IoT-Based Intelligent Medication Dose Calculator for Kids in Drugstore

Zhe Jie Tan, Ricky Jin Yuan Kiing, Ahmad Amirul Hakimi Ahmad-Sabri, Noor Shafika Mohd-Rafee, Nur Afiqah Junizan, *Wan Amir Fuad Wajdi Othman

School of Electrical & Electronic Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia

**Corresponding E-mail:* wafw_othman@usm.my

Abstract— This paper introduces an IoT-based system for medication dose calculator for kids in drugstore. The system will display the correct type and dosage amount of medicine for children based on the common illness among them by measuring their body weight. This device is specific only for the used in the clinic and drugstore. It also based on the apps application. The common illness that we take into consideration is fever, flu, asthma, headache, cough and cough with phlegm. By entering weight (manual) or measure the weight on the scale (automatic), we can provide suitable medicine type based on the children weight entered or measured with the correct dosage amount based on specific formula.

Keywords— Smart system; medication; dose calculator; low cost; mechatronics system

I. Introduction

Generally, fixed-dosing regimen is potentially more convenient than weight-adjusted dosing regimen for both patients and clinicians. However, for the sake of safety and efficacy, weight-based dosing method is needed for population and specified in prescribing information for many medications. Joint Commission International (JCI) Accreditation Standards for Hospitals (5th edition) requires that the hospital policy should specify the weight-based dosing strategy in the circumstance such as pediatric patients and frail elderly patients.

Pharmacist should consider writing weight-adjusted orders whenever possible. Organizations must strive for strategies that achieve goals such as establishing processes for weighing and weight documentation, requiring pharmacy review of weight-based dosing regimens, ensuring sufficient and convenient availability of appropriate and properly functioning equipment for patient weighing and medication delivery, and using health information technology and clinical decision support software to promote safe and appropriate dosing.

However, prescribing appropriate doses of drugs requiring weight-based dosing is still challenging due to poor awareness and adherence. A study showed that 3–12-year-old children with uncomplicated malaria were significantly more susceptible to receive wrong dose of artemether lumefantrine, which should be prescribed based on body weight.

A retrospective cohort study of vancomycin prescribing in the emergency department (ED) showed that only 19.6% of patients received a consensus-guideline recommended dosing regimen (15–20 mg/kg). The effect of body weight on drug action may vary in extent. In some cases, weight can primarily determine the dosage; in other cases, the weight effect may be minimal, or dosage can be affected only when weight is combined with other factors.

Findings of sporadic studies in recent years indicated that fixed dosing was more advantageous than weight-based dosing in some cases, and some key factors may challenge the necessity of weight-based dosing despite being specified in prescribing information. Therefore, it is necessary to let clinicians know the latest developments and the true circumstance in which weight-based dosing is of clinical relevance.

We have paid close attention to the knowledge of weight-based dosing during the preparation phase. Here we present a prototype weight-based calculator with weighing scale. Furthermore, a short introductory video of this work has been uploaded to the YouTube with the link https://youtu.be/ApgoZLh1Mao.

II. Related Works

A. *Smartphone Based Medication*

Nowadays, advanced mobile communications and portable computation are now combined in handheld devices called "smartphones", which are also able of running third-party software. The smartphone users' number are kept on growing rapidly, including among the healthcare professionals [1]. Research show that, in 2009, more than half of the world's population having a mobile phone and more than 4.1 trillion text messages were sent.

In many developed countries, the number of mobile phone subscriptions overtake their own population. In undeveloped countries, mobile communication technology accelerated in the growing sector of the communications industry and geographical coverage is high. The flexibility and popularity of mobile technologies means that people are carrying their mobile phone with them wherever they go [2].

A full of 80% to 90% of the developed countries population will have one of these devices are estimated within 10 years range since the introduction of smartphones and high possibility that many more applications are available today compared to last time. Information technology is finding various type applications in the field of health and Medicine.

Recently, short message service (SMS) communication has tested its versatility in helping smokers to stop smoking. Smartphone applications designed to collaborate with healthcare personnel in training and in decision making processes in daily clinical practice and in emergency care are rising, and there is already some proved showed their effectiveness [3].

Smartphones run on operating systems (OS). Several operating systems have been developed and each of it has their own advantages and disadvantages [4].

Besides, the upgrade in medical field are not only seen by its advances in surgical applications or diagnostic and therapeutic modalities but also by opportunities that have been given to the medical community by way of technology to access data and interact in new ways [4].

Mobile health, the use of mobile computing and communication technologies in health care and public health, is a rapidly expanding area within e-health. There is considerable enthusiasm for mobile-health interventions, and it has been argued that there is huge potential for mobile-health interventions to have beneficial effects on health and health service delivery processes, especially in resource-poor settings [2].

Also, mobile health interventions designed to be better health care service delivery processes have been used to provide support and services to health care providers (such as education, support in diagnosis or patient management) or target communication between health care services and consumers (such as appointment reminders and test result notification).

The popularity, mobility, and technological capabilities characteristic of mobile technologies make them particularly appropriate for improving health care service delivery processes. As we know, the fame of mobile technologies increased the number of ownerships of mobile technologies, which means interventions can be delivered to large numbers of people [2].

Crucial needs in new initiative for the improvising the effectiveness of secondary prevention programs. eHealth solutions (electronic communication and health information technology in health care practice) have been shown to improve self-management, adherence to lifestyle modification, and medical therapy [5].

Smartphone-based application also offering the analysis and the cloud data storage possibilities. Facility of automatic calibration feature for rapid and on-site usage also provided by the developed smartphone-based application [6].

The increasing of apps, software programs that run on devices like smartphones, creates novel opportunities for healthcare and disease management. Furthermore, consumer surveys also suggest that three-fifths of US adults, and over 1.5 billion worldwide, have an app capable smartphone by themselves. App stores are crowded with rising numbers of cheap or free information apps, diaries, and other tools intended to help individuals manage their health and share data with professionals [7].

Mobile health apps are software platform that can help users manage their health through a smartphone or tablet, ranging from simple diaries or reminders to more complex programs certified by health authorities as medical devices which also mean that mobile apps are user friendly. The potential for mobile health apps cannot be denied, with half a billion users already [8].

These studies should include assessment of the system interface ease of use, user accuracy, selection of appropriate settings, usability of the user instruction materials, and any other factors that are designed to prevent user errors [9].

On the other hand, the messaging program for smartphone, WhatsApp messenger is the trendiest communication field used. Research also showed that, WhatsApp Incorporated announced that it served more than 900 million users in 2016, making it the highest globally famous messaging application users [10].

Others smartphone application include Viber, eBuddy and Skype. WhatsApp's not only do these applications allow users to make calls and send messages using the internet but the platform offered user for sharing of photographs and videos instantly. This may be particularly helpful for getting instant opinions on radiographs, MRI and CT images and electrocardiograms. Also, it is often said that a picture is worth a million words. A well taken image of a wound in the emergency room is perhaps much more informative and give clearer persecution than any amount of written or verbal description of the same [4].

Using WhatsApp Messenger, an instant messaging application, in the primary health care education setting has tested several advantages for undergraduate nurses. These also include the usefulness of the application for integrating theory and clinical practice; rising the availability of resources for test preparation and providing a tool for clarification of uncertain aspects of the course [11].

B. *Medication Dosage for Children / Medical Dosing Error*

Fever is one of the most common clinical symptoms managed by pediatricians and other health care providers and accounts, by some estimates, for one-third of all presenting conditions in children. Fever in a child usually occurred because of unscheduled physician visits, telephone calls by parents to their child's physician for advice on fever control, and the wide use of over-the-counter antipyretics [12].

Parents are always anxious with the need to maintain a "normal" temperature in their ill child. Parents administer antipyretics even though there is either minimal or no fever faced by their child. Studies showed that approximately one-half of parents consider a temperature of less than 38°C (100.4°F) to be a fever, and 25% of caregivers would give antipyretics for temperatures of less than 37.8°C (100°F).

Furthermore, 85% of parents (n=340) noted awakening their child from sleep just only to give antipyretics. Unfortunately, as many as one-half of parents administer incorrect dosing amount of antipyretics to their child; approximately 15% of parents give supratherapeutic doses of acetaminophen or ibuprofen.

Caregivers who understand that dosing should be based on weight rather than age or height of fever are much less likely to give an incorrect dose [12]. Besides fever, asthma is also a common illness faced by children. Asthma is also known as the leading cause of childhood morbidity.

Analysis prove that in the USA alone, around 7 million children and adolescents suffer from asthma, and in the UK, one in every seven children aged 2–15 years has asthma symptoms requiring regular treatment.

A considerable proportion of asthma in children is inadequately controlled by inhaled corticosteroid guideline therapy compared to adult patient, which represents a significant healthcare concern. Moreover, to the negative impact on patients' quality of life, this considerably increases their risk of future exacerbations, with associated increased requirement for healthcare utilization and costs.

Data for the USA show that in 2011, 56% of children with asthma suffered an attack, where almost 20% visiting an emergency department [13].

Besides from that, the medication errors are also a global issue. Medication errors are one of the most frequent causes of adverse events in hospitalized patients [14].

The process of medication use is classified into five important stages including prescribing, dispensing, transcribing, preparing and administering of which the processes of prescribing and administering of medication are the stages of highest reported medication error. Prescribing and drug administration appear to be associated with the greatest number of medication errors (MEs), whether harm or else [15].

Eliminating the causes for prescribing, dispensing and administration errors is the first most step towards controlling medication errors. In addition, the NCC MERP has put forwarded certain recommendations to check these medication errors like those linked to human mistakes (as in writing prescription orders or other at-risk behaviors by healthcare professionals) or those linked to packaging, labelling, dispensing and administration errors.

Emerging technologies like computerized physician order entry or smart cards, computerized physician order entry with clinical decision support systems, automated drug utilization review system, automated drug dispensing system, bar coding, clinical pharmacy information system can gives patient care with high accuracy, efficiency and promising advancement [16].

Besides, it also recorded up to one in seven patients report having experienced a medication error in the past two years. The potential for new risks increasing from the use of medication apps is suggested by the withdrawals of a small number of products, including an insulin dose calculator developed by a pharmaceutical company, because of clinically relevant errors.

While calculator apps designed for use by healthcare professionals have been subject to scrutiny, the safety features of those intended for patient use are largely unknown. [7].

Drug administration also plays a crucial role because the possibilities to prevent or correct errors at this stage are limited. Two recent systematic reviews show median error rates between 8% and 10% (excluding time errors) in medication preparation and administration.

Most of these studies have been carried out in developed countries because in such countries, patient safety issues have been recognized a long time ago and efforts to developed a better medication safety such as implementation of electronic prescribing systems, barcoding, and involving clinical pharmacists at the ward level are ongoing[17].

The reality that medical treatment can harm patients is one that the healthcare community has had to come to terms with over recent years. In the Vietnamese hospitals, based on few large studies found that 2.5% to 18.4% of hospital admissions were associated with an adverse event and about 30% of those resulted in the death of the patient numbered is higher compared to developed countries. This situation occurred because of the poor health system infrastructure and inadequately trained healthcare staff probably contributed [17].

Despite variability in the incidence of medication errors, children still are at higher risk of experiencing an adverse drug event. Previous study also found that the frequency of potentially harmful medication errors was three times higher in pediatric patients than in adults.

Pharmacological factors such as age-based variability in absorption, metabolism and excretion of drugs pose special vulnerabilities to the risk of overdosing among children as compared with adults. Dosage calculations in children are much more prone to human error because of the constant need for weight- and surface area-based dosing and unit conversion to reflect the very small doses required [14].

Other studies also found that 1 in 11 families among a sample of 471 families in a large children's hospital reported that their child experienced error during hospitalization. Most of these events were validated as medical errors on physician review, yielding a medical error rate of 6.0 per 100 admissions and a preventable adverse events rate of 1.8 per 100 admissions [18].

A review also estimates that 5% to 27 % of medication orders for children contain an error somewhere along prescribing, dispensing and administering. The review also estimates that there are 100 to 400 prescribing errors per 1000 patients [19].

In West Ethiopia, medication errors cause many adverse drug events with negative patient health outcomes and are a major public-health burden contributing to 18.7–56 % of all adverse drug events among hospitalized patients. Out of 233 patients who were included in the study, 175 (75.1 %) of patients were exposed to medication errors. From the 1,115 medication orders reviewed, 513 (46.0 %) medication errors, 75 (6.7 %) potential adverse drug events and 17 (1.5 %) actual adverse drug events were identified.

Of the 17 adverse drug events, eight (47.0 %) were preventable while nine (53.0 %) were not. Most medication errors were dosing errors (118; 23.0 %), followed by wrong drug (109; 21.2 %) and wrong time of administration (79; 15.4 %) [20]. In low income countries like Ethiopia, however, healthcare coverage is prioritized to medication safety. Moreover, the medication use system is not evidence based [21].

Besides the common illness and the medication error for child, the other problem faced is the dosing amount for obese child. The risk of accidental overdosing of obese children poses challenges to anesthetists during dose calculations for drugs with serious side effects, such as analgesics [22].

There are almost 80 % of drugs have not been studied in children, and dosing of these drugs is derived from adult doses by adjusting for body weight/size [23].

A survey conducted by Collier et al high- lights the problem of drug dosing in obese children. The authors identify two aspects that require greater attention from pediatric practitioners which are the identification of the obese child and the lack of use of ideal body weight for drug calculation in that obese child. Both also involve effort from prescribers to go over/beyond simply measuring total body weight.

Studies agree that aminophylline maintenance doses using total body weight may be over-predicted in obesity, for child initial dosing based on either ideal body weight or total body weight for a target concentration of 10 mg/L is unlikely to be toxic, while the use of total body weight is to calculate initial doses may not be ideal for the maintenance dose, the problem could have been avoided by measuring theophylline concentrations to individualize the dose [24].

Obese children are at risk of overdose if dose calculations are proceed using total body weight. Due to the increased proportion of fat and lean mass that complicates the distribution, metabolism and excretion of drugs among the obese children, an adjustment of body weight may be necessary depending on the specific drug. Opioid-induced respiratory depression and paracetamol leads hepatic injury are examples of potential harm due to accidental overdose [22].

Obese children are more likely to develop comorbidities such as diabetes, fatty liver infiltration, obstructive sleep apnea, hypertension and asthma [3]. Weight-based drug dose calculation and pharmacokinetics are poorly understood. Serious complications and death have been reported when drugs have been inappropriately dosed according to an obese child's total body weight [22].

Besides, medicine like Paracetamol (acetaminophen) is an analgesic and antipyretic agent commonly used during childhood illness by parents and physicians worldwide. Analysis showed that, in country like Australia and New Zealand, paracetamol is a common pharmaceutical agent leading to contact with Poisons Information Centers and the most common cause for all age drug overdose-related presentation and admission to hospital [25].

In children, paracetamol overdose due to deliberate self-poisoning, accidental exposure or medication errors can lead to pediatric acute liver failure and death. In Australia and New Zealand, the nature of ingestion and outcomes of paracetamol-associated pediatric acute liver failure have not been described [25].

C. *Raspberry Pi / Internet of Thing (IoT)*

The advanced development in information and communications technologies (ICT) and the rising in the number of smart things shift from an old trend healthcare system to a modern and better suited for a population of the 21st century. New healthcare approaches based on Internet of Things (IoT)/Internet of Medical Things (IoMT) powered systems make health monitoring, diagnostics and treatment more personalized, timely and convenient, enabling a global approach to the healthcare system infrastructure development [26].

Internet of Things (IoT) is the interconnection between people, animal or object that ability to exchange data over network without involving humans or human with machine such as computer interaction. IOT also offer many types of connectivity from devices, systems, and services that work within machine to machine communications (M2M) and cover with applications, domains and protocols [27].

Nowadays, there have many accomplishments of IoT devices, for instances, heart monitoring implants, automobiles built-in sensors, farm animals equip with biochip transponders, field operation device used by fire-fighters in search and rescue [27].

Quality of life and social welfare in modern society have been broadly well recognized are the role and the importance of healthcare system. The ultimate goal of any economic, technological and social development are to improve the human health and wellbeing. Thus, the health of the population has become a state responsibility, affecting also the competitiveness of modern economies [26].

The Raspberry Pi is a low cost, small and portable size of computer board. Raspberry Pi can be used to plug in to computer monitor or television, keyboard, mouse, pen-drive etc. Raspberry Pi has built in software such as Scratch which enables users to program and design animation, game or interesting video. Besides, python language is the main core languages in Raspbian operating system where programmers can also develop script or program using Python language [8].

Raspberry Pi B+ is evolution of Model B. Python language has been used in this work to write the script for client/server communication. Moreover, there are improvements such as adding more GPIO header PIN, more USB ports, lower power consumption etc. It is also recommended to use model B+ for school learning because it offers more flexibility than model A especially for embedded projects and require low power as well as providing more USB ports compared to Model B [27].

One of the great things about the Raspberry Pi is that it has a wide range of usage [28]. Remember that there is no hard drive on the Raspberry Pi and everything is stored on a Secure Digital (SD) Card. The minimum required size of SD card is 2 GB although large SD cards holding 32 GB, 64 GB or more are available but at the same time they are often prohibitively expensive [28].

Besides, Raspberry Pi also very flexible and there is no single way to use it. For example, it can be used for: general purpose computing, learning to program or integrate it with electronics projects [28].

Studies also said that Raspberry Pi is used as an embedded Linux board which is used as a communication terminal in wireless sensor network. ARM 11 system structure of the microcontroller is been used by Raspberry Pi in which Linux operating system can install in it. The embedded Linux board connects the entire sensor node via ZigBee protocol in the wireless sensor network and collects sensors data from the sensors.

This board will continue to collect all the real time data from different sensor nodes a save in the raspberry pi board which can be accessed remotely on more than one client computer. Thus, we design the application which can group a large number of data based on the embedded Linux system platform. The advantages of this is It could reduce the power consumption of the wireless sensor node and at the same time it also able to improve the quantities of data processing ability and strengthens the data transmission speed [29].

D. *Accuracy of Digital Weight Scale*

Inaccuracies in reporting the body weights often are attributed to social desirability or erroneous measurements or recalls. Minimal research however has examined the accuracy of a common tool used to measure self-reported weights, that is the home bathroom scales. The limited available data suggest that home scales, as well as medical grade scales used by physicians, can vary in accuracy and precision.

A study of 37 dial-type bathroom scales in British clinics reported inaccuracies of more than 1% compared with a calibrated electronic scale, suggesting that digital scales may be more accurate. Further, an evaluation of 233 scales (type not specified) from United States primary care, diabetology and endocrinology clinics, and fitness and weight loss centers found that more than a quarter of the scales were more than 0.9 kg imprecise when tested with a 45.5 kg standard weight [30].

Findings from this study indicate that home bathroom scales are consistent in the weights measured. Dial scales were significantly more imprecise than digital scales at all calibration weight test loads measured with digital home scale weights differing significantly at the 75 kg test load. The imprecision at the 75 kg test load likely is due to human error in recording of data. Study also give suggestion that home bathroom scales, especially digital scales, provide sufficiently accurate and consistent results for use in public health research [30].

In practice, existence of asymmetry in lower limb loading among healthy populations is a controversial issue. Measurement of limb loading during while standing is crucial in various orthopedic and neurological conditions. However, the current measurement tools are not readily available in clinical practice. Hence, the present study proposed the use of two digital weight scales for measurement of limb load asymmetry and tested the accuracy relative to the Nintendo Wii. As for the result, the digital weight scale showed more accuracies compared to Nintendo Wii [31].

From the literature review that been discussed above, we conclude that smartphone-based application is the most suitable platform to improve over lifestyle and the smartphone application are more efficient compared to manual works. Besides, many studies show that medication error occurred not only among the adult but also among the children.

This occurred because of human mistake during the writing in prescription orders or other at-risk behaviors by healthcare professionals or maybe occurred during the process of packaging, labelling, dispensing and administration errors. We also get to know that there is different consideration that should be taken in calculating the dosage amount for obese children. For internet of thing (IoT) itself, using raspberry pi is the most suitable platform to accomplish the mission. Finally, digital weighing scale showed more accuracies compared to other weighing scale o measure human body weight.

III. Materials & Method

A. *Hardware Component*

The Raspberry Pi provides IoT and computing capability to the edge device (the weighing scale) where it processes data pulled from the scale and sends it out to the smartphone apps on real time. It is a general-purpose computer that can run multiple program at a time and is able to do intense calculation.

Figure 1: Raspberry Pi

In this work, Model 3B+ is selected due to its range of connectivity option (4x USB2.0, Gigabit Ethernet, Wi-Fi 802.11 b/g/n/ac, Bluetooth Low Energy) and great processing capability (1.4GHz, 4-core ARM Cortex processor with 1GB RAM).

Figure 2: Load Cell Amplifier Module

This small breakout board for the HX711 IC reads load cells to measure weight. By connecting this amplifier to microcontroller, changes in resistance of the load cells will be observed and with some calibration it is able to get very accurate weight measurements.

HX711 is a 24-bit precision ADC that outputs at maximum rate of 80 samples/second and has on-chip low-noise PGA with selectable gain of 32, 64 and 128. It uses a two-wire interface (Clock and Data) for communication with Raspberry Pi's GPIO pins. Numerous libraries can be found online, making it easy to read data from the HX711.

Figure 3: EVO-H-X-F8H3

This scale uses Bioelectric Impedance Analysis to get body composition with reference to weight, body fat %, body water %, muscle mass % and bone mass kg. When user stand barefoot on metal plates, some weak electric will be collected as data and the scale will analyses the data together with inputs of age, height and gender. In addition, the scale also measures Body Mass Index (BMI) and calories requirement (Basal Metabolic Rate) in kcal.

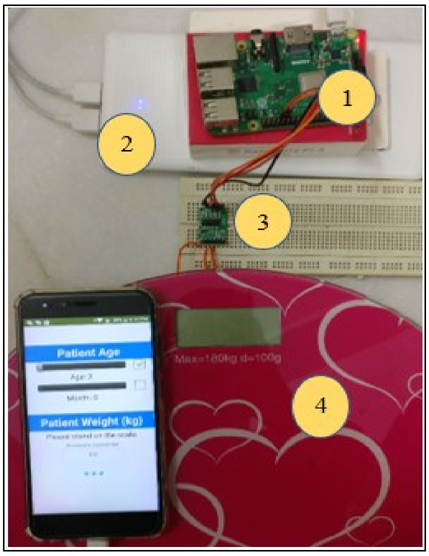

Figure 4: Prototype Setup

This is the prototype for the proposed system. It consists of:

1. Raspberry Pi
2. Power bank
3. HX711
4. Weighing Scale
5. Smartphone Apps

Since Raspberry Pi is remote accessed using RealVNC (monitor and external peripheral such as mouse and keyboard are not required), this setup is completely portable.

B. Software Development

App Inventor for Android is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create software applications for the Android operating system (OS). It uses a graphical interface as shown in figure 5 which allows users to drag-and-drop visual objects to create an application that can run on Android devices.

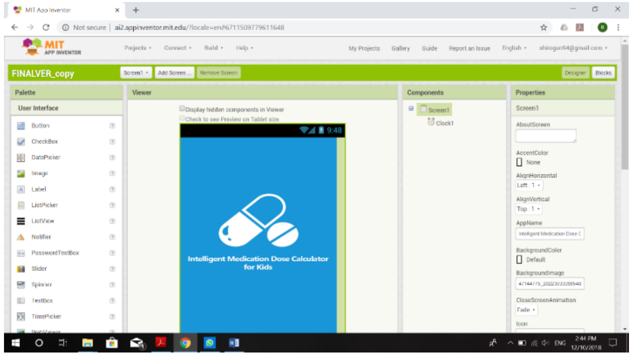

Figure 5: MIT App Inventor Design Environment with Graphical Interface

In this dose calculator system, an app was developed to help users to calculate the dose by using age and weight. The purpose of this app is to provide convenience to pharmacy user to save more time deal with customer. Customers can key in the required information in this app by themselves as show in Figure 6. Then, the app will do the dose calculation for them. This system can also call as customer self-service counter.

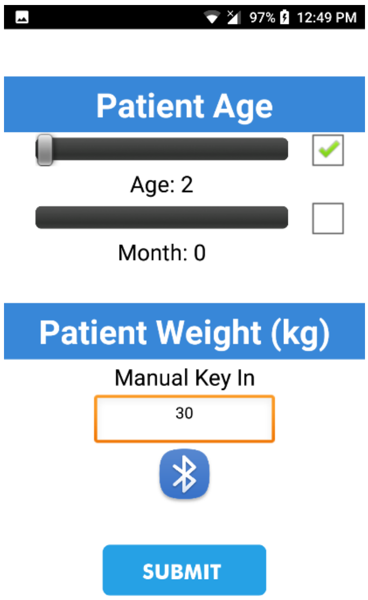

Figure 6: Customers' Age and Weight Registration Interface (Manual)

Furthermore, the app also provides Bluetooth functions for receive real time weight value from weighing scales as show in Figure 7. This is due to some customers are forgetful and have not fixed weight every day. Different weight may have different dose per times. Connect with weighing scales via Bluetooth may prevent them from overdose.

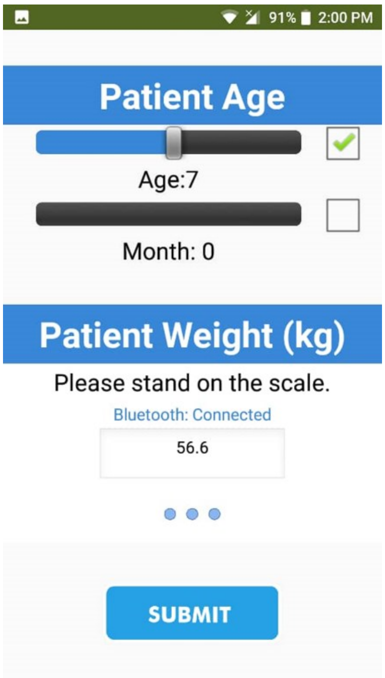

Figure 7: Customers' Age and Weight Registration Interface (Bluetooth)

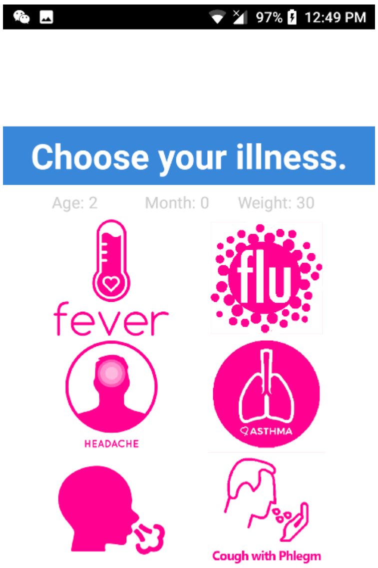

Figure 8: Illness Selection Interface

The second feature is illness selection where the dosage formula function stored at. Customers can choose one of the illness from the page as shows in Figure 8. All the illness selection is simplified into icon to help customers more convenience to use and understand. A notifier will pop out after choosing one of the illness to confirm the illness with customers. Then, dosage calculation is made after confirmation with customers.

The third feature is prescription medications as shown in Figure 9 which teach customers how to take medicine. A medicine is recommended to customers to buy it. The app will also display the way where to find the medicine in the store. Besides, customers can also share the prescription medications to their phone as a note to remind them. They just need to key in their phone number and press the share button to send out via WhatsApp.

Figure 9: Prescription Medications Interface

The safe dose for the child needed to be calculated by using formula below:

$$1 \text{ Dose x Weight in kg x } \frac{\frac{mg}{kg}}{dose} = 1\ Safe\ Dose\ in\ mg$$

Where mg/kg/dose is dose range by weight and weight is child's weight. There are many medicines with different dose range by weight as shown in Table 1. q.i.d. (or qid) means 4 times a day (from the Latin quater in die). The abbreviation q.i.d. is also sometimes written without a period in capital letters as "QID".

Other examples include:

- o.d. (od or OD) is once a day; o.d. stands for " omne in die " (which means, in Latin, once a day).

- b.i.d. (or bid or BID) is two times a day; b.i.d. stands for "bis in die" (in Latin, 2 times a day).
- t.i.d. (or tid or TID) is three times a day; t.i.d. stands for "ter in die" (in Latin, 3 times a day).
- t.d.s (or tds or TDS) is three times a day; t.d.s. stands for "ter die sumendum" (in Latin, 3 times a day).

TABLE 1: DOSE RANGE BY WEIGHT OF MEDICINES

MEDICINES	DOSE BY WEIGHT
PARACETAMOL	10-15mg/kg/dose tds-qid
IBUPROFEN	Not for routine dose of antipyretic for <5months old. 10mg/kg/dose qid/prn
CHLORPHENIRAMINE	2 years above only: 0.1mg/kg/dose tds
DESCHLORPHENIRAMINE	0.05mg/kg qid
CETRIZINE	0.25mg/kg od
BROMHEXINE	2 years above only: 0.3mg/kg/dose tds
AMBROXOL	1.5-2.0mg/kg tds
CARBOCYSTEINE	10-15mg/kg
DIPHENYDRAMINE	2 years above only: 1-2mg/kg qid
DEXTROMETHORPHAN	0.2-0.4mg/kg tds
GUAIFENESIN	4-8mg/kg
PROMETHAZINE	2 years above only: 0.2-0.5mg/kg tds-qid
SALBUTAMOL	0.1-0.15mg/kg tds-qid
TERBUTALINE	0.1mg/kg tds

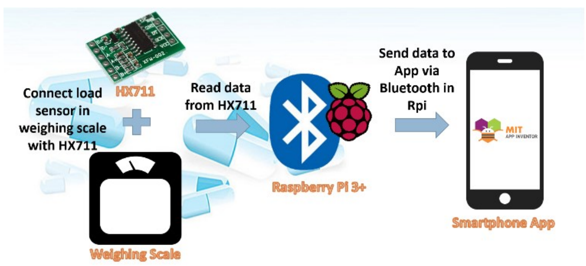

Figure 10: Overall Block Diagram of Dose Calculator System

For better illustration of the operation behind the whole system, the dose calculator system is summarized as a block diagram as shown in figure 10. On the right quarter is made up of the software development part; while on the left presented the connected hardware components part to the microcomputer, Raspberry Pi 3+. And the main connection between the software and hardware is through the Bluetooth realizing the IoT concept.

C. *Working Principle*

1) Setup System Flow

In the beginning, Raspberry Pi 3+ must pair with smartphone via Bluetooth first. After paired, then only run the data processing script to send out the weight value to smartphone. Before running the data processing script, several calibration of weighing scale must be done in in order to get an accurate weight.

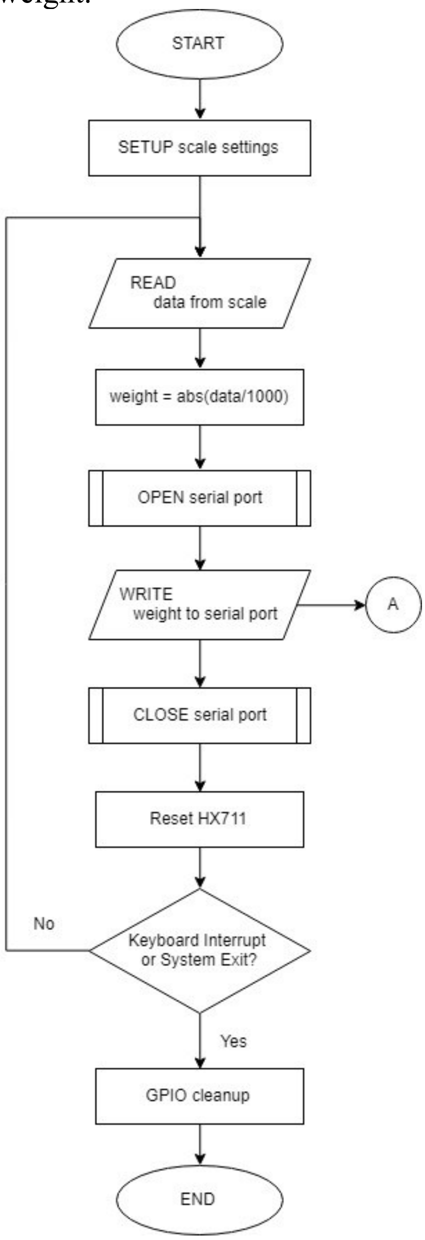

Figure 11: Rpi_data_proc.py flowchart

The script begins by mapping DOUT and CLOCK pin to the GPIOs, initializing scale settings (OFFSET and RATIO obtained from Calibration step) and carry out tare function, which essentially remove the weight of container if there's any.

To read data from the scale, hx.get_grams() is called from python library hx711.py. It will automatically subtract out the OFFSET from value measured and divide by RATIO, giving an accurate reading of current weight placed on the scale. Since measured value are in unit of grams, it is divided by 1000 to get kilograms and turn it into positive reading by using abs () function.

Data sending using Bluetooth is mainly handled by these 3 lines of code:

```
ser = serial.Serial('/dev/rfcomm0')
ser.write(b'%.1f'%weight)
ser.close()
```

Bluetooth communication between Raspberry Pi and smartphone apps is done using RFCOMM serial protocol. So after successfully open serial port in RFCOMM channel 0, data can be sent out through serial.write() function, followed by serial.close() to close the port. Error in executing any of these Bluetooth command will raise an exception that leads the script to System Exit.

HX711 needs to be reset before another read function executes. Reset is done by power_down() the device and power_up() after 1ms. This data reading and Bluetooth sending cycle will keep on running until a Keyboard Interrupt or System Exit is encountered. Before the script exits, GPIO.cleanup() is executed to reset all GPIO pin used in this program back to input mode. This act as precautionary step to prevent accidental short-circuit.

2) Calibration Script Working Flow

Due to internal noise of the circuit, there will be a non-zero value even though no weight is applied onto the scale. This value is known as offset. Hence the script begins by reading this non-zero value and saves ss OFFSET.

Then user is requested to place a known weight onto the scale. The scale reads this value and subtract out the OFFSET acquired earlier. Once the user input exact weight, ratio is calculated by dividing measured weight by item's weight and saved as RATIO.

But the script exits, user are given options of RECALIBRATE, DISPLAY saved OFFSET and RATIO or EXIT.

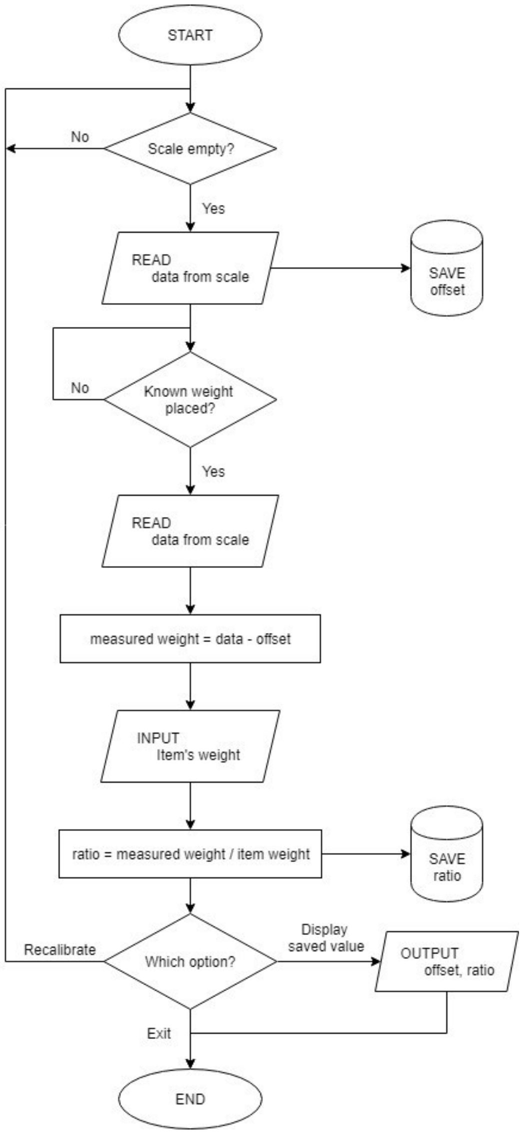

Figure 12: Calibration.py flowchart

3) Smartphone apps (software) Working Flow

When one opens the Dose Calculator smartphone application, it will go to the Main Page of application. The system connects to Raspberry Pi 3+'s Bluetooth by MIT App Inventor 2's code. If it connects successfully, the application will receive weight value from Raspberry Pi 3+ continuously. If it fails to connect, the application is in standby mode to wait customers to manual key in.

When the weight value is more than zero, a submit button will pop out so that customers can submit their weight and age for calculation. Customers are also able to change mode (Manual

Key In or Receive Weight from Bluetooth) of getting weight value by press a toggle button.

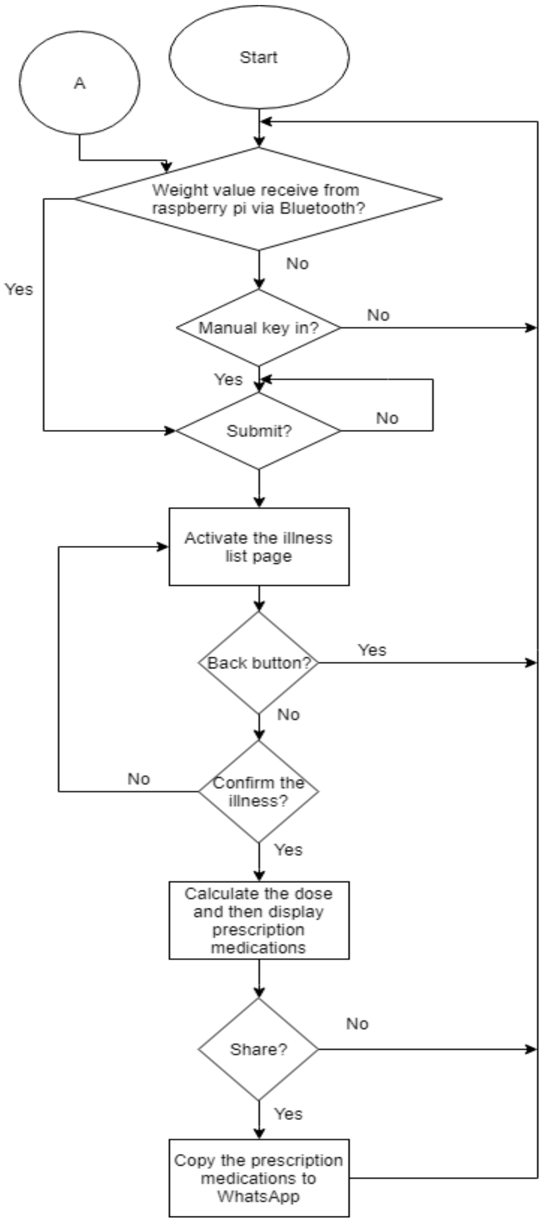

Figure 13: Dose Calculator App flowchart

If button Submit is pressed, the app will bring the collected data to illness page. In illness page, customers are required to choose an illness from the page then only can do the dose calculation for them. If an illness is chosen, the notifier will pop out which ask the customers is it they are having an ill. If customers found that the weight or age or illness are not correct or not in the list, they can back to main page by pressing back button.

If button Yes is pressed, the application will go to Prescription Medication Page. In Prescription Medication Page, the application will display the recommended medicine and dose frequency per time. A text box is ready for customers to key in their phone if they want to copy the prescription medication to their phone. After key in the phone number, they just need press button share to send out the copied message via WhatsApp application. If button cancel is pressed, the application will back to main page.

IV. Result & Discussion

A. Bluetooth Connection

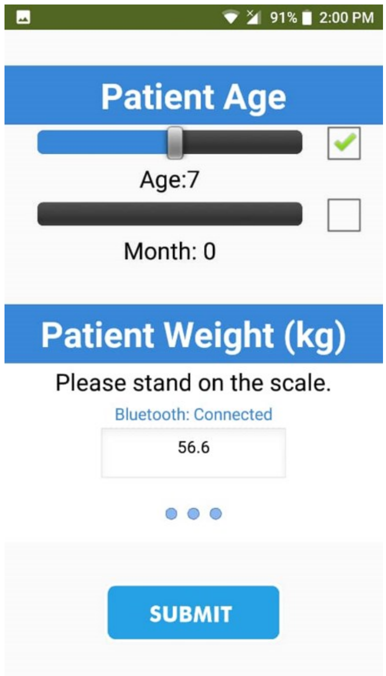

Figure 14: Patient Age and Weight Page

When Bluetooth connection is successfully established between Raspberry Pi and weighing scale, “Bluetooth: Connected” is shown and the value from the scale will be shown.

B. Calibration

Disparity between weight from the scale and value obtained in apps are within ±0.1kg. This disparity is tolerable in terms of medical dosage calculation accuracy. This phenomenon is probably due to unstable wire connection between the scale and HX711. Another factor is that the calibration factor of the scale itself has slight difference from the value obtained in calibration step.

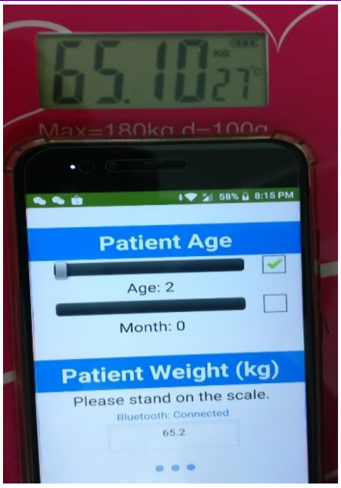

Figure 15: After calibration

Dosage Formula

Some medicines dose recommended by pharmacist and app are similar to each other. These medicines are paracetamol 120mg and 250mg per 5ml respectively and chlorpheniramine. This indicate the formulas of medicines are accurate enough. There are also some medicines dose recommended by pharmacist and app are different like ibuprofen, salbutamol, dextromethorphan and bromhexine. Obviously, these medicines' formulas are different due to different in concentration. Some have higher concentration which will bring strong effect to patient.

V. Future Improvement

This project is scalable in terms of sensor to maximize the advantage of Internet of Things, such as heart rate monitor, height measuring, blood pressure gauge and more. Besides, huge data gathered by sensors can be logged and further analyses to deepen the understanding of patient. More sophisticated medical formula can be included to cater not only children but another category of patient as well.

VI. Summary

In conclusion, a sustainable "Medical Dose Calculator for Kids" is successfully developed. It can be placed at drugstores or clinics for self-service device.

A simple and friendly user interface has been designed by using MIT App Inventor to ease the user to use the device. This app can be download and can be used by various ages of people. Besides, we have learned about load cell and Wheatstone Bridge in the process of developing this device.

It was hard to hack the weight scale at first as the bit is too small, but we managed to amplify the signal by using Load Cell Amplifier HX711. A Raspberry Pi also was included in this design as we need a small computer to process the dosage calculation and use its Bluetooth module to calibrate with the weight scale.

Finally, we also have exposed it's how to design the prototype using SolidWorks CAD tool, especially in terms of how to place the electronic components in a more compact way, to reduce the size of the prototype.

A short demonstration video of this work also has been uploaded to the YouTube with the link https://youtu.be/cs1KX4NS50g.

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