Drug Dosage Administration Assistant for Nurses: DruDAA

Oyeleke, Richard O.
Department of Computer Sciences, University of Lagos, Nigeria.

Alamu, Femi O.
Department of Computer Science & Information Technology, Bowen University, Nigeria.

Fagbemi, Seun O.
Department of Computer Sciences, University of Lagos, Nigeria.

ABSTRACT
The prevalence of drug administration errors and its associated harmful effect on patient calls for a new and effective approach in minimising their occurrence in nursing drug administration activities.

DruDAA is an application developed using C-Sharp programming language on Microsoft visual studio 2005. As drug calculations often appear so rigorous and daunting, DruDAA offers a simplified approach for computing required drug dosage to be administered to patients.

Keywords:

Drug Calculation, Drug Dosage Administration, Drug Administration Error.

1. INTRODUCTION
The Institute of Medicine's (IOM) first Quality Chasm report, *To Err Is Human: Building a Safer Health System*, stated that medication-related errors (a subset of medical error) were a significant cause of morbidity and mortality; they accounted "for one out of every 131 outpatient deaths, and one out of 854 inpatient deaths". Medication errors were estimated to account for more than 7,000 deaths annually. Building on this work and previous IOM reports, the IOM put forth a report in 2007 on medication safety, *Preventing Medication Errors*. This report emphasized the importance of severely reducing medication errors, improving communication with patients, continually monitoring for errors, providing clinicians with decision-support and information tools, and improving and standardizing medication labeling and drug-related information (Hughes and Blegen, 2008).

Another study showed that medication errors occur in nearly 1 of every 5 doses given to patients in a typical hospital with approximately 7% of those errors being rated as potentially harmful. This is an important outcome to focus on for patient safety issues because many adverse drug events (ADEs) are the result of medication errors (MEs) (Morgan, 2011).

A recent report by the Institute of Medicine (IOM) estimated that errors in medical management cause between 44,000 and 98,000 deaths each year in USA hospitals.3 In the USA it has been suggested that the rate of serious medication error is approximately 7%. Medication errors are not confined to the hospital setting. Reports from the Medical Defence Union and the Medical Protection Society revealed that 25% and 19%, respectively, of legal claims against general practitioners related to medication errors (IMS Department, 2008).

One of the prevalent forms of medication error is administration error. Drug administration is associated with one of the highest risk areas in nursing practice. The "five rights" have long been the basis for nurse education on drug administration i.e. giving the right dose of the right drug to the right patient at the right time by the right route (IMS Department, 2008).

Nurses are primarily involved in the administration of medications across settings. Nurses can also be involved in both the dispensing and preparation of medications (in a similar role to pharmacists), such as crushing pills and drawing up a measured amount for injections. Early research on medication administration errors (MAEs) reported an error rate of 60 percent, 34 mainly in the form of wrong time, wrong rate, or wrong dose. In other studies, approximately one out of every three Adverse Drug Events (ADEs) were attributable to nurses administering medications to patients (Hughes and Blegen, 2008).

In nursing internationally there has been growing concern regarding the numeracy skills of nurses in relation to drug calculations, fuelled by high profile research studies such as Gladstone (1995) and a proliferation of research studies examining the calculation skills of nurses and student nurses.(Wright, 2009).

The lack of basic maths skills can be a major problem when it comes to nurses administering drugs to patients. Calculations are still a significant source of drug error (Haigh, 2002). Hence, considering the undesirable effect of ill-drug administration (precisely in dosage calculation) to patients by nurses, the need for development of an assistive drug dosage administration application cannot be overemphasized.

2. DRUGS
Drugs are defined as "a substance intended for use in the diagnosis, cure, mitigation, treatment or prevention of disease; a substance (other than food) intended to affect the structure or any function of the body; and a substance intended for use as a component of a medicine but not a device or a component, part or accessory of a device (Hughes and Blegen, 2008).

3. MEDICATION ERRORS (MEs)

Medication errors have been a focus in healthcare since reports both in United States and the United Kingdom (UK) have highlighted the large number of errors occurring in hospitals (Wright, 2009). An error is an unintended action, either of omission or commission, or an act that does not achieve its intended outcomes (Morgan, 2011). Several definitions exist for the term 'Medication Error', however, a more general definition is:

Any preventable event that may cause or lead to inappropriate medication use or patient harm while the *medication is in the control of the health care professional, patient, or consumer (Hughes and Blegen, 2008).*

Further, Medication errors are broadly defined as incidents in which an error has occurred somewhere in the medication process, regardless of whether any harm occurred to the patient (Williamson, 2009). It can also be defined as any error in the prescribing, dispensing or administration of a drug whether there are adverse consequences or not, are the single most preventable cause of patient injury. These errors can occur at any stage in the drug use process from prescribing to administration to the patient (IMS Department, 2008).

The occurrence of medication errors can compromise patient confidence in the healthcare system and in addition, increase healthcare costs. Economic consequences may include the award of damages to the patient, extension of a patient's stay in hospital and the potential financial support required for long term care of a patient who suffers permanent injury. In the USA, it has been estimated that the cost of adverse drug events, a proportion of which are due to medication errors, was $5.6m per year for a 700 bed teaching hospital (IMS Department, 2008).

4. TYPES OF MEDICATION ERRORS

Medication process implies the process of delivering drugs to patients. It is a five stage process with each of the stages associated with potential error. Hence, we have five medication error types, namely:

(a) Ordering / Prescribing

(b) Transcribing and verifying

(c) Dispensing and delivering

(d) Administering

(e) Monitoring and Reporting (Hughes and Blegen, 2008).

5. ADMINISTRATION ERROR

A drug administration error may be defined as a discrepancy between the drug therapy received by the patient and the drug therapy intended by the prescriber. Drug administration is associated with one of the highest risk areas in nursing practice. The "five rights" have long been the basis for nurse education on drug administration i.e. giving the right dose of the right drug to the right patient at the right time by the right route. (IMS Department, 2008).

Leape, et al., showed where medication errors took place within the medication-use system and what percentage of those errors were intercepted before they reached the patient. (Morgan, 2011).

Table 1: Common places where MEs occur and ADE interceptance rate. (Morgan, 2011).

Task	MEs that Occurred	ADEs Intercepted
Physician ordering	**39%**	**48%**
Pharmacy dispensing	**11%**	**34%**
Transcription/verification	**12%**	**33%**
Nurse administration	**38%**	**2%**

In the same study, it was shown that wrong dose errors were the most common errors committed during nurse administration. By combining the data from the *Harvard Medical Practice Study* with the data that shows where errors most frequently occur and are detected, it becomes apparent that healthcare professionals need to focus their attention on drug administration as an area where patient safety can be improved and where the greatest yield can be realized (Morgan, 2011).

Nurses are primarily involved in the administration of medications across settings (Hughes and Blegen, 2008). Drug administration and preparation has been considered as an area of 'high risk' within nursing practice. Many drug administration errors are errors of omission but also include failure to check patient identity, ***incorrect administration technique*** and administration of a wrong or expired drug. The literature suggests that the medication error rate for administration of intravenous (IV) drugs may be as high as 25% and these errors have significant risk to patients. One of the most common types of error identified is 'deliberate violation of guidelines', for example, where practitioners have injected IV medication faster than the recommended time stated in the guidelines (Williamson, 2009). Early research on medication administration errors (MAEs) reported an error rate of 60 percent, mainly in the form of ***wrong time, wrong rate, or wrong dose*** (Hughes and Blegen, 2008).

6. DRUG DOSAGE ADMINISTRATION ASSISTANT (DruDAA)

Drug Dosage Administration Assistant (DruDAA) is a front-end application developed using C-Sharp (C#) programming language on Microsoft Visual Studio 2005. It offers a simplified and user-friendly interface which helps to address the difficulties associated with drug calculations by nurses (i.e. incorrect technique) which often results to wrong dosage administration (i.e. wrong rate, wrong dose).

Drug calculations appear to be impossibly difficult, unless you break them down into small steps. They are vitally important to get right, yet they are so easy to get wrong (Haigh, 2002). DruDAA employs the famous nursing equation: "What you Want, times what it's in, over What you've Got" (i.e. What you want * What it's in / What you've Got) in solving the difficulties associated with calculating drug dosage.

According to (Haigh, 2002), commonly used drug calculations and the way that mistakes can happen are classified into five (5) types, namely:

Type A Calculations

When the dose you want is not a whole ampoule. For example:

- Prescription states 200mg (milligrams)

- You have an ampoule of 500mg (milligrams) in 4ml (millilitres).

-What volume contains the dose you need?

If you have an ampoule of 500mg in 4ml, and you need 200mg, it can appear to be a daunting calculation. The first step is to find out what volume contains 1mg (4/500) and then multiply it by how many mg you want (200).

The easy way to remember this is the famous nursing equation:

'What you want, over what you've got, times what it's in'

In this instance:

200mg x 4ml / 500mg = 1.6ml

The common error here is to get it upside down, and divide what you've got by what you want. This fortunately gives you a stupid answer, which is obviously wrong, in this case 10ml. You already know that you need a fraction of an ampoule and not two and a bit ampoule, which highlights the error.

To help make sure you get it the right way up, remember WIG:

What you Want x what it's In / What you've Got

Type B Calculations

These are infusion rate calculations.

For example:

- Prescription states 30 mg/hour
- You have a bag containing 250mg in 50ml

Therefore, at what rate (ml/hr) do you set the pump?

These are the same as type A calculations, only once you have worked out the volume that contains the amount of drug you need, you set the pump to give that amount per hour.

In this instance, work out how many ml contain ONE mg of drug

Using the WIG equation

30 x 50 / 250 = 6ml

Therefore the calculation shows that, to give 30mg per hour, the infusion pump rate would need to be set at 6ml per hour.

Type C Calculations

Infusion rate is required, but dose is 'mg per kg'.

For example:

- Prescription states 0.5mg/kg/hour
- You have a bag of 250mg in 50ml
- Your patient weighs 70kg.

At what rate (ml/hr) do you set the pump?

To do this calculation you still use the WIG equation as above, but with one extra step to work out the 'what you want'.

First you need to convert the mg per kg into total mg by multiplying it by the patient's weight.

So for a person who weighs 70kg, 0.5mg per kg is the same as 35mg. Once you have calculated this, the infusion rate can be worked out as in the Type B calculations.

In this instance:

0.5mg/kg/hr x 70kg x 50ml / 250mg = 7ml / hr

Type D Calculations

Infusion rate required, but dose is in mg/kg/min.

For example:

- Prescription states 0.5mg/kg/min
- You have a syringe of 250mg in 50ml
- Your patient weighs 70kg

At what rate (ml/hr) do you set the pump?

As before, you will need to calculate what you want by multiplying the amount per kg by the patient's weight.

In this case:

0.5mg x 70kg = 35mg

This time, however, the prescription states the rate per minute. The pump demands that the rate be set in ml per hour, therefore the rate per minute will need to be converted before the equation can be completed, by multiplying 35 by 60; that is, 35mg/min (35 milligrams per minute) is converted to 2100mg/hr (2100 milligrams per hour).

From here, once again we use the type B calculation to find the infusion rate, which as shown will be 420ml/hr.

2100 x 50 / 250mg = 420ml/hr

Type E Calculations

Infusion rate is required, but the dose is in mcg/kg/min. For example:

- Prescription states 3 micrograms (mcg)/kg/min
- You have a syringe of 100mg in 50ml
- Your patient weighs 70kg.

At what rate do you set the pump (ml/hr)?

The Type E calculations are similar to Type D calculations as the only discrepancy in the prescription is the unit that precedes the …/kg/min which is in micrograms (mcg). Hence, by checking the check box and selecting corresponding Type D option under Dosage Computation Type section, this will allow for a type E calculation. More so, Type A-D calculations could as well have prescriptions stated in micrograms (mcg) too. Hence, DruDAA caters for drug calculations with prescriptions stated in micrograms, the user, only needs to select the checkbox labeled 'Unit in (mcg)…' and the corresponding type calculation under the dosage computation type section of the application.

All of these calculation types could be daunting task especially for nurses that lack basic maths skill. More so, increased nurse workload and distractions such as: call lights, physician rounds, clinical alarms are some latent failures within nursing which could cause serious errors.

7 HOW DruDAA WORKS

Once DruDAA executable file is installed successfully on the personal computer (PC), the application can be launched by clicking on the DruDAA icon which will display the application environment on the screen. It offers users options to perform Type A-D drug calculations. However, units of prescription in type A-D could as well be expressed in micrograms (mcg), it provides a selection checkbox to perform calculations with prescription unit in mcg which would also allow for a type E calculation to be performed.

DruDAA also captures important data which are of importance in drug administration such as: Nursing staff name and date of drug administration. More so, 'Patient dosage administration information' segment which includes: Patient's name, Prescription, Dosage Computation Type.

The 'supply values for Computation' segment is where user is expected to input the values required and specified in the prescription for correct computation with respect to type calculation as selected under the 'Dosage computation type' segment. Further, it presents four clickable action buttons which are: 'Compute Volume of dose / Pump rate' button, Print Button, Clear button and Exit button. Figure 1 is a display of the DruDAA platform when it is launched from a PC on which it is installed. All fields appear blank except for the date which is automatically displayed and is dependent upon the time settings of the PC on which DruDAA is installed. Dosage Computation Type selection will be determined by the dose prescription required to be administered to the patient by the nurse. This prescription needs to be captured in the prescription field of the DruDAA platform. Other information that needs to be supplied include the nursing staff name and the patient's name as stated on the prescription form given to the nurse. Once the nurse makes a selection of the dosage computation type, the values specified in the prescription form must be entered accordingly under the "Supply Values for Computation" section which is in three sections namely: 'What you Want', 'What You've Got' and 'What It's in'.

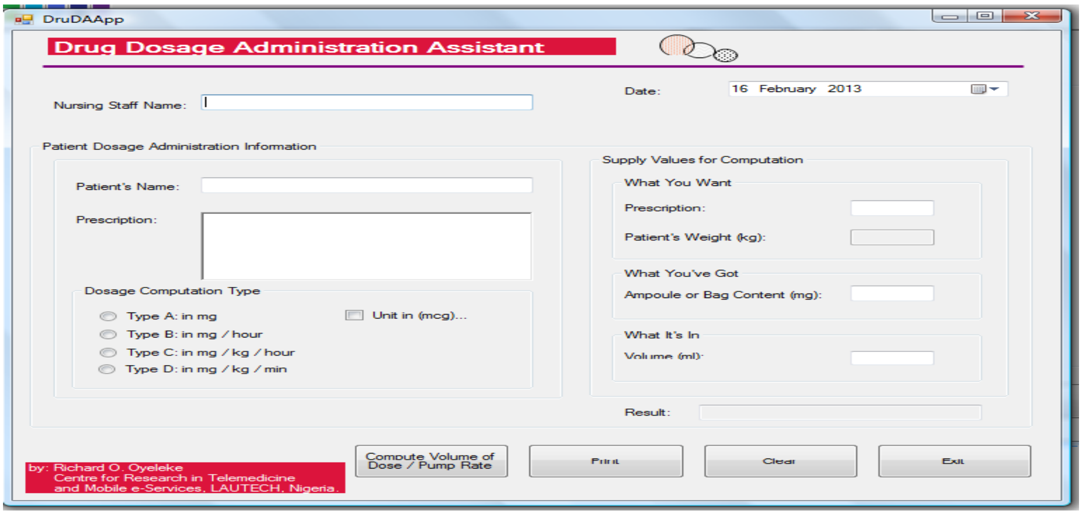

Figure 1: Drug Dosage Administration Assistant (DruDAA) Platform.

Volume of Dose / Pump rate' Button

Once the user supply all details as required in corresponding field and the values needed for the drug calculation type selected, a click action on this button yields the required result of the amount of dose to be administered and what rate.

Print Button

Drug administration errors may be minimised by the following: Checking patients' identity, having dosage calculations checked independently by another healthcare professional before the drug is administered and having the prescription, the drug and the patient in the same place so they can be checked against one another (IMS Department, 2008).

For the purpose of documentation, double-check on dosage to be administered and to trace error source, the print button, once clicked allows user to send all information and result of computation on the DruDAA platform to a printer to generate a hardcopy for future reference in order to identify the main source of error if there exist any.

Clear Button

This button clears the existing information on the DruDAA platform to allow for new entries for another patient.

Exit Button

This button is used to close the application program when no computation is required.

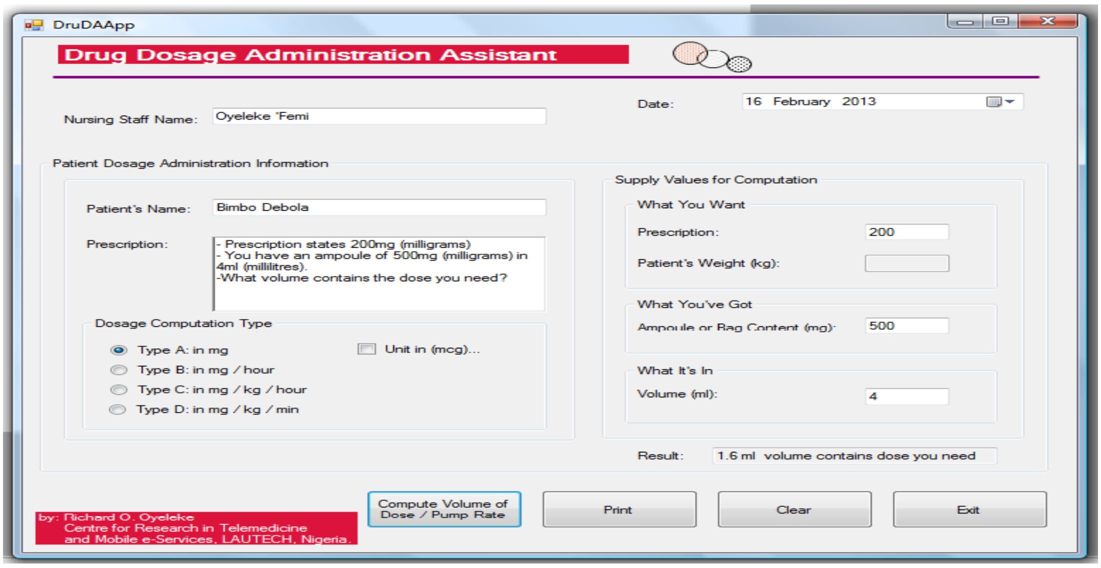

Figure 2: Patient Dosage Administration using Type A Drug Dosage Computation

Figure 2 shows an instance of drug administration made using DruDAA. It is an implementation of the Type A calculations stated earlier. The result of the computation as shown in the result field is the same as what we derived with computation by hand. However, the computation rigors have been eliminated. This to a large extent will help nurses who are deficient in maths' skill in dosage calculation.

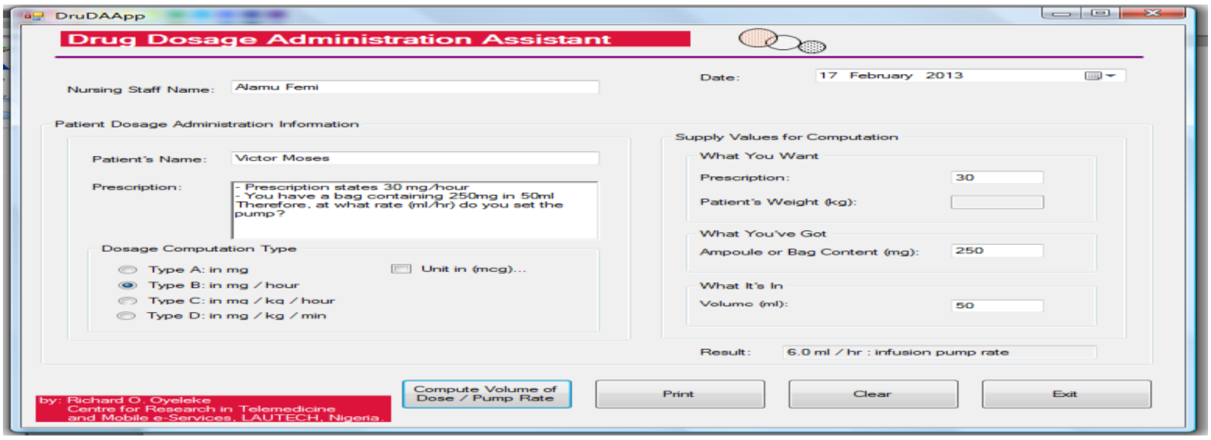

Figure 3: Patient Dosage Administration using Type B Drug Dosage Computation.

Figure 3 is an instance of Type B calculations done by hand as seen earlier. DruDAA presents simplified computation approach which helps nurses to easily interpret the prescription values accordingly and to avoid getting the calculations done upside down. Same result was obtained for the computation as seen in the result field but the approach is simple. It also emphasizes that results from DruDAA are reliable.

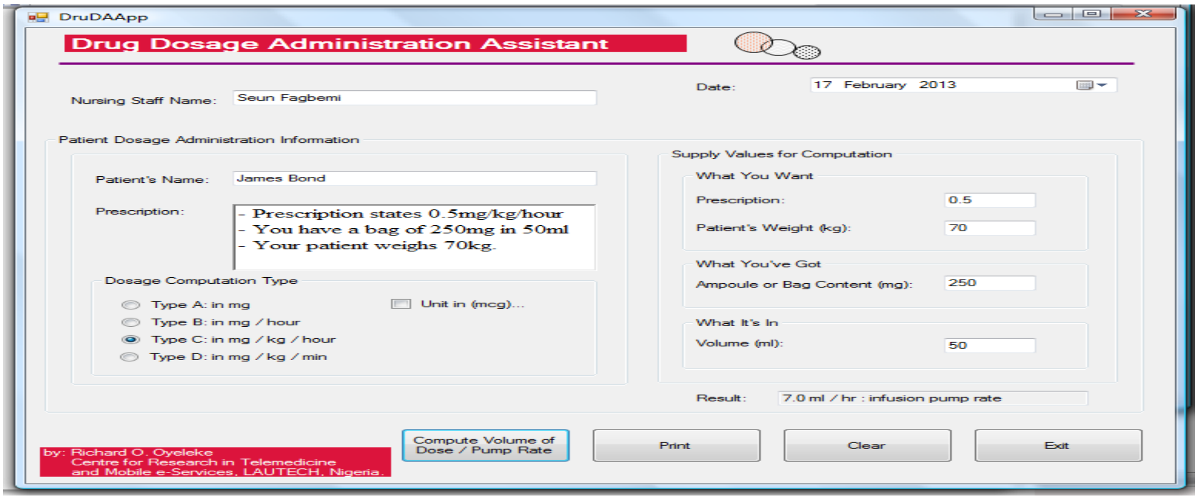

Figure 4: Patient Dosage Administration using Type C Drug Dosage Computation.

Figure 4 illustrates Type C calculations as discussed above using DruDAA. Aside from potential errors that may arise in perform calculation by hand, much time is invested. DruDAA will help nurses save much of the time involved in the calculation.

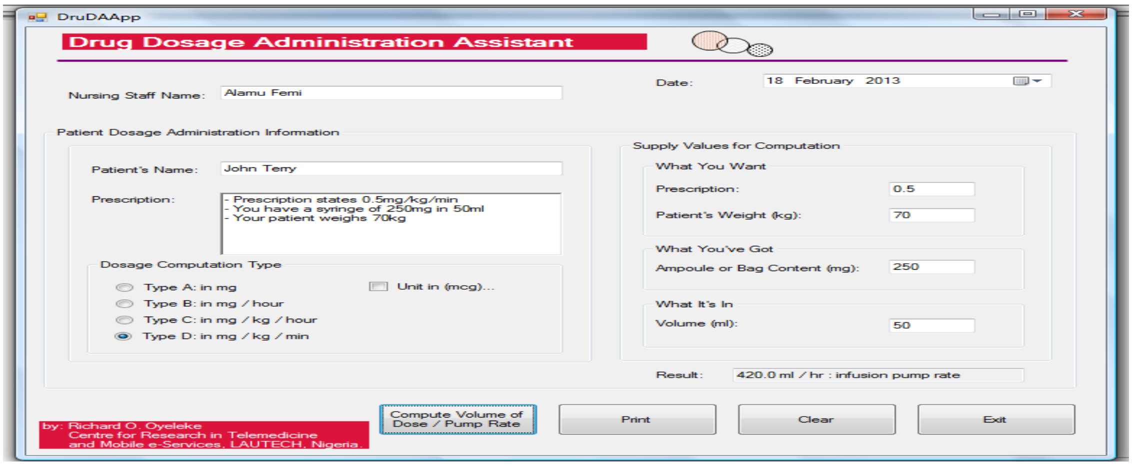

Figure 5: Patient Dosage Administration using Type D Drug Dosage Computation.

Figure 5 illustrates Type D calculations using the example stated earlier and same result was obtained as displayed in the result field textbox while still maintaining simplicity.

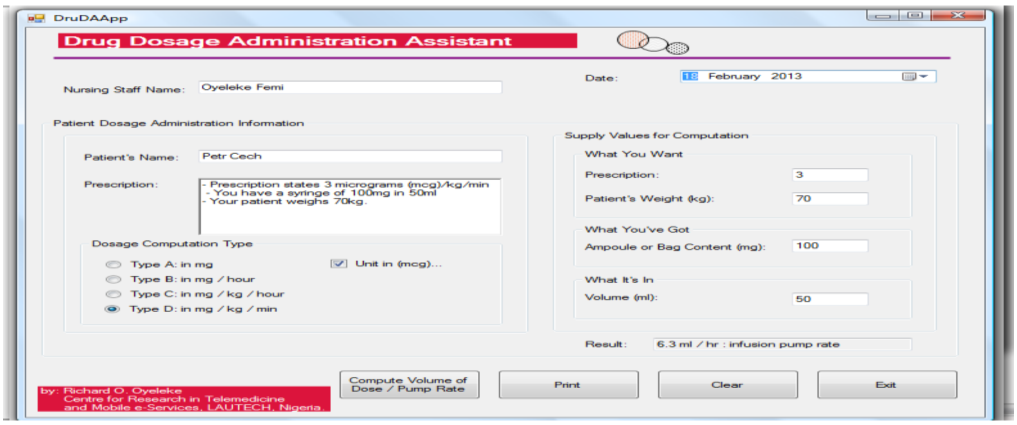

Figure 6: Patient Dosage Administration using Type E Drug Dosage Computation.

Figure 6 is an instance of Type E Calculations earlier stated. Here, the nurse needs to select both the Type D option and the checkbox labeled 'Unit in (mcg)…' to perform the required Type E calculations. Conversion from one unit to another can be daunting, especially for nurses who are deficient in basic maths skills, DruDAA takes care of the conversion without the nurse being involved as all that is needed are the right inputs for the right dosage computation type selection.

8. CONCLUSION

The potential for drug administration errors occurrence exist in healthcare systems and needs to be eliminated. Drug Dosage Administration Assistant (DruDAA) offers nurses assistance in computing drug dosage at the 'right dose' and at the 'right rate' for patients' administration. This emphasizes that results of dosage computation using DruDAA are reliable except for human error. Finally, DruDAA could be used as a double-check for dose calculations done by hand. Ultimately, it will help keep medication errors occurrence at the bare minimum.

9. REFERENCES

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