAC reference z score to help screening the children rate of nutrition based on the WHO reference standard of 2006. The reference cut-off arm circumference for children under acute malnutrition are indicative of the treatment to be given to the children. The WHO classifies MUAC for nutrition assessment in the following categories:

- Children with MUAC lesser than 11.0cm are classified to be acute malnourished

Figure 2.7: Middle Upper Arm Circumference measurement

and need direct treatment.

- Children with MUAC between 11cm and 12.5 cm are classified as moderate acute malnourished and need to be admitted to supplementary nutrition.

- Children with MUAC greater than 13.5 cm are classified as well nourished

2.2.8 Health monitoring

In some medical cases, it is required to record physiological parameters from human being without disturbing anatomical body in addition to the need of data reuse after a couple of days. During sleep, some parameters are required. The sensor technology is a solution but they are required to remain attached to the body, which disturb the comfort of the person being examined. Different researchers tried different methods to assure the wellbeing of patients. Using Internet of things (IoT), medical mirror have been developed to monitor physiological parameters (Poh et al. 2011). Extended Healthcare technology has strengthened the developed of non-contact piezo-electric respiratory rate monitoring system. Potential available system represent a notable approach in home based health monitoring system design. A number of non-wearable sensors technologies were developed to impact the effect health hazards. The design of a non-contact respiratory monitoring device based on Infra-red sensors has shown a significant advance in personal health monitoring (Das 2013) using a combination of infra-red emitter and receiver couple to detect the change in movement of the ball in a tube as the person inhale and exhale, and set the timer for a minute, with the counter increasing as the air was inhaled and exhaled. From this literacy, non-wearable sensors prove their use in detecting Respiratory apnea events.

Respiratory apnea Syndrome in children

Child development need a special attention due to their change in health for every step of their growth. A number of children experience considerable modification of the Neurophysiological factors and mechanical parts of the respiratory system during growth and development (Gaultier 1999) under which apnea is developed. Due to their week system immunity to environmental adaptation, they must be protected from any environmental toxicity which leads to diseases where asthma is one of frequent respiratory diseases met through environment toxicity (Saadeh & Klaunig 2014) but continuous detection is a preferable means to prevent child life. Sleep disorder is on of current pathology leading to high blood pressure, diabetes, and comorbidity conditions in pediatric (Morgenstern et al. 2014). Monitoring the breathing patterns is found to be an important tool to asses sleep disorder for Neonates. Early diagnosis tools uses bodily attached sensor to detect the sleep rhythm which affect the normal respiratory which lead to mental and physical disorder. Sleep Apnea syndrome is defined as a cessation of rhythmic breath for 10 second (Çavuşoğlu et al. 2005) but small change in breathing activity can rise and detected by different techniques. Çavuşoğlu et al. (2005) has used oral nasal air flow based on transistor properties to detect the change in temperature of the thermistor resistance as the subject inhale and exhale. In his work, he used to transfer data to a computer using cable connection. With the goal of the research, a reduction in material with maximum output should apply. In Obstructive Sleep Apnea Syndrome, the upper airway experience narrow size which block the normal flow of the air which is the most popular condition in obese people. In 2012, the research done by Narang et.al. has shown that sleep apnea is frequently recognized in children who experience obesity conditions in the developing and developed communities of the globe which lead them

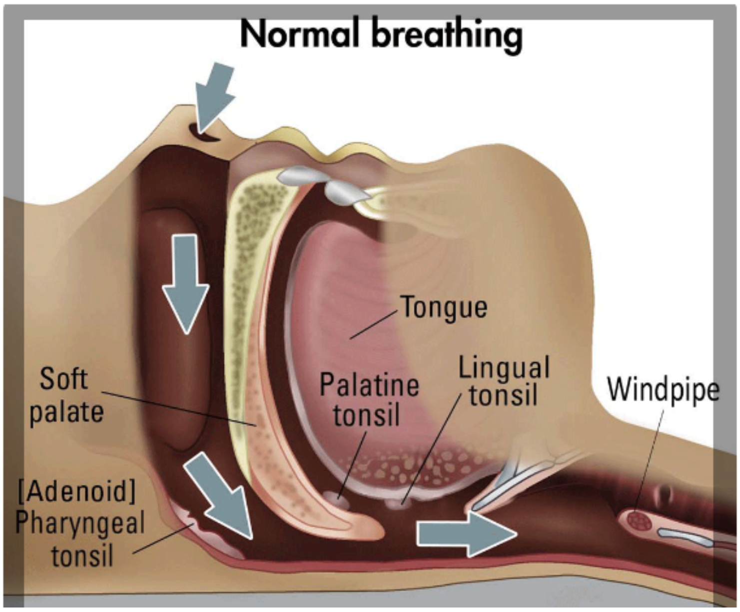

Figure 2.8: Normal breathing

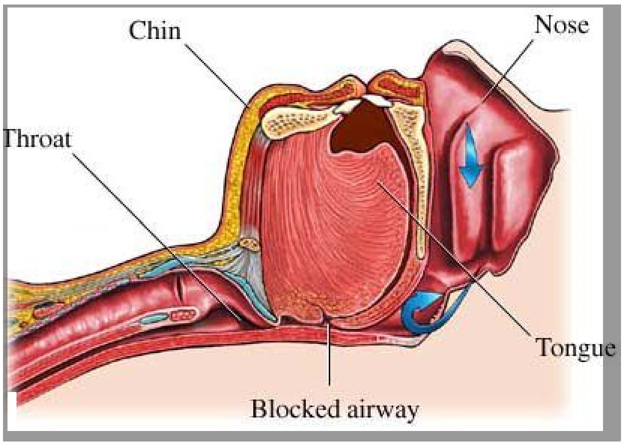

Figure 2.9: Blockage of the airway by the tongue

to shunting (Narang & Mathew 2012).

In their normal growth, adolescent and preschoolers experience a development of the tonsils without any abnormality but their increase in size can result from sore throat. Mostly, the Obstructive Sleep Apnea (OSA) examination is laboratory based with the gold standard as the frequent method used for sleep examination which oblige the patient to stay at the hospital for twelve to 24 hours (Benistant 2016). Most children experience the Central Sleep Apnea (CSA) syndrome during which the respiratory system experiences a pause in the breathing patterns (Benistant 2016), which is due to the insufficient chemoreception of the brainstem, Obesity and congenital heart failure as medical conditions. The continuous monitoring of apnea

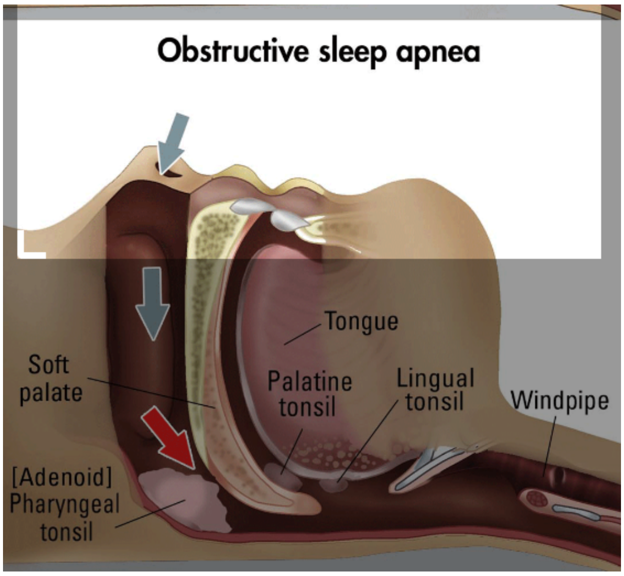

Figure 2.10: View of obstructive sleep apnea airways

syndrome requires contact sensors to the human subject under examination. In the research work done by (Rao & Sudarshan 2015) used a biosensor to detect respiration at the same time recognizing bradypnea and tachypnea .In his method, a change in temperature of the inspired and expired air cause a change in thermistor resistance. By using an INA122 amplifier, analog to dc conversion and a microcontroller AT89S52, amplified voltage was digitized and the respiratory events were detected (Rao & Sudarshan 2015). Binu & Varsha (2014*a*) developed a bio-sensor technology to wirelessly monitor events from respiratory system. In his work, position, breath and oxygen sensors were used and the resulting parameters were subjected to be transmitted to a Personal computer to be accessed by the physician in charge (Binu & Varsha 2014*b*). From long ago, the risk of child growth defects especially obesity has shown some defects leading to cardiovascular diseases and obstructive sleep apnea syndrome (Binu & Varsha 2014*a*).It is our aim and target to develop low cost affordable system that uses non-contact sensor systems to detect respiratory defects during sleep for infant. To achieve our mission, we referred to all above literacies and designed a system in which apneic events can be detected. In above examples, the authors requires a lot of instruments that cannot be easily manipulated by the population with low and middle incomes. Referred to early work by (Min et al. 2010*a*) who developed an ultrasonic sensor based sensor which detect the breath from the abdominal rise and fall as air is inhaled and exhaled, we intended to provide a data logging system for the patient under examination.in his research , he used a communication between the sensor and the laptop while the patient was sitting.in order to come up with the patient comfort and use a single system to provide all measurement and reuse, our goal was achieved by developing a real time data acquisition and logging for all individual. The system is low cost and was designed according to the questionnaire in appendix B and the interview with local child welfare at RWAZA Health Center.

Chapter 3

Materials and Methods

The frequently available health management system for infant do not have a build in saving techniques. In addition, the literature has shown a risk of cardiovascular and respiratory dysfunction in adulthood that were obese in childhood. As physiological parameters change with age, it is of great importance to control the rate of grow in terms of weight and other health parameters. To complete this work, the Centers for Diseases Control and Prevention (CDC) Body Mass Index (BMI) standard growth chart for both boys and girls was investigated in addition to questionnaire from the Health Center of Rwaza in Muzanze District, Nothern Province and Hospital of Kirehe located in Eastern province in Rwanda. As figured out by the feedback from questionnaire , we aimed to overcome the existing data management by designing a system that could offer time reduction of data collection, monitoring and saving measured anthropometry and Apnea event , error reduced data collection, and transmission capability.

3.1 Instrumentation

The hardware requirements includes Arduino MEGA 2560, weight sensing mechanism, height measurement, 4*3 keypad for age , gender entry, date of measurement and child ID number; a micro SD card module, LCD display, control switches. To accomplish the communication between sub-systems, Arduino IDE was used as a mother software

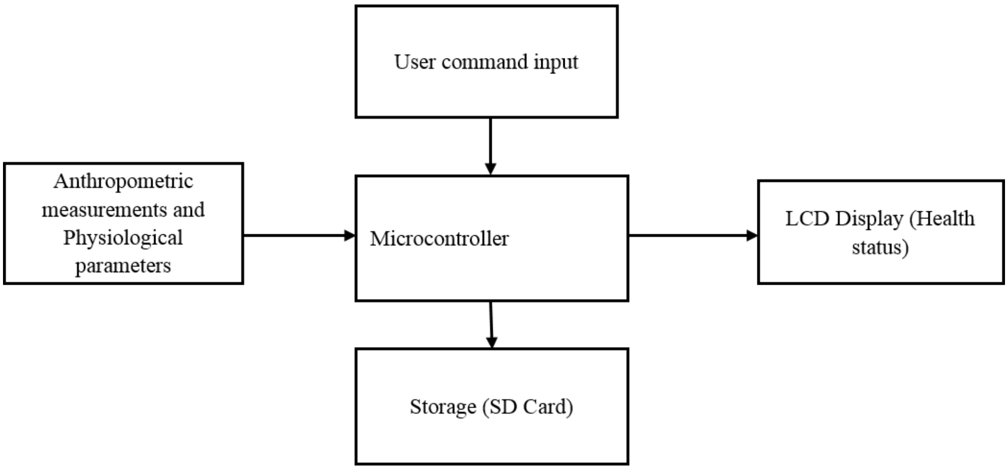

Figure 3.1: Block diagram of the designed system

section.

3.1.1 Microcontroller

In this research, the design utilizes Arduino Microcontroller. As the name suggests, a microcontroller is an integrated system provided to control the operation of embedded system. It includes a processor, a memory and peripherals to help its communication with environment.

Based on ATmega2560, this microcontroller board allow interface of a lot of external hardware. The storage capacity includes 250 Kb memory for code storage, 4 KB of EEPROM and 8KB SRAM. The input and output form a set of 54 digital pins rated at input current 40 mA which can be configured as input or output. Some pins are attributed particular functions. 4 wires serial Interface, 6 external interrupts , that allow the programmer to configure them as interrupt on a change in value, Seral Peripheral Interface (SPI) provided for Serial communication , Inter-Integrated circuit communication through pins 50,51, 52 and 53. The board contains four hardware Universal Asynchronous Receiver Transceiver (UARTs) reserved for TTL communication. The MEGA 2560 protected from over-current by means of fuse that will break the circuit when the incoming current exceeds 500 mA.

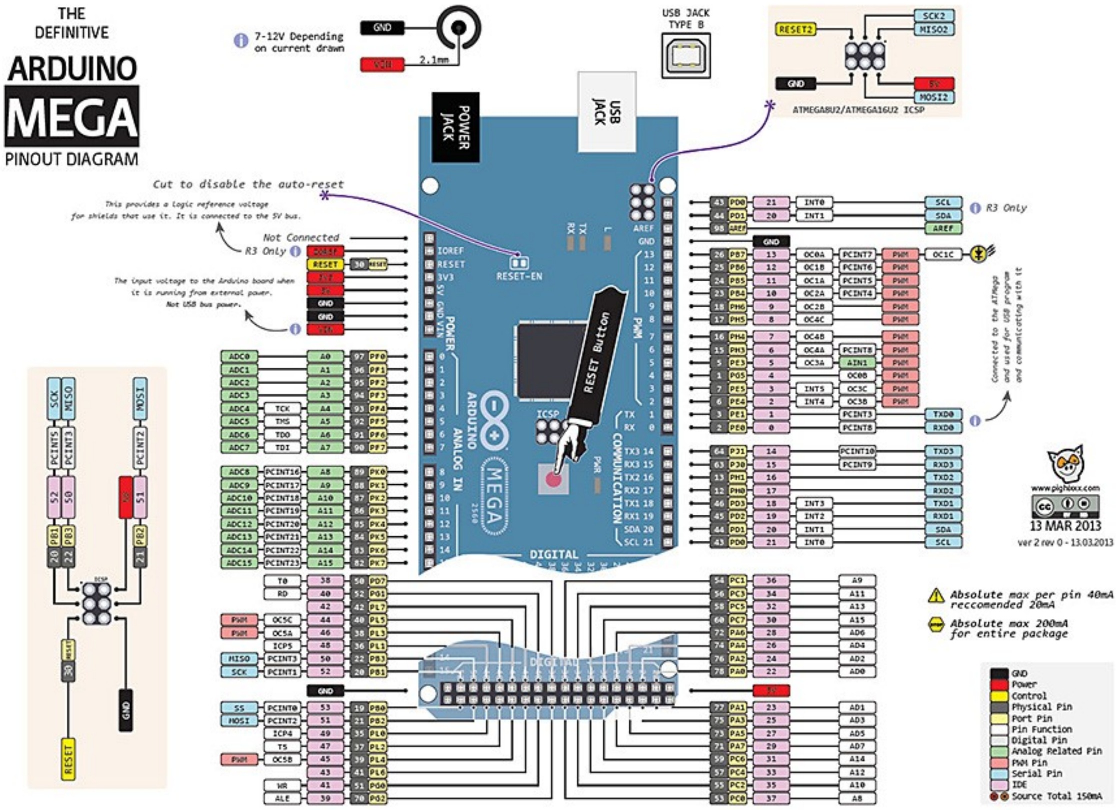

Figure 3.2: Pin diagram of MEGA 2560

3.1.2 Weight sensor

The weight sensor convert strain energy into electrical output. Four Load cell sensors interconnection to a 2560 microcontroller were used each of 40 Kg. The low amount of the electrical signal generated by the load cells need amplification. From Fig. 3.5, electrical circuit including HX711 load cell amplifier is provided.

3.1.3 Proximity sensor

An ultrasonic sensor HC-SRO4 uses sound waves to determine the distance of the object opposite to its sensing environment. The distance between its sensing element and the object is determined using the speed of sound.

$$d = c \times t \tag{3.1}$$

Where d is the distance between sensor and obstacle in meters, c is the velocity of Sound meter per second and t is the time of flight of sound energy in second.

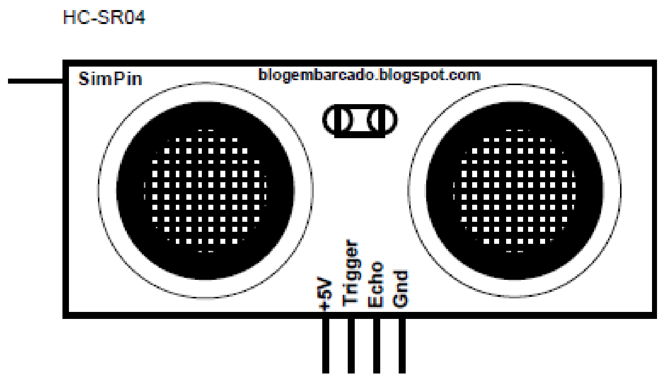

Figure 3.3: Ultrasonic sensor

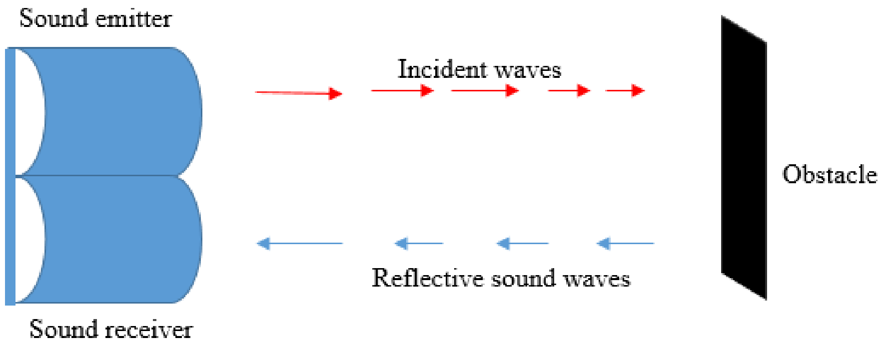

Figure 3.4: Working principles of ultrasonic distance measurement

In this project, ultrasonic technology is twice applied. Its arrangement near the object under study is based on its specifications. The operation current is 15 mA with a 0.3 cm resolution, and 40 KHz. Like other electronics used, it is supplied under 5V dc power supply. Ass seen from Fig. 3.3, the incident sound signal strikes on an obstacle in its medium and reflects. The reflecting echo is used to determine the distance by using the speed of sound and the time of flight taken by the sound signals.

In the system of Figure3, after the Tare and reset Switch is pressed (S0) from figure4, the Data command switch (S1) is pressed before taking any measurement. Thus the child under examination can stand on the system and either the height or weight can be gathered and displayed on the LCD as shown on the Fig. 3.22 - Fig. 3.25.

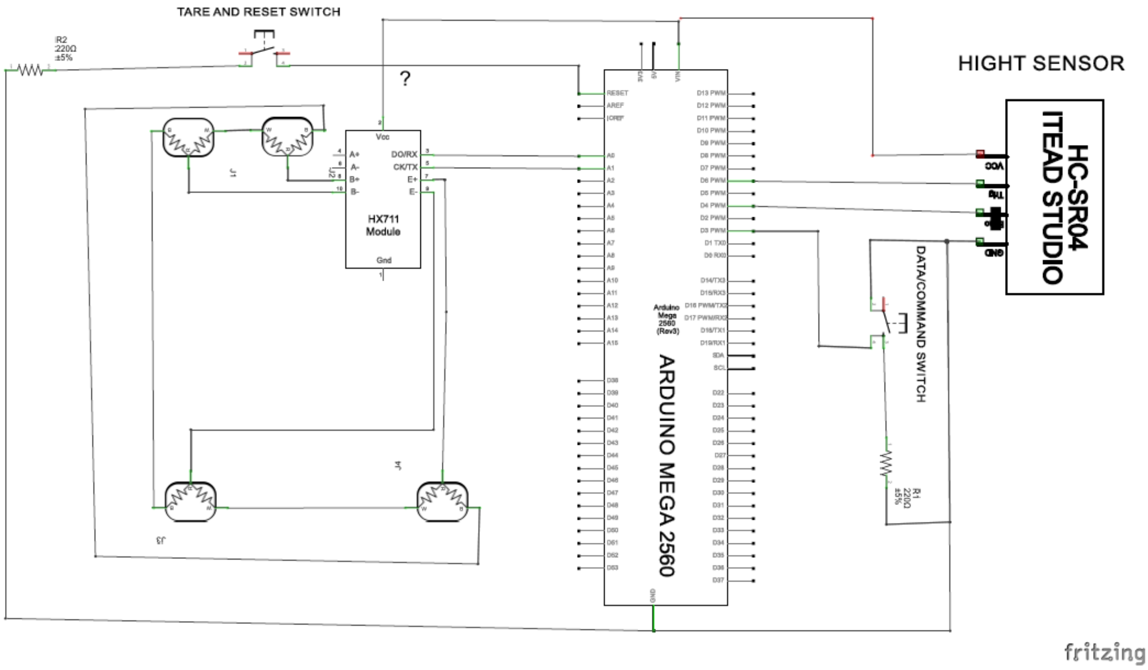

Figure 3.5: Height and weighting sub-systems

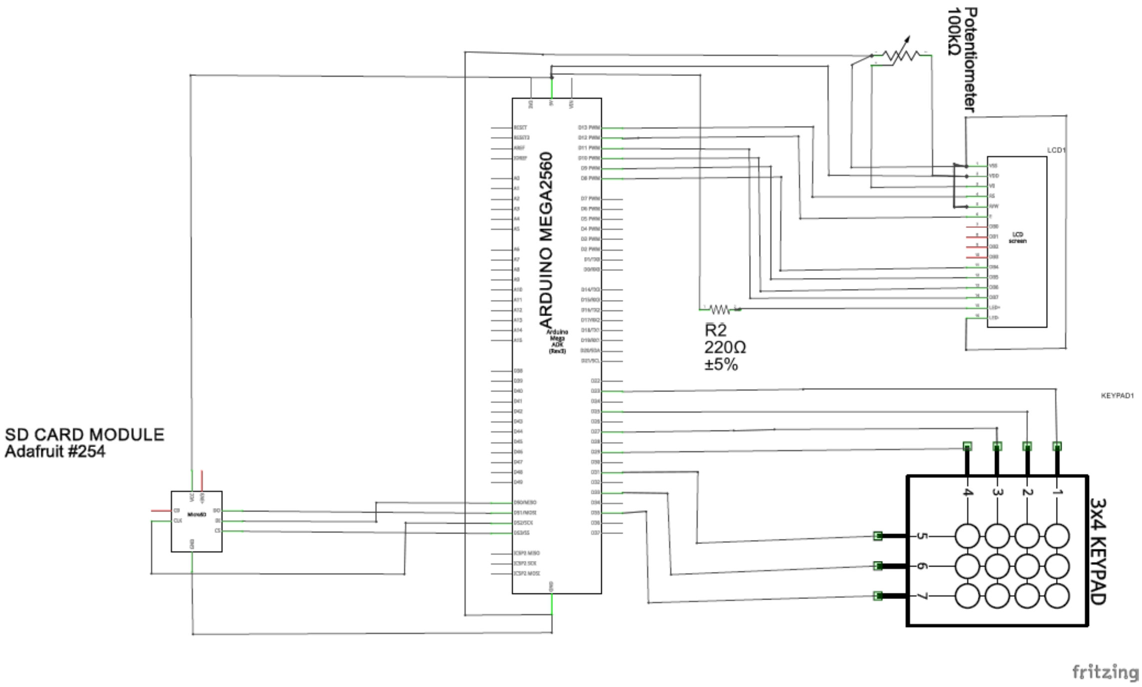

Figure 3.6: LCD, Keypad, SD card connection to Arduino MEGA 2560

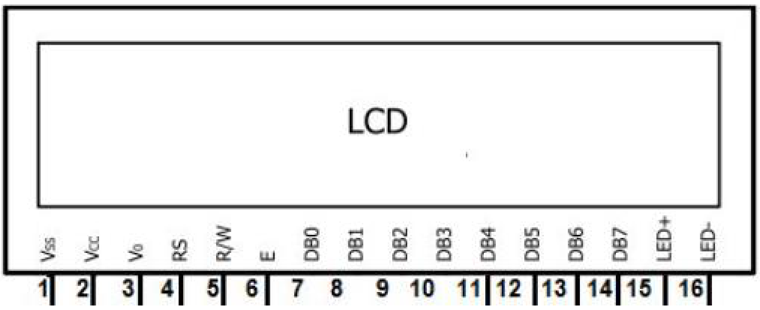

Figure 3.7: LCD display

3.1.4 Display

The Liquid Crystal displays numerical values with 20 characters in each of the rows with a yellow green color which can be deemed using a potentiometer for backlight brightness. It accepts the commands from any microcontroller embedded with. 16 pins Alpha Numerical Display interconnected with Arduino Mega 2560 through data pins DB0-DB7 and perform the Read/write operation.

3.1.5 Control commands and storage

The system is mainly functioning based on the microcontroller program. The push buttons switches are used to start and call the keypad for age, gender and Identification number of the child. Whenever the system is powered, it cannot provide any output without the user intervention through programmed switching arrangements. A Micro SD card adapter was provided based on the cost minimization of the project. The storage system contains a Micro SD Card that hold all measured weigh, height, BMI Arm circumference and the changing amplitude of the respiratory episodes. The SD card adapter is provided so that data can be transferred to a computer for later analysis.

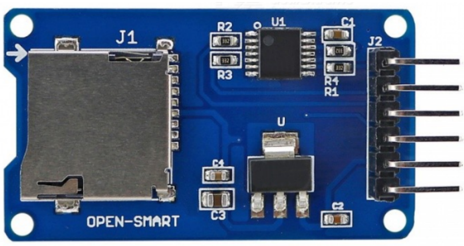

Figure 3.8: SD Card Reader

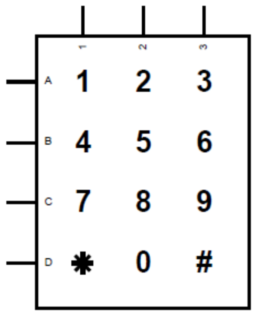

Figure 3.9: 3 by 4 Keypad

3.2 Apnea monitoring

This section contains a proximity sonic sensor that detect the occurrence of the apnea and display the status on the LCD. The breath pattern is saved to the SD card for future analysis. The respiratory events are saved in terms of the change in abdominal rise and fall as air is inhaled and exhaled.

3.3 Software section

The software section of the device provides a set of lines of codes written in Arduino Ide 1.8.3. The programmed board contains analog and digital input pins to govern connected hardware. The software encompasses the other 3 sub-sections. A control algorithm was provided for the system command. The process of the software for weight management is explained using results from figure3.22-25. The user is eligible to enter the age and sex of the child into the device after the weight and height are displayed on LCD. All measurement parameters are stored on the memory card. For the measurement of each parameter, a set of devices were provided to play that particular role. As shown in the figure3.25, the user must enter the child information using provided keyboard. The three switch S0, S1 and S2 are used for system calibration, parameter selection and weight for age. When the Arm circumference is required, the user must call it using S1. The system will be measuring the Arm circumference by pulling out the tape measure and same process of data saving directly follows.

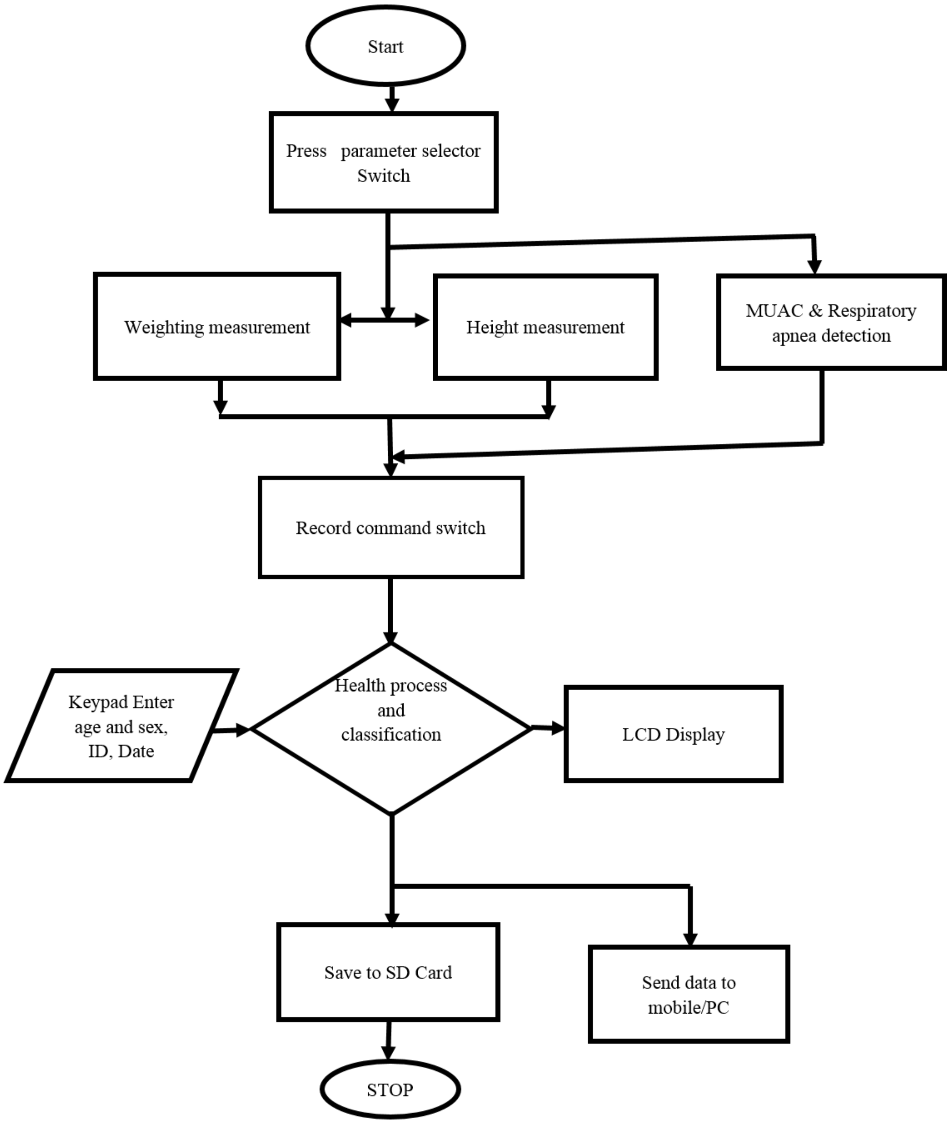

Figure 3.10: Flowchart

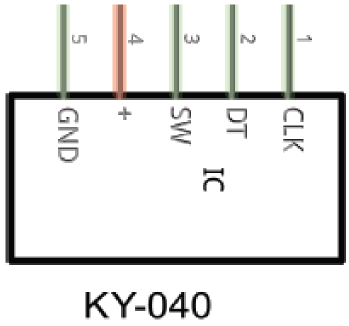

Figure 3.11: Rotary incremental encoder

3.4 Design of the Arm circumference measurement

Electronic digital measuring devices have been early developed to determine the spacing between two objects. The design courtesy was based on inspiration by the existing measuring tape and encoder technology. In 1982, a digital tape meter was developed by (Sanoner 2005, Washizuka & Tateishi 1982). The tape produces digital read out by determining the space between the magnetic and non-magnetic balls marked on the tape when it is pulled out. Same digital devices was developed in 2005 by (Sanoner 2005), where the digital measurement was produced by a rotating drum that communicates with an optical sensing device that interacts with the electronics to calculate the length of the line that was drawn from the system enclosure. The analysis from these design inspired to use the encoder to design an arm circumference measuring device for malnourished children in developing population. An encoder is an electronic devices that converts one form of information into another. By using engineering to meet the design requirements and satisfy people needs in the health medium, the rotary incremental encoder was chosen for our specifications.

3.4.1 Encoder selection

The arm circumference measurement designed in this work is to be calculated using an encoder and Arduino MEGA 2560 microcontroller. By the shaft movement, the generated pulses are feed to the controller which perform the distance calculation.

On the rotating shaft is attached a wheel that is mechanically attached to the flexible tailoring tape. By pooling out and turning the tailoring tape on the arm, the

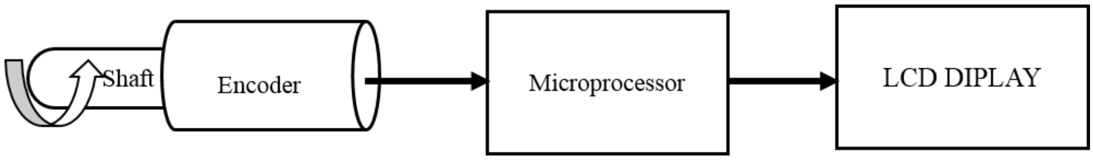

Figure 3.12: Rotary encoder operation

encoder generates pulses and feeds them to microcontroller which uses c codes and calculates the arm circumference at the same time displaying to the LCD. The rotary encoder are used in linear distance measurement based on the following parameters and formula:

- The tape measure wheel diameter: 2.5 cm
- Encoder wheel diameter: 2.5 cm
- Encoder specifications: 20 Pulses per revolution, with 0.5 cm of diameter
- Encoder wheel Circumference $(d) = 3.14 \times 2\ cm = 7.85$ cm
- System resolution: 1 mm

The resolution determines the accuracy of the measurement depends on the diameter of the wheel holding he encoder must be small.

$$pulses\ per\ revolution\ = \frac{d}{resolution} \tag{3.2}$$

Thus our design yields 78 pulses per revolution. Using the principle of linear distance measurement, the circumference is determined with same principle.

3.4.2 DC gear Motor

From Fig. 3.12, the arm circumference measuring subsystem includes a combination of an incremental rotary encoder and a wheel attached to the encoder shaft to hold the wheel turning in accordance with the tape being pulled out. To reduce the task by the user, the tape wheels shaft is connected to the DC gear motor through a gearbox that allows the user to run the motor while pulling in or out the tape. The diameter

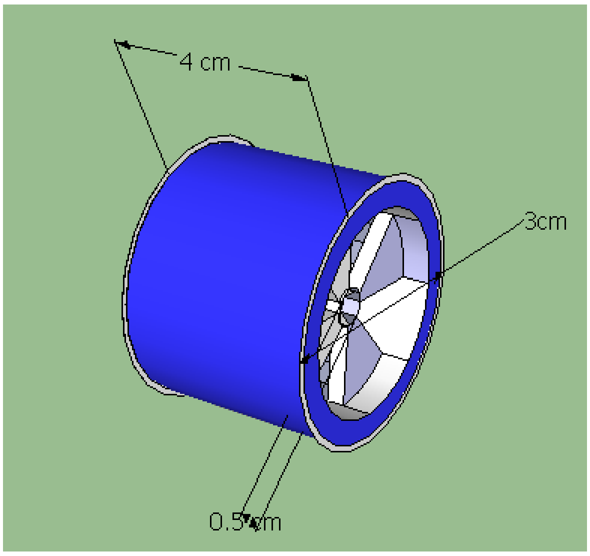

Figure 3.13: Tape wheel

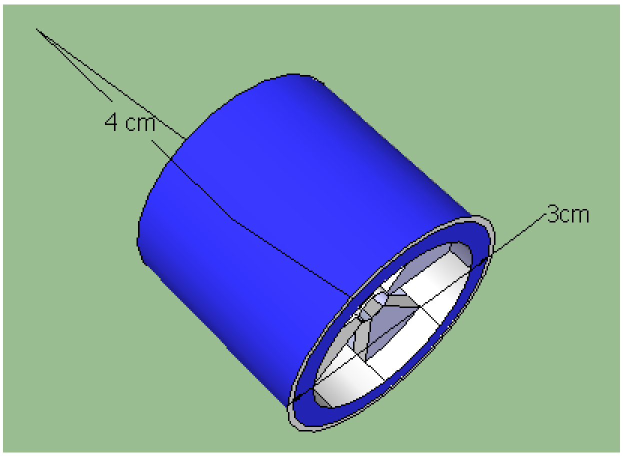

Figure 3.14: Encoder wheel

of the encoder supports the encoder wheel weight with a rotation proportional to the shaft movement caused by the tape extension. For this prototype, the encoder shaft and wheel diameters are 0.5 cm and 3 cm respectively and the wheel width is 4cm.

The tape extension movement can be provided by both manual and motor action. To avoid any damage of the patient under measurement, the user is eligible to manually pull out the tape and activates the motor when pulling back the tape measure. The motor selection was based on the low revolution per min. In this system, a 5V, 60 rpm gear motor is used to pool back the tape meter. By using a gear box, the motor is easily removed from the system and a manual operation is guaranteed Figures 3.10 and 3.11. The desired system must have a light weight, thus the motor weights 45 g. To reduce the weight of the system, plastic materials can be

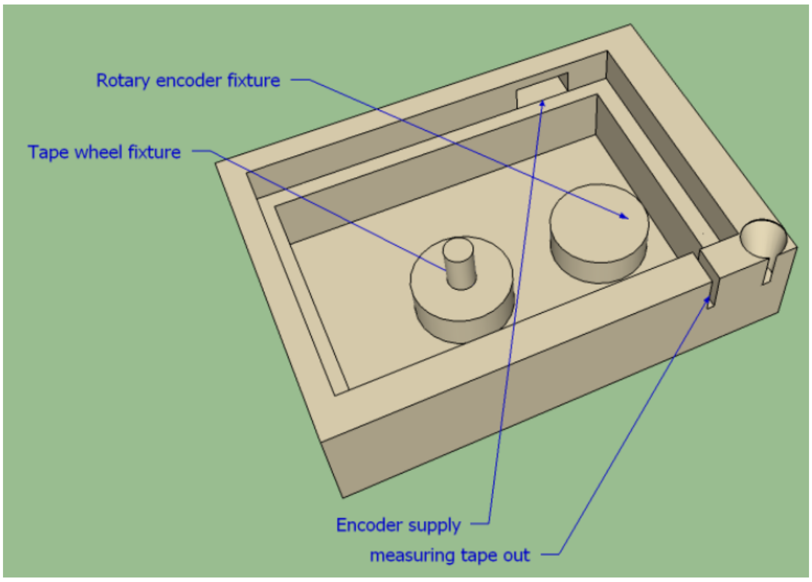

Figure 3.15: Desired mechanical support

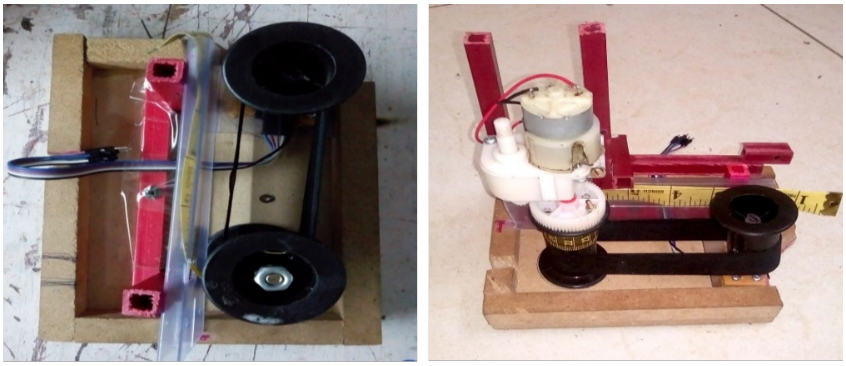

Figure 3.16: a) Arm circumference without motor b) Arm circumference measuring with motor

used and small motor meeting the system operation with maximum comfort of the patient.

3.4.3 Arm circumference hardware support

The encoder, tape holder and encoder wheel, the motor should be in a single system. In our design, we wished to use plastic material, we used a timber due to mechanical fixture.

Figure 3.17: Arm circumference measurement

3.5 Design of Respiratory apnea detection

One of the most diagnosed disease in NICU is premature apnea (Sanoner 2005). Home based health monitoring has considerable impact and improved health management. In 1986, American Academy of pediatrics has shown sudden infant death due to non-controlled children health (Meert et al. 2016, Min et al. 2010*b*). Electronic design has shown cost reduction of apnea home monitoring system and accurate detection. The medical slogan apnea stands for the cessation of the breathing activity mostly while sleeping. Inspired by the problem behind the prediction of apneic events, this invention reflects a method to monitor the respiratory activity by examine at regular interval time. In recent years infants deaths due to apneic problem has shown an issue to overcome. Despite the research works carried early, they have strongly focused on the use of alarm and body electrode that harm the normal breath of people. Das (2013) developed a low cost respiratory rate meter using Infra-red and ball movement in a glass tube. That inspiration made this research to be conducted by a concise focus on non-contact sensors technology that can detect the change in the apnea events and provides the respiration rate accordingly. The concept behind the method uses a sonar sensor to continuously store the change in amplitude of the breath cycles. All measurement are real time saved to an SD card. To analyze the breathing pattern, an algorithm is provided where a change in amplitude of a sample of the stored data at regular interval time followed by comparing it to a threshold possible change as respiration is under normal conditions.

3.5.1 Methodology

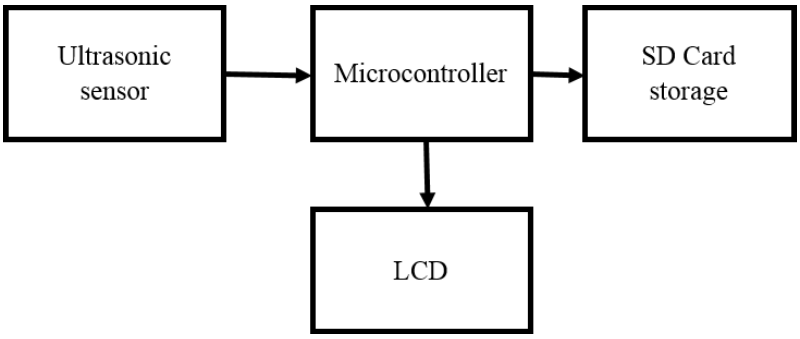

Figure 3.18: Respiration events detection diagram

The sonar HC-S04 detects the abdominal wall movement and determine the change in the amplitude due to respiratory patterns. The measured amplitude is saved on the SD card for future examination without interrupting the patient sleep. The LCD is at the same time displaying the breaths per minute and apnea if any. To examine the existence of the apnea in the recorded signal, the data can be examined by a sampling algorithm at regular intervals. Fig. 3.19 shows the flowchart under which apnea is detected.

3.6 Power supply

User of medical devices must not worry about effect of unexpected electricity hazardous that can negatively impact either the user or the individual under treatment. Thus the project power requirements was considered. The Fig. 3.18 represent the proposed power to feed the designed embedded system. Fig. 3.20 shows the power supply of system.

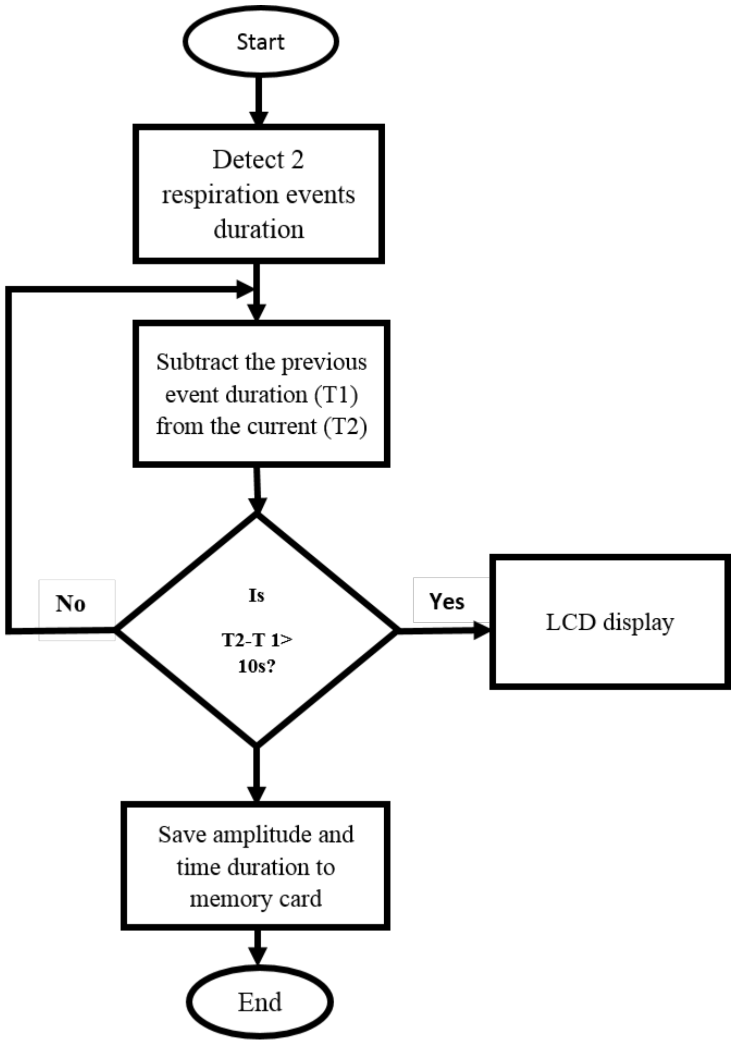

Figure 3.19: Apnea detection Algorithm

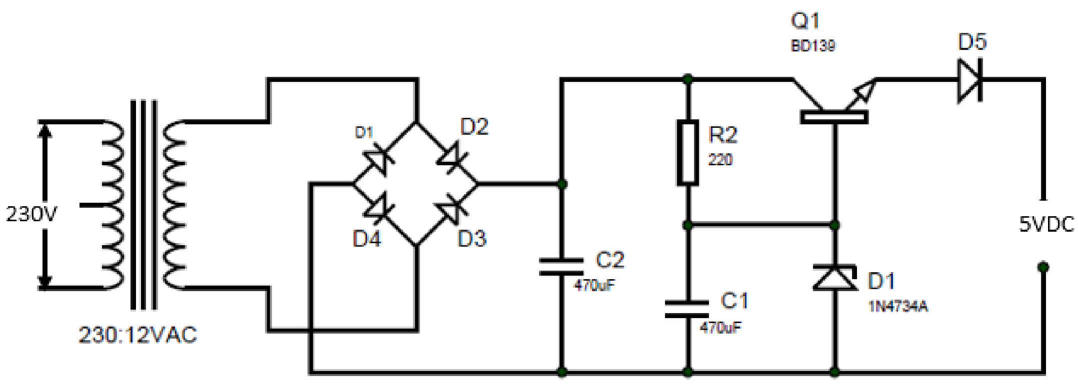

Figure 3.20: Power supply

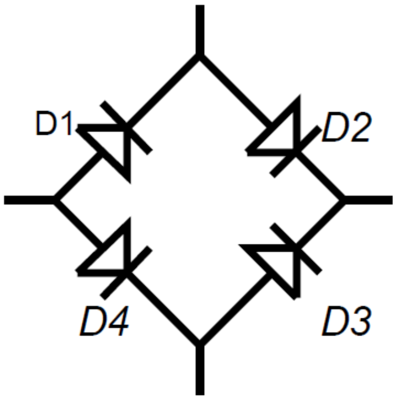

Figure 3.21: Full wave bridge rectifier

3.6.1 Parts description

Transformer

In this design, most of used electronics are 5 V rated. In order protect all devices, a 230: 12V 500 mA transformer is used to step down the 230 V alternative voltage.to allow people to used available energy source. The available ac voltage and current after step-down transformed must undergo filtering transformation to avoid any damage that can come to electronics in the embedded system.

Full wave diode rectifier

220-230V is worldwide standard alternative voltage used in communities and cannot be directly supply electronic devices. In order to limit the damage to electronic components, the secondary voltage of the transformer is feed to a full wave bridge rectifier using IN4001 diodes with 0.7V drop. Fig. 3.21 shows ac to dc conversion.

DC-DC converter

As the name suggests, the DC converter is used to modify the magnitude of the voltage from one level to another. Thus the DC-DC converter is provided to step down 10.6 VDC from the output of the full wave bridge rectifier circuit to 5 v output.

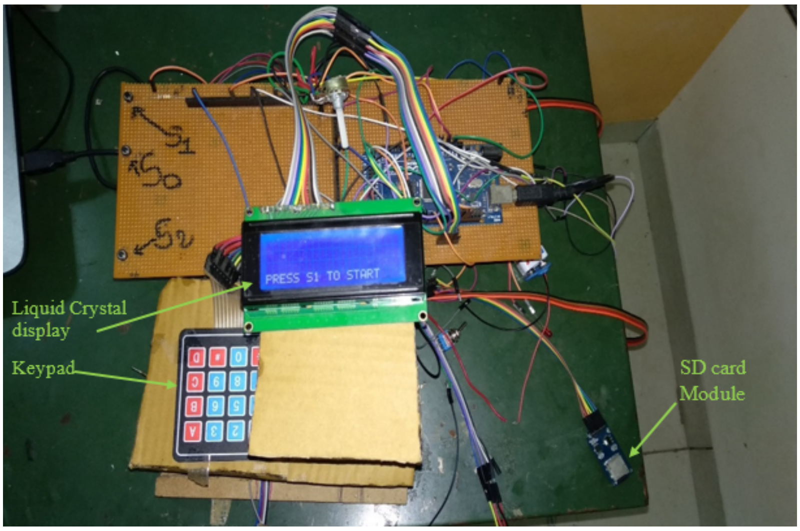

Figure 3.22: System display after it starts

Voltage stabilizer

The output of the rectified voltage is first ripple filtered by the capacitor C2 (470u) and stabilized by IN4734A Zener diode. The Zener diode contains a cut-off voltage at which the devices connected at its output terminals cannot exceed in consumption. In this design, the Zener diode used is rated at 5.6 V, 45 mA. Alternatively, voltage regulator like LM 7805/6Ncan perform same function.

3.7 Implementation of the system prototype

The designed prototype is made of 3 subsystems, the weight status classification based on Body Mass Index, the Malnutrition screening based on Middle Upper arm circumference and Indirect Respiratory apnea monitoring. Each of them is independently operated and the data is saved in the desired location on the micro SD card.After taking the measurement of height and weight, the keypad is pressed to command the microcontroller to calculate the BMI per age per sex, weight for height, weight for age. The measured data are directly stored to SD card through user command.

The device is capable of outputting the other parameters like the weight for height, the weight for age. By pressing the Switch S2, the weight for age will be displayed through 20*4 LCD. The process applies for female also. After anthropometric data

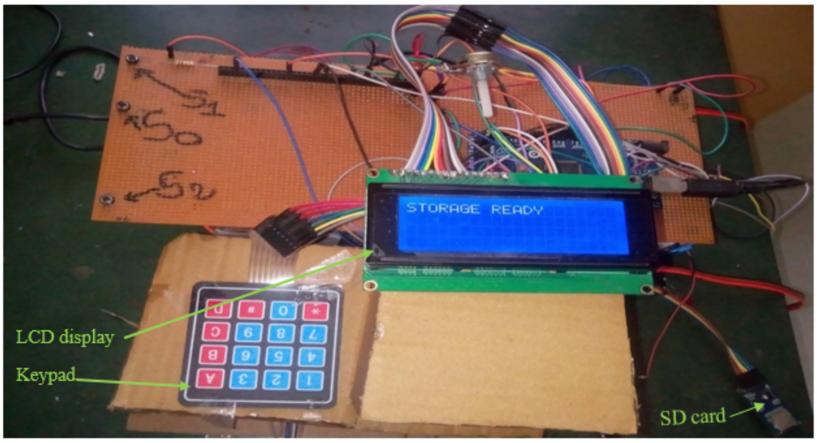

Figure 3.23: Storage indication after start switch command is given

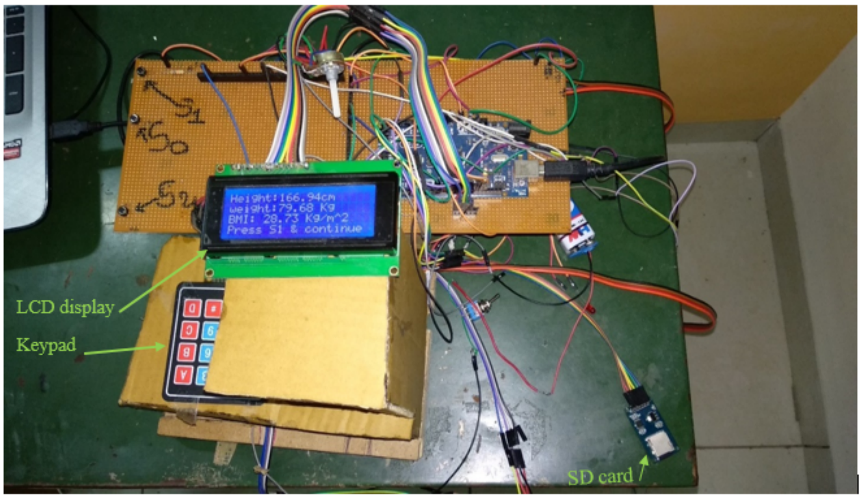

Figure 3.24: Anthropometric data collection

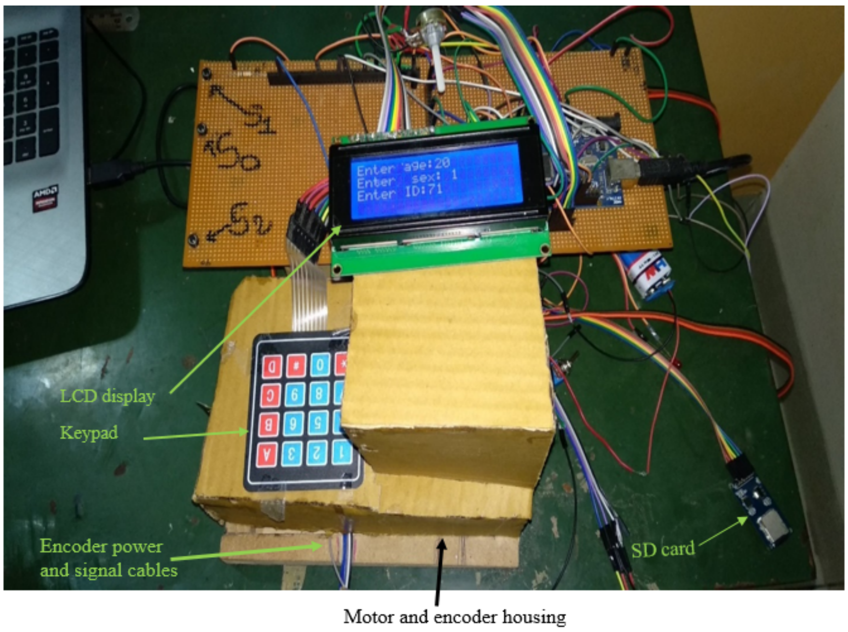

Figure 3.25: Child identification entered before decision making

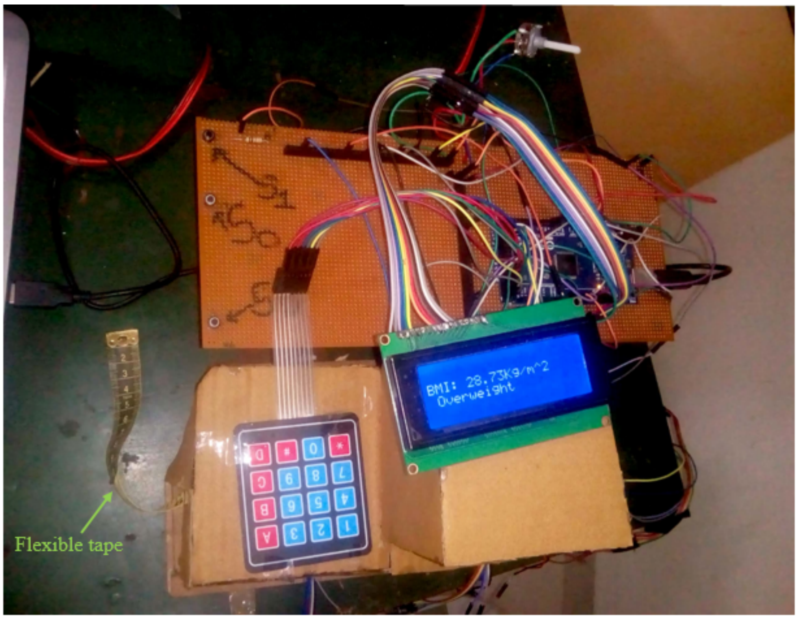

Figure 3.26: Weight classification after age and gender

are collected, age and sex are required for weight classification. Fig. 2.4 and Fig. 2.5 represent the standard weight classification based on BMI.

Chapter 4

Results and discussion

The objective of the study was to design a system that can collect health data from the children and save them for future use. The system prototype was implemented and the measurements were taken from five male at different ages. 2 people were above the age range and three remaining people were 20, 18 and 19 years. The test was done for 2 different days. The data storage was implemented by use of an 8 GB Micro SD card. The device offers the possibility to measure the physiological parameters: temperature, the respiration rate and measure Body Mass Index in function of weight and height.

4.1 Results

The results from the arm circumference measured on the wrist, the weight, height and BMI and the change in amplitude changes for 3 minutes test on the abdominal wall movement.

4.1.1 Arm circumference measurement results by Digital tape

The figure 4.3 illustrates the arrangement of the collected data that was pasted from the memory card. The results presented include the weight status control using the Body Mass Index, the Arm circumference, the respiratory events change and the memory Card after data are saved. Tables 4.1 and 4.2 illustrate the arm circumference

Table 4.1: Test results Middle upper arm circumference

Person	Real Arm circumference					Measurement by the prototype				
1	18.3	19.3	18.6	18.3	18.1	18.09	17.9	17.5	17.76	17.67
2	17.8	17.6	17.8	17.8	17.8	16.8	16.4	17.0	17.05	17.67
3	17.0	17.0	16.5	17.1	16.9	17.28	18.42	17.3	17.50	17.14
4	17.5	17.0	17.2	17.9	17.1	18.3	18.50	18.2	18.8	17.67
5	17.2	17.8	17.6	17.4	17.3	17.63	18.4	18.18	18.32	17.95

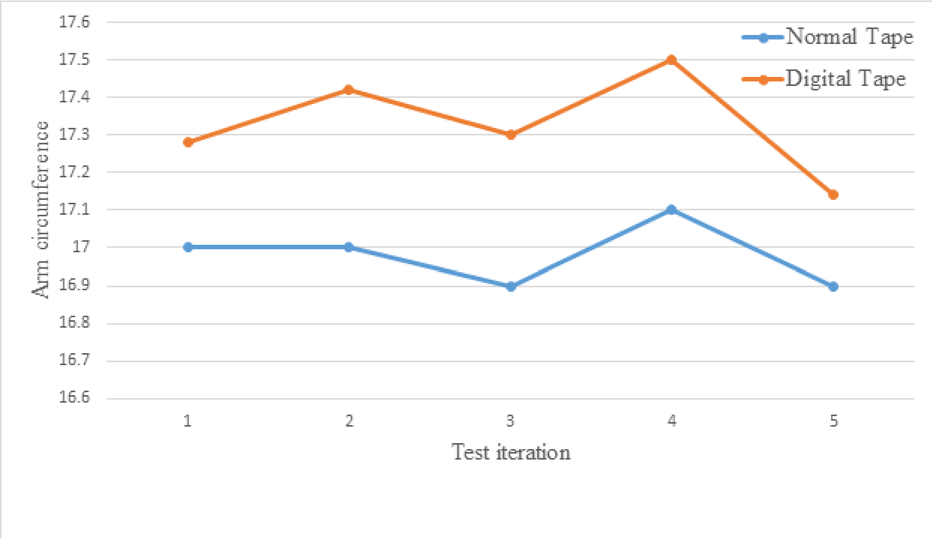

Figure 4.1: linearity test for person 3

and the BMI data measured from different individuals. The Arm Circumference was measured from the wrist due to the length of the tape used in the prototype. Each person was measured 5 times at a single position of the wrist to test the linearity. To validate the system operation, the standard deviation of the measurement taken by digital arm circumference measuring computed. From Table 4.1, the standard deviations are respectively 0.29, 0.40, 0.36, 0.37 and 0.30 and were calculated as:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(X_i - X_m)^2}{n}} \tag{4.1}$$

Where i= sample measurement n= number of measurement taken for each person and is 5 X_i=measured value and X_m= Average of the sample value. From Fig. 4.1 and Fig. 4.2, the tape measure and the digital tape output can show different measurement caused by unexpected movement or the miss contact of the shaft from the tape wheel. The remedy of it is to use non stretchable material to perform shaft role.

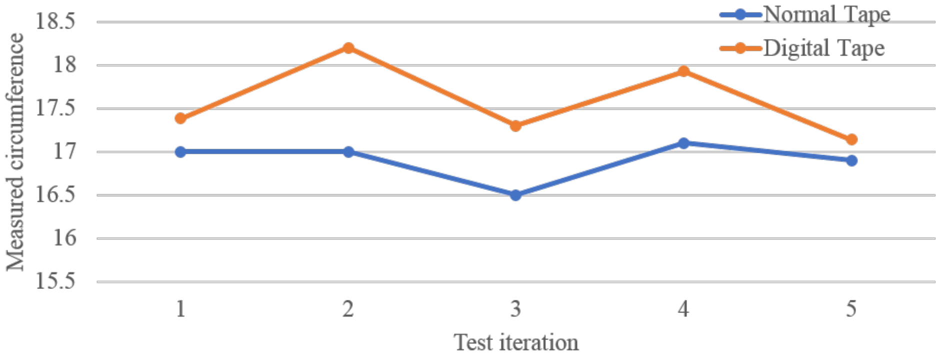

Figure 4.2: Linearity test for person 4

4.1.2 Weight classification results

Table 4.2: Weight status using BMI standards

S/N	**Test individual**	**Age (Years)**	**Sex (1 for Male and 0 for female)**	**Weight (Kg)**	**Height (cm)**	**BMI**	**Decision**
1	Person 1	27	1	72.2	173	24.12	Exceed age range
2	Person 2	21	1	77.75	177.22	24.7	Exceed age range
3	Person 3	20	1	79.68	166.94	28.73	Overweight
4	Person 4	20	1	54	159.09	21.34	Health weight
5	Person 5	19	1	78	178.93	24	Health weight

Presented results from Table 4.2 illustrate the weight, the height and Body Mass Index measured from 5 different individuals. Person 1 and 2 were above the Center for Disease Control and Prevention (CDC), BMI classification standard shown on Fig. 2.4 and Fig. 2.5.The results presented are based also on the output of the prototype decision after the age and gender were commanded by the keyboard and switches arrangements.

4.1.3 Storage

After the user provides the preliminary data and pressed provided switches, the system provides option to measure any data of choice. From figure 28, the Arm Circumference has not been measured for the first individual and was measured for

Date of Meas: 2
Month: 4
Year: 2018
ID: 1233
Age : 20
Gender : 1
Temp : 46.92 C Height: 159.09Cm weight: 54.00 Kg BMI: 21.35 Kg/m^2 ARMC: 20 cm
Date of Meas: 2
Month: 4
Year: 2018
ID: 369
Age : 19
Gender: 1
Temp :45.94 C Height: 178.93m weight: 78 0.00Kg BMI: 24.00Kg/m^2 ARMC : 0cm

Figure 4.3: Results from SD Card after measurements

the second. The system offers the selectivity to measure desired parameter and every measured parameter is saved on the provided SD Card.

4.1.4 Indirect Respiratory cessation detection

From Fig. 4.3, the change in respiratory events is not shown, since successive data for 2 minutes were recorded and cannot fit on a single paper, the Figure4-4 shows the change in distance detected by the ultrasonic sensor while the abdominal wall movement happens due to respiration. The voluntary cessation of the breath is shown by a constant amplitude while the rest shows the changing breath patterns.

Table 4.3 represents the change in amplitude between the sensor position and the body abdominal wall. The sensor was positioned at 10 cm from the abdominal and the test was don for 63 seconds. The cessation in breath is known as apnea. The change in breath reduces the distance between the two body and the sensor.

As shown from Fig. 4.4, the distance between the sensor and the test individual is 10 cm, and the breath was taken for 63 seconds as the breath is taken, the distance changes. From 1^{st} second to 6^{th}, it is clear that no change in amplitude as no breath was taken. From 49^{th} to 63^{th} second, the breath was broken.

Table 4.3: Distance change with breath activity

Time (s)	**Amplitude (Cm)**
1	9.93
6	9.93
7	9.74
8	9.49
9	9.54
10	9.52
11	9.83
12	9.54
13	9.5
14	9.49
18	9.83
19	9.54
26	9.62
27	9.54
31	9.85
32	9.83
33	9.52
37	9.59
38	9.49
39	9.79
44	9.38
47	9.72
49	9.38
63	9.38

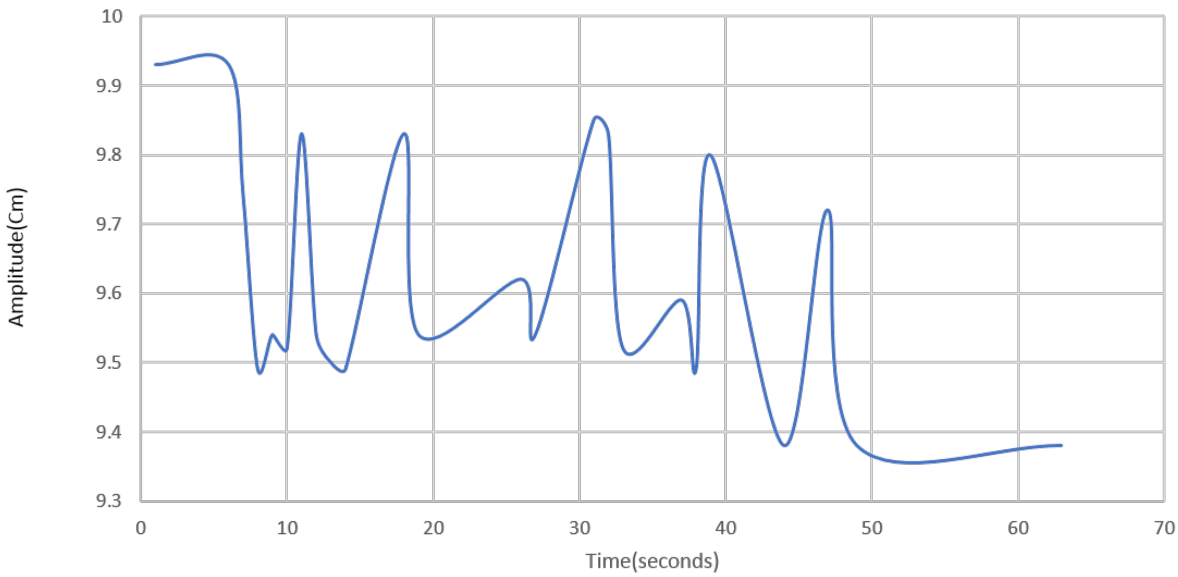

Figure 4.4: Breath Cessation detection from data saved on memory card

4.2 Discussions

The results from the research prototype implementation show that the system can be used for child growth and health monitoring. From the findings of the questionnaire in appendix B, the problem of weight management in low incomes families will be solved by the system. Results from Fig. 4.1 and Fig. 4.2 shows the measurement taken from 2 individuals. Everyone was measure 5 times to check the inside operation of the arm circumference measurement sub-system by looking the readings from the tape measure and from the display. It is now clear that the extension of the tape measure can miss turn the shaft connection the tape holder and the encoder due to the amount of tension used by the individual pulling out the tape. For then, the use of the gear motor has solved the problem. It is the wish of the user to insert or remove the motor from the circuit controlling the extension of the tape. The gear motor is attributed with a control mechanism through corresponding gearbox.

4.3 Limitations

The designed arm circumference occupies a big space due to complex interconnection of electro-mechanical control of the motor movement.

- The system design includes the 4 parameters to be measured. It is possible to incorporate more options to continue follow up the well being of children and the population in general.
- During arm circumference measurement, the tape meter tends to move the encoder and causes some undesired measurement and can lead to wrong measurement.
- The encoder do not have precise position, that make the system to turn back the tape measure and start new measurement from zero reading on the display.
- Due involuntary movement during sleep, an array of sensors with high frequency to capture sleep events with low amplitude should be integrated in the system.

Chapter 5

Conclusion and future plan

5.1 Conclusion

In this research project work, a growth and health monitoring support system was designed. The findings from rural low incomes families in addition to developed communities suffer from weight and related health complication. As biomedical researchers, we have contributed through the following works:

- Design and implementation of a child based digital weight classification system using Body Mass Index with age and gender reference BMI chart for children from 2 to 20 years

- Incorporation of a data storage system for the child and kids under examination to help the family to treat their kids and the public health for health policy planning

- Interface of the sleep apnea monitoring. This subsystem will provide the parent the detection of the break in sleep with maximum comfort of the children and guardians.

The validation of the system was tested by measuring five male and the results were correctly classified. The results have shown that the system is feasible and affordable to growth monitoring.

5.2 Future work

In this work, a community based health monitoring framework was designed. Additional physiological parameters can be added to satisfy the need in people daily health management. The current used growth monitoring devices do not consider the change in physiological parameters as infants and neonates are growing, continuous assessment of multiple health parameters are to be incorporated in the system design. The development of the child health exchange system among healthcare settings will help frequent measurement of health parameters for health management and diseases prevention decision. Mobile based child health copy will support parents to restore data when the storage is damaged. The children care givers and guardians can carry the recorded data in clinical setting to serve as reference before drug administration. By making home based child health information system available in local communities, easy access to healthcare providers will help to cure diseases and deaths related to malnutrition, physiological parameters defects and the risk of asthma. The public health policy makers shall benefit from the system and plan for the whole population.

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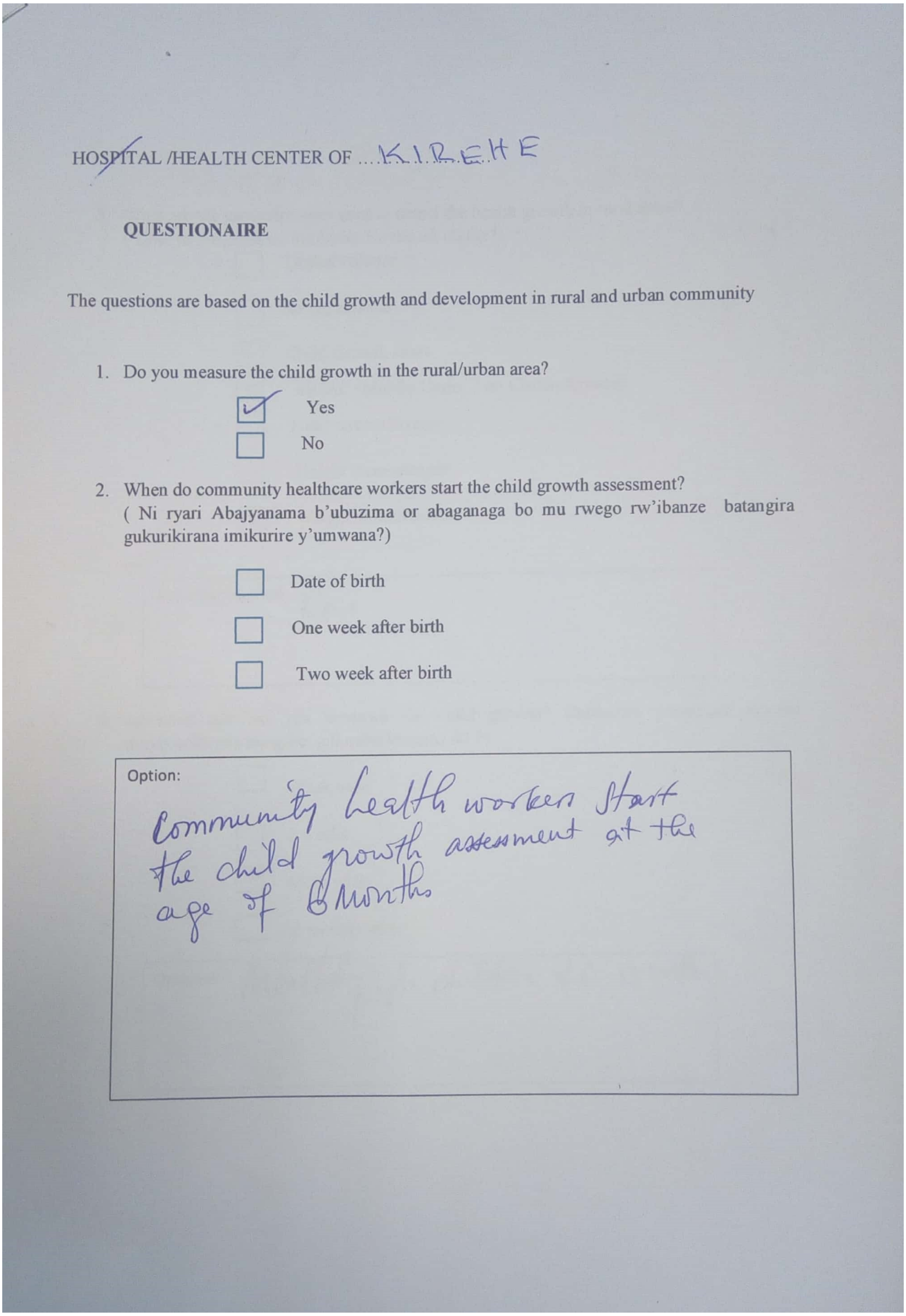
Appendix A

Questionnaire and feedback from health workers



HOSPITAL /HEALTH CENTER OF ....KIREHE

QUESTIONAIRE

The questions are based on the child growth and development in rural and urban community

1. Do you measure the child growth in the rural/urban area?

   - [x] Yes
   - [ ] No

2. When do community healthcare workers start the child growth assessment?
   (Ni ryari Abajyanama b'ubuzima or abaganaga bo mu rwego rw'ibanze batangira gukurikirana imikurire y'umwana?)

   - [ ] Date of birth
   - [ ] One week after birth
   - [ ] Two week after birth

Option:
Community health workers start the child growth assessment at the age of 6 months

3. What are the methodologies used to detect the health growth in rural areas? (Uburyo bukoreshwa mu byaro bwaba ari ubuhe?)
   - [ ] Digital balance
   - [ ] Spring balance
   - [x] Child Growth chart
   - [x] MUAC (Middle Upper Arm Circumference)
   - [ ] Head circumference
   - [ ] Height measurement
   - [x] Weight measurement

Any other method: None

4. At what rate do you measure the child growth? (Imikurire y'imwana mwaba muyikurikirana mu gihe gihoraho kingana iki ?)
   - [ ] Week wise
   - [ ] 2 weeks
   - [x] Moth wise
   - [ ] 2 months wise

Optional: Monthly. for children of 6-59 moths

5. What do community healthcare providers help to regularly check -up the child growth? (Ni iki banjyanama b'ubuzima babafsha mu rwego rwo kumenya imikurire myiza y'abana muri societe)

They do monthly growth monitoring and screening of acute malnutrition by using MUAC at the village level,

6. What are the challenges they face? (Ni izihe mbogamizi baba bahura na zo?)
   - [x] Lack of tools
   - [ ] Lack of skills on available tools
   - [ ] Both of the above options

Any other challenges: None

7. What do you expect to do to eradicate those challenges? (Ni iki muteganya mu izihe ngamba muteganya mu rwego rwo kurandura izo mbogamizi?)

To accomodate all required materials and tools

8. What are the considerations do you focus on to check the child growth and development in Rwanda community? (Ni ibiki mugenderaho ngo mumenye ko umwana akura neza) ?
   a. Age dependent factors :
      - [x] Weight
      - [x] Height
      - [ ] Head circumference
      - [ ] Chest circumference

11. How does the child get affected by inaccurate growth control? (Ni izihe ngaruka abana baba bahura na zo zituruka ku kutagenzurwa neza kw'iikurire yabo?)

- [x] Delay in intelligence
- [ ] Lack of social relation /adaptation
- [x] Slow Mental development
- [ ] Miss a lucky of child's physical career

12. How do you treat irregularly growing children in primary healthcare (especially rural community? (Mukorera iki umwana udakura neza mu rwego rw'ubuvuzi bw'ibanze?)

We give them supplementary feeding (like food support and micronutrient).

13. What can you think new technology would help to accurately evaluate the child growth and development your areas? (Ni iki iterambere ryabafasha mu kumenya neza uko umwana akura bikwiriye?)

Technology can facilitate communication and adequate Information.

14. As a healthcare provider,What do you suggest Biomedical Developers to help developing Community primary healthcare especially in Rwanda? (Ni iki abashakashatsi mu buzima bafasha communaute?)

Can help to set new indicators and target in order to develop our community

b. Age non - dependent factors (Ibitagaragazwa cg bidaterwa n'imyaka)

- [x] Mid arm circumference
- [x] Weight to height
- [ ] Skin fold thickness
- [ ] Mid upper arm/height ratio

9. Do you have any specific equipment to measure the child growth ? (Hari ibikoresho byihariye mwaba mukoresha mu kugenzura inikurire y'umwana?)

- [ ] Yes
- [x] No

10. What are the standards used? (Ni ibihe bigereranyo mwaba mukoresha ku rwego mpuzamahanga?)

Z-Score

11. What are your findings / causes of poor child growth and developments? (Mukeka ko impamvu zaba zituma umwana adakura neza ari izihe)

- [x] Poor nutrition (Kutabona indyo ihagije)
- [ ] Irregular feeding (Gufata amafunguro nabi)
- [ ] Genetic factors: parents information, race, sex, genetic disorders, phenotype Bio rhythm and maturation
- [ ] Climate: pre nature environment
- [ ] Colonic disease
- [ ] Intrauterine
- [x] Socio-economical condition

Answered by: GASANA Michel

Service Community health

On 5 /9 /2017

HEALTH CENTER OF RWAZA

QUESTIONAIRE

The questions are based on the child growth and development in rural and urban community

1. Do you measure the child growth in the rural/urban area?

   ☑ Yes

   ☐ No

2. When do community healthcare workers start the child growth assessment?
   (Ni ryari Abajyanama b'ubuzima or abaganaga bo mu rwego rw'ibanze batangira gukurikirana imikurire y'umwana?)

   ☐ One week after birth

   ☐ Two week after birth

Option:
2 months after birth

3. What are the methodologies used to detect the health growth in rural areas? (Uburyo bukoreshwa mu byaro bwaba ari ubuhe?)

- [ ] Digital balance
- [ ] Spring balance
- [ ] Child Growth chart
- [x] MUAC (Middle Upper Arm Circumference)
- [ ] Head circumference
- [ ] Height measurement
- [x] Weight measurement

Any other method:

4. At what rate do you measure the child growth? (Imikurire y'imwana mwaba muyikurikirana mu gihe gihoraho kingana iki ?)

- [ ] Week wise
- [ ] 2 weeks
- [x] Moth wise
- [ ] 2 months wise

Optional: months wise

5. What do community healthcare providers help to regularly check -up the child growth? (Ni iki banjyanama b'ubuzima babafsha mu rwego rwo kumenya imikurire myiza y'abana muri societe)

Gupima abana ibiro mu gihe gihoraho

6. What are the challenges they face? (Ni izihe mbogamizi baba bahura na zo?)

- [x] Lack of tools
- [ ] Lack of skills on available tools
- [ ] Both of the above options

Any other challenges:
Kubura aho bapimira abana (nta nyubako)
Imvura iyo yaguye gahunda zirahagarara.

7. What do you expect to do to eradicate those challenges? (Ni iki muteganya mu izihe ngamba muteganya mu rwego rwo kurandura izo mbogamizi?)

- Gushaka ibikoresho bipima uburebure
- Gushaka inyubako yo gupimira mo abana.

8. What are the considerations do you focus on to check the child growth and development in Rwanda community? (Ni ibiki mugenderaho ngo mumenye ko umwana akura neza) ?
   a. Age dependent factors :
      - [x] Weight
      - [ ] Height
      - [ ] Head circumference
      - [ ] Chest circumference

b. Age non - dependent factors (Ibitagaragazwa cg bidaterwa n'imyaka)

- [x] Mid arm circumference
- [ ] Weight to height
- [ ] Skin fold thickness
- [ ] Mid upper arm/height ratio

9. Do you have any specific equipment to measure the child growth ? (Hari ibikoresho byihariye mwaba mukoresha mu kugenzura inikurire y'umwana?)

- [ ] Yes
- [x] No

10. What are the standards used? (Ni ibihe bigereranyo mwaba mukoresha ku rwego mpuzamahanga?)

Ntabyo

11. What are your findings / causes of poor child growth and developments? (Mukeka ko impamvu zaba zituma umwana adakura neza ari izihe)

- [x] Poor nutrition (Kutabona indyo ihagije)
- [x] Irregular feeding (Gufata amafunguro nabi)
- [ ] Genetic factors: parents information, race, sex, genetic disorders, phenotype Bio rhythm and maturation
- [ ] Climate: pre nature environment
- [x] Colonic disease
- [ ] Intrauterine
- [x] Socio-economical condition

11. How does the child get affected by inaccurate growth control? (Ni izihe ngaruka abana baba bahura na zo zituruka ku kutagenzurwa neza kw'iikurire yabo?)

- [x] Delay in intelligence
- [x] Lack of social relation /adaptation
- [x] Slow Mental development
- [x] Miss a lucky of child's physical career

12. How do you treat irregularly growing children in primary healthcare (especially rural community? (Mukorera iki umwana udakura neza mu rwego rw'ubuvuzi bw'ibanze?)

Kubakurikirana babaha indyo nziza kandi agakurikiranwa no kwa muganga

13. What can you think new technology would help to accurately evaluate the child growth and development your areas? (Ni iki iterambere ryabafasha mu kumenya neza uko umwana akura bikwiriye?)

Kubaha ibikoresho bihagije harimo n'ibipima uburebure

14. As a healthcare provider,What do you suggest Biomedical Developers to help developing Community primary healthcare especially in Rwanda? (Ni iki abashakashatsi mu buzima bafasha communaute?)

Kubaha inyigisho zihagije

Answered by: HAKIZIMANA philimin

Occupation Umujyanama w'ubuzima mu Mudugudu wa NYAGISOZ,
(umurimo akora)

01.09.2017