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Microcontroller Unit Based Weighing Scale for Toddler with Emergency Drugs Dosage Calculator

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INTRODUCTION

Drug dosage calculations are based on patient's weight and can vary significantly within an age group (Kaufman, Laschat, Wappler, 2012). Hoyle, Jr., Davis, Putman, Trytko, Fales, (2011) Reported that up to 17.8% of hospitalized children are due to medication dosing errors, because this multi-step process requires experience, knowledge and the full attention of physicians or nurses involved. As stated in a report from the 1999 Institute of Medicine (IOM), medication errors cause at least 44,000 to 98,000 US citizens die each year (Kohn, L. T., Corrigan, J., & Donaldson, M. S. 2000. *To err is human: Building a safer health system*. Washington, D.C: National Academy Press). One of the most common medication fallacies is drug dosing error commonly occurring during emergency cases. Hospital emergency cases require swift action to deliver the patient's immediate attention causing the medical

attendant to generate an estimated emergency drug prescription. Toddlers are prone to drug dose error because their prescriptions are based on their weight and doses that are incorrect than the required amount may be life threatening. The highest error rates are to be expected in pre-hospital emergency medicine (Kaufman, et. al, 2012).

Medication errors are among the most common health threatening mistakes that affect patient's care leading to medical malpractices in terms both on human suffering and additional medical costs that may lead to patient's death.

When handling toddler medical emergency cases, time is vital. Weighing the patient to calculate the dosage takes time and in medical urgent situations, medical practitioners are always under pressure leading to dosage estimation and inaccurately prescribing or administering emergency drugs to toddlers. Ingestion of drug with erroneous dose will make a vast damage on human body. This blunder can lead to a very serious problem that can even lead to death.

Due to medication errors that are life threatening, the study aims to design a system that will correctly prescribe emergency drugs dosage for toddlers upon weighing. It also desires to speed up the process of attending medical emergency cases for toddlers. Likewise, it intends to lessen if not eradicate the threats caused by emergency drugs dosage estimation of medical practitioners.

The significance of this new technology will benefit the society by providing a reliable system to generate, verify and distribute precise dosage calculations. Due to this appropriate treating, patients will be assured of premeditated dosage treatment. Supply of emergency drugs for toddlers will be maximized because of the precise prescription of it. This development will elevate medical institution's quality in their medicinal management with their patients. Mortality and the relative incidence of disease rate in the country relating

emergency drug prescription will decrease due to the lessening of dosage calculation errors.

The calculated dosage is for Intravenous administration and the input medicines in the program are emergency drugs only namely: Phenobarbital-Sodium Luminal, Epinephrine, Atropine, Diazepam, Chlorpheniramine Maleate, Diphenhydramine, Paracetamol, Hydrocortisone, Ranitidine, and Metoclopramide. It is only intended for toddler ages 1-3 years old. It does not cover a wide range of medicines. The capacity of the weighing scale is not suitable for adults. The Uninterruptable Power Supply will only last for approximately 3 hours.

REVIEW OF RELATED LITERATURE

Relevance of the Study

More than 1 in 6 medication errors involve miscalculation of doses, incorrect expression of units, or incorrect ratio of administration because providing the proper drug therapy to a hospitalized child involves several steps and multiple individuals (Thimbleby and Williams 2013). Jing, Kuei, Kuan, Hsiang, Wen, You, Man, (2013) Studied that potentially harmful medication errors are three times more likely to occur in children than in adults and the differences are mainly related to the changes occurring during growth and maturation, and the required individual dosages (Elias, Antoniali, Mariano, 2004). Therefore, implementing a clinical support system to promote accurate medication dose calculations might be a useful approach to further enhance medication safety among pediatric patients.

Combination of medical support system was established for the benefit of patient, Computerized Physician Order Entry (CPOE) and Pediatric Dosing Decision Support System (PDDS) was made to provide decision support regarding pediatric dose

calculations based on age, and weight. A pediatric dosage database was established and an alerting model was designed to interact with the CPOE system (Jing, et. al, 2013).

Drug prescription may require modification at a number of stages to alter formulation, concentration, volume, availability of supply or administration times to match normal sleep–wake patterns and brand in terms of taste / palatability (Caldwell and Power, 2011).

The most common method for dose adjustment in children in pediatric clinical practice is to normalize the adult dose by body weight, assuming a linear relationship between weight and dose. This means that the dose doubles with a two-fold increase in the weight of a child. Another method for dose adjustment is based on age: the pediatric population is divided into subcategories (preterm newborns, term newborns, infants, toddlers, children and adolescents) and the dose is selected according to a child's age. This method does not take into account the changes due to developmental growth that occur within each age group. Scaling the dose from adults can also be performed by normalization based on body surface area (BSA), under the assumption that metabolic processes in humans are constant when expressed as a function of BSA (Cella, Knibbe, Danhof, Della Pasqua, 2009).

Conceptual Framework

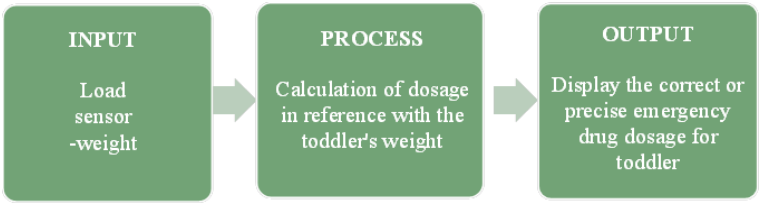

Figure 1. Conceptual Framework

A weighing scale for toddlers connected to a computer unit will be used. The LCD Monitor will display the list of emergency

drugs and also the calculated dosage of the patient based on his/her weight. When the patient's weight is already recorded by the load sensor, the data will be processed using a microcontroller unit to the Visual Basic 6 program to compute the suitable emergency drug dosage of the patient to be displayed. During power interruption, an Uninterruptable Power Supply (UPS) Unit will function switching the system from main supply to the backup battery. A four-seven segment LED display will be placed on the weighing scale to denote the weight of the toddler.

Theoretical Framework

Medication errors are preventable events that may cause or lead to inappropriate medication use or patient harm and may be classified as potential or actual (Phillips, Beam, Brinker, Holquist, Honig, Lee, Pamer, 2001). Potential errors are defined as reports of confusion or an intuition that an error will occur in the future, and more than 15% of all the medication prescribing errors that has the potential to produce adverse effects are the errors in the use of drug dosage equation in which children are particular at risk of (Lesar, 1998). Children pose special tasks in the drug ordering and prescription because drug dosages for children are based on their weight and must be calculated individually, requiring frequent dosing calculations especially in small infants (Fortescue, Causal, Landrigan, McKenna, Clapp, Federico, Goldmann, Bates, 2003). And in acquiring the patient's weight, usually an analog weighing scale is used which can lead the medical attendant weighing the patient, inaccurately read the measurement during emergency situations. Furthermore, medicine administration in children is complicated by the fact that stock solutions of medicines are often available only at adult concentrations and must be mitigated for use in children (Fortescue, et. al, 2003). Risk of prescription errors can be reduced with the use of an

alternative dosage calculation technique which uses a digitized weighing scale instead of an analog, and by using a computerized application that has a predetermined formula in computing the dosage in reference to the patient's weight for each emergency drugs.

Table 1. Emergency Drug General Specification

Emergency Drug	Time of Action	Therapeutic	Pharmacology
Atropine	Immediate	Antiarrhythmic, Bradycardia	Anticholinergics, Anti-muscarinic
Epinephrine	Rapid	Anti-Asthmatics, Bronchodilators, Vasopressors, Cardiac Arrhythmia	Adrenergic
Diazepam	1-5 Mins	Antianxiety Agents, Anticonvulsants, Sedative/hypnotics, skeletal Muscle relaxants	Benzodiazepines
Chlorpheniramine Maleate	Rapid	Allergy, Cold, and Cough Remedies, Antihistamines, Antitussives, Nasal drying agents/decongestants	Antihistamines, Opioid analgesics, Adrenergic
Metoclopramide	1-3 mins	Antiemetic, Nausea and Vomiting	
Diphenhydramine	Rapid	Allergy, Cold, and Cough Remedies, Antihistamines, Antitussives, Asthma Attack	
Paracetamol	30 mins	Antipyretics, Non-opioid analgesics	
Hydrocortisone	Rapid	Anti-inflammatories(steroidal), Adrenocortical Insufficiency	Corticosteroids
Ranitidine	15 mins	Antiulcer agents, Acute Gastric Pain	Histamine H2 antagonists
Phenobarbital-Sodium Luminal	Immediate	Anti-convulsants, Sedative/Hypnotics	Barbiturates

Project Description and Research Design

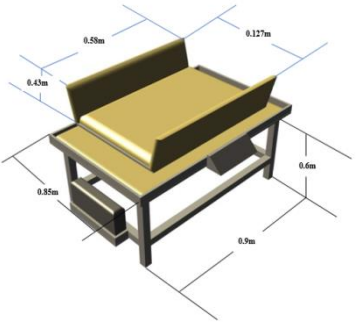

Figure 2: Project Chassis

The Microcontroller unit based weighing scale is made out of galvanized iron bars and sheets, as shown in Figure 1. Galvanized iron bars are used for a sturdy and firm foundation of the prototype. A bed pad is placed on top of the G.I. sheet toddler bed as shown in the figure above to accommodate the toddler's comfort. Also a 7-segment is attached to prototype to display the weight of the toddler.

Table 2. Project Chassis Dimension

Description	Length (m)	Height (m)	Width (m)
Frame	0.9	0.6	0.85
Weighing Scale	0.58	0.43	0.127

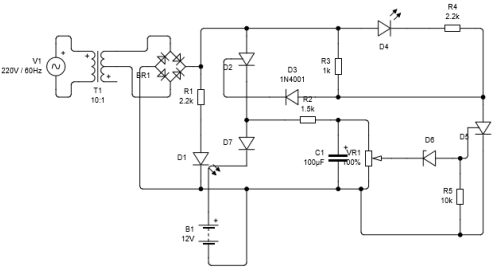

Figure 3: Battery Charger Circuit

The Uninterruptable Power Supply (UPS) placed at the lower left part of the prototype serves as the main supply for the system as shown in Figure 1. The UPS is supplied by 220 Volts AC connected to the 12V-0V-12V step down transformer and to the battery charging circuit. The Battery charging circuit has two Silicon Controlled Rectifier (SCR) as its main component. The first SCR is for triggering the Light Emitting Diode (LED) as an indicator that the backup battery is fully charged, the second SCR is connected to the potentiometer which is used to vary the output DC voltage to charge the backup battery. Figure 2 illustrates the schematic diagram of the battery charger circuit.

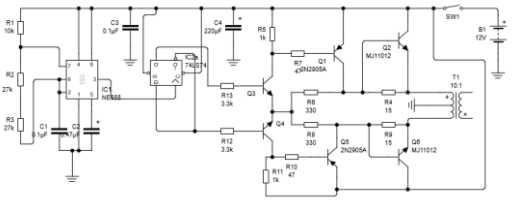

Figure 4: Power Inverter Circuit

Figure 3 depicts the power inverter circuit used to produce a 220 V to supply the computer system. The circuit consists of a 555 Timer IC which acts as an astable oscillator. The output of the oscillator is fed to the clock input of the 74C74 D-type Flip Flop. This IC has two functions: first, it divides the timer frequency into two to obtain the 60 Hz output and secondly, it simultaneously provides the complementary outputs required by the succeeding switching circuit. The transistors are responsible for the switching. The alternate switching of the two transistors creates a magnetic field on the transformer resulting to a magnetic induction which produces a 220 V at the output of the inverter.

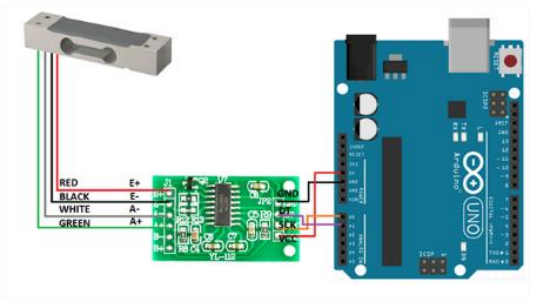

Figure 5. Load Cell to Arduino Pictorial Diagram

As shown in Figure 4 the MCU based weighing scale uses a load cell that has a weighing range of 0 - 30 kilograms. The load cell is connected to HX711 weighing sensor module used to acquire the output data of the weighing scale to pass on to the microcontroller. The Arduino Uno, is used as the microcontroller of the system, processes the data from the weighing sensor module to the Visual Basic 2013 program.

Multiple-digit LED displays as used in pocket calculators and similar devices used multiplexed displays to reduce the number of I/O pins required to control the display. For example, all the anodes of the A segments of each digit position would be connected together and to a driver circuit pin, while the cathodes of all segments for each digit would be connected. To operate any particular segment of any digit, the controlling integrated circuit would turn on the cathode driver for the selected digit, and the anode drivers for the desired segments; then after a short blanking interval the next digit would be selected and new segments lit, in a sequential fashion. In this manner an eight digit display with seven segments and a decimal point would require only 8 cathode drivers and 8 anode drivers, instead of sixty-four drivers and IC pins. Often in pocket calculators the digit drive lines would be used to scan the keyboard as well, providing further savings; however, pressing multiple keys at once would produce odd results on the multiplexed display.

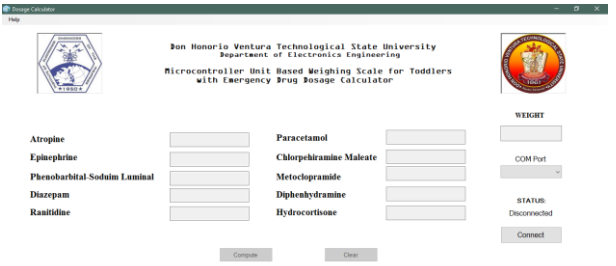

Figure 6. Visual Basic Display

The carried data to the Visual Basic 2013 is responsible for the calculations of the listed emergency drugs dosage for toddlers in the program.

As shown in Figure 5, the program has the list of the emergency drugs the project covers. Clicking the COMPUTE button of the program or pressing the ENTER key of the keyboard will automatically compute the acquired weight data of the microcontroller, and the label box opposite each emergency drug name will display the computed dosage in reference to the toddler's weight. The Status and Connect button is added to the program to display the connection of the MCU based weighing scale to the computer, and the CONNECT button is added to click if the status is disconnected.

Methods

Methodology is the process used to collect information and data for the purpose of making business decisions. The methodology may include publication research, interviews, surveys and other research techniques, and could include both present and historical information.

Methods of Research Used

Library Method

Library method was conducted at Don Honorio Ventura Technological State University Library to gather pertinent information and data about working power inverter circuit. The configuration and the possible replacement of components in reference to the power inverter circuit were gathered through an electronic catalogue. The circuit for the power inverter was also attained through looking at different electronic magazines, catalogues, books and written materials.

Observation

For the determination of the effectiveness of the Microcontroller Unit Based Weighing Scale for Toddlers with Emergency Drugs Dosage Calculator, all possible parameters were perceived. Observation of the doctors and nurses action during toddler emergency cases, the emergency drug dosage formulation of the doctor, and the difference of an analog weighing scale to the project will play part in the formulation, creation and construction of the project.

Data Gathering Instruments

Interview

Interviews were conducted to doctors of Pampanga Medical Specialist Hospital, their knowledge and answers to the interview questions were taken into consideration in formulating, creating and construction of hypothetical results that will be authenticated through actual conduction of tests. Additional information and data were put together for the improvement and development of the research.

Online Research Method

Online research method was used to acquire data and information in relation with the emergency drug specification and dosage for toddlers, the possible formulas in computing the drug dosage of patients, the possible programs that will operate the project and the relevance of the project. Online research was used in obtaining data and information by accessing online international research databases, journal, and articles through a computer network.

Calculation Method

Calculation method was bring into service in computing distinct areas of the study; this includes the therapeutic dosage for toddlers, the accuracy and precision of the MCU based weighing scale and percentage error of MCU based weighing scale over analog weighing scale.

Toddler's Dose:

$$Dose\ (mg) = Therapeutic\ Dose\ \left(\frac{mg}{kg}\right) \times Body\ weight\ (kg)$$

$$Dose\ (ml) = \frac{Dose\ (mg) \times Ampoule\ quantity\ (ml)}{Ampoule\ drug\ concentration\ (mg)}$$

Accuracy:

$$Accuracy\ (A) = \ 1 - \left|\frac{Y_n - X_n}{X_n}\right|$$

Precision:

$$Precision\ (P) = \ 1 - \ \left|\frac{X_L - \ X_A}{X_A}\right|$$

Percentage Error:

$$Percentage\ Error\ (\ \%\ e\ ) = \ \left|\frac{Y_n - \ X_n}{Y_n}\right| \times 100$$

Experiment Method

Different tests were conducted to demonstrate the operation and efficiency of the MCU Based Weighing Scale for Toddlers

with Emergency Drugs Dosage Calculator. Tests include, Accuracy of the Calculated Dosage, Speed of Calculation Test and Precision of Weighing Scale Test. Experiments were made to compare the researched project to the conventional way doctors compute the emergency drug dosage for toddler patients.

Sampling Technique

This method was use to get a specific individual from a statistical population to estimate characteristics of a whole population of medical personnel. Statistical methods were being used for a reliable and substantial interpretation of records as well as presenting the efficiency of the proposed system.

Methods in Developing the System

Planning Phase

An informal interview was set with some of the staff of Pampanga Medical Specialist Hospital to give us the idea on what project to create. From the given ideas, we have come up to a project that can calculate the drug dosage of a toddler in reference to his/her weight. A weighing scale that is programmed to calculate the dosage that is needed by the toddler patient.

Analysis Phase

Medicines are broad to study. A dosage calculator for all the medicines is near impossible, so it is decided to limit the medicines that the program will calculate to only ten emergency drugs. An interview was conducted to identify the ten most common emergency drugs also a research about the average weight of a toddler to ensure the specification of the load cell of the prototype.

Design Phase

A lot of factor affect the design of the prototype including the height, width and length of the weighing scale. The bed pad have a length of two feet for the toddler to fit. A robust and stable frame made out of galvanized iron bars were used to support the bed. It is a four-wheeled bed type weighing scale that is designed to be movable handle emergency situations. The bed pad was upholstered to provide comfort to patients. The weighing scale data provides the inputs for the visual basic application, which is responsible for the calculation of emergency drugs dosage.

Development Phase

Development of the project requires provision and knowledge about the medicine's dosage and calculation. Medicines are hard to meddle with since it has complex specifications. The therapeutic dose of each emergency drugs were enlisted to the Visual Basic application and programmed to display the output dosage IV infusion in milliliters. An uninterruptable power supply was added to ensure the capability of the project during power interruption, also a four-seven segment display was added to the weighing scale frame.

Testing Phase

To ensure the efficiency of the prototype, we have conducted three testing. Accuracy test, to prove the exactness of the Visual Basic calculation with manual calculation. Speed test, to ratify that the MCU based dosage calculator has a quick performance in computing the given medicines over manual calculation. And Precision test, to evidently prove the weighing scale adeptness.

Presentation and Analysis of Data

Table 3. Comparison of Weighing Scale Precision

Description	Analog weighing Scale (kg)	Micro-controller Unit based Weighing Scale (kg)
A Jack & Jill Chippy Snack weighing	0.14 kg	0.11 kg
Toddler's weight	11.542 kg	11.55 kg
A rim of short bond paper	2.22kg	2.24 kg
Tomasi book	1.21kg	1.19 kg
A kilo of rice	1.01 kg	1.00 kg

The Precision of Weighing Scale Test input load as seen from Table 3. Comparison of Weighing Scale Precision above, were tested for one hundred times, and the acquired data from the MCU based weighing scale has a 99.81% precision while the data gathered from an analog weighing scale has a 92.96% precision. The recorded data from the MCU based weighing scale is more precise than the data from an analog weighing scale and has a percentage error of 0.19%.

Table 4. Comparison of the Speed of Calculation

Scenario	Manual Calculation Time (seconds)	MCU Based Calculation Time (seconds)
First Scenario	40.06	7.13
Second Scenario	44	6.14
Third Scenario	38	8.97
Fourth Scenario	41	8.27

Table 4. Comparison of the Speed of Calculation shows that in an emergency scenario, manual dosage calculation takes around 40 seconds to compute, while the microcontroller unit based weighing scale dosage calculator calculates at a maximum of 10 seconds. It clearly shows that the MCU based

weighing scale calculator has a rapid calculation performance over manual dosage calculation since, it is four times faster than the latter.

Table 5. Comparison of the Accuracy Rate of the MCU based Weighing Scale Calculation

Toddler's Weight	Emergency Drug	MCU Based Calculated Dosage	Manually Calculated Dosage	Difference
10 kg	Atropine	0.4 mg	0.4 mg	0
10 kg	Epinephrine	0.2 mg	0.2 mg	0
10 kg	Diazepam	0.5 mg	0.5 mg	0
10 kg	Chlorpheniramine Maleate	1.5 mg	1.5 mg	0
10 kg	Metoclopramide	0.2 mg	0.2 mg	0
10 kg	Diphenhydramine	0.3 mg	0.3 mg	0
10 kg	Paracetamol	0.66 mg	0.66 mg	0
10 kg	Hydrocortisone	0.15 mg	0.15 mg	0
10 kg	Ranitidine	0.6 mg	0.6 mg	0
10 kg	Phenobarbital-Sodium Luminal	0.11 mg	0.11 mg	0

Table 5. Comparison of the Accuracy Rate of the MCU based Weighing Scale Calculation shows that the accuracy rate of the MCU based weighing scale calculator computation in relation to manual calculation is 100% accurate. This determines that the accuracy of dosage calculation using MCU base weighing scale calculator is reliable during emergency situations.

CONCLUSION

The microcontroller unit based weighing scale for toddlers with emergency drugs dosage calculator is a necessity to the medical institution. During emergency situation time is vital wherein, the conventional way of acquiring drug dosage takes at least 40 seconds since the process is done manually. The MCU based weighing scale can compute drug dosage for less than 10

seconds therefore, speeding up the process to at least four times than the current manual process of drug dosage prescription.

During emergency situations, doctors estimate the therapeutic dosage and set it to minimum tolerance resulting to ineffectively prescribe the emergency drug dosage that results to under dosage.

This project provides the correct calculated therapeutic dosage of emergency drugs and has a precision percentage error of 0.19%. The Microcontroller Unit Based Weighing Scale for Toddlers with Emergency Drug Dosage Calculator offers a faster, correct, precise and less complicated way of providing the drug dosage for IV administration.

RECOMMENDATION

For the future researchers, the microcontroller unit based weighing scale, Raspberry Pi can be used instead of Arduino Uno R3 Microcontroller Unit. Raspberry Pi Unit is a Micro Computer that has its own Operating System and it offers a faster clock frequency and more responsive. Also, two-parallel load cell can be used to increase the capacity of the weighing scale, the two input weights updates the signal faster. Instead of using four digit 7-segment LED Display, Liquid Crystal Display screen can be used. Four-digit 7 segments lags the updated time of the input weight in the Visual Basic. LCD screen offers more stylish, advance and it is more readable because of its blue backlight. Furthermore, high capacity and current battery is suggested since Uninterruptable Power Supply needs higher input current and it has a large power dissipation.

About the software, database can be applied to store records and data of the patient. Statistical records can be drawn from the database in reference to the drugs taken by the patient.

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