Implementation of Extemporaneous Preparation Using Bar Coding Technology
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ABSTRACT
Extemporaneous Preparation (Drug Compounding) - the creation of a drug product by mixing ingredients - is an important part of ensuring that medications are available to meet individual patient needs, the quality and extent of drug compounding have surfaced as important issues in recent years. For example, several compounding cases in the last several years have resulted in critical diseases and deaths, raising concern about observation to ensure the safety of compounded drugs.

This paper lays the groundwork for the development of Extemporaneous Preparation system. This system facilitates compounding process in systemic approach in the pharmacy of King Faisal Specialist Hospital and Research Centre - non profit tertiary care hospital- to prevent manual errors and improve patient safety and quality by using bar coding technology.

Indexing terms/Keywords
Extemporaneous Preparation, Drug Compounding.

Academic Discipline and Sub-Disciplines
Computer science; software engineering.

SUBJECT CLASSIFICATION
Information systems

TYPE (METHOD/APPROACH)
Software implementation.

BACKGROUND
Medication errors are popular in hospitals, and dispensing errors made in the pharmacy engaged extremely to these errors. Overall, dispensing error rates are relatively low, but because of the high volume of medications dispensed, more than 100 undetected dispensing errors may occur in a busy hospital pharmacy every day (1). Because only about one-third of these dispensing errors are intercepted by nurses before medication administration (2), many errors reach hospitalized patients, especially during preparation, mixing and labeling of medication before dispensing.

In details: Extemporaneous Preparation - a small scale pharmaceutical compounding as it related to pharmaceutics - includes preparation, mixing, packaging and labeling of certain medicines for internal or external use for human being in response to prescription that written by health care practitioner. For example, some of oral drugs are formulated for adults and presented as solid dosage forms or as liquids of unsuitable concentration for certain conditions or for children. Pharmacist prepared these formula by checking out references and doing calculation manually, which is usually consuming time and cannot role out of human errors. Therefore; dispensing errors are a significant target for patient safety intrusions.

It is worth to be mentioned; barcode technology became a committed strategy to prevent medication errors. Barcode technology has been widely adopted in healthcare fields, because of it’s a quick, easy to use and high reliability. In case to increase the accuracy of pharmacy dispensing, if all medications in pharmacy had a barcode that is scanned to ensure that right medication in its right dosage and formulation is being dispensed, dispensing errors will be ultimately reduced. On the basis of the theoretical benefits for patient safety, the U.S. Food and Drug Administration (FDA) has mandated barcodes for all medications used in hospitals by April 2006 (3). Many hospitals adopted this technology to increase the accuracy of the dispensing and administration processes.

LITERATURE REVIEW
There are many studies have emphasized the effect of barcode technology on medication dispensing errors.

Eric G et al. preformed direct observation - pre and post study - to evaluate whether implementation of barcode technology reduced dispensing errors. They performed their study over a twenty-month period in a 735-bed tertiary care academic medical center, where around 5.9 million dosages of medications were dispensed per year from inpatient pharmacy. They applied a bar coding dispensing system in 3 areas. In 2 areas, all dosages were scanned once through the dispensing process. In the third area, only one dosage was scanned if several dosages of the same medication were being dispensed. Of the three areas of bar code technology studied, the authors observed that the two areas that required staff to scan all dosages had a 93% to 96% relative reduction in the incidence of target dispensing errors. However, the area
that did not require scanning of every dosage had only a 60% relative reduction in the incidence of target dispensing errors. (3)

Michael et al. performed a cross-sectional survey of pharmacy directors at Canada’s 100 largest acute-care hospitals; to determine the uptake of technologies designed to improve medication safety, plans for endorsing technologies, attitudes towards technology use, and perceptions of medication error.

They found that 78% of surveyed hospitals responded. Responding hospitals averaged 499 beds and 29% were teaching facilities. Hospitals infrequently used bar coding (9% of hospitals) and computerized physician order entry (9%). A majority of respondents and hospitals favored expanded use of new technologies and planned for increased uptake. Respondents chose as their hospital’s next investment: automated dispensing (33%), bar coding (25%) and computerized physician order entry (12%). (4)

**PROBLEM DEFINITION**

While drug compounding is an important and useful for patient care, problems that have occurred during preparation raise concerns about the quality and safety of compounded drugs. Therefore; there is a need to implement Extemporaneous Preparation system that automates compounding manual process.

**OBJECTIVES**

To develop a system that will be able to organize compounding process in a systemic approach in terms of preventing human errors during the compounding preparation, avoiding time wasting for both pharmacist and patient and ensuring that the right medications were being dispensed by using bar-coding technology.

**METHODS**

− Using direct observation of compounding workflow - as defined below - at Pharmacy of King Faisal Specialist Hospital and Research Centre.

− Reviewing formula registration form.

− Collecting information by Interviewing with outpatient pharmacy manager.

**WORK FLOW**

When prescription of formula was presented to pharmacist or pharmacy technician, it follows several steps as following:

1. Pharmacist/technician check out available references to review how the formula can be prepared.
2. Calculating formula depends on the quantity needed.
3. Preparing the quantity needed by adding specific ingredients which checked again by another pharmacist/technician.
4. Documenting the prepared formula in a special form which signed by the one who prepared it and checked by another one.
5. Checking formula stability and calculating expiry date (considering near expiry date of ingredients).
6. Filling the prepared compounding in a jar/bottle.
7. Printing label that contains formula’s information (lot number, name, expiry date, storage method, instructions.)
8. Adhesive the label on the jar.

**SCENARIO**

S.A is four years old, girl, diagnosed with hypertension two years ago and she was on Captopril 2.5 mg oral twice daily, but still her blood pressure uncontrolled. Her’s doctor decided to increase dose to 5 mg twice daily. According to that, Her’s doctor prescribed for her Captopril 5 mg twice daily, for three months.

Her mother took the prescription and went to the pharmacy to take her daughter’s drug.

At the Pharmacy, Pharmacist/technician received prescription, checked the dose, after that, he/she start to prepare the drug.

The stock of Captopril available in the pharmacy is 25 mg and 50 mg tablet while the dose in the prescription is 5mg. The patient is a baby who cannot swallow tablet, so pharmacist/technician must follow compounding references to prepare Captopril syrup to dispense the required dose.

By Checking out preparation he/she found that; Captopril syrup final concentration is 1mg/ml; prepared by 4 tablets of Captopril 25 mg which are dissolve in 50 ml of water, add 1 tablet of ascorbic acid 500mg, then complete volume to 100 ml of water. Stability of preparation is 30days, that must be kept in refrigerator and shake before take it.

The patient needs 900 mg (900 ml) for three months, but the preparation stability is only 30 days, so pharmacist/technician will do the calculation to prepare one month only and give refill card for the other two months.
SYSTEM SCOPE

The main features of Extemporaneous Preparation project include the following:

1. Keeps tracking of formulas, where each formula will affix with a barcode of Type EAN-13. It will use picture 17 - screenshot as shown in Appendix A
2. Recalls medications form existing legacy system, which will use picture 18 - screenshot as shown in Appendix A
3. Keeps tracking of formula references. Reference will use picture 19 - screenshot as shown in Appendix A
4. Keeps tracking of prepared formula
5. Provides statistical reporting based on pharmacy area workload
6. Print human-readable labeling with barcode as picture 20 - screenshot shown in Appendix A and
7. The system must be accessed over all pharmacy divisions web based application.

SYSTEM ANALYSIS

1. USE CASE MODEL

Figure 1 Use case model
Use Cases Describing Processes

1. Use Case: Register Formula
Actor: Drug's Information Pharmacist.
Goals: To record formula with its information.
Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enter formula's information</td>
<td>3. Display confirmation that the formula has been recorded.*</td>
</tr>
<tr>
<td>2. Confirm information by selecting add command.</td>
<td></td>
</tr>
</tbody>
</table>

* Error message will be displayed if an error occurs while entering data.

1.1 Related Use Cases:

Use case: Add ingredients to formula (inclusion)
Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enter ingredients information</td>
<td>3. Display confirmation that the ingredients has been recorded to the formula.*</td>
</tr>
<tr>
<td>2. Confirm information by selecting add command.</td>
<td></td>
</tr>
</tbody>
</table>

* Error message will be displayed if an error occurs while entering data.

1.2 Related Use Cases:

Use case: Add Reference to formula (inclusion)
Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enter reference information</td>
<td>3. Display confirmation that the reference has been recorded to the formula.*</td>
</tr>
<tr>
<td>2. Confirm information by selecting add command.</td>
<td></td>
</tr>
</tbody>
</table>

* Error message will be displayed if an error occurs while entering data.

2. Use Case: Edit formula information
Actor: Drug's information pharmacist.
Goals: To modify formula information as required.
Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select Specific formula</td>
<td>2. Display formula information</td>
</tr>
</tbody>
</table>
3. Change formula information as required.
4. Confirm change information by select update command.
5. Display confirmation that the formula information has been updated

* Error message will be displayed if an error occurs while entering data.

### 2.1 Related Use Cases:

Use case: Modify ingredient information (inclusion)

Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Change ingredient information as required</td>
</tr>
<tr>
<td>2.</td>
<td>Confirm change information by selecting update command.</td>
</tr>
<tr>
<td>3.</td>
<td>Display confirmation that the ingredient information has been Updated.*</td>
</tr>
</tbody>
</table>

* Error message will be displayed if an error occurs while entering data.

### 2.2 Related Use Cases:

Use case: Delete Reference from formula (inclusion)

Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select specific reference.</td>
</tr>
<tr>
<td>2.</td>
<td>Select delete command.</td>
</tr>
<tr>
<td>3.</td>
<td>Display message if you are sure to delete reference from formula</td>
</tr>
<tr>
<td>4.</td>
<td>Confirm deletion</td>
</tr>
<tr>
<td>5.</td>
<td>Display confirmation that the reference has been deleted from formula</td>
</tr>
</tbody>
</table>

### 2.3 Use Case: Find Information about Specific Formula

Actor: Pharmacist /Technician.

Goals: To help pharmacist or technician to find formula information if he/she want to prepare it.

Steps:

<table>
<thead>
<tr>
<th>Actor actions</th>
<th>System Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Enter formula name/part of name and select search command</td>
</tr>
<tr>
<td>2.</td>
<td>Display formula information if it's exist*.</td>
</tr>
</tbody>
</table>

* Message will be displayed if it does not exist.

### 2.3.1 Related use cases:

Use case: Prepare Formula (inclusion)
Steps:

Actor actions
1. Select Prepare formula
2. Enter quantity needed and confirm by select add command.

System Responses

2.3.2 Related use cases:
Use case: Add ingredients to prepared formula (inclusion)
Steps:

Actor actions
1. Enter ingredient's information to prepared formula.
2. Confirm by selecting add command.

System Responses
3. Display confirmation that the ingredient's information has been added to prepared formula.

2.3.3 Related Use Cases:
Use case: Print label (inclusion)
Steps:

Actor actions
1. Select show label command.

System Responses
2. Display label information
3. Select print command
4. Print label

SEQUENCE DIAGRAM

Figure 2: Sequence Diagram showing Formula Registration Process
Figure 3: Sequence Diagram showing Add Ingredient to Formula

Figure 4: Sequence Diagram showing Reference registration to Formula Process

Figure 5: Sequence Diagram showing Modify Ingredient of specific Formula
DeleteReferencefromFormula
:GUI
:Reference_Registration
Find Reference (FormulaNo,RefID)
DeleteReference

Figure 6: Sequence Diagram showing Reference deletion from Formula Process

PrepareFormula(Formula_name)
:GUI
:Formula
:Formula_Registration
AddIngredientToPreparedFormula
Create:
Add_new_Formula
FindFormula(Formulaname)
Create

Figure 7: Sequence Diagram showing Prepared Formula Process
COMMUNICATION DIAGRAM

Figure 8: Communication Diagram showing Formula Registration Process

Figure 9: Communication Diagram showing Ingredient's Registration Process

Figure 10: Communication Diagram showing Reference’s Registration Process
GUI Ref: Reference Registration

1. Ref: Retrieve(RefNo) →

Reference Registration

2. delete(Ref) →

Reference Registration

Figure 11: Communication Diagram showing Reference deletion Process

Ingredient Registration

Ing=1: Find(FormulaNo, DrugCode)

GUI

3. EditIngredientInfo() →

Ingredient Registration

Ingredient Registration

Ing: Ingredient Registration

Find(FormulaNo, DrugCode) →

Figure 12: Communication Diagram showing Modify Ingredient of specific Formula
Figure 13: Communication Diagram showing Prepare Formula Process
ENTITY RELATIONSHIP (ER) DIAGRAM

Figure 14: Entity Relationship (ER) Diagram
CONCEPTUAL MODEL

Figure 15: Conceptual Model
### Figure 16: Class Diagram

```
CLASS DIAGRAM

Formula
- FormulaNo : Integer
- Formula_name : String
- Quantity : Double
- Validate_Date : Date
- Procedure_Steps : String
- Storage.Condition : String
- Instructions : String
- BarCode_No : String
  - RegisterFormula()
  - Edit_Formula_Information(FormulaNo)
  - Find_Specific_Formula(FormulaNo)
  - Add_Ingredient_To_Formula()
  - Delete_Ingredient_from_Formula(FormulaNo, DrugCode)
  - Assign_Reference_To_Formula()
  - Delete_reference_From_Formula(FormulaNo, RefNo)

Ingredients
- Quantity : Double

Drug
- DrugCode : Integer
- Generic_Name : String
- Brand_Name : String
- Description : String
  - AddDrug()
  - Edit_Drug_Information(DrugCode)
  - Find_Specific_Drug(DrugCode)

Reference
- RefNo : Integer
- Ref : RefType
- Author : String
- Additional_Information : String
  - AddReference()
  - FindReference(RefNo)

Unit_Form
- UnitNo : Integer
- Form : Char
  - Add_Unit_Form()

DosageForm
- FormNo : Integer
- Form : Char
  - Add_New_DosageForm()

EPS
  - Contains

Formula_Registration
- RegNo : Integer
- Quantity : Double
- EntryDate : Date
  - Prepare_New_Formula()
  - Find_Specific_Regisred_Formula(RegNo)

Formula_Ingredients_Preparation
- PrepararionNo : Integer
- DrugQuantity : Double
- LotNo : Char
- ExpiryDate : Date
- Manufacturer : String
  - Register_Medication_Droration(PreparationNo)

Pharmacy_Area
- AreaNo : Char
- Area_name : String
  - Add_New_Area()

Pharmacy_Staff
- PadNo : Char
- FName : String
- LName : String
- Password : Char
  - Register_New_Staff()

Registered_to
- PreparedBy

EnteredBy

Has

Contains

Class Diagram
```
IMPLEMENTATION

Visual Basic.Net has been used for implementing the system.

CONCLUSION

As noted earlier Extemporaneous preparation system was developed to prevent human errors during the compounding preparation, avoid time wasting for both pharmacist and patient and ensure that the right medications were being dispensed by using bar coding technology.

Developing the system goes through three stages: First, implementing new system that automates the repetitive and manual process of Drug compounding. Then Building database by recalling medications from existing legacy system and adding formulas information’s where each formula affixed with a barcode. Finally, integrating between new system and existing ScriptPro Robotic (Dispensary machine) which apply a barcode scanning technology along the way of dispensing to ensure that pharmacist is dispensing the right medication, strength, and dosage form to the right patient.

APPENDIX A

![Figure 17: Formula’s form](image1)

![Figure 18: Medication’s form](image2)
REFERENCES


5. Michael Saginur, Ian D. Graham , Alan J. Forster, Michel Boucher and George A. Wells The uptake of technologies designed to influence medication safety in Canadian hospitals. Evaluation in Clinical Practice ISSN 1356-1294

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