A NOVEL DECISION ALGORITHM FOR REDUCING MEDICATION ERRORS IN CPOE SYSTEMS

By

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Implementing Pop-Up Alerts Coupled with Confused Drug Names

And Doses within a CPOE to Prevent Medication Errors

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ABSTRACT

The projection of the U.S. national healthcare expenditure in year 2019 is $4.7 trillion. Medical errors are part of this increasing healthcare costs because they cause tens of thousands of deaths in the U.S. hospitals each year, more than major diseases such as AIDS, breast cancer combined to highway accidents (Chiang S. Jao, Daniel B. Hirer) [**10**]. Based on a research published in the British Medical Journal (BMJ) in 2016 and conducted by (*Michael Daniel* & *Martin A Makary)* [**98**], Medical error is ranked the third cause of death in the US.

With the advancement in technology, we have seen during the last years, important improvements in the design as well as the use of electronic health records (EHRs), Computerized Physician Order Entry (CPOE), and Clinical Decision-Support Systems (CDSS), and Diagnosis Decision-Support Systems (DDSS) to improve the quality of health care delivery; progress have been made but challenges remain. Medication errors can be:

- Wrong drug,
- Wrong dose,
- Wrong route,
- Wrong patient,
- Bad combination,
- Bad reaction

to list a few, and are found at every stage from prescription and administration of drugs to monitoring. They hurt about 1.5 million people, and cost billions of dollars each year

according to the Institute of Medicine of the National Academies. Medication errors can happen anywhere, from Doctors offices to hospitals, and pharmacies and your home.

Sound-Alike / Look-Alike also known as drug name errors, are the most common causes of medication errors, they originate from poor communication between health care providers, poor communication between patients and their providers. To reduce the likelihood of ham related to medications and Adverse Drug Events (ADEs), many interventions have been attempted including notably: The US Food and Drug Administration (FDA), government legislation, policy makers, drug utilization reviews, health professionals, and patients education, all of this with limited success.

The aim of this dissertation is to evaluate medication errors related to **Sound-Alike** drug names, and to propose a new approach of preventing them by **"Embedding the Novel Decision Algorithm" coupled with "Confused Drug Names, Generic and Brand drug names" and "Doses"** within a computerized provider order entry (CPOE) during the drug prescribing process.

DEDICATION

I wish to dedicate this dissertation to Dr. Melany Imbo. To my deceased parents Francisca Ngo Ndomb, Jean Mbenoun and Gertrude Ngo Mbongmam, thank you for being my role models. I will always be indebted for your unconditional Love.

Miss you !

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I have been blessed with managers Lori Knott, Oscar Jarquin, Daxa, Queen Smith, Rick Decker, friends and colleagues at Caltrans in Los Angeles that have made this journey less difficult. They have always cheered me up in difficult times. I truly thank you for your support. Thank you my friends in crime Ken Simon and Karim Salari.

I would also like to thank the U.S. Food and Drug Administration (FDA), the Institute for Safe Medication Practices (ISMP) for their advice in gathering the data used to create the Novel Decision Algorithm (**NDA**) database for this dissertation.

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STRUCTURE OF THIS RESEARCH

This research is divided into 8 chapters

- Chapter 1 Introduction to the Study: it covers the overview of the study, background of the study, problem statement, research questions and hypotheses , dissertation goal, relevance and significance, and various research barriers.

- Chapter 2 Literature Review: a survey of books, articles and other sources relevant to the area of this research. It also provides critical evaluation of previous studies in relation to the problem being investigated. This research area covers computerized provider order entry (CPOE), Clinical Decision Support Systems (CDSS), Sound-Alike / Look Alike, and Drug Safety Alerts.

- Chapter 3 Creating the Novel Decision Algorithm Database : This chapter covers the design, development, implementation and test cases of the database where data to support the Novel Decision Algorithm application is stored.

- Chapter 4 Designing, Developing, Implementing and Testing Novel Decision Algorithm Embedded in a CPOE: It examines and covers the design and implementation of this module on a stand-alone system or, integrated in a CPOE; In this chapter we also design and run Test Cases to support the effectiveness of the proposed module.

- Chapter 5 Contrasting Existing and Proposed Systems: This chapter discusses key differences between the two systems.

- Chapter 6 Discussion : In this chapter we discuss the Dissertation Research Question to answer the question whether or not "The Novel Decision Algorithm (NDA) system could Lower Medication Error Rate Caused by LASA and Drug Confused Names ? "

- Chapter 7 Adverse Drug Events (ADEs) : This chapter presents a statistical analysis of Adverse Drug Events (ADEs) in U.S. Hospitals in 2014. This statistical brief covers from the admissions to the hospital to the hospital stays, to the discharges, to patients demography, cost analysis etc…

- Chapter 8 Conclusion: The Final Statement, Research Limitations, Future Work, and Recommendations will be discussed in this chapter.

CHAPTER I

INTRODUCTION TO THE STUDY

1.1 Introduction

Medication names that look alike or sound alike are serious problems in healthcare and account for 29% of medication dispensing errors. More than 770 000 people are injured by medication errors and cost $177 billion each year. In the United States, name confusion is a contributing factor in 15-25% of all medication errors and responsible for 10 000 patient injuries each year [**20**]. As of June 2015, the US FDA has received 50 reports of medication error cases describing brand name confusion with *Brintellix* and *Brilinta*. Most of the cases reported concerns that similarities in the **sound**, **look**, or **both sound** and **look** of the two brand names could cause confusion for prescribers and pharmacists [**31**]." *An example of a medication error is taking over-the-counter products that contain acetaminophen (Tylenol, others) when you're already taking a prescription pain medicine that contains acetaminophen, possibly exceeding the recommended acetaminophen dose and putting yourself at risk of liver damage*" [**9**]. Medication errors reported to the U.S. FDA may stem from:

- Misinterpreted handwriting;
- Confusing drug labels,
- Labeling, and packaging,

- Lack of employee knowledge,
- Lack of patient understanding about a drugs directions, and
- Sound-Alike / Look-Alike also known as drug name errors.

Over the past decade, we have seen major changes in the health care system, notably in the design, adoption and implementation, and use of the electronic health records (EHRs), Clinical Decision Support Systems (CDSS), and Computerized Physician Order Entry (CPOE). Clinical Decision Support Systems are known as active knowledge systems that use case-based reasoning to assist clinicians in the way they:

- Assess diseases status,
- Make diagnosis, and
- Select the right treatment (Chiang S. Jao, Daniel B. Hier) [**10**].

Since the late 1950s to now-a-days, Decision Support Systems have greatly influenced the domain of E-prescribing systems, and computerized physician order entry, and Medication reconciliation. Researchers and healthcare industry have acknowledged the potential of these systems to improve the quality of health care delivery and especially patient safety, while reducing costs to the medical system. As a result, the Centers for Medicare and Medicaid Services (CMS) made available an incentive payments to eligible professionals (EPs) and hospital who adopt, implement, upgrade, or demonstrate meaningful use of certified electronic health record (EHR) technology [**22**]. According to a survey conducted by the Leap FrogGroup: “In 2014, an all-time record of 1,339 hospitals reported using a CPOE system in at least one patient unit, compared to 384 in 2010”. Consequently, only a slight decline of medication errors

from 15.2% in 2013 to 13.9% in 2014 was observed. Thus additional improvements are still needed [**23**].

The goal of this dissertation is to **reduce the likelihood of harm related to Sound Alike medication errors** by "**Embedding the Novel Decision Algorithm**" coupled with "**Confused Drug Names, Generic and Brand drug names**" and "**Doses**" within a computerized provider order entry (CPOE) during the drug prescribing process.

1.2 Background

1.2.1 A review of the area being researched

1.2.1.1 Medication errors

1.2.1.2 Clinical Decision Support Systems (CDSS)

1.2.1.3 Computerized Physician Order Entry (CPOE)

1.2.1.4 CDSS / CPOE

1.2.1.5 Sound Alike

1.2.1.6 Pop-Up Alerts

1.2.1.1 Medication errors

1.2.1.1.1 Medication error definition:

According to the National Coordinating Council for Medication Error and Prevention (NCCMERP), a medication error 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. Such events may be related to professional practice, health care products, procedures, and systems including: prescribing; order communication; product labeling, packaging*

and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use" [**40**].

Patient safety is a worldwide public health issue. Many patients are harmed every day while receiving care, impacting unfortunately their safety.

1.2.1.1.2 When do Medication Errors occur ?:

Medication errors occur in all the steps of the medication management process [38] as showed in **Table1** below. Those steps are as followed:

- **Prescribing**: the clinician must select the appropriate medication and the dose frequency at which it is to be administered
- **Transcribing**: the clerk must read the order correctly and communicate it to the pharmacist
- **Dispensing**: the pharmacist must check for drug interactions and allergies, then release the appropriate quantity of the medication in the correct form
- **Administrating**: the nurse must receive the medication and supply it to the correct patient (PSNET) [**47**].

Table 1: Steps, Errors, Rates, and IT Systems in Medication Management

Stage	Error rate %	Intercept rate %	True error rate %	Relevant IT systems
Prescription	39	48	22	CPOE with decision support Electronic medication reconciliation

Transcription	12	33	11	Automated transcription
Dispensing	11	34	10	Robots, automated dispensing cabinets
Administrating	38	2	51	Bar-coding, electronic medication administration
CPOE, computerized physician order entry				

Source: http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2125.2009.03427.x/full

Table 1 *above describes the various steps in a typical medical management process, the estimated error rate for each step, and the true error rate based on the likelihood that the error will be intercepted. Since medication administration is the last step in the process, the intercept rate is understandably very low. The last column shows IT Systems that target each step in the process*

Medication errors are part of the increasing healthcare costs because they cause tens of thousands of deaths in the U.S. hospitals each year, more than major diseases such as AIDS, breast cancer combined to highway accidents [**10**].

1.2.1.1.3 Major Reasons for Medication errors:

Three major reasons may explain the why of medication errors:

- **Human factor:**

  Medication error originating from human are a result of human imperfection, because no one wants to make an error, especially an error that hurts. Besides human imperfection, one can cite the following reasons for medication errors:

- Overwork and fatigue,
- Inadequate or lack of training,
- Shortages of healthcare personnel (Physicians, Nurses, Pharmacists …)

- **Poor/Obsolete systems design**:

Poor and or Obsolete systems design also contributes to medication errors. The amount of healthcare data is skyrocketing, making the process of patient information harder and harder. A wide gap exists between what should be done (evidenced-based medicine) and what is in fact being done. Not all healthcare settings have clinical decision support systems (CDSS) to help in the prevention and detection of errors.

Lack of a centralized and standardized healthcare database prevent from sharing information about the patients as computers do not communicate with one another, keeping sometimes **partial** healthcare data locally.

- **Use of archaic practices**:

Prior to using computer systems, especially Computerized Physician Order Entry (CPOE), prescriptions and drug orders were handwritten. Because of **poor handwriting**, reading prescription was hard, thus leading to misreading, and confusion. Another archaic method is **Verbal Orders**; this practice leads to misinterpretations and confusion of names (Sound - Alike) drug names [**2**].

1.2.1.1.4 Preventing Medical Errors

Medical errors happen during

- Treatments,
- Diagnoses,

- Medication (prescription and administration of drug) to list a few.

Medical errors have important implications for patient safety therefore, identifying them is crucial in order to reduce or eliminate their risks of harm. General speaking, ***an early detection always greatly increases the chances of success treatment***. It is a fact that while medications can improve patients health, the process of prescribing them is complex. Computerized provider order entry (CPOE) with clinical decision support systems can improve medication safety because CPOE introduces automation at the time of ordering, then the knowledge-based clinical decision support (CDS) review assures that the order is safe and compliant with guidelines [**26**]. The pathway for preventing medication errors is presented in the **table** below as well as the appropriate strategy for adverse drug events prevention:

Table 2: Strategies to prevent adverse drug events

STAGE	SAFETY STRATEGY
Prescribing	• Avoid unnecessary medication by adhering to conservative prescribing principles • Computerized provider order entry, especially when paired with clinical decision support systems • Medication reconciliation at times of transitions in care
Transcribing	• Computerized provider order entry to eliminate handwriting errors
Dispensing	• Clinical pharmacists to oversee medication dispensing process • Use of "Tall Man" lettering and other strategies to minimize confusion between look-alike, sound-alike medications
Administration	• Adherence to the " Five Rights" of medication safety (administering the Right Medication, in the Right Dose, at the Right Time, by the Right Route, to the Right patient) • Barcode medication administration to ensure medications are given to the patient • Minimize interruptions to allow nurses to administer medication safely • Smart infusion pumps for intravenous infusions • Patient education and revised medication labels to improve patient comprehension of administration instructions

Source: https://psnet.ahrq.gov/primers/primer/23/medication-errors

1.2.1.1.5 Detecting medical errors

Detecting medical errors is a very important step in the process of reducing the risks of harm. The following table (**Table 3**) presents the majors methods of errors detection:

- Chart review
- Claims data
- Incident reporting (sentinel events)
- Voluntary reporting
- Administrative data examination
- Computer monitoring
- Direct care observation
- Patient monitoring

Table 3: Detection Methods used to investigate medication errors and adverse events

Method	Advantages	Limitations	Efficacy	Costs
Chart review	Retroactive; disposable data; commonly used; standardized criteria; poor at capturing latent failures	Difficult; time-consuming; labour intensive; planning criteria/indicators necessary	Gold standard to detect adverse events; less medication errors detected; reviews, papers	Reviewers' training and time (nurses, pharmacists, students, physicians)
Claims data	Local data; captures latent failures	Litigation based; legal implications	Adverse events detected	Reviewers' training and time
Incident reporting (sentinel events)	High-quality data; root cause analysis due; captures active and latent failures	Only detects severe, unexplained events/deaths; underestimated rates (blame and fear of punishment)	Reports and alerts; detects adverse events; less medication errors detected	Root cause analysis
Voluntary reporting	Variety of sources; structured simple form; Captures active and latent failures; promotes a culture of safety	Variable quality; underreporting; blame culture; problem of data integration	Reports and alerts; feedback and corrective actions; medication errors detected	Time for feedback and analysis
Administrative data examination	Disposable and retroactive data; easy; standardized	Absence of clinical data	Statistical	Routine evaluation
Computer monitoring	Multidata source integration; real time; adverse events prevention	Inserted errors; poor software; poor triggers; undetermined future risks	Prescribing faults, prescription errors, and dispensing errors (CPOE)	High costs for software and implementation
Direct care observation	Accurate; captures active errors	Time-consuming; training difficult;	Good quality data about administration errors	Nurse training
Patient monitoring	Data from outpatients; wide impact	Not standardized tools (interviews, questionnaires, focus groups, etc)	Future development	Nurse training

Table 1: (Germana Montesie, Alessandro Lechi (2009))

1.2.1.1.6 Best Detection Methods

A) Adverse Drug Events

Adverse Drug Events are injuries that result from the use of a drug. Best methods to use for their detection are:

- Chart review,
- Computer monitoring,
- Incident reporting and Claims data;

B) Medication Errors

The following are methods to use to detect medication errors:

- Direct observation,
- Voluntary reporting (by doctors pharmacists, nurses, patients and others), and
- Chart review, are best methods used for detection [**4**].

1.2.1.2 Clinical Decision Support Systems (CDSS)

The term "clinical decision support system" has been defined in many ways. According to Chiang S. Jao, and Daniel B. Hier, a "*CDSS is a computerized system that uses case-based reasoning to assist clinicians in assessing disease status, in making a diagnosis, in selecting appropriate therapy or in making other clinical decisions*" [**10**].

A typical CDSS suggests default values for drug doses, routes of administration, or frequency and may offer more sophisticated drug safety features such as checking for drug allergies or drug–drug or even drug–laboratory (e.g., warning a clinician before ordering a *nephrotoxic* medication in a patient with elevated *creatinine*) interactions.

For instance if a physician enters an EHR order for morphine for post-operative pain, and the patient is allergic to morphine, EHR alone does not prevent the order from

being entered or executed; it is the addition of CDSS which prevents the EHR from accepting the order for the drug and notifies the clinician that the patient is allergic to morphine. The system would then ask if the physician wants to prescribe the drug anyway or suggest alternatives that may work for the patient [**64**].

At the highest level of sophistication, CDSS prevents not only errors of commission (e.g., ordering a drug in excessive doses or in the setting of a serious allergy), but also of omission. (For example, an alert may appear such as, "You have ordered *vancomycin*; would you like to order serum vancomycin level after the third dose?") (PSNET) [47].

1.2.1.2.1 Benefits of CDSS

Among other benefits, clinical decision support systems can:

- Help physicians reach appropriate diagnoses, perform the correct assessment, and execute appropriate tests on the front end of the decision making process, preventing errors of omission, also stop errors of commission on the back end during treatment (Neil Versel, 2011) [**84**].
- Lower cost
- Improve efficiency
- Reduce patient hassle

We have seen noticeable improvement in the quality of health care notably in pharmaceutical medicine since computer systems support (e.g.: Clinical Decision Support Systems) are in use.

CDSS aims to assist, rather than replace the clinicians. It may offer suggestions, but it comes to the clinicians to review the information and make appropriate decision.

The following table provides examples of CDSS that address a range of target areas (Eta S. Berner, Ed. D.(2009) [**85**].

Table 4: Examples of CDS interventions by target area of care

Target Area of Care	Example
Preventive care	Immunization, screening, disease management guidelines for secondary prevention
Diagnosis	Suggestions for possible diagnoses that match a patients signs and symptoms
Planning or implementing treatment	Treatment guidelines for specific diagnoses, drug dosage recommendations, alerts for drug-drug interactions
Follow up management	Corollary orders, reminders for drug adverse event monitoring
Hospital, provider efficiency	Care plans to minimize length of stay, order sets
Cost reductions and improved patient convenience	Duplicate testing alerts, drug formulary guidelines

Table 1: *Examples of CDS interventions by target area of care* (Eta S. Berner, Ed. D. (2009) [**85**] Retrieved from: https://healthit.ahrq.gov/sites/default/files/docs/page/09-0069-EF_1.pdf

1.2.1.2.2 Trends of Clinical Decision Support Systems

One of the major trends of clinical decision support systems is related to Patient Safety Confidentiality. How to make sure that patient Safety and Quality improve? Patient Safety and Quality Improvement Act (PSQIA) helps create an environment where the reporting and analysis of medical errors is encouraged. PSQIA has become effective on January 19, 2009 (HIPPA) [**86**].

CDSS help improve clinical diagnostic, reduce unwanted testing, and diagnostic errors. However, clinical decision support systems face significant barriers to their implementation as shown in the following table:

Table 5: Common barriers to integrate research evidence into clinical practice

Categorized Barriers	Potential Impacts to clinical practice
Evidence-Related	
• Lack of supportive research evidence	• Decision may not be able to draw an acceptable conclusion or judgment
• Incomplete or contradictory evidence • Inaccessible evidence at the point of care	• Decision may be infeasible to the clinical case • Evidence could be not be reached to assist practitioners in decision making
Clinician-Related	
• Lack of in-depth knowledge in the specific nature of evidence	• Could not make full use of evidence to the specific type of a diagnostic problem
• Failure to use the CDSS or non - acceptance of computerized recommendations	• Could not efficiently manipulate evidence or adapt recommendations to accommodate the variance of diagnoses
• Obedience to others diagnostic decision	• Will not employ independent analytic thought and reasoning on evidence
System-Related	
• Multiple requirements (e.g., billing and EMR) converge to stress clinicians for coding patients disease with accurate diagnoses	• Throughput -oriented concerns may discourage the deliberate processes of analytic diagnostic thinking
• External incentive s (e.g., reimbursement, patient satisfaction, quality demerits , malpractice) through the use of research evidence	• Desire for rewards or fear of punishments may influence diagnostic strategies more strongly than analytic thought using research evidence
• Poor usability or integration into practitioners workflow	• Good system performance depends on the motivational effect of the developers enthusiasm, creation of more usable and integrated software, better access to technical support and training, and improved on-site promotion and tailoring

[65].

Retrieved from :http://www.intechopen.com/books/decision-support-systems/clinical-decision-support-systems-an-effective-pathway-to-reduce-medical-errors-and-improve-patient-#article-front

1.2.1.2.3 Categories of Clinical Decision Support

There are two major categories of clinical decision support systems:

- **Diagnostic support tool which helps physicians in their daily tasks**
  - Prescribe medications,
  - Make better diagnosis
  - Medical records etc…
- **Treatment support tool which helps clinicians**
  - Stay away from known drug iterations
  - Providing the right medication to the right patient
  - Change catheters on time (Michael J. Yuan) [**83**].

Those Clinical Decision Support, especially medication-related Decision Support are introduced into healthcare in two stages: basic and advanced

Basic decision support systems include:

- Drug allergy checking
- Basic dosing guidance
- Formulary decision support
- Duplicate therapy checking
- Drug interaction checking

Advanced decision support systems include:

- Guidance for medication-related laboratory testing
- Drug pregnancy checking
- Drug disease contraindication checking [**26**].

The following figure shows key elements of a clinical decision support system:

Figure 1: Key Elements of a Clinical Decision Support System

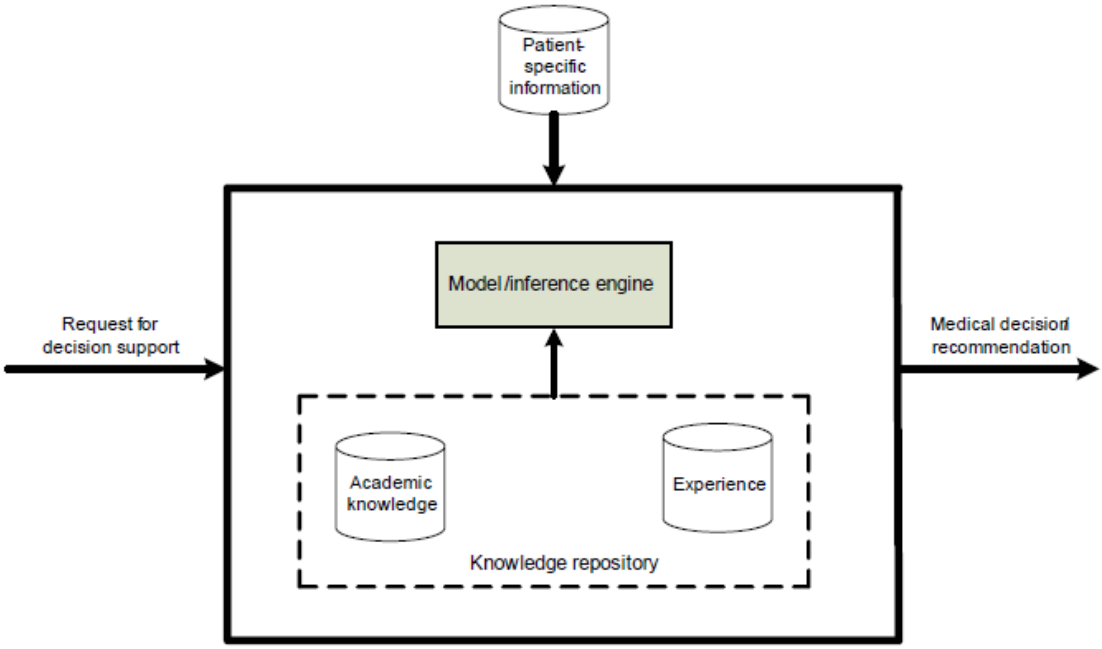

Fig 1. Clinical decision support systems (CDSS)
Omar F. El-Gayar; Amit deokar; Mattew Wills (2008). P. 353

1.2.1.2.4 Challenges in implementing clinical decision support systems

Even if clinical decision support systems have a positive impact on healthcare, they also have clinical and technical challenges for their implementation that need to be addressed:

- **Clinical challenges**

  Clinical decision support systems (CDSSs) have been largely successful in the following two sectors of the healthcare domain: Pharmacy (Prescription ordering systems do checking of orders for negative drug interaction and report warning to the ordering professional) and Billing (Claims filing, Medicare reimbursements for hospitals and other healthcare providers).

  Despite this success, widespread adoption has still not yet achieved because most of the time, these systems are stand-alone applications, meaning that the user has to stop performing his/her current task(s), switch to the clinical decision support system, then enter and submit data in order to receive the desired information. As we can see, the use of these systems is costly in time, and then it breaks users workflow into sections.

- **Challenges related to privacy**

  What information (medication, laboratory and diagnostic test results, clinical notes) should be shared with patients?

- **Technical Challenges**

  In regards to technical challenges, the clinical decision support systems may have to handle a large amount of data especially when working with biological systems. Another technical issue is maintenance. These systems are not easy to update, they require significant expertise and effort

- **Future Challenges**

  With the evolution of information technology, it is now possible to develop more sophisticated computerized-based applications that utilize

information available in the EMR. It is too premature to consider those new CDSS clinically useful, also they might be of poor quality for not being fully tested.

1.2.1.2.5 Impacts and effectiveness of CDSS

There is no one-size-fits-all approach in the selection of a given design approach of effective Clinical Decision Support Systems (CDSS) because clinicians often differ in their preferences. Measuring the quality of care is not an easy thing. Even though studies confirm the ability of CDSS to prevent medical errors, the ability to avert adverse drug event is controversial. In general, the degree of satisfaction depends on factors such as:

- Match of CDSS to user intentions or expectations
- User control. Disruptiveness, and risk
- Integration of CDSS into work processes [**5**].

1.2.1.3 Computerized Physician Order Entry (CPOE)

According to the Leapfrog Group, Computerized physician order entry (CPOE) systems are "*electronic prescribing systems that intercept errors when they most commonly occur at the time medication are ordered.* ***With CPOE, physicians enter into a computer rather than on paper****. Orders are integrated with patient information, including laboratory and prescription data. The order is then automatically checked for potential errors"* [**23**].

1.2.1.3.1 Definition of CPOE

Over time, CPOE as a concept has evolved. The term "CPOE" has been defined in many ways: In 2003, Harvard researchers defined CPOE as *. . . a variety of computer-based systems that share the common features of automating the medication ordering process and that ensure standardized, legible, and complete orders*.[**63**].

1.2.1.3.2 Advantages of CPOE

Computerized physician order entry (CPOE) systems has numerous advantages. According to Koppel R, Metlay JP, Cohen A, et al [**78**], some of those advantages are as followed:

- Free of handwriting identification problems
- Faster to reach the pharmacy
- Less subject to error associated with similar drug names
- More easily integrated into medical records and decision-support systems
- Less subject to errors caused by use of apothecary measures
- Easily linked to drug-drug interaction warnings
- More likely to identify the prescribing physician
- Able to link to ADE reporting systems
- Able to avoid specification errors, such as trailing zeros
- Available and appropriate for training and education
- Available for immediate data analysis, including post marketing reporting
- Claimed to generate significant economic savings
- With online prompts, CPOE systems can
    - Link to algorithms to emphasize cost-effective medications

- Reduce underprescribing and overprescribing
- Reduce incorrect drug choices

1.2.1.3.3 Benefits of CPOE

Developing an in-house CPOE system or purchasing a commercial one is costly, but the benefits or return on investment (ROI) after their acquisition vary from patient safety to cost reduction and quality improvement, to improved coding and billing [**63**]. As noted by Tierney et al (1993) [**79**], the use of CPOE linked to an electronic health records (EHRs) resulted in a decrease of $887 (12.7%) per admission, based on a study conducted at the Brigham and Womens Hospital (BWH) [**79**]. As reported by Tech JGlaser (1996) [**80**], BWH estimated net savings of $5 to $10 million per year after implementing CPOE system [**80**]. The following table lists some benefits of CPOE.

Table 6: Benefits of CPOE Implementation

Benefit	Details	Citation
Medical error reduction	Meta-analysis study in 2008 estimated 12.5 percent reduction in medication errors, or about 17.4 million medication errors averted in the United States in one year by using CPOE.	Radley et al. (2013)
	Prescribing errors decreased 91 percent with implementation of CPOE.	Aronsky et al. (2007)
Cost reduction	Brigham and Women's Hospital saved $28 million over the course of 10 years by reducing medical errors and ADEs.	Kaushal et al. (2006)
CDSS integration	Alert systems prevented a significant amount of potentially inappropriate medication orders, with the number of inappropriate orders dropping by 20 to 30 percent.	Mattison et al. (2010)
	Drug interaction checks, drug allergy checks, and prompts for the provider about when to order a service for a patient reduced ADEs 7 to 10 times out of every 100 hospital admissions.	Kaushal and Bates (2013)
	CPOE with CDSSs decreased prescribing errors or ADEs as much as 55 to 86 percent.	Bates (2010); Georgiou et al. (2013)
Duplicate test check	Physicians have instant access to their patients' EHRs and their prior test results.	Callen et al. (2006)
	Checking for tests that had been performed saved $92,000 per year.	Levick et al. (2013)
	Once a test has been selected, alerts let the physician know if that patient has previously had the test done.	Baron and Dighe (2011)
Interruptive/noninterruptive pop-ups	Interruptive alerts only pop up for serious issues, whereas noninterruptive alerts pop up for issues that are not crucial.	Baron and Dighe (2011)

Table 2: Benefits of CPOE Implementation; Retrieved from : http://perspectives.ahima.org/can-utilizing-a-computerized-provider-order-entry-cpoe-system-prevent-hospital-medical-errors-and-adverse-drug-events/#.VtKz_ebLKew

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1.2.1.3.4 Disadvantages of CPOE

Like every other thing, computerized physician order entry (CPOE) has advantages and disadvantages. Some of CPOE systems disadvantages include:

- The cost of implementing CPOE is high, in the order of millions of dollars
- The cost of CPOE maintenance is high, $500,000 annually [**63**]
- CPOE systems crashes may prevent users from achieving their daily task using CPOE
- Data loss caused by CPOE crashes might lead to financial expenses
- Reentering data after CPOE systems crashes might lead to financial expenses
- Resistance to change

1.2.1.3.5 Barriers in implementing CPOE

Barriers that faces the implementation of a CPOE are the same when comes to integrating a new module within a CPOE or implementing a stand-alone application. According to a research conducted by the Leapfrog Group in 2015, various barriers for implementing a CPOE range from

(1) Financial: the upfront cost of development and implementation of CPOE,

(2) Technical: the significant amount of customization after implementation,

(3) Cultural: the resistance of change as some physicians resist utilizing computerized decision-support tools, relying instead on practice experience [**32**].

The following **table** summarizes some barriers to implementing CPOE [**82**].

Table 7: Barriers to CPOE Implementation

Barrier	Details	Citation
Cost	CPOE implementation cost ranged from $1.3 million in critical care and rural hospitals to $4.4 million in urban hospitals.	Ohsfeldt et al. (2005)
	Brigham and Women's Hospital spent $11.8 million dollars to implement CPOE.	Kaushal et al. (2006)
	Cost was found to be the number one barrier to adopting CPOE.	Goldzweig et al. (2009)
Physician hesitation	Patient satisfaction does not decrease with physicians using CPOE systems.	Irani et al. (2009)
Lack of system interoperability	Lack of interoperability with other systems hinders the physician's ability to access a patient's medical record.	Yaffee (2011)
User errors	Errors include selecting the wrong dosage route, inappropriate product, or incorrect dosage and missing drug allergies. Prescribing errors occur in 0.3 to 39.1 percent of medication orders for hospital inpatients, and harm due to prescribing errors has been reported in approximately 1 percent of inpatients.	Reckmann et al. (2009)

ADE, adverse drug event; CDSS, clinical decision support system; CPOE, computerized provider order entry.

Table 3: Barriers to CPOE Implementation ; Retrieved from: http://perspectives.ahima.org/wp-content/uploads/2014/09/CanUntilizingaCPOESystem_Table3.pdf

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1.2.1.3.6 Impacts of CPOE on medical errors

With no doubt, computerized physician order entry systems (CPOE) can reduce the number of medication errors and adverse drug events (ADEs) in healthcare institutions [**25**]. CPOE systems are designed to automatically intercept errors at the time the prescribing order is entered, or through the drug-use process that starts from the physician prescriber, followed by the pharmacist reviewer and dispenser of the actual drug [**27**].

The following paragraphs talk about a study that was conducted in a tertiary care University Hospital **Table 3,** comparing the impact of the use of a computerized unit versus a traditional paper-based-unit when prescribing drugs. In regards to the results of the study: A total of 2,510 medication and fluid prescriptions were evaluated by the clinical pharmacist, comprising 1,286 in the Computerized Units (C-U) and 1,224 in the Paper-based Units (PB-U). Through the use of Computerized Units (C-U), **44** Medication Prescription Errors (MPEs) (**3.4%**) occurred versus **331** in the Paper-based Units (PB-U) (**27.0%**); $P < 0.001$ [**27**].

Table 8:

Medication prescription error analysis in computerized and paper based units

	Computerized unit	Paper-based unit	*P*
Total prescriptions (*n*)	1,286	1,224	NS
Total MPEs (*n*)	44	331	<0.001
% MPEs	3.4	27.0	<0.001
Minor MPEs	9	225	<0.001
Per 100 orders	0.7	18	
Intercepted MPEs (*n*)	12	46	<0.001
Per 100 orders	0.9	3.8	
Non-intercepted potential ADEs (*n*)	21	48	<0.001
[illegible] orders	1.6	3.9	

Colpaert, K Et al **[27]**

Overall, the implementation of the Intensive Care Information System (ICIS) resulted in a relative **reduction of 86.7%** for all types of errors associated with medication ordering. These results are shown in table above [**27**]

Data Simulation in SAS:

Table 9: Simulating error analysis in CPOE and Paper based in SAS

Observations	Computerized Unit C-U	Paper-based Unit PB-U
Total MPE	44	331
% MPE	3.4	27
Minor MPE	9	225
Intercepted MPE	12	46
Potential ADE	21	48
Intercepted MPE per 100	0.9	3.8
Minor MPE per 100	0.7	18

The type of test selected is **TTest**, a two independent sample test because it allows to compare the scores before and after the adoption of CPOE. Let's say paper-based units (PB-U) is the state before, and computerized unit (CU) the state after.

Table 10: PAIRED TTest

PAIRED TTest on CU AND PBU

Obs	Name	CU	PBU
1	Total MP	44.0	331.0
2	MPE_%	3.4	27.0
3	MinorMPE	9.0	225.0
4	InterMPE	12.0	46.0
5	PotenADE	21.0	48.0
6	InMPE100	0.9	3.8
7	MiMPE100	0.7	18.0

Table 11: TTest Procedure Difference

PAIRED TTest on CU AND PBU

The TTEST Procedure

Difference: CU - PBU

N	Mean	Std Dev	Std Err	Minimum	Maximum
7	-86.8286	114.7	43.3700	-287.0	-2.9000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-86.8286	-193.0	19.2940	114.7	73.9417	252.7

DF	t Value	Pr > |t|
6	-2.16	0.0737

Figure 2: Distribution of Difference CU, PBU

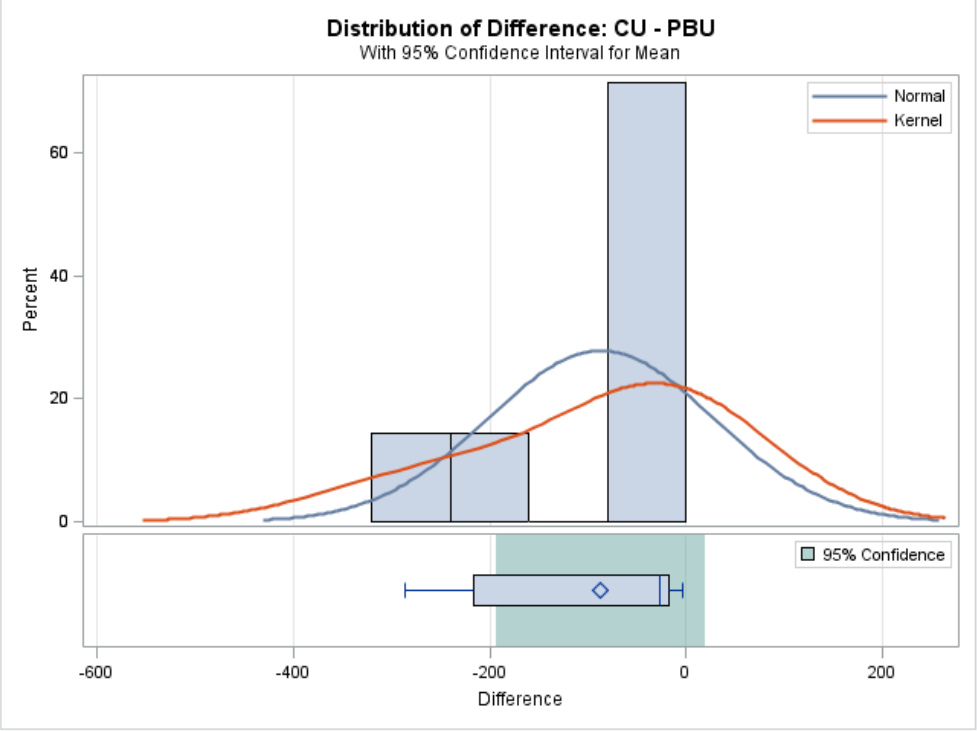
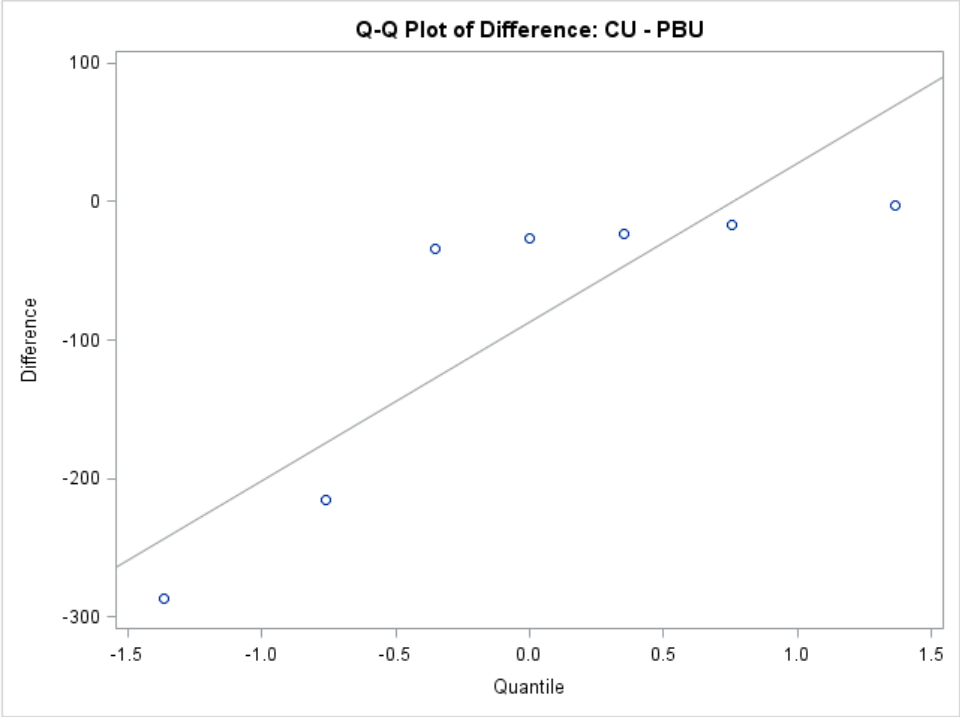


Figure 3: Q-Q Plot of Difference: CU, PBU



By analyzing the results of this graphical representation, we can conclude that the use of CPOE reports less medical errors than paper-based units. In other words, the results corroborate with the assertion that computerized physician order entry (CPOE) systems are effective in reducing errors.

1.2.1.4 CPOE / CDSS

While medications can improve patients health, the process of prescribing them is complex. Almost all CPOE systems include or interface with CDSSs of varying complexity. Basic clinical decision support may include suggestions or default values for drug doses, routes, and frequencies. More sophisticated CDSSs can perform drug allergy checks, drug-laboratory value checks, drug-drug interaction checks, in addition to providing reminders about corollary orders (e.g., prompting the user to order glucose checks after ordering insulin) or drug guidelines to the physician at the time of drug ordering. Computerized physician order entry (CPOE) with clinical decision support (CDS), can improve patient safety and lower medication-related costs.

The following **Table 13** evaluates Computerized physician order entry (CPOE) with clinical decision support (CDS). In this evaluation, *Adverse drug events* (ADEs) injuries that result from the use of drugs are classified as of Level 1, Level 2, and Level 3:

- By definition, *Adverse drug events* (ADEs) constitute clinical outcomes (Level 1).
- Mixture of serious medication errors with a significant potential for patient injury constitute clinical outcomes (Level 2)
- Other deviations from recommended practice that do not have a clear or established connection to adverse events constitute clinical outcomes (Level 3)

Table 12: Studies of CPOE with Clinical Decision Support Systems (CDS)

Study	Study Design	Study Outcomes	Results
Overhage, 1997.[21] Impact of faculty and physician reminders (using CPOE) on corollary orders for adult inpatients in a general medical ward at a public teaching hospital affiliated with the Indiana University School of Medicine	Level 1 (RCT with physicians randomized to receive reminders or not)	Levels 2 & 3 (errors of omission in corollary orders)	25% improvement in ordering of corollary medications by faculty and residents (p<0.0001)
Bates, 1998.[22] CPOE with CDSSs for adult inpatients on medical, surgical, and intensive care wards at BWH, a tertiary care center affiliated with Harvard University	Levels 2 & 3 (two study designs)	Level 1 (ADE rates) and Level 2 (serious medication errors)	55% decrease in non-intercepted serious medication errors (p=0.01) 17% decrease in preventable ADEs (p=0.37)
Bates, 1999.[23] CPOE with CDSSs for adult inpatients in 3 medical units at BWH	Level 3 (retrospective time series)	Level 1 (ADEs) and Level 2 (main outcome measure was medication errors)	81% decrease in medication errors (p<0.0001) 86% decrease in non-intercepted serious medication errors (p=0.0003)
Teich, 2000.[24] CPOE with CDSSs for all adult inpatients at BWH	Level 3 (retrospective before-after analysis)	Levels 2 & 3 (changes in 5 prescribing practices)	Improvement in 5 prescribing practices (p<0.001 for each of the 5 comparisons)

* ADE indicates adverse drug event; BWH, Brigham and Women's Hospital; and RCT, randomized controlled trial.

Retrieved from http://archive.ahrq.gov/clinic/ptsafety/chap6.htm

To realize the medication-related benefits of CDS within CPOE, one must overcome significant challenges. Healthcare organizations implementing CPOE must understand what classes of CDS their CPOE systems can support [26]. Computerized physician order entry (CPOE) with clinical decision support (CDS) can improve medication safety and reduce medication-related expenditures because it introduces automation at the time of ordering, a key element in the medication process. Furthermore, CPOE with CDS can improve medication dosing through the use of **lists complete order sentences**, defined as "*complete pre-written medication orders that include dose, dose form (when necessary), route of administration, frequency, and a PRN (PRO RE NATA (Whenever Needed)) flag and reason (if necessary)*" (see **Figure 1** below). Choosing

from pre-defined lists decreases errors due to a mental "slip," a misplaced decimal point, or using the wrong dosing unit (e.g., grams instead of milligrams). One study determined that pre-defined order sentences might prevent over 75% of dosing errors. Another study of outpatient prescribing determined that default dose and frequency suggestions might have eliminated 42% of prescribing errors and 53% of potential adverse drug events [**26**].

Figure 4: Order Sentences Pick List for ATENOLOL

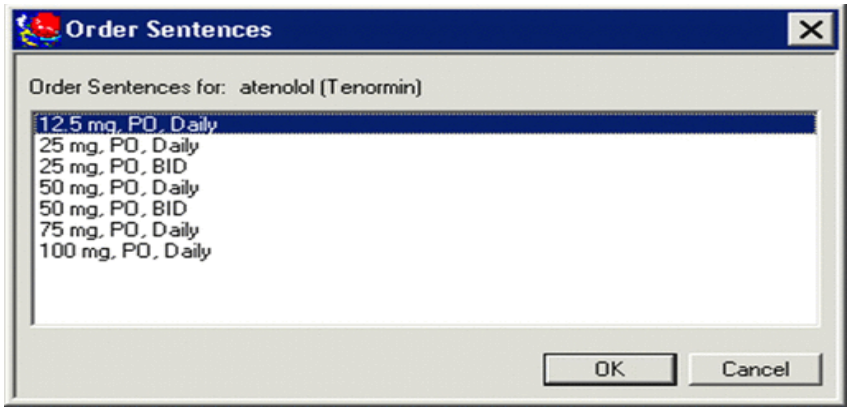


Figure 1:Order sentence pick list for *atenolol*.
Retrieved from :http://jamia.oxfordjournals.org/content/14/1/29

Given that most errors occur at the prescribing step, using computerized physician order entry (CPOE) systems allows to:

- Make sure that the order is legible and complete, including all necessary information, such as dose, route, and dosage form;
- Check for problems such as drug allergies and drug–drug interactions;
- Provide dosage adjustment calculations based on clinical features such as weight or renal function;
- Check for appropriate baseline laboratory results, such as platelet count and international normalized ratio for patients receiving anticoagulants;

- Compute drug–laboratory interactions, such as alerting the prescriber to a low potassium concentration when *digoxin* is being prescribed;
- Update the prescriber with the latest drug information, such as the need to avoid *rofecoxib* after it had been withdrawn by the manufacturer [**38**].

Computerized physician order entry (CPOE) systems are effective in reducing errors during prescribing; however, unless there is an established communication between patient and prescriber, a CPOE system itself cannot detect an error if the physician does not remember to prescribe a medication that the patient was taking at home [**38**]. Only a CDSS equipped with a smart electronic discharge summary can remind physicians to prescribe those medications [**38**].

Computerized physician order entry (CPOE) with clinical decision support system (CDSS) is a potentially powerful intervention for improving patient safety. Common prescribing errors include:

- Using the wrong drug
- Using the wrong dosage form,
- Using incorrect dose calculation,
- Not checking for allergies,
- Failure to adjust dosages in patients with renal or hepatic dysfunction [**38**].

The range of literature and studies on CPOE and CDSS interventions is limitless: A study conducted at the Indiana University showed that CPOE with CDSS could improve the completeness of specific order sets such as scheduled partial *thromboplastin* time laboratory draws to accompany a heparin drip [**29**]. Furthermore one randomized trial

tested a systematic process for designing order sets (which are CDSS components) and showed reduced physician cognitive burden when using the order set [**29**].

The following table presents studies of computerized physician order entry (CPOE) with clinical decision support systems (CDSSs) .

1.2.1.5 Sound Alike Drug Names

Medications for which generic or trade names of the product sounds similar in the spoken or written words are categorized as Sound-Alike drugs [**51**].

- A 59 year old man was mistakenly prescribed **Slow-Na** instead of **Slow-K** due to *incorrect selection from a drop-down list in the prescribing software* [**45**].

- Dear Doctor, Mr. Smith has been taking ***chlorampicillin*** for some time. I think that he could now stop. ***Chlorampicillin* doesn't exist**; ***the patient was taking chlorambucil*** [48].

- A 40-year-old man was given ***Apresoline*** (*hydralazine*) in hospital for hypertension. His doctor, inquiring about hisprogress, was told that he had been given ***isoprenaline*** [**48**]

Cited above are examples of Sound-Alike drug names confusion. These types of medication errors are common, they should be avoidable by being well informed about the drug being prescribed, but they are still causing harm to patients, regardless numerous efforts undertaken to stop or reduce the number of their occurrence.

Look-Alike/Sound-Alike (LASA) drug names are a serious problem in health care. Since year 2000, the number of medication errors reported to FDA exceeds 95,000.

Around 25% of errors reported to National Medication Error Reporting Programs are caused by drug names that Look or Sound Alike.

According to the Institute of Medicine (IOM) of the National Academies, there are more than 7,000 deaths a year due to medication errors. Medication errors may occur due to sound-alike or look-alike names, as a result, accurate interpretation of a products name is essential to ensure that the correct product is procured, prescribed, prepared, dispensed, and administered to the patient. In the following table, criteria used to identify LASA are given :

Table 13: Criteria used to Identify Product Names that Look and Sound similar to a Proposed Proprietary Name

Type of similarity	Considerations when searching the databases		
	Potential causes of product name similarity	**Attributes examined to identify similar product names**	**Potential Effects**
Look-alike	Similar spelling	Identical prefix Identical infix Identical suffix Length of the name Overlapping product characteristics	Names may appear similar in print or electronic media and lead to product name confusion in printed or electronic communication Names may look similar when scripted and lead to product name confusion in written communication
	Orthographic similarity	Similar spelling Length of the name Upstrokes Downstrokes Cross-stokes Dotted letters Ambiguity introduced by scripting letters Overlapping product characteristics	Names may look similar when scripted, and lead to product name confusion in written communication
Sound-alike	Phonological similarity	Identical prefix Identical infix Identical suffix Number of syllables Stresses Placement of vowel sounds Placement of consonant sounds Overlapping product characteristics	Names may sound similar when pronounced and lead to product name confusion in spoken communication

Table 1**:** Criteria Used to Identify Product Names that Look or Sound Similar to a Proposed Proprietary Name. Retrieved from :http://www.fda.gov/downloads/drugs/guidancecomplianceregulatoryinformation/guidances/ucm072229.pdf

1.2.1.5.1 Potential Sources of drug names confusion [48]

Following are four risk factors in drug name confusion errors:

- Diverse drugs with similar names
- Formulations with the same brand name containing different drugs

- Similar drug marketed in formulations with different names
- Abbreviated drug names.

Drug name confusion is common with many national medications. This confusion is over amplified when dealing with international drug names because differences between proprietary names exist in different countries. This provides room to Look-Alike/Sound-Alike (LASA) medication errors. The following table lists some "Recommended International Non-Proprietary Names " (rINNs) that differ from " United States Adopted Names" (USANs) in order to avoid any eventual drug name confusion [**48**]

Table 14: Some USANs that are different from their corresponding rINNs

USAN	rINN
Glyburide	Glibenclamide
Isoproterenol	Isoprenaline
Moricizine	Moracizine
Metaproterenol	Orciprenaline
Acetaminophen	Paracetamol
Meperidine	Pethidine
Rifampin	Rifampicin
Albuterol	Salbutamol
Torsemide	Torasemide

rINN: Recommended International Non-proprietary Name; USAN: United States Adopted Name.

Retrieved from :http://dx.doi.org/10.1517/14740338.3.3.167

1.2.1.5.2 Preventing Sound-Alike medication Errors:

Drug with similar names are a threat to patient safety, and strategies that may help prevent medication errors related to Look-Alike/Sound-Alike (LASA) vary from the readability of orders and prescriptions from physicians working in healthcare facilities

that do not possess any electronic prescribing system, to the use of computerized physician order entry (CPOE), to the inclusion of drugs indication on the prescription, the use of proper drug devices when measuring drug that is to be administered, and to patient education about the appropriate use of their medications (taking the medication as ordered), to list a few.

Added to the list of strategies mentioned above, the US FDA on the other hand has taken various steps to restrain LASA medication errors, some of them are as followed:

- Use of bar codes to electronically read distinct assigned codes on medication packages and containers.
- Creating guidance on how to prescribe and dispense drug, also promoting public education about medication errors [51].
- Review of drug names: having distinct drug names limits the risk of occurrence of LASA names. The US FDA is urging manufactures to revise their drug naming convention to overcome this problem.

1.2.1.5.3 Why do these Errors occur ?

According to the theories of human error, errors in prescribing, as in any other complex and high-risk procedure, are occasioned by and depend on failure of individuals, but are generated, or at least facilitated, by failures in systems [**50**].

Some actions that can be taken to reduce the risk of errors over LASA are presented in the following table retrieved from:

http://dx.doi.org/10.1517/14740338.3.3.167

Table 15: Actions that could be taken to reduce the risk of errors through confusion of drug names

Group	Recommended actions
Regulatory agencies	• INNs should be used internationally • Licensing authorities should exercise more control over the naming of new proprietary formulations • New proprietary names should be internationalised • Commonly used prefixes in names should be avoided if possible • Computerised databases should be used in comparing proposed names with existing names; the Levenshtein distance provides a simple method of predicting possible conflicts
Pharmaceutical manufacturers	• Manufacturers should play their part in ensuring that new names are carefully chosen and internationalised • They should use a single standard tag to indicate modified-release formulations • Tags used in OTC formulations (e.g., 'Plus', 'Extra') should have a uniform meaning from one manufacturer to another; a standard glossary should be used • They should test potential new names on patients and prescribers • They should be prepared to change brand names if necessary, and to do so worldwide • Generic formulations for prescription should be marketed under their non-proprietary names, not under new proprietary names • OTC formulations should be given unique brand names • Packaging and package inserts should emphasise the non-proprietary name of the drug above the brand name
Prescribers	• Prescribers should inform patients about the nature and risks of their therapy • They should issue computer-printed prescriptions if possible, and in handwritten prescriptions use clearly penned upper case letters • They should always check unfamiliar names of medicines that patients are taking • In most cases they should use INNs when prescribing • They should never abbreviate drug names • They should inspect patients' medicines, especially when adverse events occur • They should report errors to their regulatory authority
Pharmacists	• Pharmacists should discuss the nature and risks of patients' therapy with them and check that they recognise the medicines they are taking • Pharmacists should ask patients to hand in their old medicine containers when they fill a new prescription • In hospital, clinical pharmacists should check prescriptions and liaise with prescribers, advising on correct therapy • They should report errors to their regulatory authority
Patients	• Patients should educate themselves about the medicines they are taking and tell each new prescriber about them • They should bring their medicines with them when they go to consult a prescriber or pharmacist

INN: International Non-proprietary Name; OTC: Over-the-counter.

1.2.1.6 Pop-Up Alerts

Alerts and prompts from clinical decision support systems (CDSS) are essential in preventing and/or limiting medication errors.

As research shows, drug safety alerts as well as prompts are often overlooked by the prescribers. A review paper in 2006 reported alert override-rates of 49% to 96%. Especially drug-drug interaction (DDI) and drug-allergy checking suffers from low specificity due to too many false positive warnings which results in high override-rates [**25**].

Alert fatigue is a frequent complaint about CPOE systems with CDSS. An increasing number of drug safety alerts is a motivating factor for clinicians tendency to ignore repeated alerts, and consequently, this leads to an override of both important (even highly important) and unimportant alerts and prompts [**25**].

Previous research studies have shown that to be effective, alerts need to be much more selective, carefully designed, and ideally customized to the individual patient characteristics and context [**71**]; [**72**].

The study of alerts through the use of our **Novel Decision Algorithm** within a clinical decision support systems (CDSS) or our standalone application designed to acknowledge the presence of **Sound-Alike** (SA) drug names, is relevant as it provides prescribers with additional information such as "**Generic name**" that makes one drug name "Unique", different from one another.

The **pop-Up alert** within this research is a sort of **navigational tool** with "**Pop-Up Menus**" that assists and guides prescribers throughout their drug prescribing process, therefore cannot be neither irritating nor overwritten.

This innovative and revolutionary type of prompts or alerts represents promising types of decision support because it tackles inadequacies during the drug

prescribing process*. *This may improve patient safety while reducing adverse drug events (ADE).

However even if these Pop-Up alerts warn clinicians about potential drug names confusion, clinicians can mistakenly select then prescribe a wrong drug name that ultimately will jeopardize patient safety.

1.2.2 Current information surrounding the issue

The number of patients dying from medical errors was still unknown until the publication in 1999 of a book called *"**To Err is Human—Building a Safer Health System**"*. This book from the Institute of Medicine (IOM) received a widespread attention nationally as well as internationally. The *"To Err is Human"* is a seminal research that conducted two medical errors studies: one in New York in 1984 and another from Colorado and Utah in 1992. According to the author, between 44,000 to 98,000 deaths from medical errors occur annually in the U.S.A.

For decades, the results of the *"To Err is Human"* research study were accepted as the finest estimate and report on medical errors, until a newer research conducted in 2013 made an assertion that: the *"To Err is Human"* had counted and reported less medical errors.

This new research published in the *Journal of Patient Safety*, estimated that the annual number of Americans dying from medical errors is instead between 210,000 and 440,000 [**49**], which is almost an increase of 449 % between 1999 and 2013.

As of June 2015, the US FDA has received 50 reports of medication error cases describing brand name confusion with Brintellix and Brilinta. Most of the cases reported

concerns that similarities in the **sound**, **look**, or both **sound and look** of the two brand names could cause confusion for prescribers and pharmacists.

According to the US FDA, 12 of the 50 reports of medication error cases resulted in a patient being given the wrong drug; however, none of the reports indicate that a patient actually consumed the wrong drug. Of these 12 cases, the US FDA says half resulted from errors in the prescription and half were due to errors when the drugs were dispensed. Following are factors that have contributed to the confusion between *Brintellix* and *Brilinta* [**52**]:

1. **Both brand names begin with the same three letters.**

   In addition to information overload in healthcare, lack of alerts when ordering medication, similarities in spelling and pronunciation of drug brand names are common and difficult to differentiate the wrong from the right drug from a drop-down list containing tens of product names.

   The proposed "Pop-Up Alerts" module in this research *offers ways to succeed in controlling drug names beginning with same letters in order to prevent medication errors.* The drug name search will be based on the first **FOUR** letters instead of **THREE** therefore there won't be any confusion between *Brintellix* and *Brilinta* [**52**].

2. **Both brand names are presented when selecting medications in a computerized physician order entry (CPOE) system.**

   Confusion over brand names, poor Information systems as well as lack of Clinical decision Support Systems (CDSS) can cause or contribute to medication errors.

In this research, the proposed "Pop-Up Alerts" module *handles this issue by adding additional filters or criteria to differentiate drug brand names.*

3. **The pharmacist was not familiar with the new medication Brintellix and so dispensed Brilinta**:

   It is important to have a ***centralized formulary*** *(Formulary Database) that would be available to all drug prescribers to inform about new drugs, prescribe the Highest value and Lowest cost medication for a patient* [**66**] . *Unfortunately that's not the case yet.*

4. **The brand names look and sound similar**.

   Putting in place a National Tall Man Lettering Standard in prescribing software as it was recommended by the Australian Commission on Safety and Quality in Healthcare following a review in 2007, may have drawn attention to the Look-Alike/Sound-Alike (LASA) error before it perpetuated through the medication process to the patient [**45**].

"**Tall Man**" lettering is a textual format recognized and recommended by the US Federal Drug Administration (FDA), which involves writing the “confusable” parts of LASA drug names in uppercase. It has been established that Tall Man lettering does improve accuracy in the perception of drug names [**45**] .

The escalating number of deaths per year from medication errors requires corrective actions from all of us (healthcare providers, legislators and patients) to overcome this problem of harm to patients. Progress is made but a lot is still needed to be done.

1.2.3 Previous studies on the issue

To the best of my knowledge, this is the first study evaluating the impact of implementing a "Prescribing Pop-Up-Alerts Module coupled with Confused Drug Names, Generic Drug Names and Doses" within a CPOE to prevent Sound-Alike medication errors. This study, like the preceding ones shows that the use of CPOE allows a significant reduction of medication errors. When coupled with the proposed module, all Sound-Alike drug names are detected, eliminating therefore any type of confusion. However, it is the responsibility of the prescribers to select the right medication to be prescribed.

1.2.4 Relevant history on the issue.

Over the past decades, the subject of medication errors has received and is still receiving worldwide attention than major diseases such as AIDS, breast cancer to list a few. Pharmacists have a long history of conducting research on medication errors. More than 40 years ago, they conducted a study that demonstrated that errors are much serious problem than anyone realized (Elizabeth A. Flynn) [**46**].

As noted by “Montesie, G and Lechi, A.” (2009) [4], organizations need tools to detect medication errors prior to preventing them and reducing their risk of harm. This approach or philosophy was already used in the 1960s by “Barker” and “McConnel” when they compared the *effectiveness of incident reports* and *voluntary reports* to direct observation of nurses as errors detection methods. **Thirty-six errors** were documented by incident reports during the year studied. By comparison, two week worth of data collected by direct observation when extrapolated over the same one year period

indicated that **51,200 errors** may have occurred (including **600 wrong time errors**). This figure is **1,422 times** the number identified by incident reports. Other studies have confirmed the difference between the two methods [46]. From the definition and terminology used to discuss medication errors to ways to detecting and preventing them, these pioneers (“Barker” and “McConnel") were truly part of the early heroes whose research studies have spawned nowadays, hundreds of publications on medication errors. Although the techniques of detection and prevention used today are much more sophisticated than their predecessors. The following are examples of error detection methods that have been used decades ago in research:

- Direct observation
- Chart review
- Incident reports involving medication errors
- Stimulated self-report using interview
- Attending medical rounds to listen for clues that an error has occurred
- Doses returned to pharmacy
- Urine testing as evidence of omitted drug and unauthorized drug administration
- Examination of death certificates
- Attend nurse change of shift report
- Medication administration record comparison to physician orders
- Computerized analysis to identify patients receiving target or tracer drugs that may be used to treat a medication error.
- Comparison of drugs removed from an automated drug dispensing device for a patient to physician orders [**46**].

The following **Table** : Detection methods used to investigate medication errors and adverse events discusses advantages, limitations as well as efficacy of some of the detection methods.

History has a tendency to replicate itself, consequently some of these error detection methods are still being used today. In fact neither the time factor itself nor the use of information technology is enough to stop the propagation of medication errors because, according to "PSNET", 77% of medication errors occur during the Prescription and Administration of drug, crucial steps involving human intervention. Everyone makes mistakes, so healthcare personnel will always have to cope with medication errors.

An additional source of information regarding the "Historical Timeline" of medication error can be found at the following web address:

https://www.ismp.org/about/timeline.asp

Table 16: Detection methods to investigate medication errors and adverse events

Method	Advantages	Limitations	Efficacy	Costs
Chart review	Retroactive; disposable data; commonly used; standardized criteria; poor at capturing latent failures	Difficult; time-consuming; labour intensive; planning criteria/indicators necessary	Gold standard to detect adverse events; less medication errors detected; reviews, papers	Reviewers' training and time (nurses, pharmacists, students, physicians)
Claims data	Local data; captures latent failures	Litigation based; legal implications	Adverse events detected	Reviewers' training and time
Incident reporting (sentinel events)	High-quality data; root cause analysis due; captures active and latent failures	Only detects severe, unexplained events/deaths; underestimated rates (blame and fear of punishment)	Reports and alerts; detects adverse events; less medication errors detected	Root cause analysis
Voluntary reporting	Variety of sources; structured simple form; Captures active and latent failures; promotes a culture of safety	Variable quality; underreporting; blame culture; problem of data integration	Reports and alerts; feedback and corrective actions; medication errors detected	Time for feedback and analysis
Administrative data examination	Disposable and retroactive data; easy; standardized	Absence of clinical data	Statistical	Routine evaluation
Computer monitoring	Multidata source integration; real time; adverse events prevention	Inserted errors; poor software; poor triggers; undetermined future risks	Prescribing faults, prescription errors, and dispensing errors (CPOE)	High costs for software and implementation
Direct care observation	Accurate; captures active errors	Time-consuming; training difficult;	Good quality data about administration errors	Nurse training
Patient monitoring	Data from outpatients; wide impact	Not standardized tools (interviews, questionnaires, focus groups, etc)	Future development	Nurse training

Retrieved from :http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2125.2009.03422.x/epdf

1.3 Problem Statement

Medication errors are part of the increasing healthcare costs because they cause tens of thousands of deaths in the U.S. hospitals each year, more than major diseases such as AIDS, breast cancer combined to highway accidents (Chiang S. Jao, Daniel B. Hier) [**10**]. Despite the use of Computerized Physician Order Entry (CPOE) with Clinical Decision Support System (CDSS) that can decrease the occurrence of medication errors from 55% to 80% [**27**], the problem is still occurring. The Institute of Medicine estimates that, on average, hospitalized patients are subject to **at least one medication error per day** [**30**]. As of June 2015, FDA has received 50 reports of medication error cases describing brand name confusion with Brintellix and Brilinta. Most of the cases reported concerns that similarities in the sound, look, or both sound and look of the two brand names could cause confusion for prescribers and pharmacists [**31**]. Regardless of the ongoing heavy utilization of CPOE in the healthcare industry for more than 40 years, there is still a lack of qualitative and quantitative evidences of the impact of CPOE with Pop-Up Alerts on medication names. ***This quantitative research will examine the effect of "Embedding Pop-Ups Alerts" coupled with "Confused Drug Names, Brand and Generic drug names" and "Doses" within a computerized provider order entry (CPOE) during the drug prescribing process***. This will add filters or constraints to the process of selecting and prescribing medication by:

(1) Notifying the prescriber of the presence of Sound Alike medication names and displaying those drug names that sound alike;

(2) Giving the prescriber additional information such as corresponding "Confused Drug Name Generic Name; Doses" in order to select the right drug and dose.

1.4 Research Questions

Sound-Alike Drug Name Errors:

Could a CDSS, a "CPOE with Embedded Decision Algorithm coupled with Confused Drug Names, Generic drug names and Doses" improve health care providers decisions with a lower prescribing error rate?

1.5 Dissertation Goal

The main goal of this dissertation is:

(1) To inspect and identify some of the key issues in the use of Computerized physician order system (CPOE) as a tool for preventing and or decreasing medication errors rate,

(2) To propose an alternate solution by:

a) Designing and Developing a new module (Object),

b) Implementing and presenting the developed module (Object),

c) Running test cases against the implemented module to demonstrate these issues.

This module can be used as a stand-alone application or embedded (integrated) in an existing CPOE.

This main goal can be viewed as a project, thus requires the study and execution of all phases of project management such as:

(1) Initiation phase;

(2) Definition phase;

(3) Design phase;

(4) Build phase;

(5) Testing phase;

(6) Training;

(7) Implementation (Go Live);

(8) Maintenance.

However, because of the time frame allocated to this dissertation, we will only focus on the design, development, implementation and testing phases, while briefly elaborating on the remaining phases.

The intent of this module (Object) is:

(1) To explore and demonstrate its effectiveness in reducing Sound Alike medication errors,

(2) To recommend its utilization by healthcare,

(3) To determine variability between this proposed module and the existing functionality within the CPOE,

(4) To explore and discuss barriers to its implementation

(5) To identify recommendations for further research,.

1.6 Relevance and Significance

Medication errors are still occurring despite the increased use of computerized physician order entry as reported by a survey conducted by the Leapfrog Group in 2014. In fact, it must be pointed out that this is a strong reason (the rationale) why the ongoing research that we are conducting is necessary. This research study is timely and relevant because of a lack of research performed on "*Embedded Pop-Ups Alerts coupled with*

Confused Drug Names, Generic drug names and Doses" within a CPOE during the drug prescribing process. Moreover this research is timely and relevant because, as noted in June 2015 by the US Food and Drug Administration (FDA), **medication errors caused by similar drug names are still being reported** to the Medication Error Reporting Program operated cooperatively by U.S. Pharmacopeia (USP) and the Institute for Safe Medication Practices (ISMP) [**8**].

Possible solutions to this existing problem should be for example

(1) More innovative solutions and creativity from information technology,

(2) Increased willingness by healthcare providers to use the new technology,

(3) Increased willingness of patients to comply with prescribed medication.

Healthcare industry, stakeholders, and patients will be placed in a more advantageous position on account of this research, by reducing the cost associated to medication errors, by improving patients safety to list a few.

At last, this dissertation will serve as a future reference for researchers on the subject of medication errors, specifically on embedding a Decision Algorithm within a computerized physician order entry (CPOE) in order to intercept sound alike drug names that lead to confusion and potentially harmful medication errors.

1.7 Various Research Barriers

Conducting this study required challenging computer programming, application and database development. It also required knowledge of Extract, Transform and Load (ETL) process in order to:

- Extract data from homogeneous or heterogeneous data sources for example the U.S. "Food and Drug Administration" (FDA),
- Transform the data in the proper format
- Load data into tables for the purpose of querying the drug database.

While this phase of study did not require human intervention, we expect:

- Resistance to change prior to implementing this application,
- Financial concerns for:
    - Equipment acquisition,
    - Maintenance,
    - Training,
    - Return on investment (ROI), to list a few.
- Technical

CHAPTER II

LITERATURE REVIEW

2.1 Context :

The Literature review of this dissertation will be structured based on the key issues or questions that are part of this thesis. These issues or questions are related to:

(1) Computerized physician order entry (CPOE),

(2) Clinical decision support systems (CDSS),

(3) Medication errors,

(4) Sound Alike medication errors,

(5) Drug safety Alerts.

2.2 Literature review Computerized physician order entry (CPOE):

This section of the literature review talks about computerized physician order entry (CPOE). The review was conducted in three phases:

1) Status of CPOE adoption and Implementation in U.S.A

2) Expected medication error rates without CPOE

3) Expected reduction in medication rates resulting from CPOE

Status of CPOE adoption and Implementation in U.S.A

Based on a study conducted by David C Radley [**30**] on 4701 eligible hospitals in the USA, approximately 34% (1589 of 4701) of US acute-care hospitals had adopted CPOE in 2008. Among the 2833 hospitals responding to the EHR survey, larger hospitals (≥400 beds) were more likely to have adopted CPOE (56%) compared with medium-sized or small hospitals (35% and 30%, respectively). CPOE adoption was more common among urban hospitals (41% versus 28% among rural hospitals, $p<0.001$) and major teaching hospitals (53% versus 32% in non-teaching hospitals, $p<0.001$). CPOE adoption was higher among private not-for-profit hospitals (37%) compared with public hospitals (31%) and private for-profit hospitals (32%). CPOE adoption did not significantly differ between independent and health system-affiliated hospitals (34% versus 36%, $p = 0.13$). The following **Table 1** summarizes CPOE adoption in 2008 by hospital characteristic [30].

- Values are number (%).
- Data in this table are aggregated only from the 2833 hospitals that provided responses to the EHR adoption database supplement questions regarding CPOE adoption.
- * = Geographic region was missing for 72 hospitals.
- EHR = electronic health record.

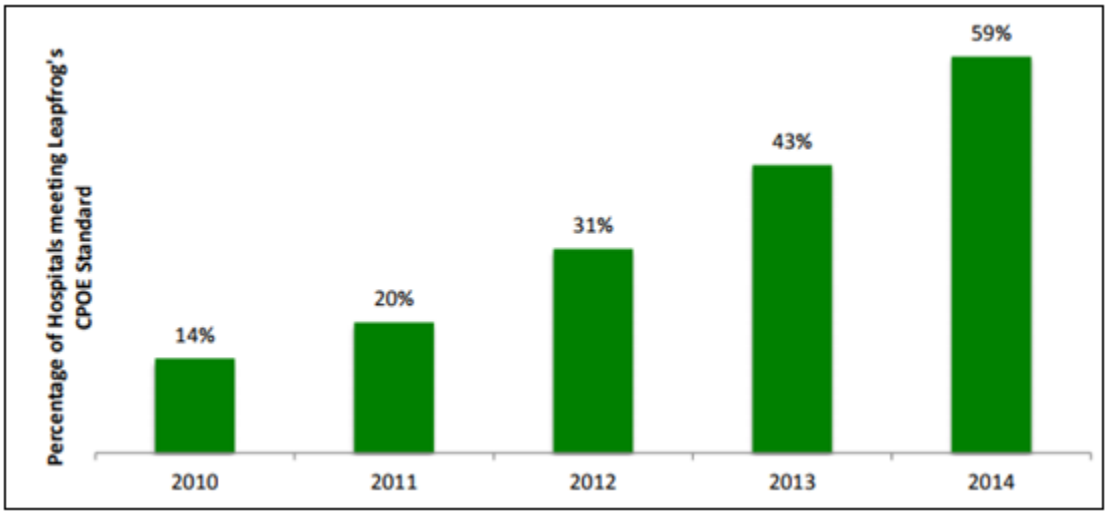
Table 17: CPOE adoption by hospital characteristic, 2008

Characteristic	With CPOE	Without CPOE	p Value
All acute hospitals	992 (35)	1841 (65)	NA
Pediatric specialty hospitals	14 (100)	(0)	NA
Bed size			
Small (6–99)	389 (30)	910 (70)	
Medium (100–399)	430 (35)	795 (65)	<0.001
Large (≥ 400)	173 (56)	136 (44)	
Census region*			
Northeast	173 (44)	224 (56)	
Midwest	298 (32)	633 (68)	0.001
South	356 (36)	639 (64)	
West	141 (32)	297 (68)	
Ownership type			
Public	211 (31)	471 (69)	
Not-for-profit	670 (37)	1131 (63)	0.005
For-profit	111 (32)	239 (68)	
Member of a health system			
No	452 (34)	894 (66)	0.128
Yes	540 (36)	947 (64)	
Location			
Rural	360 (28)	928 (72)	<0.001
Urban	632 (41)	913 (59)	
Teaching status			
Non-teaching hospital (0 full-time residents)	705 (32)	1505 (68)	
Minor teaching hospital (between 1 and 20 full-time residents)	98 (37)	169 (63)	<0.001
Major teaching hospital (more than 20 full-time residents)	189 (53)	167 (47)	

Retrieved from :http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3628057/table/AMIAJNL2012001241TB1/

Another research conducted by the Leapfrog Group shows the national low percentage of hospitals from 2010 to 2014 meeting the Computerized Physician Order Entry (CPOE) standard [**100**]

Figure 5: Hospitals Fully Meeting Leapfrogs Computerized Physician Order Entry (CPOE) Standard



Retrieved from http://www.leapfroggroup.org/sites/default/files/Files/2014LeapfrogReportCPOE_Final.pdf

Expected medication error rates without CPOE / Expected reduction in medication rates resulting from CPOE

The following table evaluates and summarizes the comparison of computerized physician order entry systems before and after implementation in healthcare environment.

Table 18: Studies Comparing CPOE to the Standard of Care

Author	Year	Design	Intervention[a]	Findings
Graumlich et al[14]	2009	Randomized controlled trial	Discharge software[b]	No changes in patient satisfaction with discharge; improvement in outpatient provider perceptions of discharge quality; worsening of inpatient provider perception of time required to complete the discharge process
Graumlich et al[15]	2009	Randomized controlled trial	Discharge software[b]	No change in hospital readmissions, emergency department visits, or adverse events
Mir et al[16]	2009	Before/after analysis	CPOE	There was a 10-fold decrease in erroneous (missing, incomplete) prescription information
Leung et al[17]	2012	Before/after analysis	CPOE	Decreased preventable adverse drug events by 33%, but increased overall adverse drug events
van Doormaal et al[18]	2009	Before/after analysis	CPOE	Significant reduction in medication errors, but no change in preventable adverse drug events
King et al[19]	2003	Before/after analysis	CPOE	Significant decrease in medication errors, but not in adverse drug events
Devine et al[20]	2010	Before/after analysis	CPOE	Significant reduction in errors, especially of illegibility; no significant reduction in preventable adverse drug events
Collin et al[21]	2008	Before/after analysis	CPOE	The ordering of some tests (full blood counts, urea and electrolytes, and chest roentgenograms) was reduced, while the ordering of other tests (computed tomography under some circumstances) increased
Bartos et al[22]	2008	Before/after analysis	CPOE	All clinical providers—physicians, nurses, unit secretaries, physician extenders, and "other staff" who do not interact with CPOE directly—perceived themselves to be less powerful after CPOE implementation. All but the "other" category—all who interacted with CPOE—perceived it more negatively after implementation
Longhurst et al[23]	2010	Before/after analysis	CPOE	Mortality in the children's hospital decreased by 20% (0.8%-40%) following implementation of CPOE

Abbreviations: CPOE, computerized physician order entry.
[a] These studies all compared CPOE to the pre-CPOE, handwritten orders standard of care (except for the first 2). Of note, almost all CPOE systems, especially the more recent ones, incorporate varying amounts of clinical decision support, whether by the structure of the order entry itself or by the provisioning of order sets, clinical alerts, and other cues to encourage or discourage certain kinds of orders.
[b] Both of these publications are about the same randomized trial. Of note, the intervention was a form of CPOE in that it generated a medication reconciliation, but not the comprehensive kind (ie, wherein providers can order any and all interventions from admission to discharge) commonly considered under the aegis of CPOE.

Retrieved from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3869307/

Despite CPOE systems effectiveness at lowering cost and preventing medication errors, its adoption and use in US hospitals remain modest. Current policies to increase CPOE adoption and use will likely prevent millions of additional medication errors each year [**82**]. The following table shows the benefit of Computerized Physician Order Entry by comparing it pretest and posttest implementation.

Table 19: CPOE System Implementation and Adoption Outcomes

Author(s) and Year	Study Design	Outcome
Devine et al. (2010)	Pretest-posttest study of CPOE implementation	70 percent reduction in medication errors
Mattison et al. (2010)	Pretest-posttest study of CPOE implementation	Significant decrease of inappropriate medication orders
Gabow and Mehler (2011)	Postimplementation study of CPOE	Out of 112 medical centers, Denver Health was rated first and had the lowest mortality ratio.
Cartmill et al. (2012)	Pretest-posttest study of CPOE implementation	Average time from ordering to administration decreased from 100 to 64 minutes.
Magid et al. (2012)	Posttest study of CPOE implementation	Decrease in duplicate orders by 84.8 percent
Jozefczyk et al. (2013)	Pretest-posttest study of CPOE implementation	Increase in orders with no opportunity for medication errors from 42 percent to 98 percent
Zimlichman et al. (2013)	Posttest study of CPOE with CDSSs	ADE costs that were avoided ranged from $7 to $16 million.

ADE, adverse drug event; CDSS, clinical decision support system; CPOE, computerized provider order entry.

Table 1 Retrieved From: http://perspectives.ahima.org/can-utilizing-a-computerized-provider-order-entry-cpoe-system-prevent-hospital-medical-errors-and-adverse-drug-events/#.VufB6ubLK2I

SOURCES

Cartmill, R. S., J. M. Walker, M. A. Blosky, R. L. Brown, S. Djurkovic, D. B. Dunham, D. Gardill, M. T. Haupt, D. Parry, T. B. Wetterneck, et al. “Impact of Electronic Order Management on the Timeliness of Antibiotic Administration in Critical Care Patients.” *International Journal of Medical Informatics* 81, no. 11 (2012): 782–91.

Devine, E. B., E. C. Williams, D. P. Martin, D. F. Sittig, P. Tarczy-Hornoch, T. H. Payne, and S. D. Sullivan. “Prescriber and Staff Perceptions of an Electronic Prescribing System in Primary Care: A Qualitative Assessment.” *BMC Medical Informatics and Decision Making* 10, no. 72 (2010): 72–83.

Gabow, P. A., and P. S. Mehler. “A Broad and Structured Approach to Improving Patient Safety and Quality: Lessons from Denver Health.” *Health Affairs* 30, no. 4 (2011): 612–18.

Jozefczyk, K. G., W. K. Kennedy, M. J. Lin, J. Achatz, M. D. Glass, W. S. Eidam, and M. J. Melroy. “Computerized Prescriber Order Entry and Opportunities for Medication Errors: Comparison to Tradition Paper-based Order Entry.” *Journal of Pharmacy Practice* 26, no. 4 (2013): 434–37.

Magid, S., C. Forrer, and S. Shaha. “Duplicate Orders: An Unintended Consequence of Computerized Provider/Physician Order Entry (CPOE) Implementation: Analysis and Mitigation Strategies.” *Applied Clinical Informatics* 3, no. 4 (2012): 377–91.

Mattison, M. L., K. A. Afonso, L. H. Ngo, and K. J. Mukamal. “Preventing Potentially Inappropriate Medication Use in Hospitalized Older Patients with a Computerized Provider Order Entry Warning System.” *Archives of Internal Medicine* 170, no. 15 (2010): 1331–36.

Zimlichman, E., C. Keohane, C. Franz, W. L. Everett, D. L. Seger, C. Yoon, A. A. Leung, B. Cadet, M. Coffey, N. E. Kaufman, and D. W. Bates. “Return on Investment for Vendor Computerized Physician Order Entry in Four Community Hospitals: The Importance of Decision Support.” *Joint Commission Journal on Quality and Patient Safety/Joint Commission Resources* 39, no. 7 (2013): 312–18.

Even if CPOE System Implementation and Adoption in the above table shows positive outcomes, many healthcare organizations have not been able to achieve the desired benefits with their implementation. Researchers conducting different studies have concluded that

a major factor determining approval of healthcare computer systems is physician acceptance (Berger & Kichak, 2004; Bhattacherjee & Hikmet, 2007; Sidirov, 2006; Yarbrough & Smith, 2007).

Several research studies contended that the use of CPOE in healthcare environment has both advantages and disadvantages as presented in the following paragraphs:

- A study led by David Bates, MD, Chief of General Medicine at Boston Brigham and Women's Hospital, demonstrated that CPOE reduced error rates by 55% - from 10.7 to 4.9 per 1000 patient-days after implementing CPOE. Rates of serious medication errors decreased by 88% in a following study by the same group [**23**]. The CPOE at the time of the study included only basic decision support, with limited checking for allergies and drug-drug interactions.

- Another study conducted at LDS Hospital in Salt Lake City by David Classen, MD, demonstrated a 70% reduction in antibiotic-related ADEs after implementation of decision support for these drugs [**23**], also these systems tend to produce a large number of partly irrelevant alerts, in turn leading to alert overload and causing alert fatigue [**25**].

- Bates et al (1999) demonstrated that at Brigham and Women's Hospital in Boston, the use of CPOE reduced serious medication errors by 55 percent in one study and reduced all errors (excluding missed doses) by 81 percent over four and a half years in another study.

- Potts (2004) [**57**] in the other hand reported a reduction in both medication errors and adverse drug events (ADE)

- king et al (2003) [**56**] demonstrated that the implementation of CPOE led to a reduction in medication errors but not in adverse drug events (ADE)

- Daniel L. Roberts (2013) revealed that, based on a study conducted at Mayo Clinic, Phoenix, AZ, in 2008, the frequency of medication errors per 1000

patient-days was significantly reduced from 14.1 to 10.4 after implementation of CPOE [**33**]

- J. M. Teichet al (2000) discovered that prescribing practices, such as the use, dose, and frequency of a recommended drug, have been improved with the use of CPOE at this hospital.

- Han YY, Carcillo JA, Venkataraman ST, et al (2005) reported an unexpected increase in hospital mortality after implementation of CPOE [**33**]

- As noted by (Jorge Rakela 2013) other research studies have conceded benefits of CPOE but pointed to remaining substantial vulnerabilities [**35**].

- Taking the same view, G D Schiff (2014) pointed that computerized physician order entry have been shown to decrease errors and are being widely adopted. However, CPOE also have potential for introducing or contributing to errors.

- Khanna, R., & Yen, T. (2014) found that CPOE in fact caused errors ranging from wrong dosing to duplication [**29**].
- As noted by D.W. Bates (2000), The increased use of information technology—computerization of all ordering, pharmacy systems, bar coding, and event monitors—has the potential to improve quality and reduce errors [**60**].

- Schiff GD, D.W. Bates (2014) concluded based on a study "*Analyzing medication error reports where CPOE was reported as a contributor caus*e" between 2003 and 2010 that: Of **1.04** million medication errors that were reported to United

States Pharmacopeia MEDMARX, **63 040** (6.1%) were reported as CPOE related. Even if CPOE has been shown to decrease errors, these systems are also vulnerable [**61**].

- Khanna and Yen (2013) summarized in the following table, mixed results of before and after studies comparing CPOE system and pre-CPOE [**62**].

- Tierney et al (1993) [**73**] found that implementation of a POE system on a medical service resulted in a reduction in the average length-of-stay days by 0.89 days and a 12.7% reduction in charges.

- Overhage et al (1997) [**74**] demonstrated a greater than 25% improvement in the rates of corollary orders with implementation of computerized reminders.

- Chertow et al (2001) [**75**] demonstrated a 13% decrease in inappropriate dose and a 24% decrease in inappropriate frequency for nephrotoxic drugs in patients with renal insufficiency ($P<.001$) after implementation of CPOE.

2.3 Literature review Clinical decision support systems (CDSS)

Clinical decision support systems (CDSS) are tools that assist clinicians in decision making in order to reduce medical errors, enhance drug selection and dosing.

- A study conducted at LDS Hospital in Salt Lake City by David Classen, MD, demonstrated a 70% reduction in antibiotic-related ADEs after implementation of decision support for these drugs [**23**].

- In contrast Riedmann, D (2011) found that these systems tend to produce a large number of partly irrelevant alerts, in turn leading to alert overload and causing alert fatigue [**25**].

- Another study indicated that it is not proven yet whether or not the use of CDSS can improve diagnostic accuracy (Bates et al, 1998 [68]; Bates et al 2003 [**69**]; Kaushal et al, 2001 [**70**])

- Other studies assessed the effectiveness of Clinical Decision Support Systems and found that at least a quarter of all harmful Adverse Drug Events (ADEs) are preventable with the use of CPOE and CDSS. According to (Bates et al., 1998) [**90**], there is good evidence for the use of computerized order entry with clinical decision-support systems for prevention strategies of ADEs in the hospital setting, (Gurwitz JH, Field TS, Rochon P, Judge J, Harrold LR, Bell CM, et al.. 2008) for prevention strategies in the long-term care setting [**93**];
  (Graumlich JF, Novotny NL, Stephen Nace G, Kaushal H, Ibrahim-Ali W, Theivanayagam S, et al. . (2009) [**95**]; (Kuperman GJ, Teich JM, Tanasijevic MJ, Ma Luf N, Rittenberg E, Jha A, et al.. 1999) [96].
- Also studies evaluated the effect of CDSSs to improve discharge planning as noted by (Graumlich JF, Novotny NL, Stephen Nace G, Kaushal H, Ibrahim-Ali W Theivanayagam S, et al.. 2009) [**95**];
  (Graumlich JF, Novotny NL, Nace GS, Aldag JC. 2009) [**94**].

- Some other studies evaluated the effectiveness of Clinical Decision Support Systems and found that these systems can be used for detecting critical laboratory values (Kuperman GJ, Teich JM, Tanasijevic MJ, MaLuf N, Rittenberg E, Jha A, et al.. 1999) [**96**], and also detecting potentially inappropriate or inadequate antimicrobial therapy as noted by (McGregor JC, Weekes E, Forrest GN, Standiford HC, Perencevich EN, Furuno JP, et al..) [**97**].

- Other studies assessing isolated CDSSs evaluated computerized antibiotic drug advice and demonstrated lower rates of toxic levels, improved pathogen susceptibility, and a decreased anti-infective drug–associated ADE rate.

The following table 4 presents relevant studies of Clinical Decision Support Systems (CDSS), studies conducted from 1986 to 1998.

Table 20: Studies of Clinical Decision Support Systems (CDSSs)

Source	Study Description	Study Design	Study Outcomes	Results
Hurley et al,[43] 1986	Use of a computerized theophylline dosing program for 48 inpatients at Preston and Northcote Community Hospital, Northcote, Victoria	Level 1 (RCT)	Level 1 (clinical manifestations of theophylline toxicity; level 2 (toxic serum theophylline levels)	2 Patients with clinical toxicity in control group vs none in study group ($P = .13$) Lower rates of toxic levels in intervention patients (18.9%) vs controls (37.8%) ($P = .04$)
White et al,[45] 1987	Use of a computerized warfarin dosing program for 39 inpatients at Veterans Administration Medical Center, Palo Alto, Calif, or the University of California, Davis, Medical Center	Level 1 (RCT)	Level 1 (bleeding complications); level 2 (overanticoagulation)	None of the intervention patients had bleeding complications vs 3 control patients (8%) ($P = .07$) Fewer intervention patients were over anticoagulated (5% vs 17%) ($P = .11$)
Burton et al,[39] 1991	Use of a computerized aminoglycoside dosing program for 75 inpatients at the Dallas Veterans Affairs Medical Center, a 680-bed tertiary care center in Texas	Level 1 (RCT)	Level 2 (toxic serum aminoglycoside levels)	Lower rates of toxic levels in intervention patients (5.6%) vs controls (9.3%) ($P = .40$)

Casner et al,[42] 1993	Use of a computerized theophylline dosing program for 17 inpatients at the Thomanson General Hospital, El Paso, Tex	Level 1 (RCT)	Level 1 (clinical manifestations of theophylline toxicity); level 2 (subtherapeutic or supratherapeutic serum theophylline levels)	No significant differences in any outcome. One patient (6%) in study group exhibited signs of toxicity vs none in control group ($P = .30$). One patient in each group had a toxic level ($P = .90$); proportions of patients with subtherapeutic levels was 23.5% for study group and 16.7% for control group ($P = .60$)
Evans et al,[40] 1994	Use of a computerized antibiotic drug selection consultant for 451 inpatients at LDS Hospital, a 520-bed community teaching hospital and tertiary referral center in Salt Lake City, Utah	Level 1 (RCT with a crossover design)	Level 2 (1 of 5 primary outcomes was pathogen susceptibility to prescribed antibiotic regimens)	17% Greater pathogen susceptibility to an antibiotic drug regimen suggested by a computer consultant vs physicians ($P<.001$)
Mungall et al,[44] 1994	Use of a computerized heparin dosing program for 25 inpatients at McLaren Regional Medical Center in Flint, Mich, and Midland Regional Medical Center, Midland, Mich	Level 1 (RCT)	Level 1 (bleeding events)	Fewer intervention patients bled (4.2%) vs controls (7.7%) ($P = .6$)
Evans et al,[41] 1998	Computer-based anti-infective drug management program for 1136 patients from a 12-bed ICU at LDS Hospital	Level 2 (prospective before-after analysis)	Level 1 (one primary outcome was ADEs due to anti-infective agents)	70% Decrease in ADEs caused by anti-infective agents ($P = .02$)

Abbreviations: ADE, adverse drug event; ICU, intensive care unit; RCT, randomized controlled trial.

Retrieved from : http://archinte.jamanetwork.com/article.aspx?articleid=215756#ref-ira20041

SOURCES

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White RHHong RVenook AP et al. Initiation of warfarin therapy: comparison of physician dosing with computer-assisted dosing. *J Gen Intern Med.* 1987;2141- 148 Link to Article

Burton MEAsh CLHill DP JrHandy TShepherd MDVasko MR A controlled trial of the cost benefit of computerized bayesian aminoglycoside administration. *ClinPharmacolTher.* 1991;49685- 694 Link to Article

Casner PRReilly RHo H A randomized controlled trial of computerized pharmacokinetic theophylline dosing versus empiric physician dosing. *ClinPharmacolTher.* 1993;53684- 690 Link to Article

Evans RSClassen DCPestonik SLLundsgaarde HPBurke JP Improving empiric antibiotic selection using computer decision support. *Arch Intern Med.* 1994;154878-884 Link to Article

Mungall DRAnbe DForrester PL et al. A prospective randomized comparison of the accuracy of computer-assisted versus GUSTO nomogram: directed heparin therapy. *ClinPharmacolTher.* 1994;55591- 596 Link to Article

Evans RSPestotnik SLClassen DC et al. A computer-assisted management program for antibiotics and other antiinfective agents. *N Engl J Med.* 1998;338232- 238 Link to Article

2.4 Literature review Medication errors

Medication errors are expensive and sometimes harmful to patients. The Institute of Medicine estimates that, on average, hospitalized patients are subject to at least one medication error per day [**30**].

Prevalence of medication errors

Research suggests that 19 percent of doses of medication in U.S. hospitals are administered in error [Barker(b) 1897]. One study in long-term care centers and small hospitals observed an error rate of 12.2 percent [Barker(a) 987]. Other studies suggest that 1.7 to 3.9 percent of patients who visit an emergency room do so because of a drug misadventure and 66 percent of these are preventable (Schneitman-McIntire, et al 1416; Dennehy, et al 1422). Even worse, the largest study so far suggests that 3.7 percent of hospitalizations occur because of the adverse effects of medication. The extent of adverse drug events (ADEs) in older persons (65 and older) was recently reported in the *Journal of the American Medical Assn.* (*JAMA*) (Gurwitz, et al 1107) [**2**].

Prevention of medication errors

For preventing medication errors, many efficacious error prevention strategies are available, especially for hospital care. In the hospital setting, there is good evidence for the effectiveness of computerized order entry with clinical decision-support systems (Bates et al., 1998) [**13**], for clinical decision-support systems themselves (Evans et al., 1994) [**14**], and for pharmacist participation on hospital rounds (Leape et al., 1999) [**15**]. Bar coding and smart intravenous (IV) pumps show promise for the hospital setting, but their efficacy has not yet been clearly demonstrated [**88**].

The following " Appendix S1 " retrieved Feb. 02, 2016 from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4205477/#SD1 is a set of articles from the 2013 Scientific Literature Regarding Medication Errors and Adverse Drug Events in Older Adults*. This appendix is divided into two sections: (a) **medication errors** and (b) **adverse drug events** [**81**].

A. MEDICATION ERRORS

1. Suboptimal Drug Use
2. Medication Administration Errors
3. Medication Adherence/Knowledge
4. Medication Monitoring

B. ADVERSE DRUG EVENTS

Note : Refer to Appendices Section Page 266

Older studies on medication errors were previously conducted by some researchers. The following **Table 21** summarizes data from systematically peer-reviewed literature evaluating medication error frequency before (pre) and after (post) implementation of computerized provider order entry (CPOE) from 1999 to 2008.

Table 21: Summary of Reviews evaluating error frequency before and after implementation of CPOE

Author (year of publication)	CPOE implementation and study setting (hospital department)	Duration (months)		Medication orders		Medication errors		Rate per 1000 orders		Percentage difference (unweighted)*
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	
Bates *et al* (1999)[10]	Select medical and intensive care units (inpatient)	1.7	5.6	10070	42516	255	340	25	8	−68
Bizovi *et al* (2002)[12]	Emergency department	2	2	2326	2169	54	11	23	5	−78
Cordero *et al* (2004)[13]	NICU	6	6	136	117	16	0	118	0	−100
Evans *et al* (1998)[14]	Intensive care unit	24	12	1813	942	787	134	434	142	−67
Igboechi *et al* (2003)[15]	Hospital wide (inpatient)	24	12	1868274	934137	5441	1247	3	1	−54
Kim *et al* (2006)[16]	Pediatric oncology unit	8	9.9	1259	1116	84	69	67	62	−7
Mahoney *et al* (2007)[17]	Hospital wide (inpatient)	12	12	1452346	1390789	4815	2227	3	2	−52
Taylor *et al* (2008)[11]	NICU	11	9	254	272	50	31	197	114	−42
Walsh *et al* (2008)[18]	NICU, PICU, select pediatric medical and surgical units (inpatient)	7	9	5777	6895	106	155	18	22	23

Table 3 Retrieved from :http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3628057/table/AMIAJNL2012001241TB3/

SOURCES :

Bates, D. W., Teich, J. M., Lee, J., Seger, D., Kuperman, G. J., MaLuf, N., …Leape, L. (1999). The Impact of Computerized Physician Order Entry on Medication Error Prevention. *Journal of the American Medical Informatics Association : JAMIA*, *6*(4), 313–321.

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Leandro Cordero, Lynn Kuehn, Rajee R. Kumar, Hagop S. Mekhjian J Perinatol. Impact of computerized physician order entry on clinical practice in a newborn intensive care unit. 2004 February; 24(2): 88–93. doi: 10.1038/sj.jp.7211000

R. Scott Evans, Ph.D., Stanley L. Pestotnik, M.S., R. Ph., David C. Classen, M.D., M.S., Terry P. Clemmer, M.D., Lindell K. Weaver, M.D., James F. Orme, Jr., M.D., James F. Lloyd, B.S., and John P. Burke, M.D. A computer-assisted management program for antibiotics and other antiinfective agents. N Engl J Med 1998; 338:232-238 January 22, 1998 DOI: 10.1056/NEJM199801223380406

Igboechi C, Ng C, Yang C, et al. Impact of computerized prescriber order entry on medication errors at an acute tertiary care hospital. Hosp Pharm 2003;38:227–31

Kim GR, Chen AR, Arceci RJ, et al. Error Reduction in Pediatric Chemotherapy: Computerized Order Entry and Failure Modes and Effects Analysis. *Arch PediatrAdolesc Med.* 2006;160(5):495-498. doi:10.1001/archpedi.160.5.495.

Mahoney CD, Berard-Collins CM, Coleman R, Amaral JF, Cotter CM. Effects of an integrated clinical information system on medication safety in a multi-hospital setting *Am J Health Syst Pharm September 15, 2007 64:1969-1977;*

James A. Taylor, Lori A. Loan, Judy Kamara, Susan Blackburn, Donna Whitney. Medication Administration Variances Before and After Implementation of Computerized Physician Order Entry in a Neonatal Intensive Care Unit. Pediatrics Jan 2008, 121 (1) 123-128; DOI: 10.1542/peds.2007-0919

Kathleen E. Walsh, Christopher P. Landrigan, William G. Adams, Robert J. Vinci, John B. Chessare, Maureen R. Cooper, Pamela M. Hebert, Elisabeth G. Schainker, Thomas J. McLaughlin, Howard Bauchner. Effect of Computer Order Entry on Prevention of Serious Medication Errors in Hospitalized Children. Pediatrics Mar 2008, 121 (3) e421-e427; DOI: 10.1542/peds.2007-0220

2.5 Literature review Sound Alike medication errors

Medication errors (medicines mistakenly being chosen and administrated inadvertently because of similar sounding or looking names) have great potential to cause

harm. Studies report that: Up to 25% of medication errors in the USA are reported to involve drug name confusion [**98**]. The following set of articles summarizes data from systematically peer-reviewed literature evaluating Look-Alike / Sound-Alike **(LASA**) medication errors.

Reference	Lambert *et al*. (2001)[11]
Type	Journal Article
Design	laboratory experiment
Conclusion	Drug name similarity increases false recognition memory errors

Reference	Berman (2004)[12]
Type	Journal Article
Design	Overview
Conclusion	Systems and recommendations are reported, which can reduce the occurrence of LASA medication errors

Reference	JCAHO (2005)[14]
Type	Journal Article
Design	list and recommendations
Conclusion	Developed to assist healthcare organizations develop and maintain programs to minimize risks from LASA drug names

Reference	Schulmeister (2006)[18]
Type	Journal Article
Design	Overview
Conclusion	Describes examples of LASA medication errors, describes some of their causes and suggests a range of risk reduction strategies
Reference	Cohen (2002)[19]
Type	Letter to the editor
Design	Error Correction

Conclusion	Clarifies a number of perceived errors in an earlier article describing solutions to LASA medication problems

Reference	Lee (2007)[20]
Type	Grey literature
Design	Survey study
Conclusion	The problem of LASA medication packaging and labeling has grown and requires a policy response

Reference	Phillips and Williams (2006)[21]
Type	Journal article
Design	Professional organization statement
Conclusion	Medical errors involving LASA neuromuscular blocking medications continue to result in patient morbidity and mortality

Reference	AHA (2005)[25]
Type	Grey Literature
Design	Medication safety brief
Conclusion	Provides case studies and an action agenda for reducing errors from LASA drugs

Reference	Aronson (2004)[26]
Type	Journal Article
Design	Editorial
Conclusion	Regulatory authorities and manufacturers should be vigilant when naming new drugs and formulations, in order to avoid drug name confusion

Reference	Lambert *et al*. (2010)[27]
Type	Journal article
Design	Laboratory experiment

Conclusion	Clinician and lay person ability to identify spoken drug names is affected by signal-to-noise ratio, subjective familiarity, prescribing frequency and the similarity of drug names

Reference	Kenagy and Stein (2001)[28]
Type	Journal Article
Design	Overview
Conclusion	Drug names, labels and packaging are not chosen and designed in accordance with human factors principles and this contributes to medication errors that cause patient injuries and deaths

Reference	Santell and Cousins (2005)[29]
Type	Journal Article
Design	Overview
Conclusion	Efforts by regulatory authorities, drug manufacturers, pharmacists, other health care professionals and patients can reduce medication errors

Reference	Schwab *et al*. (2002)[30]
Type	Journal Article
Design	clinical observation
Conclusion	Using trade names and omitting INNs can result in serious adverse drug events by overdose
Reference	McCoy (2005)[31]
Type	Journal Article
Design	Case Study
Conclusion	Evaluation of potential LASA medication errors should occur proactively

Reference	ACSQHC (2002)[32]
Type	Grey Literature
Design	Report

Conclusion	Report seeks to increase general understanding of things that can go wrong with medicines, the size and nature of the problem in Australia, strategies that can make a difference and national directions being taken to improve medication safety

Reference	USP CAPS (2004)[33]
Type	Grey Literature
Design	Report
Conclusion	Provides a list of drug names that have caused confusion and reasons for that confusion

Reference	US Pharmacopeia (2010)[34]
Type	Website
Design	Database
Conclusion	Provides a free tool for accessing drug names that have been associated with medication errors, as well as evidence on how communicating drug orders can lead to medication errors

Reference	Friedman (2005)[35]
Type	Journal Article
Design	Overview
Conclusion	Healthcare organizations should integrate JCAHO safety goals into their policies, procedures and clinician education, in order to avoid dangerous and costly medication errors
Reference	Kovacic and Chambers (2010)[36]
Type	Journal Article
Design	Orthographic analysis of drug names
Conclusion	Specialty areas of medical practice may require a proactive system for reviewing LASA drug name pairs

Reference	Lambert (1997)[37]
Type	Journal Article
Design	Observational retrospective

Conclusion	Automated measures of medication name similarities can be accurate, sensitive and specific

Reference	Kondrak and Dorr (2006)[38]
Type	Journal Article
Design	Laboratory experiment
Conclusion	A new orthographic measure outperforms other commonly used measures of similarity for LASA drug names

Reference	Filik*et al*. (2006)[39]
Type	Journal Article
Design	Laboratory experiment
Conclusion	Provides some support for the use of tall-man lettering to reduce look-alike medication errors

Reference	Filik*et al*. (2004)[40]
Type	Journal Article
Design	Laboratory experiment
Conclusion	Drug names using tall-man lettering were less likely to be incorrectly identified

Reference	Emmerton and Rizk (2010)[41]
Type	Conference paper
Design	Review
Conclusion	Proposes an interactive model for cautions about LASA medicines in community and hospital pharmacy
Reference	Emery *et al*. (2010)[42]
Type	Conference paper
Design	Review
Conclusion	Contribution of increased use of generic medicines to labeling problems

Table 22: Definition of terms

ACSQHC	:	Australian Council for Safety and Quality in Health Care;
AHA	:	American Hospital Association;
INN	:	International non-proprietary name;
JCAHO	:	Joint Commission on Accreditation of Healthcare Organizations;
LASA	:	Look-alike, Sound-alike;
USP CAPS	:	United States Pharmacopeia Center for the Advancement of Patient Safety.

Retrieved from : http://onlinelibrary.wiley.com/doi/10.1111/j.2042-7174.2012.00210.x/full

2.6 Literature review Drug safety Alerts

Alerts are a vital component of a CDSS. They are an alarm system designed to signal the presence of a hazard requiring urgent attention. Riedmann, D (2011) [**25**], stated that: Computerized physician order entry systems (CPOE) can decrease the number of medication errors and adverse drug events (ADEs) in healthcare institutions.

Another study found that clinical alerts are part of current error reduction strategies seeking to affect the cost, quality, and safety of health care delivery (Kuperman et al., 2007; Raschke et al., 1998) [**66**]; [**67**] .

On the other hand, another study noted that alerts tend to produce a large number of partly irrelevant alerts, in turn leading to alert overload and causing alert fatigue.

As noted by (WebM&M 2013) [**36**], *most studies evaluating the impact of alerts on prescribing behavior demonstrate benefit. However, physicians override computerized*

alerts up to 95% of the time. Associated with excessive alerts, "alert fatigue" has been identified as the prime reason for alerts override.

Sharing the same point of view for medical alerts, an Agency for Healthcare research and Quality (AHRQ) (WebM&M 2013) [**36**] commentary provided several suggestions on how to minimize alert fatigue in CPOE systems:

- *Increase alert specificity by reducing or eliminating clinically inconsequential alerts*
- *Tailor alerts to patient characteristics and critical integrated clusters of physiologic indicators. For example, incorporate renal test results into the alert system so that alerts for nephrotoxic medications are triggered only for patients at high risk.*
- *Tier alerts according to severity. Warnings could be presented in different ways, in order to key clinicians to alerts that are more clinically consequential.*
- *Make only high-level (severe) alerts interruptive.*
- *Apply human factors principles when designing alerts (e.g., format, content, legibility, and color of alerts).*

Paradoxically to these suggestions in order to control medical alerts, *System developers have thus far been unwilling to remove alerts for fear of being held liable if patients were harmed in the absence of warning* (WebM&M 2013) [**36**].

The following Tables retrieved Feb. 02, 2016 from https://jamia.oxfordjournals.org/content/13/2/138 are a list of selected publications

(literature review) discussing unsolicited drug safety alerts that appear during the prescription process [**99**].

- **Table 23** covers overriding safety alerts in Computerized Physician Order Entry (CPOE),

Table 23: Publications on Overriding Drug Safety Alerts During the Order Entry Process

Investigator, Year of Publication	Type of Publication	Type of Clinic	Type of Alerts	Type of Research	Quantitative or Qualitative
Nightingale et al., 2000[13]	Full article	Teaching hospital, Birmingham, AL	Drugs	Order analysis, questionnaire survey	Quantitative and qualitative
Abookire et al., 2000[14]	Proceedings	Teaching hospital, Boston, MA	Drugs	Order analysis	Quantitative
Peterson et al., 2001[15]	Abstract	Teaching hospital, Boston, MA	Drugs	Order analysis	Quantitative
Payne et al., 2002[16]	Proceedings	Teaching hospital, Seattle, WA	Drugs	Order analysis	Quantitative
Oppenheim et al., 2002[17]	Proceedings	Teaching hospital, New York, NY	Drugs	Order analysis	Quantitative
Kalmeijer et al., 2003[18]	Full article	Teaching hospital, Amsterdam, The Netherlands	Drugs	Unknown (topic of article is implementation)	Quantitative
Weingart et al., 2003[19]	Full article	Primary care, Boston, MA	Drugs	Order analysis	Quantitative
Hsieh et al., 2004[20]	Full article	Teaching hospital, Boston, MA	Drugs	Order analysis	Quantitative
Taylor and Tamblyn,	Proceedings	Primary care, Montreal,	Drugs	Order analysis	Quantitative

2004[21]		Canada			
Magnus et al., 2002[22]	Full article	General practitioners United Kingdom	Drugs	Questionnaire survey	Qualitative
Ashworth et al., 2002[23]	Commentary on Magnus				Qualitative
Glassman et al., 2002[2]	Full article	Ambulatory care and community clinics, USA	Drugs	Questionnaire survey	Qualitative
Overhage et al., 1997[24]	Full article	Teaching hospital Indianapolis, IN	Corollary orders (drug-lab)	Randomized, controlled trial	Quantitative
Krall and Sittig, 2001[25]	Proceedings	Primary care, Portland, OR	Best practice, health maintenance	Questionnaire survey	Qualitative
Krall and Sittig, 2002[26]	Proceedings	Primary care, Portland, OR	Best practice, health maintenance	Focus groups	Qualitative
Ahearn and Kerr, 2003[27]	Full article	General practitioners, Australia	Drugs	Focus groups	Qualitative
Feldstein et al., 2004[28]	Full article	Primary care, Portland, OR	Drugs and health maintenance	In-depth interviews	Qualitative

Table 1: Retrieved from : https://jamia.oxfordjournals.org/content/13/2/138#T1

- **Table 24** focuses on the frequency: How Often and in What Kinds of Situations are Safety Alerts Overridden.

Drug safety alerts are used to improve patient safety. Even if they can overburden physicians, turning them off without careful error management may impair patient safety.

Table 24: Override Rates of Drug Safety Alerts

Investigator, Year of Publication	Duration of Measurement	No. of Orders	% Alerts/No. of Orders	% Override Rate	Kind of Alert(s)
Nightingale et al., 2000[13]	11 mo	87,789	20	90	Contraindication, drug-drug interaction, overdose
				73	High-level contraindication
				85	Low-level contraindication
				85	High-level interaction
				93	Low-level interaction
				27	High-level overdose
				53	Low-level overdose
Abookire et al., 2000[14]	5 yr	*		49–73	Definite allergy-drug interaction
				54–80	Possible allergy-drug interaction
Peterson et al., 2001[15]	6 mo	*		57	7 life-threatening drug-drug interactions
Payne et al., 2002[16]	4 wk	42,641	11	78	Drug-drug interaction, drug-allergy interaction
				88	Critical drug interaction
				69	Drug-allergy interaction
Oppenheim et al., 2002[17]	3 mo	4,596	11	68	Incorrect dose in renal patients
				48	True positive incorrect dose in renal patients
Kalmeijer et al., 2003[18]	1 yr	150,358	36	90	Drug-drug interaction, overdose,

					duplicate orders
Weingart et al., 2003[19]	3 mo	24,034	14	94	Drug-drug interaction, drug-allergy interaction
				91	Drug-allergy interaction
				89	High-level interaction
				96	Medium-level interaction
				85	Low-level interaction
Hsieh et al., 2004[20]	3 mo	*		80	Drug-allergy interaction
Taylor and Tamblyn, 2004[21]	3 mo	6,260	30	55	Contraindications, allergy, intolerance, incorrect dose, duplicate orders, drug-drug interaction, toxicity
				43	Contraindication
				92	Allergy and intolerance
				90	Incorrect dose
				86	Duplicate orders
				35	Drug-drug interaction
				84	Toxicity

- ↵* Not documented.

Table 2 - Retrieved from : https://jamia.oxfordjournals.org/content/13/2/138#T2

CHAPTER III

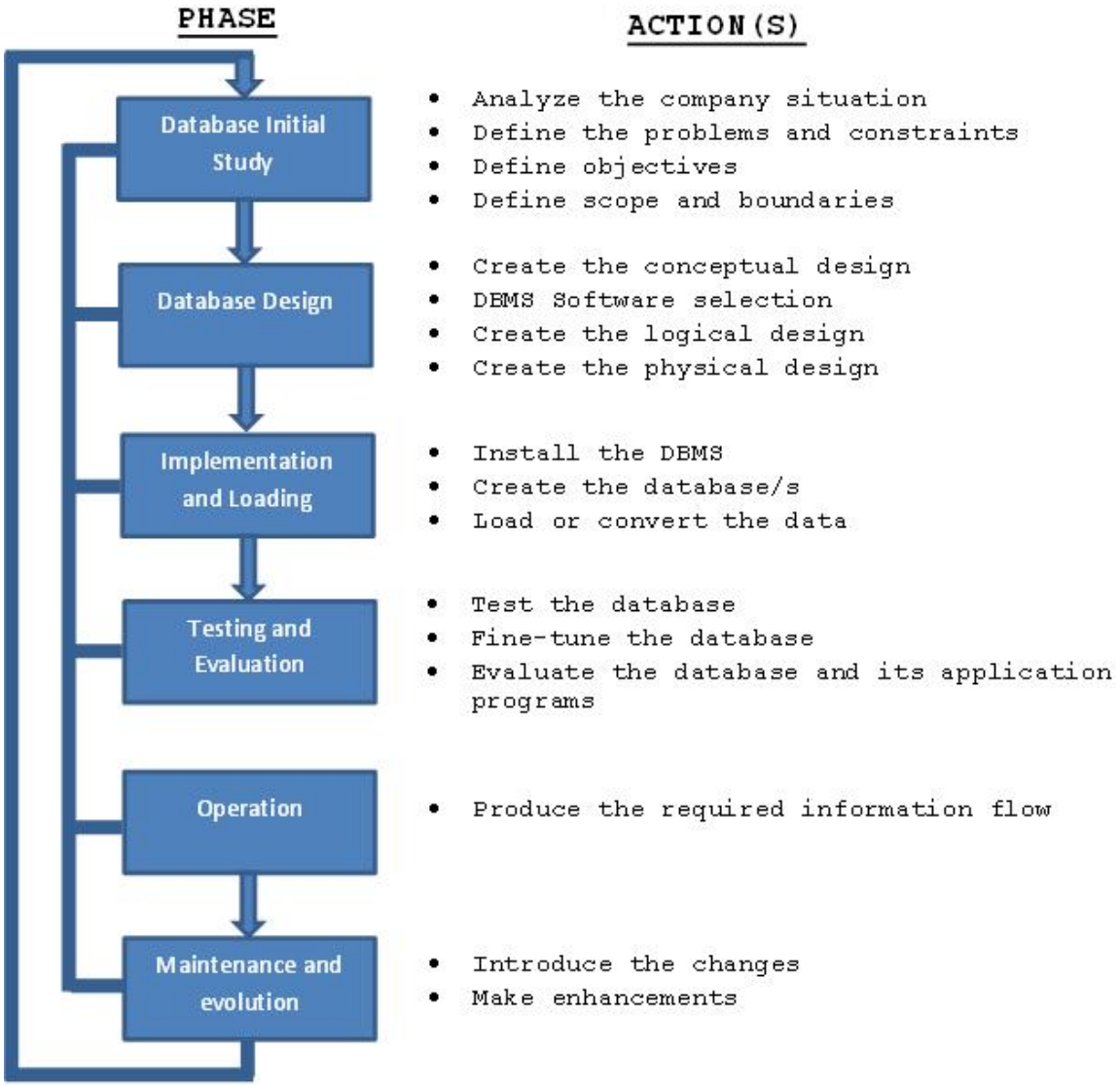
NOVEL DECISION ALGORITHM DATABASE CREATION

3.1 Introduction

This chapter covers the design, development, implementation and test cases of the database where data to support the Novel Decision Algorithm application is stored. Like everything else, the database has a life cycle associated to it. Database applications do not have the same characteristics as other software applications and therefore requires a specific life cycle. According to Engrade [**96**] the database life cycle (DBLC) contains six phases as shown in the figure below.

As we are using a portion of a pre-existing database from the Food and Drug Agency (FDA), we assume various tasks have been performed and thus only phases that have an impact on our study will be taken into account.

Figure 6: **Database Life Cycle**



Retrieved from : https://wikis.engrade.com/databaselifecycledblc

3.2 Database Initial Study

During this initial study, as a physical database already exists, the focus will be on updating the production database (add new tables, modify the existing entity relationship

diagram know as ERD, change the physical size of the database, and so on) in accordance with the new company's expectations but not recreating a new version.

3.3 Database Design

This phase focuses on the design of the database where company data will be stored. The database design phase is divided into three steps: Conceptual , Logical and Physical design.

3.3 .1 Conceptual design of the NDA

Prior to developing the conceptual model using ER Diagrams, creating the Data Dictionary and scripts for table creation, we first introduce the data flow diagram to show different sources of data used to create the database that supports this research.

3.3 .1.1 Data Flow Diagram

The figure below shows the migration of data from three different sources:

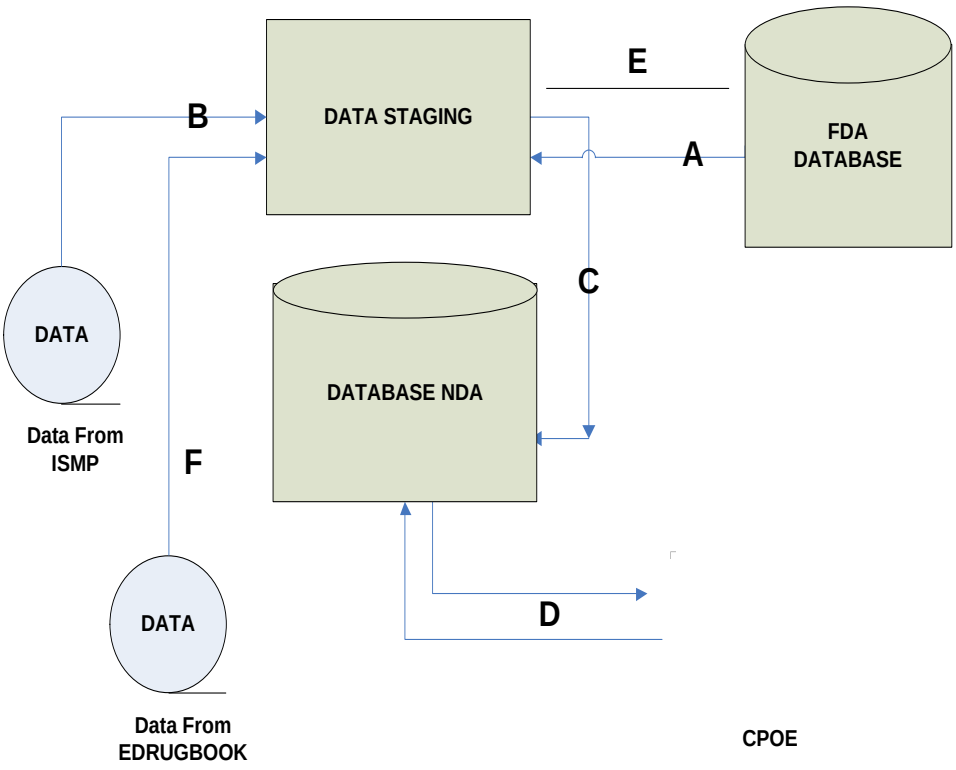
- FDA (Food and Drug Administration) Database
- E-Drugbook, the Clinicians Pocket Drug Reference 2015
- Institute for Safe Medication Practices (ISMP)

to the Staging Area (Data Staging), where data is :

- Cleaned to avoid invalid characters and values,
- Reformatted,
- Converted into tables

prior to being exported into the NDA Relational Database.

Figure 7: Data Flow Diagram for the Proposed System



A : Data Files from FDA Database to create the Embedded Pop-Up Alerts (NDA) Database

B : List of Confused drug Names (Text File) From the Institute for Safe Medication Practices

C : At the end of the ETL process, Tables are created then migrated into the NDA Database

D : Interaction between the CPOE and the NDA Database

E : Night Job. Script to periodically extract Data from FDA Database

F : Data from Clinicians Pocket Drug Reference 2015

Data Flow Diagram for NDA

3.3.2 Logical and Physical design of the NDA

In this logical and physical design of the NDA relational database, the task is to amend the pre-existing design by defining new entities (Tables) and attributes (Columns), determine the relationships (one-to-one, one-to-many) between these new entities and specify primary and foreign keys, while allowing interrelationships where applicable between existing and new entities.

3.3.3 Database Design Documents

The objective of this section of the database design is to introduce the :

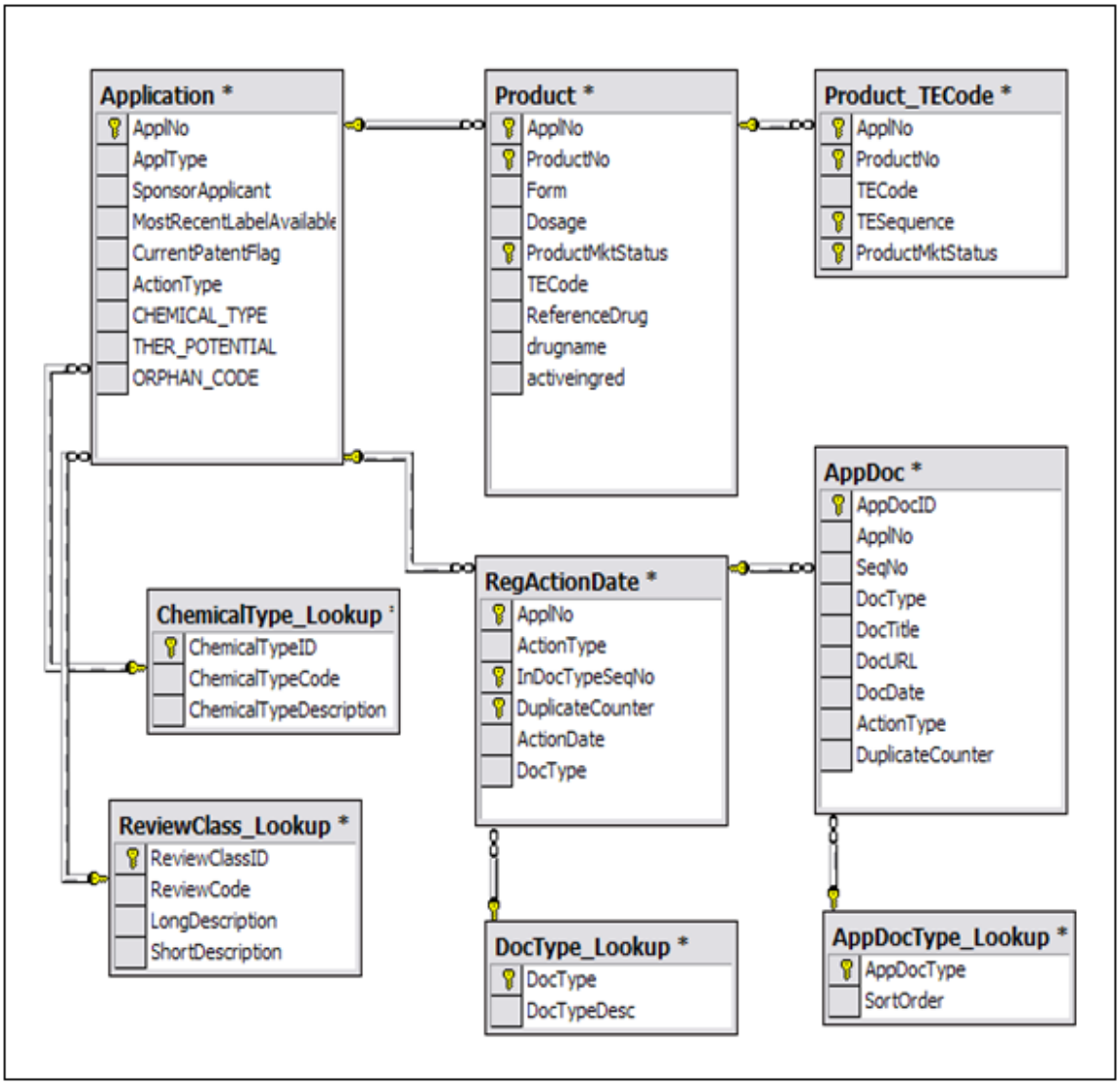
- Entity relationship Diagram
- Data Definitions
- Data Dictionary
- Table Creation Scripts

for the relational NDA database

3.3.3.1 FDA Data Definition and Entity relationship Diagram (ERD)

The entity relationship diagrams below show the relationships among all tables in the original database from the USA Food and Drug Agency (**FDA**), and the one intended to be used for this prescribing drug application.

Figure 8: Entity Relational Diagram for the FDAs Database



FDA Entity Relationship Diagram

Retrieved from : **Entity Relationship Diagram (ERD) for Drugs@FDA (Previous Version)**

Data Definitions

This section provides the description of all tables in the USA FDA database, and defines the type of their attributes.

Drugs@FDA consists of 9 tables:

1. **Application Documents (AppDoc)**: Document addresses or URLs to letters, labels, reviews, Consumer Information Sheets, FDA Talk Papers, and other types.
    - AppDocID [int, 4] (Primary Key)
    - ApplNo [varchar, 6]
    - SeqNo [varchar,4]
    - DocType [varchar, 50]
    - DocTitle [varchar, 100, nulls]
    - DocURL [varchar, 200, nulls]
    - DocDate [datetime, 8, nulls]
    - ActionType [varchar, 10]
    - DuplicateCounter [int, 4, nulls]

2. **Application Document Type Lookup (AppDocType_Lookup)**: Type of document that is linked, which relates to the AppDoc table.
    - AppDocType [varchar, 50] (Primary Key)
    - SortOrder [int, 4]

3. **Application (Application)**: Application number and sponsor name.
    - ApplNo [varchar, 6] (Primary Key)
    - ApplType [varchar, 5] (A=ANDA, N=NDA, B=BLA)
    - SponsorApplicant [varchar, 50]
    - MostRecentLabelAvailableFlag [bit, 1]
    - CurrentPatentFlag [bit, 1]
    - ActionType [varchar, 10]
    - Chemical_Type [varchar, 3, nulls]
    - Therapeutic_Potential [varchar, 2, nulls]
    - Orphan_Code [varchar, 1, nulls]

4. **Document Type Lookup (DocType_Lookup):** Supplement type code and description to the application number.
    - DocType [varchar, 4] (Primary Key)
    - DocTypeDesc [varchar, 50, nulls]

5. **Product (Product)**: This table contains the products included in each application. Includes form, dosage, and route.
    - ApplNo [varchar, 6] (Primary Key)
    - ProductNo [varchar, 3] (Primary Key)
    - Form [varchar, 255, nulls]
    - Dosage [varchar, 240, nulls]
    - ProductMktStatus [tinyint, 1] (1=prescription, 2=OTC, 3=discontinued, 4=tentative approval) (Primary Key)
    - TECode [varchar, 100, nulls]
    - ReferenceDrug [bit, 1] (0=not RLD, 1=RLD, 2=TBD)
    - Drugname [varchar, 125, nulls]
    - Activeingred [varchar, 255, nulls]

6. **Product_TECode**: Therapeutic Equivalence Code for Products.
    - ApplNo [varchar, 6] (Primary Key)
    - ProductNo [varchar, 3] (Primary Key)
    - TECode [varchar, 50]
    - TESequence [int, 4] (Primary Key)
    - ProdMktStatus [tinyint, 1] (Primary Key)

7. **Supplements (RegActionDate)**: Approval history for each application. Includes supplement number and dates of approval.
    - ApplNo [varchar, 6] (Primary Key)
    - ActionType [varchar, 10]
    - InDocTypeSeqNo [varchar, 4] (Primary Key)
    - DuplicateCounter [int, 4] (Primary Key)

- ActionDate [datetime, 8, nulls]
- DocType [varchar, 4, nulls]

8. **ChemicalType_Lookup**
    - ChemicalTypeID [int, 4] (Primary Key)
    - ChemicalTypeCode [varchar, 3]
    - ChemicalTypeDescription [varchar, 200]

9. **ReviewClass_Lookup**
    - ReviewClassID [int, 4] (Primary Key)
    - ReviewCode [varchar, 1]
    - LongDescritption [varchar, 100, nulls]
    - ShortDescription [varchar, 100]

3.3.3.2 NDA Data Definition and Entity relationship Diagram (ERD)

The NDA Database is created based on two tables from the USA Food and Drug Administration:

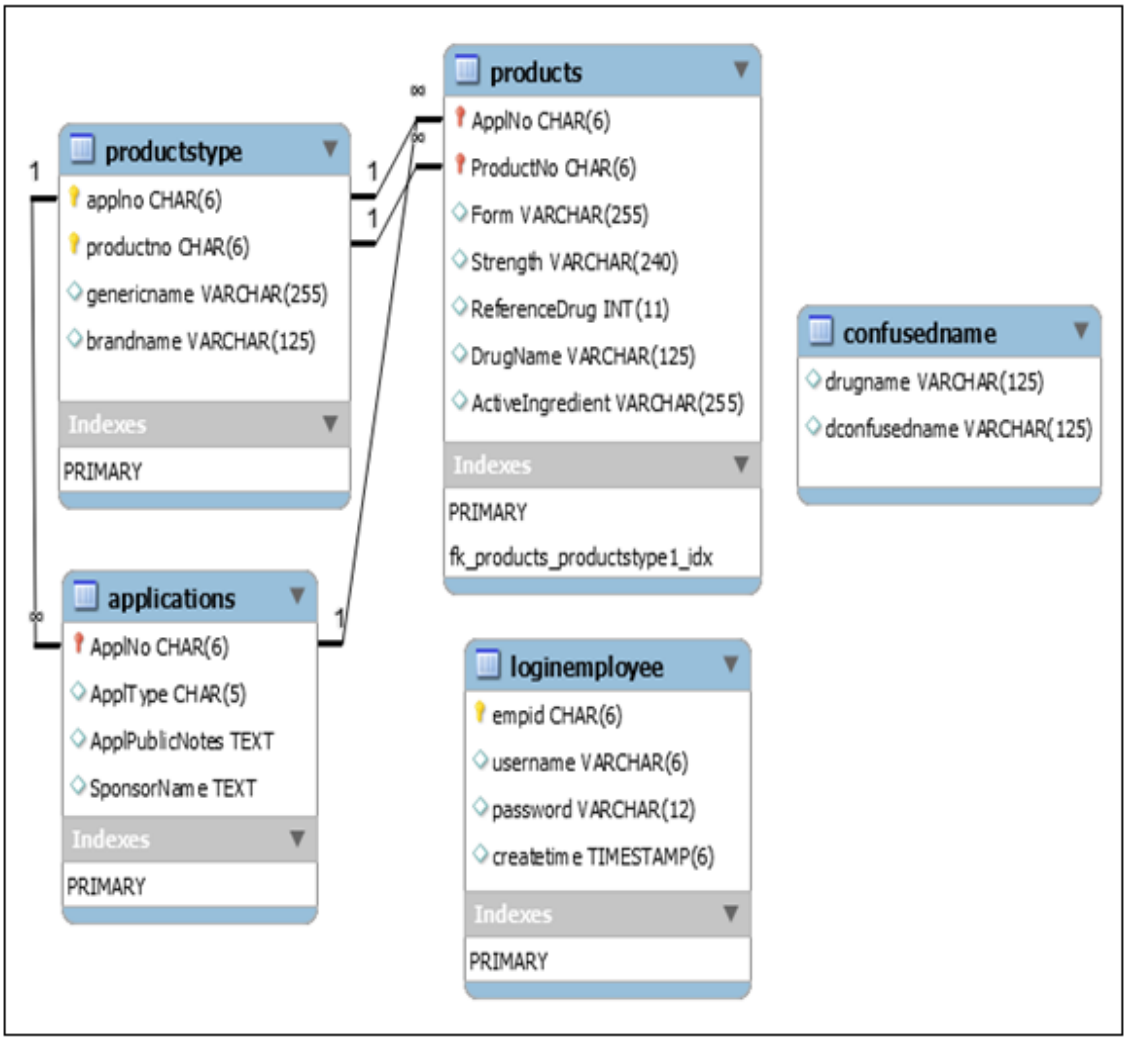
- Table Products
- Table Applications

and three tables from external data sources.

- Table ConfusedName (list of Look-Alike, Sound-Alike Drug Names)
- LoginEmployee
- ProductsType

Entity relationship Diagram (ERD):

Figure 9: Entity Relational Diagram for the NDAs Database



Data Definitions :

This section provides the description of all tables in the NDA database, and defines the type of their attributes.

NDA database consists of 5 tables:

1. **Products (Products)**: This table contains the products included in each application. Includes form, dosage, and route.
    - ApplNo char(6) (Primary Key)
    - ProductNo char(6) (Primary Key)

- Form varchar(255) null
- Strength varchar(240) null
- ReferenceDrug int(11) null
- Drugname varchar(125) null
- ActiveIngredient varchar(255) null

2. **Applications (Applications)**: Contains Application number and sponsor name.
    - ApplNo char(6) (Primary Key)
    - ApplType char(5) (A=ANDA, N=NDA, B=BLA)
    - ApplPublicNotes text null
    - SponsorName text null

3. **LoginEmployee (LoginEmployee)**: Contains EmpId and UserName.
    - EmpID char(6) (Primary Key)
    - UserName varchar(6) not null
    - Password varchar(12) not null
    - CreateTime timestamp(6) not null

4. **ProductsType (ProductsType)**: This table contains the products included in each application. Includes Generic and Brand Drug Names.
    - ApplNo char(6) (Primary Key)
    - ProductNo char(6) (Primary Key)
    - GenericName varchar(255) null
    - BrandName varchar(125) null

5. **ConfusedName (ConfusedName)**: This table contains a list of Confused Drug Names.
    - DrugName varchar(125) not null
    - DconfusedName varchar(125) not null

3.3.3.3 Data Dictionary :

This section describes the contents (list of objects that are in the NDA database), their format as well structure.

Table 25: Data Dictionary

Data Dictionary

Table Products				
Field	**Type**	**Null**	**Key**	**Comment**
ApplNo	char (6)	NOT NULL	PRI	Application Number
ProductNo	char (6)	NOT NULL	PRI	Product Number
Form	varchar (255)	NULL		Tablets, Drops, Injection
Strength	varchar (240)	NULL		Unit of dosage e.g. 20mg
ReferenceDrug	Int (11)	NULL		Drug Reference Number
DrugName	varchar (125)	NULL		Name of the drug
ActiveIngredient	varchar (255)	NULL		Components of a drug

Indexes Products				
Table	**Key Name**	**Column Name**	**Index Type**	**Index Comments**
Products	PRIMARY	ApplNo	BTREE	
Products	PRIMARY	ProductNo	BTREE	

Table ProductsType				
Field	**Type**	**Null**	**Key**	**Comment**
ApplNo	char (6)	NOT NULL	PRI	Application Number
ProductNo	char (6)	NOT NULL	PRI	Product Number
BrandName	varchar (125)	NULL		Brand Name of the drug
GenericName	varchar (125)	NULL		Generic Name of the drug

Indexes ProductsType				
Table	**Key Name**	**Column Name**	**Index Type**	**Index Comments**
Products	PRIMARY	ApplNo	BTREE	
Products	PRIMARY	ProductNo	BTREE	

Table APPLICATIONS				
Field	**Type**	**Null**	**Key**	**Comment**
ApplNo	char (6)	NOT NULL	PRI	Application Number
ApplType	char (6)	NOT NULL		A, N, B
ApplPublicNotes	text	NULL		
SponsorName	text	NULL		Name of the Sponsor
Indexes APPLICATIONS				
Table	**Key Name**	**Column Name**	**Index Type**	**Index Comments**
Applications	PRIMARY	ApplNo	BTREE	

Table LoginEmployee				
Field	**Type**	**Null**	**Key**	**Comment**
EmpID	char (6)	NOT NULL	PRI	Employee Number
UserName	char (6)	NOT NULL		Employee User Name
Password	varchar (12)	NOT NULL		Employee Password
CreateTime	timestamp (6)	NOT NULL		Time of creation
Indexes Employee				
Table	**Key Name**	**Column Name**	**Index Type**	**Index Comments**
LoginEmployee	PRIMARY	EmpID	BTREE	

Table ConfusedName				
Field	**Type**	**Null**	**Key**	**Comment**
DrugName	varchar (125)	NULL		Name of the drug
DconfusedName	varchar (125)	NULL		Confused Drug Name
Indexes ConfusedName				
Table	**Key Name**	**Column Name**	**Index Type**	**Index Comments**

3.4 Database Implementation

The implementation phase in the database life cycle (DBLC) is the phase where the following tasks are performed :

- Install the database management system (DBMS)
- Create the database
- Create tables
- Import and Load the data
    - Import the data (Text File Format) From the FDA database
    - Convert the data from Text file to Excel file
    - Convert the data from Excel CSV to SQL
- Set up the security
- Implement the backup and restore system

3.4.1 Install the database management system (DBMS)

The selected database management system software for this research is MySQL version 5.7, installed on a Window 7 Operating System.

3.4.2 Creating the database

The Database Instance called fda_12272016 was created using the following create statement:

CREATE DATABASE `fda_12272016 ` ;

3.4.3 Create the NDA tables

Following are the scripts used to create all tables in the NDA database:

Table products

```
CREATE TABLE `products` (
        `ApplNo` char(6) NOT NULL COMMENT NOT NULL,
        `ProductNo` char(6) NOT NULL COMMENT NOT NULL,
        `Form` varchar(255) DEFAULT NULL COMMENT NULL,
        `Strength` varchar(240) DEFAULT NULL COMMENT NULL,
        `ReferenceDrug` int(11) DEFAULT NULL COMMENT NULL,
        `DrugName` varchar(125) DEFAULT NULL COMMENT NULL,
        `ActiveIngredient` varchar(255) DEFAULT NULL COMMENT NULL,
         PRIMARY KEY (`ApplNo`,`ProductNo`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

Table applications

```
CREATE TABLE `applications` (
        `ApplNo` char(6) NOT NULL COMMENT NOT NULL,
        `ApplType` char(5) DEFAULT NULL COMMENT NOT NULL,
        `ApplPublicNotes` text COMMENT NULL,
        `SponsorName` text COMMENT NULL,
         PRIMARY KEY (`ApplNo`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

Table loginemployee

```
CREATE TABLE `loginemployee` (
        `empid` char(6) NOT NULL,
        `username` varchar(6) DEFAULT NULL,
        `password` varchar(12) DEFAULT NULL,
        `createtime` timestamp(6) NULL DEFAULT NULL,
```

```
        PRIMARY KEY (`empid`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

Table productstype

```
CREATE TABLE `productstype` (
        `applno` char(6) NOT NULL COMMENT NOT NULL,
        `productno` char(6) NOT NULL COMMENT NOT NULL,
        `genericname` varchar(255) DEFAULT NULL,
        `brandname` varchar(125) DEFAULT NULL,
         PRIMARY KEY (`applno`,`productno`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

Table confusedname

```
CREATE TABLE `confusedname` (
        `drugname` varchar(125) DEFAULT NULL,
        `dconfusedname` varchar(125) DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=utf8
```

3.4.4 Import and Load the data

The task of importing and converting data from the US FDA is done through three steps as follows :

- import the data from FDA
- Convert the data from text file to Excel spreadsheet
- Convert the data from Excel CSV to SQL

3.4.4.1 Import the data (Text File Format) from the FDA database

N.B: See steps in appendice page 273

3.4.4.2 Convert the data from Text File to Excel File format

The following are the steps for migrating data from the FDA database. The FDA offers a copy of their database in text file format, giving the opportunity to import and convert it in a data type of your choice. As the use of Data Export and Import Wizard in MySQL is not straightforward in this specific case :

- Non existence of the DUMP Database where to Import from ,
- Data offered by the FDA is in Text Format but not in SQL format

the following steps were used to perform the conversion :

Figure 10: Steps for Extracting and Converting Files to Excel (CSV)

N.B: See steps in appendice page 273

3.4.4.3 Convert the data from Excel CSV to SQL

Figure 11: Steps for Extracting and Converting files from CSV to MySQL

N.B: See steps in appendice page 277

3.4.5 Set up the security

Protecting the database and its content has always been a bigger concern when comes to handle threats. Threats can be :

- Human threats (employees or hackers),
- Natural (hurricanes and fires etc),
- Technology failure (hardware and/or software crashing).

3.4.6 Implementing the backup and restore system

The NDA database being a portion of the main database that already exists, we assume that all security measures from accessing to backing up the database have been put in place; therefore, only authenticating users applies in this section and, will be discussed in chapter four.

3.5 Database Test Cases

According to Tutorials Point [**97**], "Database testing includes performing data validity, data integrity testing, performance check related to database and testing of procedures, triggers and functions in the database".

The performance won't be tested in this phase, because it is usually done when there is a high number of concurrent connections to the database thus, high volume of inputs/outputs. In our case, there is only one user connecting to the NDA database.

In the following paragraphs we perform data integrity testing using various Data Definition Language (**DDL**) such as Create, Modify and Delete; Data Manipulation Language (**DM**L) such as Select, Insert, Update; Data Control Language (**DCL**) such as: *GRANT*.

Table 27: List of Test Cases

Title		Test Case A	Results	Notes
Test Purpose		Find Duplicate Rows in the Database		
Test Steps	**1**	Open MySQL Database then type your password GoTo File - New Query Tab		
	2	**Test Table Products**		
		Select Count(*) c FROM products group by applno, productno HAVING c>1;	0 Rows	
	3	**Test Table Applications**		
		Select Count(*) c FROM applications group by applno HAVING c>1;	0 Rows	
	4	**Test Table LoginEmployee**		
		Select Count(*) c FROM loginemployee group by empid HAVING c>1;	0 Rows	
	5	**Test Table ProductsType**		
		Select Count(*) c FROM productstype group by applno, productno HAVING c>1;	0 Rows	
	6	**Test Table ConfusedName**		
		Select Count(*) c FROM confusedname group by drugname HAVING c>1; Note: /* *Same Brand Name can have multiple Strength e.g. 10mg, 40mg, so Brand Name will appear more than one. Also a Brand Name can have multiple Generic Names from multiple Generic Companies* */	127 Rows	This is Okay
Title		**Test Case B**	**Results**	**Notes**
Test Purpose		Count Total Number of Rows to check any discrepancy after data migration		

Test Steps	**1**	**Test Table Products**		
		Select Count(*) FROM products;	34739 Rows	
	2	**Test Table Applications**		
		Select Count(*) FROM applications;	20661 Rows	
	3	**Test Table LoginEmployee**		
		Select Count(*) FROM loginemployee;	0 Rows	Okay
	4	**Test Table ProductsType**		
		Select Count(*) FROM productstype;	34739 Rows	
	5	**Test Table ConfusedName**		
		Select Count(*) FROM confusedname	945 Rows	
Title		**Test Case C**	**Results**	**Notes**
Test Purpose		Random Testing		
Test Steps	**1**	**Test Table Products**		
		Select Count(*) FROM products WHERE drugname LIKE AC% /* List of all drug names that START With " AC" */	419 Rows	
	2	**Test Table Applications**		
		Select * FROM applications WHERE applNo **NOT IN** (Select ApplNo FROM **Products**); /* List of Application Number from Application Table that are missing in Product Table: **EX: 020380** */	47 Rows	
	3	**Test Table Products based on Test #2 above**		
		Select * FROM Products WHERE applNo = 020380 ; /* Search ApplNo = 020380 in Table Products */	0 Rows	
Title		**Test Case D**	**Results**	**Notes**
Test Purpose		Backups and Restore Testing		
Test Steps	**1**	**Backup database or database objects**		
	2	**Restore database or database objects**		

3.6 Database Rollout (Operation)

Rolling out or deploying the NDA database is the process of implementing it from a Test to a Production environment thus, making it available to designated users for everyday use. Two options are available : Create a new database, or Use the existing one. Some of their advantages and disadvantages are presented in the table below

Table 28: Implementing New Database Vs Using the Existing one: Pros and Cons

	Create New Database	Use Existing Database
Method	Migrate the development database in production environment	Prepare Night job to create all objects from the Test to Production database
Maintenance	- Easy (small database) - Few objects for : a) Backup./recovery b) Disk Space management	- More complex Maintenance plan is already in place.
Security	Set up the security for the entire database	Security already in place. Must give access rights to new tables
Availability	Doesn't depend on any other database	Cannot access any table if the database is down
Performance	- Fast: Only drug prescribers can connect into the NDA database	- Slow because of : a) High number of objects in the database b) High number of concurrent connections to the database c) High volume of inputs/outputs (Select, Open, Close, Create)

Even if the NDA can operate as a stand-alone application, we suggest that it be embedded in an existing system (CPOE), to avoid breaking users workflow into sections (have them stop performing their current task(s), switch to the NDA system, then search for the desired information).

3.7 Database Maintenance

Over a period of time, with an increase volume of data, users, the aim to adopt a new technology to list a few, the production database becomes slow, obsolete therefore, unable to satisfy business needs. Keeping a database up to date or maintaining it is a never-ending task that requires the following functions :

- Control Disk Storage and Memory
- Backup and Restore (daily incremental backup, weekly full backup)
- Running Weekly night job to check new drugs from the FDA database
- Maintaining tables (partitioning, adding, dropping table, increasing size, adding, dropping columns etc)
- Maintaining user accounts (adding, removing, updating, managing passwords)
- Maintaining data integrity
- Maintaining security (system, and objects privileges)
- Maintaining indexes (adding, dropping)
- Provide user manual
- Training

CHAPTER IV

DESIGNING, DEVELOPING, IMPLEMENTING AND TESTING THE NOVEL DECISION ALGORITM EMBEDDED IN A CPOE

4.1 Introduction

This chapter examines and covers the creation, design, development, implementation and testing of the **Novel Decision Algorithm** module in a stand-alone system or, integrated in a CPOE; In this chapter we also design and run Test Cases to support the effectiveness of the proposed module.

4.1.1 Definitions

Stand-alone System

A standalone computer system refers to any laptop or desktop computer that can run local applications on its own without needing a connection to a wide area network (WAN) or a local area network (LAN). All the application programs required for general use are installed on the hard disk [**90**]

Integrated System

Combined; merged. A collection of distinct elements or components that have been built into one unit [**91**]. The concept of integrated system is used in system engineering, system analysis, and operations research [**92**].

System Integration

The process of bringing together the component subsystems into one system and ensuring that the subsystems function together as a system [**93**].

The task of developing a software can be split in two parts:

- Software Creation
- Software Project

4.1.2 Software Creation

Creating a software is more than just writing a program code.

A program is a set of logical instructions, an executable code that performs a particular task, while a software is considered to be a collection of executable programming code. Therefore the project of creating a software to monitor and prevent Sound-Alike Drug Name Errors will be broken down into *executable programming code,* smaller and more manageable tasks that are involved in achieving the bigger aim.

4.1.3 Software Project

4.1.3.1 Definition

A project can be considered to be any series of activities and tasks that:

- Have a specific objective to be completed within certain specifications
- Have defined start and end dates
- Have funding limits (if applicable)
- Consume human and nonhuman resources (i.e. money, people, equipment)
- Are multifunctional (i.e. cut across several functional lines). (PMBOK)[**95**].

According to Tutorials Point [**94**], "A Software Project is the complete procedure of software development from requirement gathering to testing and maintenance, carried out according to the execution methodologies, in a specified period of time to achieve intended software product".

As every project needs to be managed, the software project management in the context of this research, will only apply on 2 (two) constraints of the triple constraint functions of the software project management as shown in the figure below :

Figure 12: Functions of the Software Project Management

Retrieved from : https://programsuccess.wordpress.com/2011/05/02/scope-time-and-cost-managing-the-triple-constraint/

4.1.3.2 Time constraint : This refers to the actual time from start to finish to *produce the Novel Decision Algorithm* (NDA) application

4.1.3.3 Scope/Quality constraint : This refers to the success, the quality upon delivery of the *Novel Decision Algorithm* (NDA) application

4.1.3.4 Cost constraint : Not applicable. No data to evaluate the Cost (amount of money required to complete the project, risk estimates, resources etc …,) constraint.

4.2 Creating the Decision Algorithm

4.2.1 Introduction

As mentioned in the rubric "**Dissertation Goal**", because of the time frame allocated to this dissertation, we will only focus on the

- Requirements gathering
  - Business requirements
  - User requirements
  - Software (System) specification
- Design,
- Development,
- Implementation,
- Testing

phases that are part of the System Development Life Cycle (SDLC), with the assumption that the Feasibility Study and System Analysis were successfully accomplished, and that the Maintenance tasks will be performed in order to :

- Address and resolve issues discovered after deployment of the module (software),
- Prevent any hindrance to the expected performance,
- Release new updates due to changes in users needs or equipment replacement .

4.2.2 Requirements

A requirement is a statement provided by stakeholders (Those who have the final say) about the

- Why
- What
- How

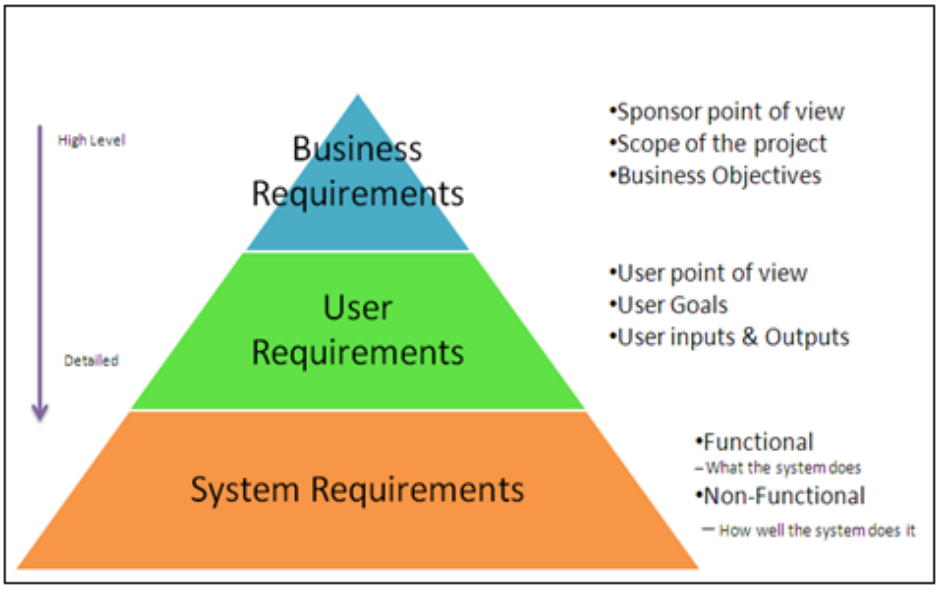
of a project, a new or altered product.

Type of Requirements:

According to Justin Mifsud [**89**] in the Requirements Gathering: A step by step approach for better user experience (Part 1), there are three types of requirements :

- Business Requirements (The Why)
- User Requirements (The What)
- System Requirements (The How) as shown in the diagram below

Figure 13: Types of Requirements Gathering



Retrieved from : **http://satheespractice.blogspot.com/2012/08/importance-of-non-functional.html**

4.2.2.1 **Business Requirements for the Novel Decision Algorithm** (NDA)

Every new product, new activity or product in any organization is created in response to a business need. The ultimate goal of the business requirements is to help understand the business needs in order to build a complete picture of what the project, the mew or altered product should accomplish. In the context of the Novel Decision Algorithm system, the business need is to build an application that minimizes the number of medication errors caused by drug names that sound alike. The following is a prototype, a diagram, figure or model of the system that is expected to be delivered.

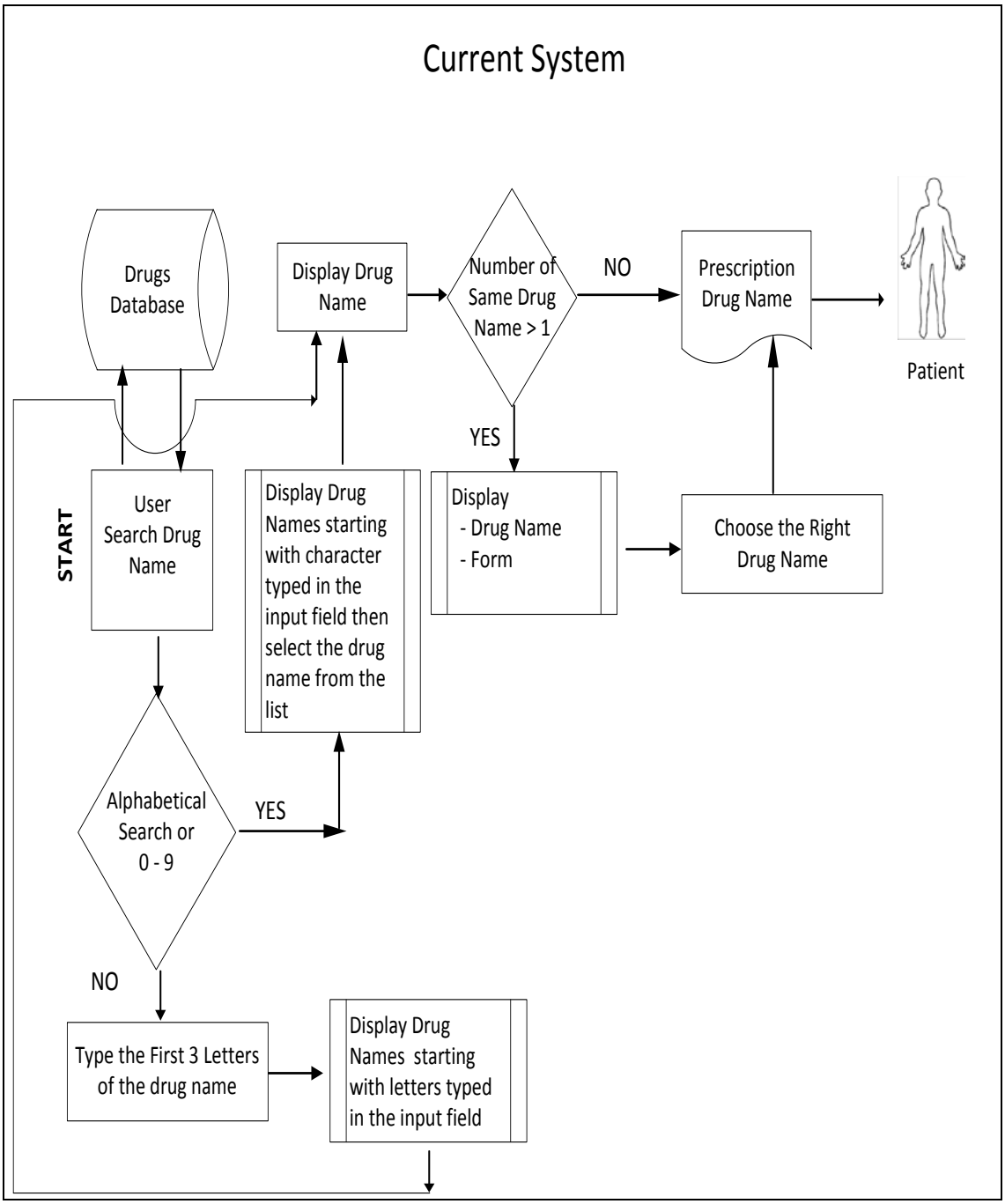


Figure 14: Diagram of the Existing System

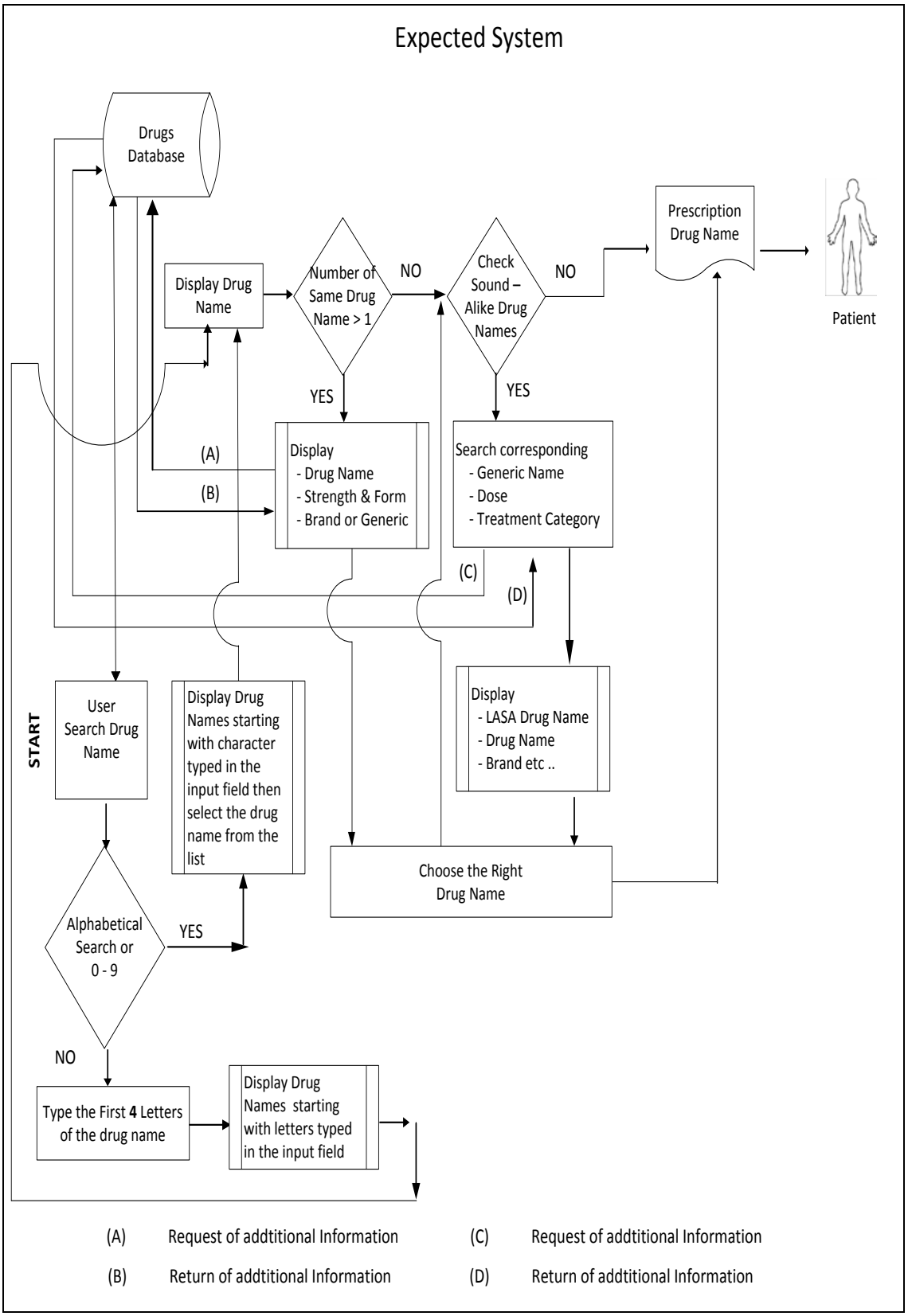


Figure 15: Diagram of the Proposed System

Table 29:

4.2.2.1.3 Table describing limitations and benefits of the two systems

	Current System and Its Limitations	**Expected System And its Benefits**
Search criteria	3 Characters required : High volume of records returned by the query High probability to select the wrong drug name	4 Characters required : Low volume of records returned by the query Low probability to select the wrong drug name
Drug Information	Display less information about the drug, thus requires additional verification	Display more information about the drug to make it as distinct as possible. Facilitates the drug selection
Confused Drug Names (LASA)	N/A	Verifies whether or not the medication requires more attention in order to reduce the risk of errors.

4.2.2.2 User Requirements for the Novel Decision Algorithm (NDA)

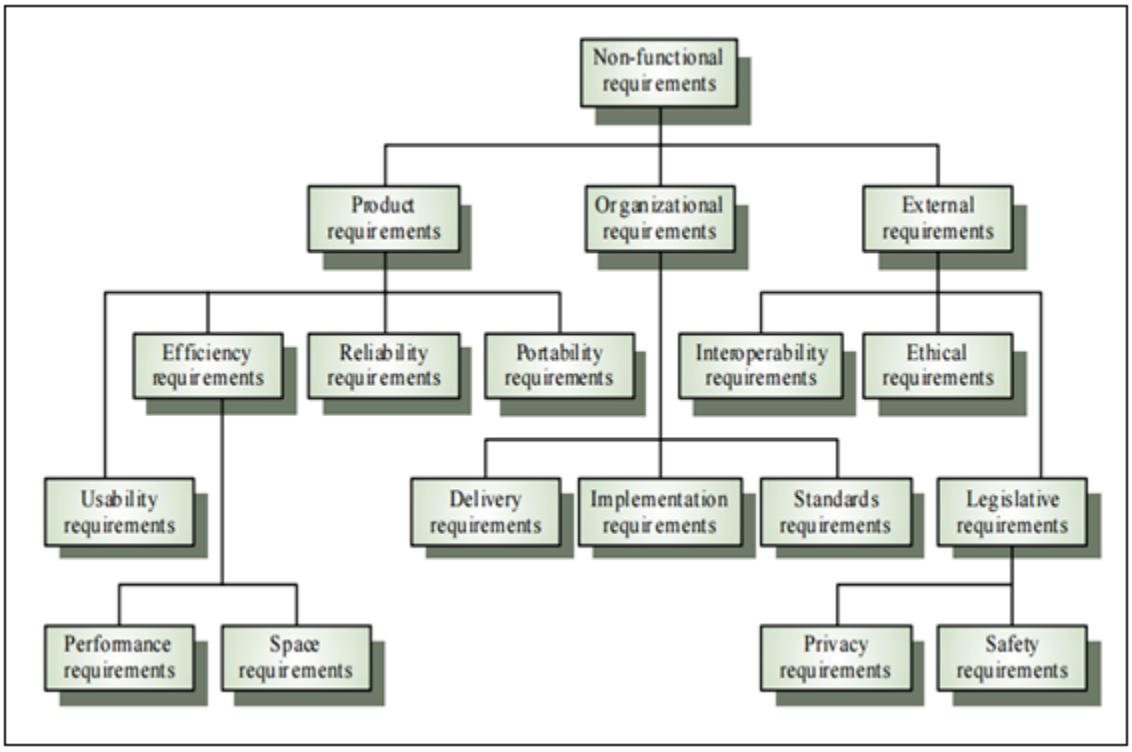
User requirements are a set of specifications, a document that specifies what is wanted and expected from the users perspective. in the context of this research, we assume user and business requirements are combined (same).

4.2.2.3 System Requirements for the Novel Decision Algorithm (NDA)

The system requirements defines how the aimed product or service should work from the end-users perspective. These requirements are called *functional* because they

describe the features and functions with which the end-user will interact directly to accomplish his/her tasks. The system requirements also identifies *non-functional* requirements that are **Constraints** and **Standards** that the system must have or comply with as shown in the following diagram:

Figure 16: Non Functional Requirements



Retrieved from : http://usabilitygeek.com/requirements-gathering-user-experience-pt1/

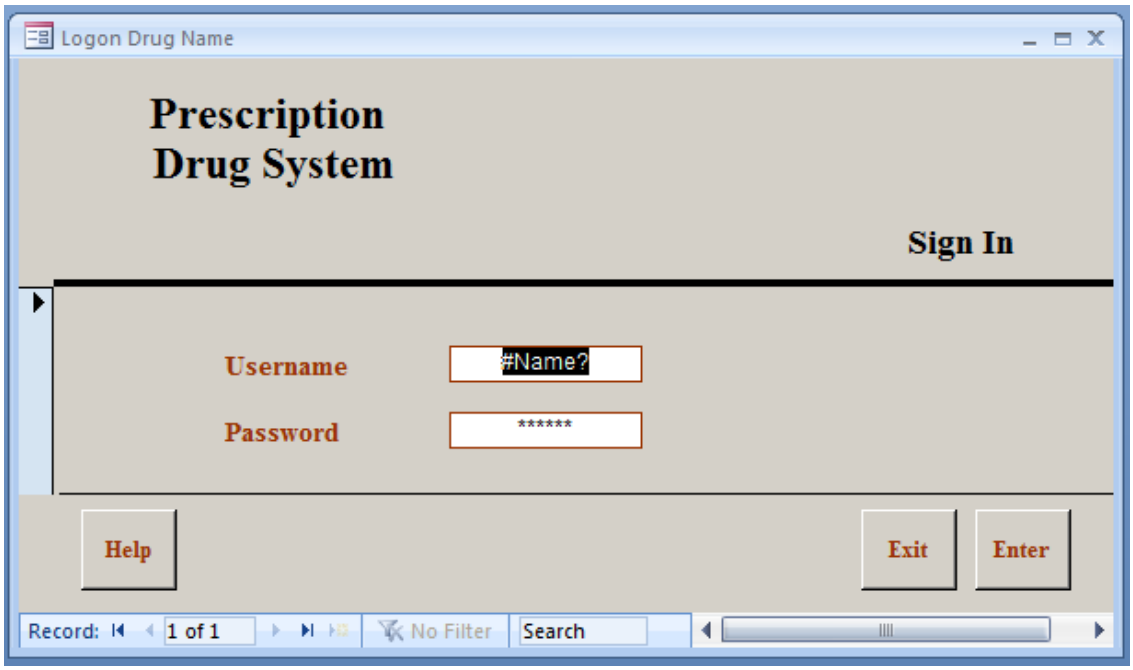
In this section of system requirements, we are building a Prototype, a User Interface without adding detail functionalities to interpret the futures on the expected product. It is relevant to do so because it gives users an idea of what the final product will look like.

4.2.2.3.1 Graphical User Interface

Login Screen:

This screen is used for the security purpose. It only allows authorized users to enter the system.

Figure 17: System Login Screen



Menu Screen:

This screen presents a list of choices to search for medication to be prescribed

Figure 18: Menu Screen

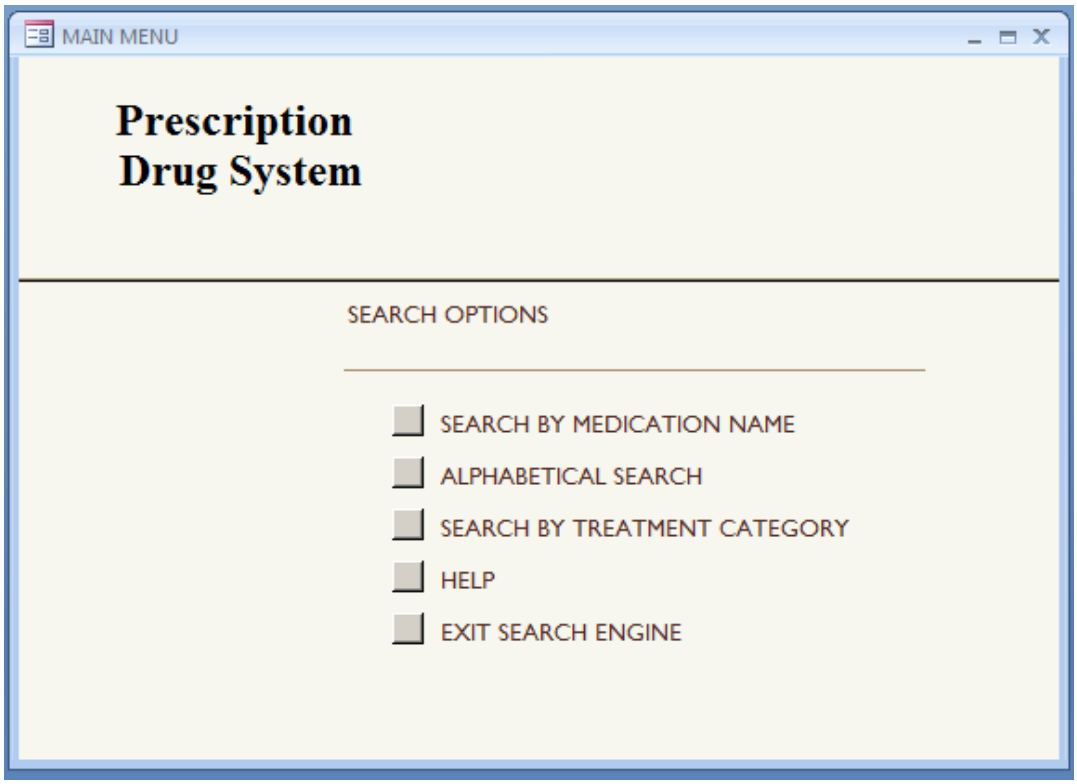


Figure 19: Drug Search By Name Screen

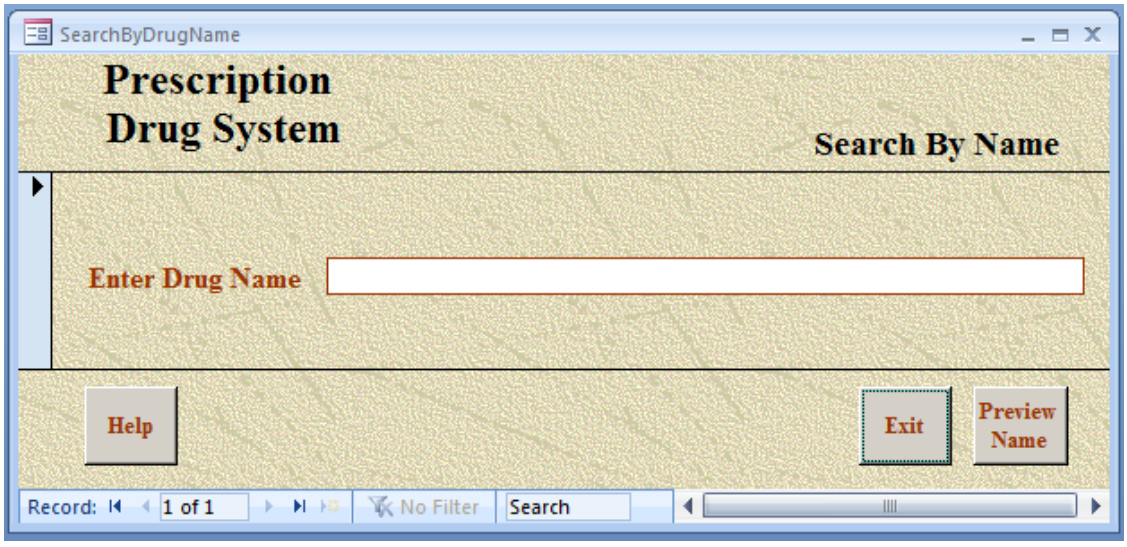


Figure 20: **Drug Name Search Alphabetically**

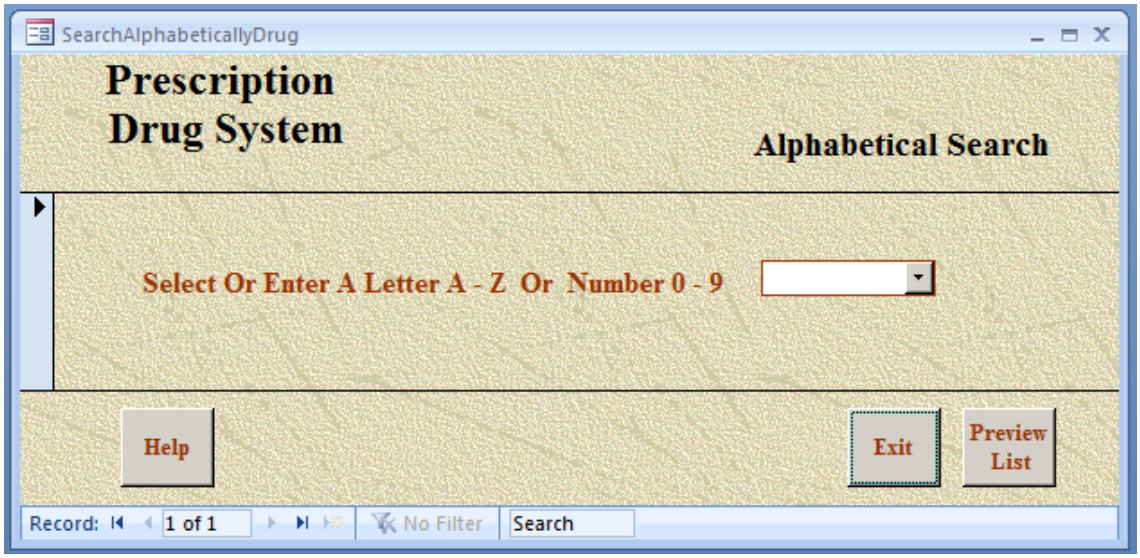
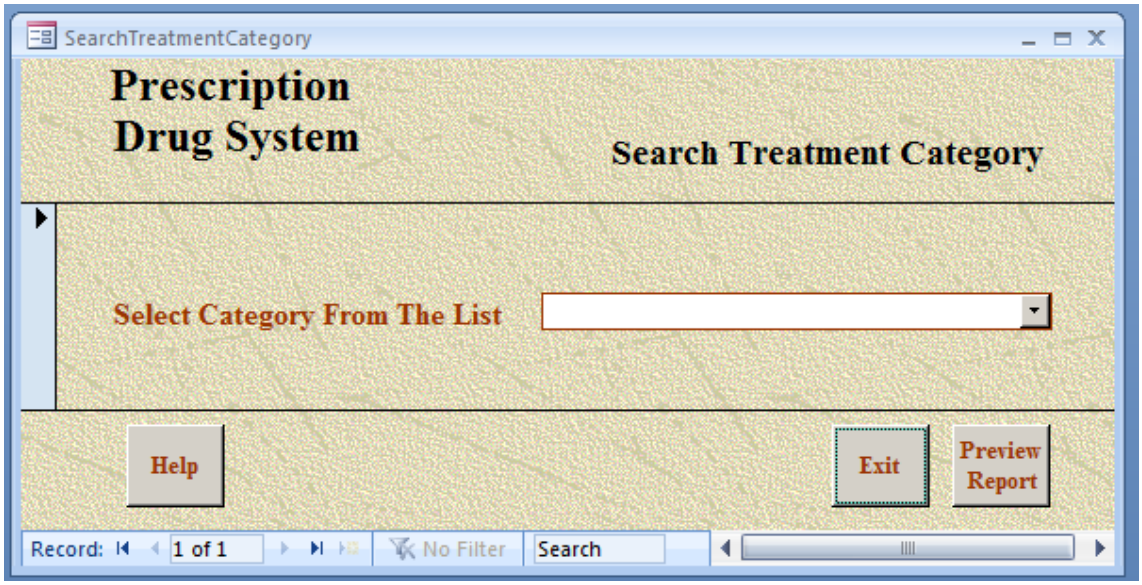


Figure 21: **Drug Name Search By Category**



This screen is a filter, the first that prompts to users during the priscribing process in order to execute the search by drug category first, then by drug name or letters within that specific drug category. This will eliminate all cross reference drug names.

4.2.3 Software Design

4.2.3.1 Introduction

Software design is the process of transforming user requirements into programming code. According to the Institute of Electrical and Electronics Engineers (IEEE) in its IEE90 which is the Standard Glossary of Software Engineering Terminology [**87**], design is both " the process of defining the architecture, components, interfaces, and other characteristics of a system or component", and "the result of that process".

The structure of information presented in this section is based on guidelines, a template, an annotated outline for a software design document from the Institute of Electrical and Electronics Engineers (IEEE) recommended Practice for Software Design Description. The template used in this section is adapted to the needs of this project and provides the reader with a better understanding of the inner workings of the **Novel Decision Algorithm** (NDA) system.

4.2.3.2 **Software Design Documents (SDD)** for NDA System

Table 30: Content of Software Design Documents

INTRODUCTION	
Purpose	This software design document describes the architecture and system design of the **Novel Decision Algorithm** (NDA)system.
Scope	The main goal of this project is to build an application that minimizes the number of medication errors caused by drug names that sound alike, during the drug prescribing process.

Type	Depending on the context, this application can be used as a: - Module - Program - Subprogram - Class
Overview of document	This overview is a short description of how the document is organized and also what can be found in the rest of this document. Topics that will be discussed in the rest of document are: - System Architecture . It help understand how subsystems collaborate with each other to achieve the desired functionality, the dependencies, order of execution, data validation and data flow etc. - Component design: to take a closer look at what each component of this application does, provides a summary of algorithm for each function of this application (optional), describes all objects and local data if applicable. - Interface design : It describes the functionality of the system from the user perspective. It explains the interaction between user and system etc. - Data design, - Resources: to give a complete description of all internal and external resources (hardware or software) required to carry out the functions of this application, to list a few.
SYSTEM OVERVIEW	
This module is an upgrade of any existing drug prescribing system. The intent is to	

add a second level of validation or security in order to assist drug prescribers in selecting the right drug name to be prescribed. This extra step in the process of selecting drugs takes into account and manages drug confusing names (LASA), also it displays or provides additional information on whether the medication is Generic or Brand name, dosage, form etc …all of this to make the selection of drug during the drug prescribing process as more unique as possible, and therefore minimize the risk of medication errors. Following is the description of how the proposed system works.

- User authentication is the very first step where the system verifies the identification of the prescriber. Valid usernames and passwords are required to access the system. User has three attempts. At the fourth one, the system locks you out, provides you with help on how to connect, then stops.
- A valid authentication takes the user to the main menu where multiple choices are offered.
- In case of search by name, a search by name function (procedure) is called to validate (query the database) the name of medication entered, then to process the request.
- If the name of medication doesn't exist or misspelled, the user gets an error message.
- If the name of medication exists in the database then the system operates as described in the prototype (diagram) called " ***Expected System*** ".
- However, the compatibility issue or ability of this system to interact with other system is not known yet as the ***functional testing*** is made on a Standalone Computer. Because this function or module is viewed as an ***object*** which is : ("*A self-contained entity that consists of both data and procedures to manipulate the data* ") according to (Webopedia), we believe it can be called or integrated in another program, therefore it has the capability to interact with other systems.
- There is no special requirements in terms of computer hardware or software for running this module. Any computer with Microsoft Windows operating system along with Microsoft Office 2007 or greater, MySql Database can be used to

run this application.	
SYSTEM ARCHITECTURE	
This section introduces the various components and subsystems of the NDA system	
Module Security	The purpose of this module is to validate the access to the system. A valid username and password are required prior to accessing the system.
Module Storage	This module allows user to : - Store - Query - Retrieve the information from the database or from the system in general
Module Search Engine	This module offers user tools to perform various search types on the database such as : - Search Drug by Name - Search Drug by alphabetical letters - Search Drug by treatment category. Based on users need, a query is sent to the database, the database engine processes the information then sends back the results to user who analyzes them and takes some actions. No search is possible without the use of the database.
Module Validation	The purpose of this module is to validate users requests based on applications predefined conditions. The system has to performs some tests prior to moving to the next step of the execution of a given task. The output of this test might lead or not to another test or to the execution of a given action.

Module Display	This module displays the information from the system that user has requested.
Module Output	This module allows user to send to an output device, the information received from the system
DATA DESIGN	
This section describes the major data used to develop the (NDA) module. A rubric Database Creation provides detail information in regards to how and where the data is stored. We include a Data Dictionary in this section to describe the structure and attributes of data to be used.	
Data Dictionary	
SEE CHAPTER III, SECTION **3.3.3.3**	
USER INTERFACE	
This section presents all the screens that allow user and system interaction.	
Sign In Screen	
Username	The username is created by user. The length of username is 6 characters (mix of numbers and letters), case sensitive.
Password	Length of password 12 characters (mix of symbols, upper and lower case, numbers and letters), case sensitive
Help Button	On click, help about the current screen is offered to user
Enter Button	Enter Button : On click, the system validates users action
Exit Button	Exit Button : On click, the system lives the current screen (object)
Search Options Window	

Search by Medication Name	When you click on this option, a screen "Search by Name" is called.
Alphabetical Search	When you click on this option, a screen "Alphabetical Search" is called. You can type in, or select an alphabetical letter or a number between 0 and 9.
Search by Treatment Category	Clicking on this option calls a screen "Search Treatment Category" where you can select your category from the drop down menu
Help	The Help option provides user with information related to the "Search Options" menu
Exit Search	Clicking on this option removes the current window from the screen
Search by Name Screen	
Enter Drug Name	This field is used to search the drug name. You can type in the drug name, max 135 characters.
Exit	Clicking on this option removes the current window from the screen, then takes the user back to the Search Options menu
Help	The Help button provides user with information related to how to use this screen
Preview Name	When clicked, the result of the search is displayed on the screen
Alphabetical Search Name Screen	
Select A - Z or 0 - 9	This field accepts alphabetical letters (A-Z) and numeric numbers between 0 - 9 when entered or typed in the field, then the search is performs against the database to display the list of drug names. Symbols are not accepted
Help	The Help button provides user with information related to how to use this screen
Preview List	When clicked, the result of the search is displayed on the screen. The

	user selects a drug name from the list, then the drug name is displayed in the same format as for the "Search by Name".
Exit	Clicking on this option removes the current window from the screen, then takes the user back to the Search Options menu
Search Treatment Category Screen (Optional)	
Select Category	This field is a drop box list where user selects the category to search in, then select the appropriate drug name.
Help	The Help button provides user with information related to how to use this screen
Preview Report	When the category is selected as well as the drug name, the result of the search is displayed on the screen in the same format as for the "Search by Medication Name".

4.2.4 Software Development

4.2.4.1 Introduction

As the software design stage has been completed, the aim of the software development is to create or write the code and actually develop the proposed system.

The Search Engine Interface of the Old (Drugs@FDA) and New (NDA) systems being identical because they both allow a search by Medication Name, Alphabetical search etc, we deliberately chose not to rewrite thousands lines of interrelated programming code for:

- The GUI (Graphical User Interface),

- Data capture forms (Forms allowing inputs into data fields),
- Data input forms (e.g. Drop-Box: Used to reduce errors and ensure consistency)

But instead focus on how data from the Old and New databases is

- Retrieved,
- Manipulated,
- Submitted to users.

Therefore the NDA has to be viewed as a proof of concept, that might need additional testing and review prior to being deployed in production environment. This first version of NDA includes the following modules:

- Login
- Search for Brand and corresponding Generic drug names
- Search for Look-Alike / Sound-Alike drug names
- Search for LA/SA and Confused Drug names
- Search for Drug and Confused Drug Names
- Pop Up Alert Reminder when prescribing Confused Drug Names

In the next sections, we list and describe functions, queries, procedures and validations rules used during the input as well as the extraction and display of data. The programming languages used are PHP, JavaScript and SQL (Structured Query Language).

4.2.4.2 Data Validation:

Validating data is relevant even if this application does not allow users to save data into the database. While users are either entering their credentials or interacting with

the system when submitting requests to the database, it is necessary that we set rules to make efficient the use of this system. Two modules, *Login Screen* and *Search By Name* are affected.

4.2.4.2.1 Code for Login Screen :

Validating User Name and Password:

For the security purpose, users are required to identify themselves in order to access the system. Each user will be assigned a unique User Name and Password by the administrator. A screen shot of the Login user interface is shown below as well as the programming and validation code used for its creation:

- Function **trim()**

The purpose of this function is to remove whitespace and other user predefined characters from both sides of a string.

- Function **preg_match()**

This function searches string for pattern, returning true if pattern exists, and false otherwise.

- **Login Screen** :

Figure 22: Login Form Screen

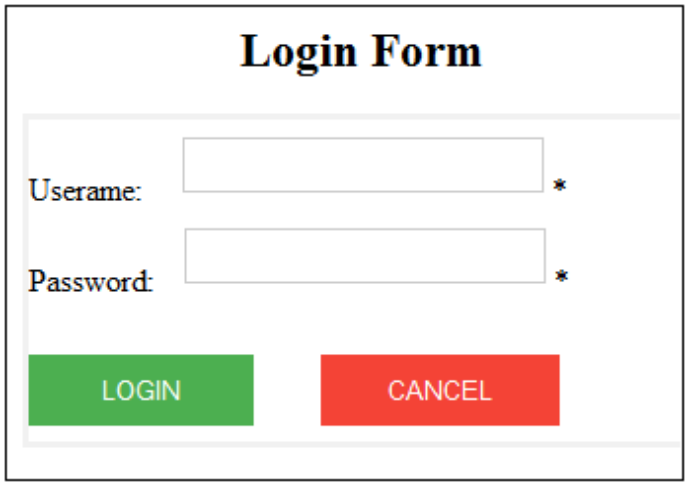
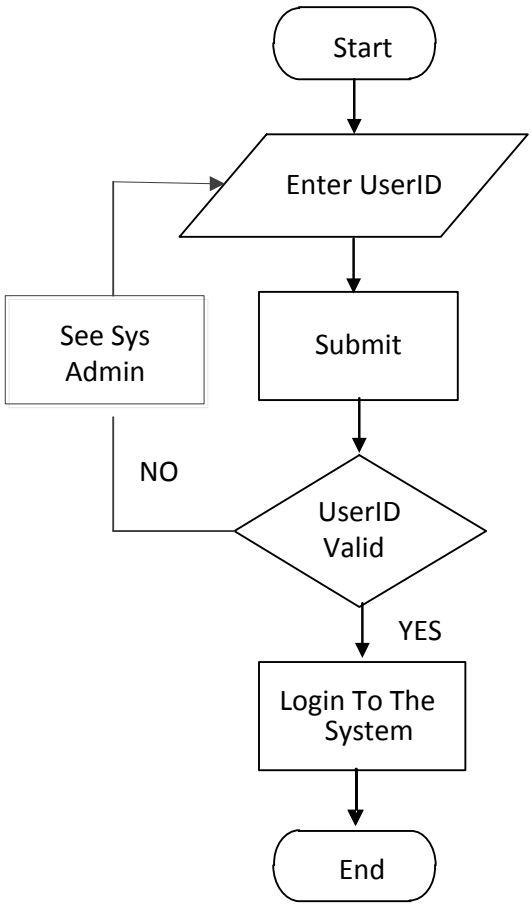


Figure 23: Algorithm for Login



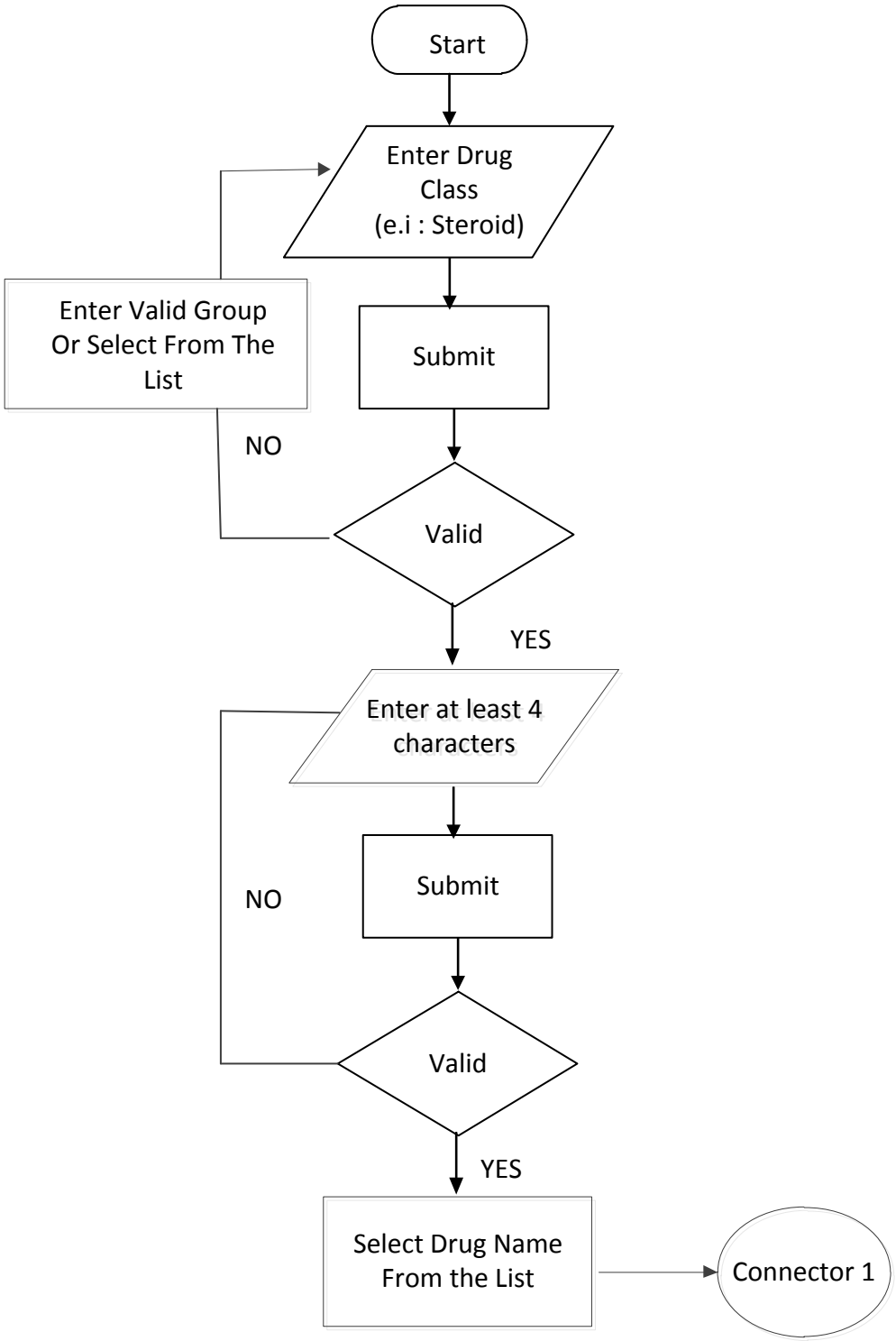
4.2.4.2.2 Code for Search Screen :

In the following paragraphs we provide PHP, HTML and JAVA programming code in the appendice and algorithm that were used to create the GUI (Graphical User Interface) as well as the scripts to connect, validate data entry, query and retrieve data from the database.

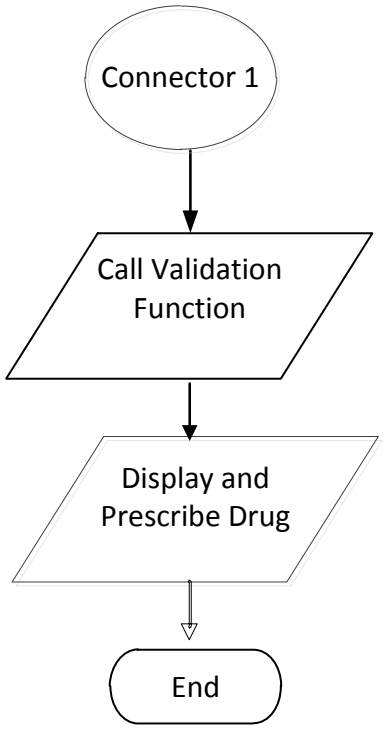
4.2.4.2.2 .1 Search Drug Alphabetically :

Figure 23: Search by Letter

Figure 25: Algorithm for Search by Letter


Start
Enter Drug Class (e.i : Steroid)
Submit
Enter Valid Group Or Select From The List
NO
Valid
YES
Enter at least 4 characters
Submit
NO
Valid
YES
Select Drug Name From the List
Connector 1

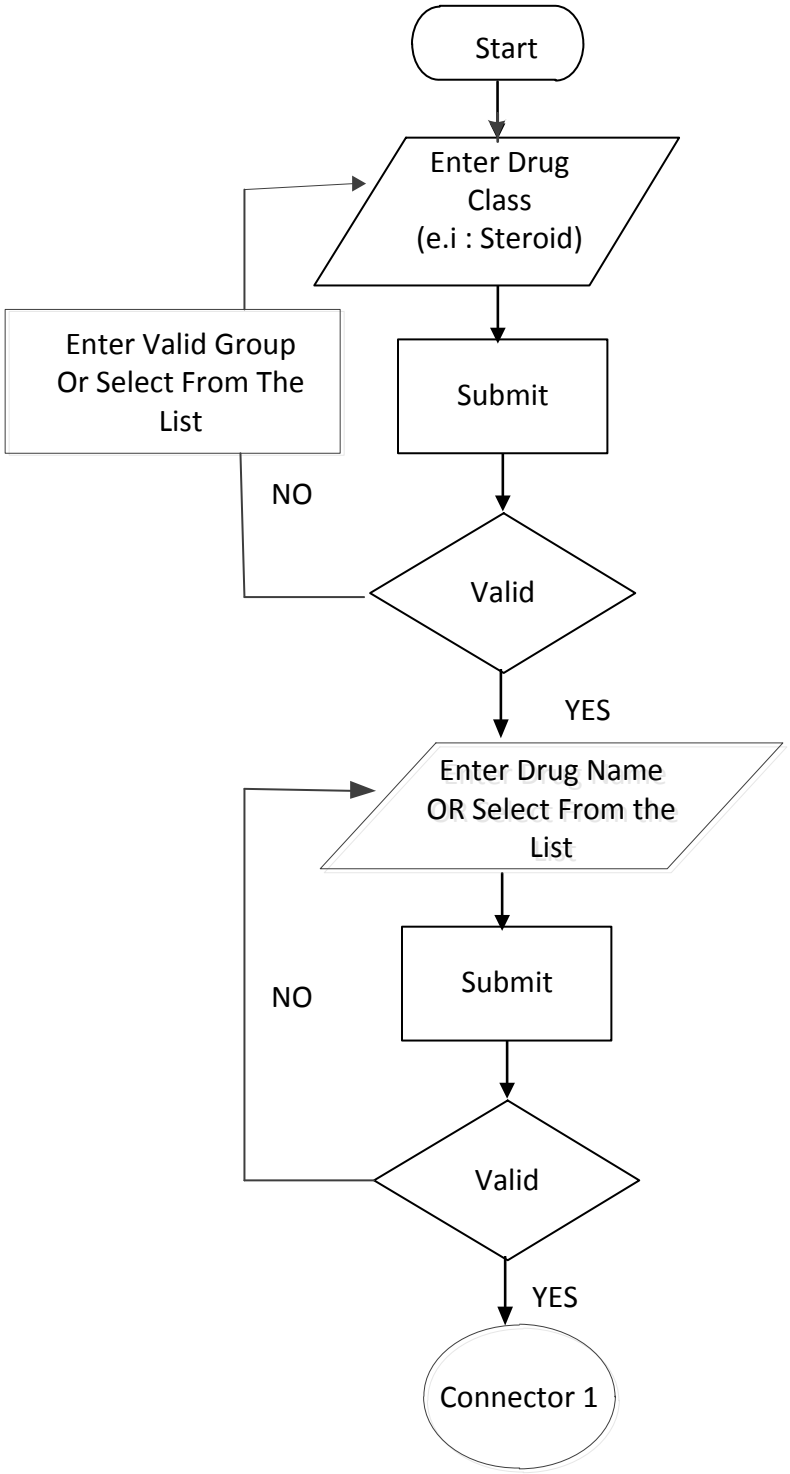
CONNECTOR ALPHABETICAL DRUG NAME SEARCH



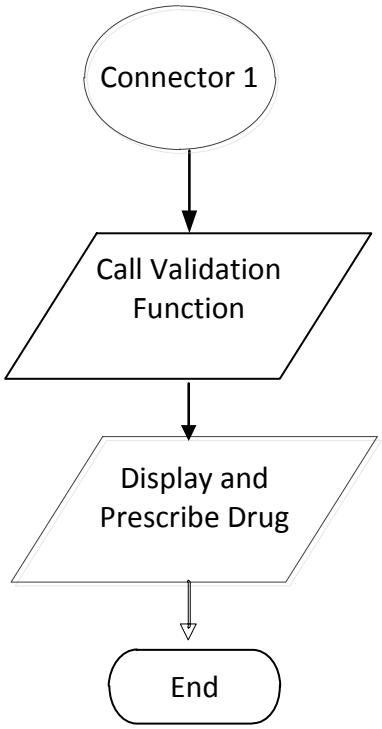
4.2.4.2.2 .2 Search Drug by Name :

Figure 26:

Figure 27: Algorithm for Search by Name



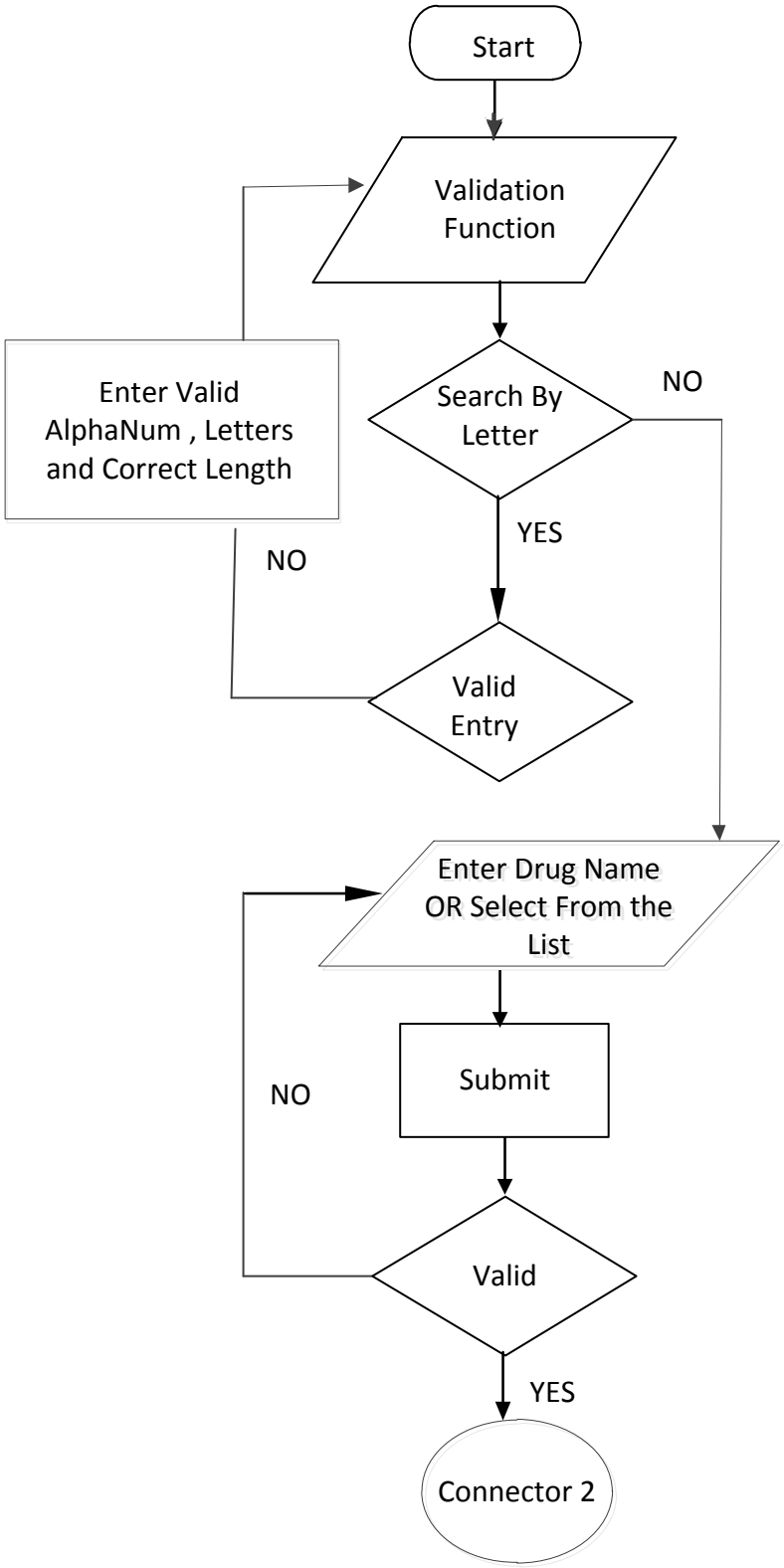
CONNECTOR DRUG NAME SEARCH



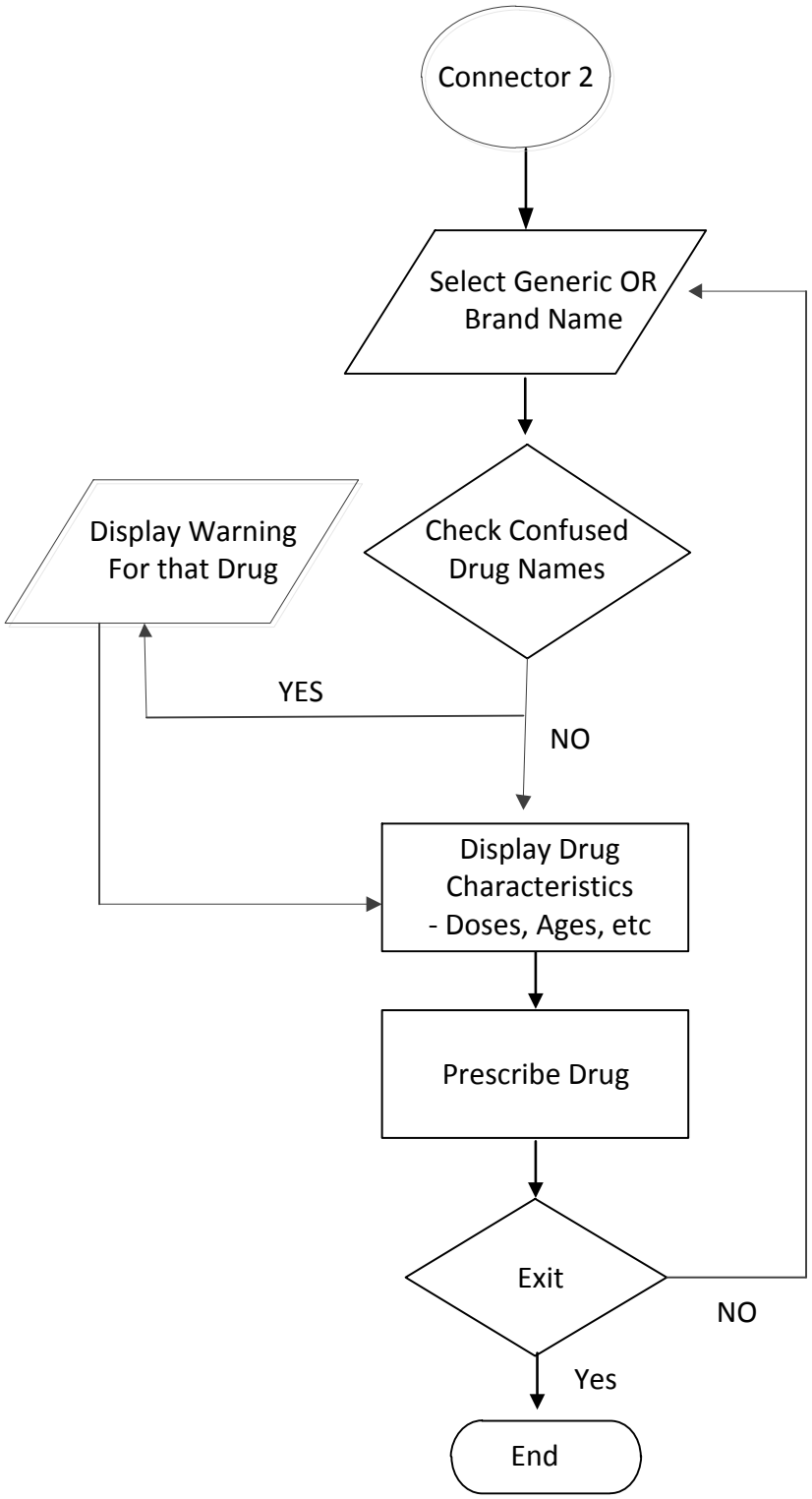
VALIDATION FUNCTION

The purpose of this function is to ensure the correctness of all necessary data entered by the user. This data correctness goes from checking the data types (Characters, String, Numeric, Alphanumeric to list a few) that are allowed, the length of field, to whether mandatory fields are filled in or not etc. All those restrictions guarantee the accuracy and consistency of any kind of user input into the application.

Figure 27_A: Algorithm for Function Validation



CONNECTOR FOR FUNCTION VALIDATION



4.2.4.3 Use of Functions for database cleansing

As data is becoming more and more a valuable input in the decision making process, maintaining excellent quality of data is essential to avoid costly mistakes, partial or no data retrieval from tables or database. One of the techniques to cleanse data is to search for duplicates in the table or database. This task is accomplished in Section 3.5 of this document: *Database Test Cases, Test Case A*

4.2.4.4 Use of Functions and Queries for data retrieval and display

In this section we present some of the major queries used to retrieve data from the database. We believe that other queries can added to this list as needed.

The following script is designed to search all drug names alphabetically. Letter selected by user can be either **Hard Coded or Passed as a parameter** in " **AlphaSearch.php** " which is the script for search.

Search 1: Search Brand Drug names starting with letter A with their corresponding Generic Drug Names . Limit search to 15

Query:

```
Select brandname, genericname
  From gen
    Where brandname LIKE A%
      Order by `brandname` ASC  LIMIT 15;
```

Result:

Table 31: Listing of Brand Drug Names starting with Letter A

Number of Items (15)	
Generic Name	**Brand Name**
zafirlukast	Accolate
quinapril HCI	Accupril
quinapril/HCTZ tablet	Accuretic
rabeprazole sodium	Aciphex
alclometasone dipropionate cream	Aclovate
risedronate sodium tablet	Actonel
pioglitazone hydrochloride	Actos
nifedipine CR tablet	Adalat cc
dextroamphetamine-amphetamine ER capsule	Adderall XR
ketotifen fumerate OTC solution	Alaway OTC
albuterol inhalation solution	Albuterol Inhalation Solution
spironolactone and hydrochlorothiazide	Aldactazide
spironolactone	Aldactone
ramipril	Altace
glimepiride	Amaryl

Search 2: Search Brand Drug names starting with letter **T** with its corresponding Generic Drug Names . Limit search to 15

Query:

Select brandname, genericname

From gen

Where brandname LIKE T%

Order by `brandname` ASC LIMIT 15;

Table 32: Listing of Brand Drug Names starting with Letter T

Number of Items (15)	
Generic Name	**Brand Name**
tamoxifen citrate tablet	Tamoxifen citrate tablet
methimazole tablets	Tapazole
carbamazepine tablet	Tegretol
atenolol/chlorthalidone tablet	Tenoretic
atenolol tablet	Tenormin
benzonatate	Tessalon Capsule
topiramate	Topamax tablets
labetalol HCL tablet	Trandate
pentoxifylline ER tablet	Trental
triamcinolone cream, 0.1%	Triamcinolone cream, 0.1%
triamcinolone ointment, 0.1%	Triamcinolone ointment, 0.1%
fenofibrate	Tricor
trifluoperazine HCl tablet	Trifluoperazine HCl tablet
fenofibric acid DR capsule	Trilipix
trospium chloride tablet	Trospium Chloride tablet

Search 3: Search Brand Drug names starting with letter **A** with its corresponding Generic Drug Names; AND check if that drug is a Confused Drug Name . Limit search to 15

Query:

Select brandname, genericname

From gen

Where brandname LIKE A%

AND** brandname **IN

(Select drugname

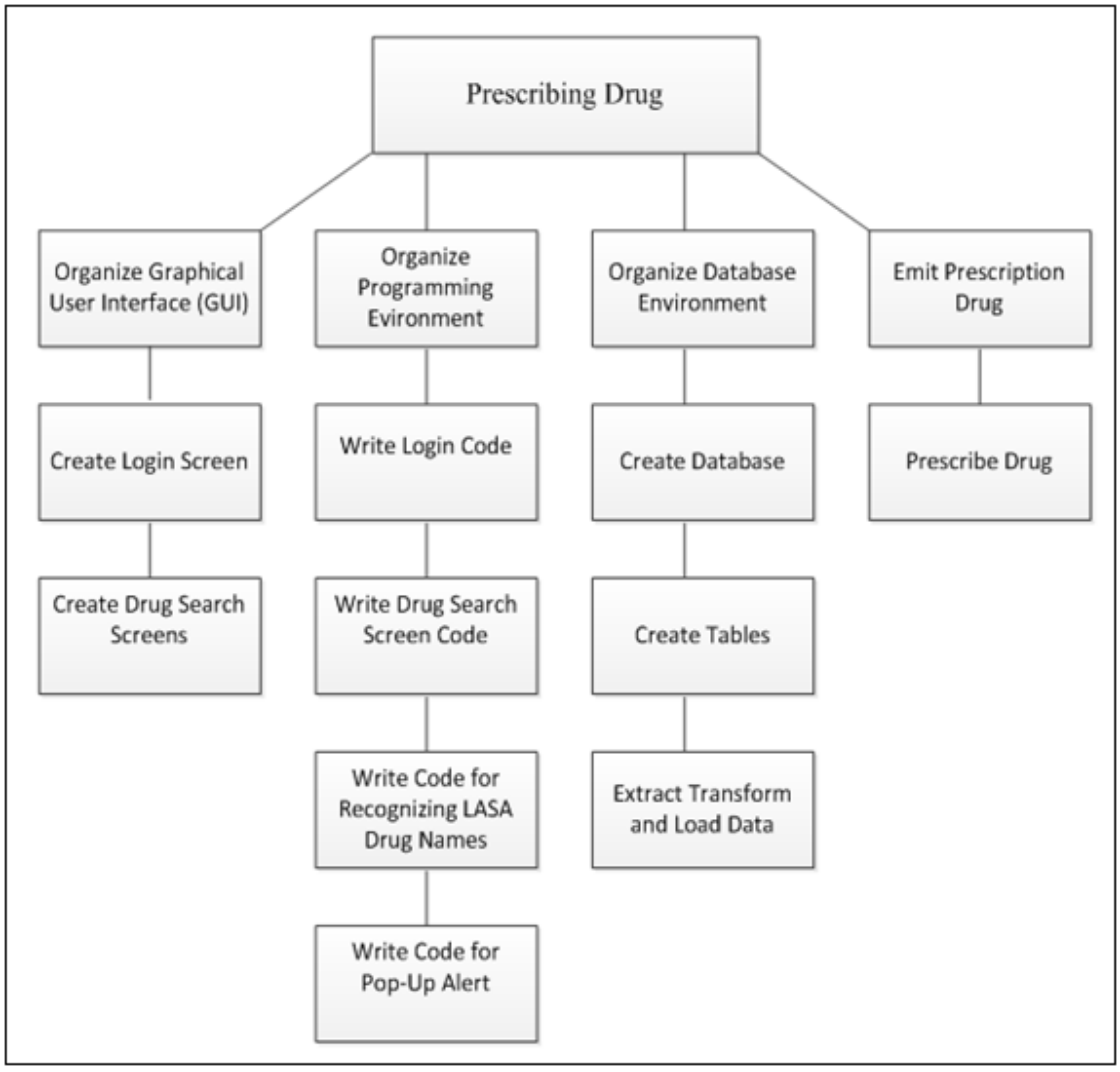
From confusedname);

4.2.5 NDA Software Implementation

The implementation of the **NDA** system was done based on the Structured programming techniques that aim to perform:

4.2.5.1 Top-down analysis: Breaking down the problem into small pieces, making therefore the programming and testing tasks more easy to accomplish. The following figure shows the NDA Top-Down Design (Analysis)

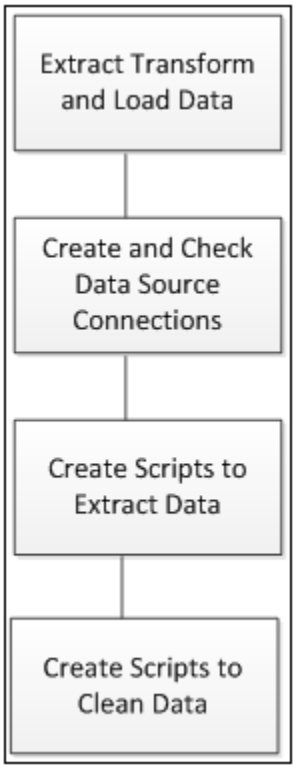
Figure 28 NDA System Top-Down Analysis



4.2.5.2 Modular Programming: This programming technique is based on the understanding of the top-down analysis. Each element of the top-down analysis constitutes a modules or an object that can be replicated or called within the program.

4.2.5.3 Structured Coding: With the structured coding technique, any module of the top-down analysis can be further subdivided into smaller modules if applicable. Example for breaking down the module *Extract Transform and Load Data (ETL):*

Figure 29 ETL Top-Down Analysis



4.2.6 The NDA Software Testing

The **NDA** Software Testing is the evaluation of **NDA** against requirements gathered from users. In this section, we execute test cases to examine whether or not the **NDA** produces the expected results, free of coding mistakes and bugs. We then present test results and analysis to describe the functionality and robustness of this application. There are many testing approaches:

- Functionality testing,
- Implementation testing

and testing levels

- Unit Testing,
- Integration Testing,
- System Testing,
- Acceptance Testing,
- Regression Testing

Only some of them (Implementation testing, Unit testing, Integration testing, and System testing) are relevant to this research and will be discussed in the following paragraphs.

4.2.6.1 **Implementation Testing:** (White-box testing):

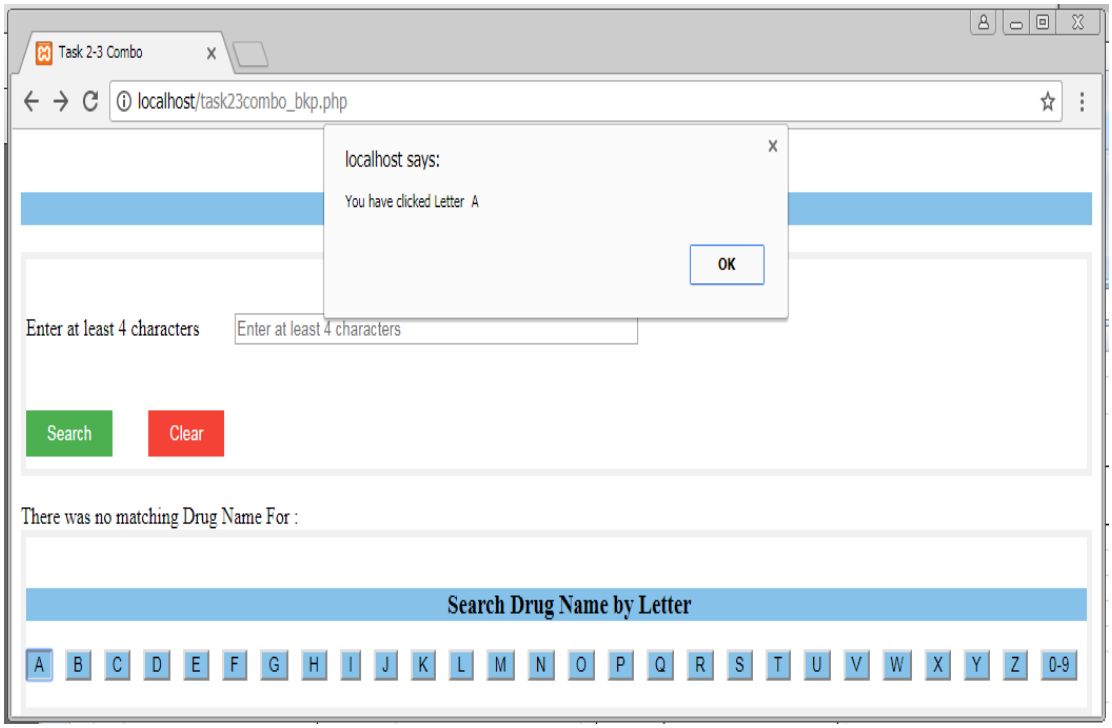
In opposite to the functionality testing also known as *Black-box testing*, Implementation testing is conducted to test both program and its implementation. As the structure of the code, inputs and outputs are know by the tester, performing testing will be easier.

List of Test Cases for the NDA:

Test Case 1	4.2.6. 1.1 User Login Test Case			
Entered by :	S.I.		**Date Entered:**	09/18/2017
Steps in Test Case	**Values Entered**	**Expected Output**	**Actual Output**	**Comments**
User Enters Username	emp1			
User Enters Password	password1	Search Screen	Search Screen	**Passed**

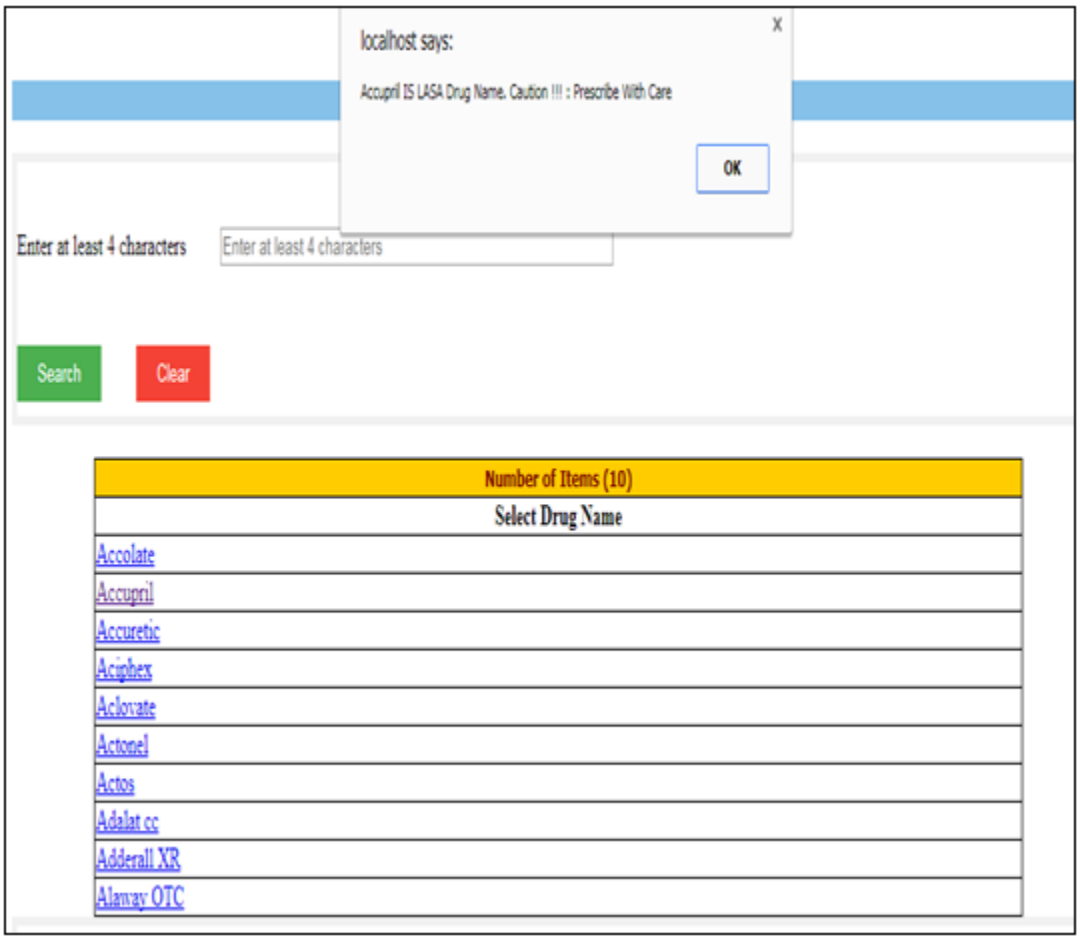
Test Case 2	4.2.6. 1.2 Search Drug Name by Letter "A"			
Entered by :	S. I.		**Date Entered:**	09/18/2017
Steps in Test	**Values**	**Expected**	**Actual Output**	**Comments**

Case	Clicked	Output		
User Click a Letter	**A**			
Limit Search Result to 10 Drug Names		List of Drug Names Starting with Letter "A"	List of Drug Names Starting with Letter "A"	**Passed**



Number of Items (10)
Select Drug Name
Accolate
Accupril
Accuretic
Aciphex
Aclovate
Actonel
Actos
acyclovir capsule
acyclovir tablet
Adalat cc

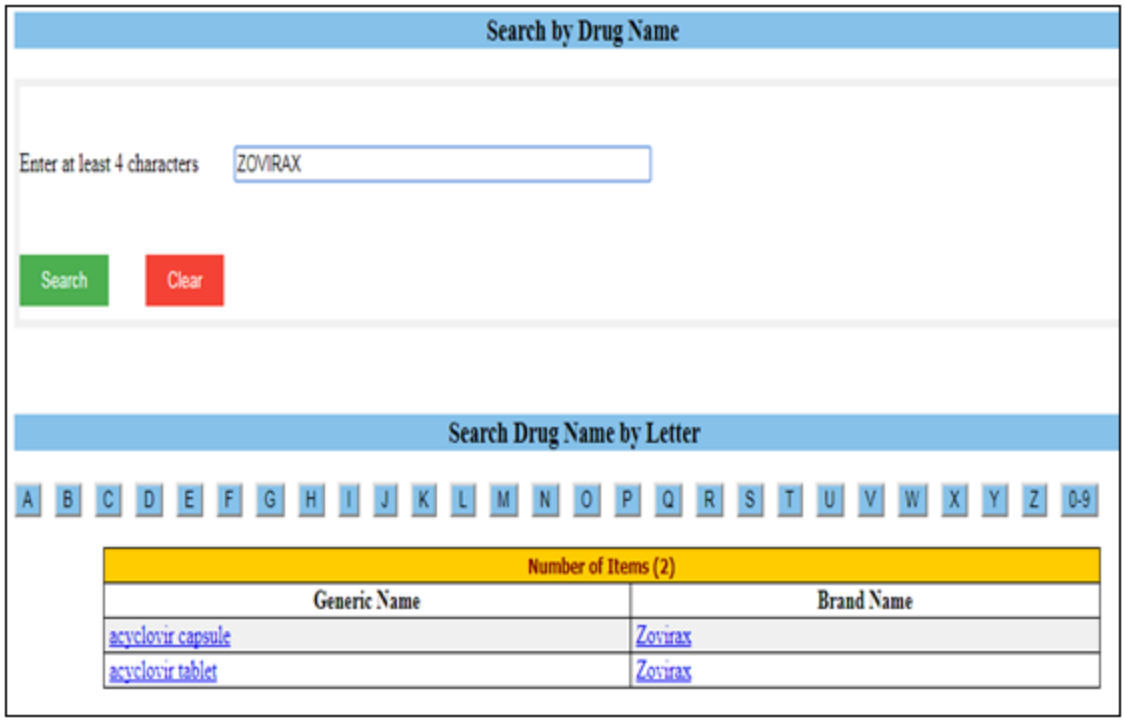
Test Case 3	Select Drug Name ACCUPRIL from Search by Letter "A"		
Entered by :	S. I.	**Date Entered:**	09/18/2017
Steps in Test Case	**Value Clicked**	**Expected Output**	**Actual Output**	**Comments**
User Click on Drug Name	**Accupril**			
		List of Drug Names Accupril	List of Drug Name (s) ACCUPRIL	**Passed: Name Retrieved**



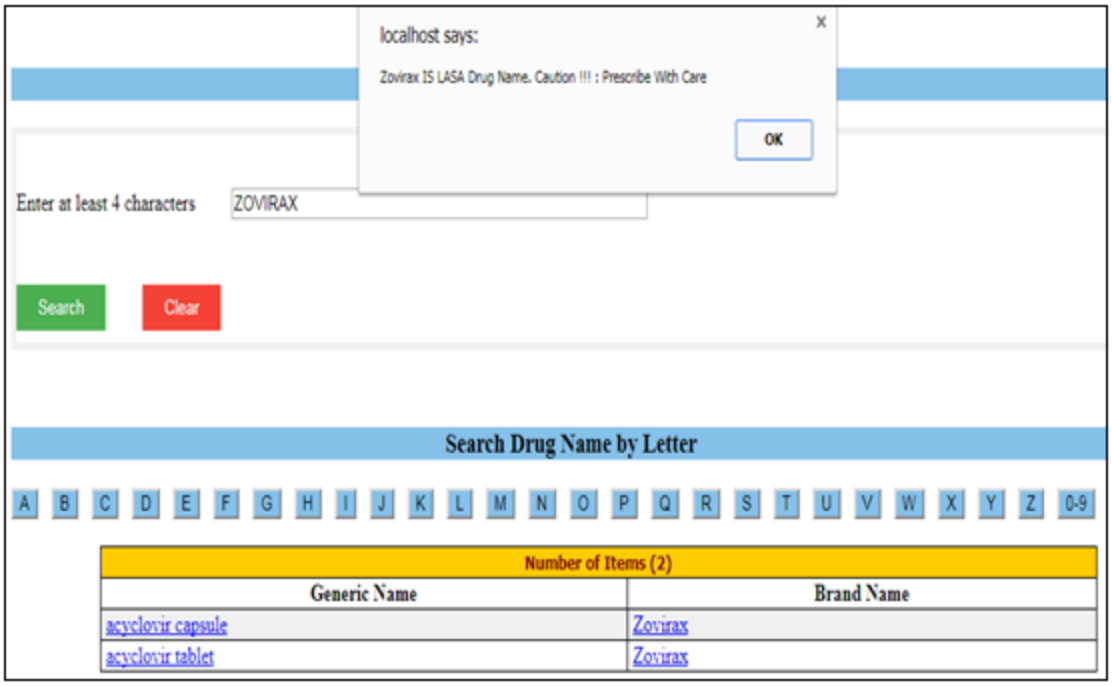
Number of Items (4)				
Drug Name	Form	Strength	Generic Name	Confused Name
Accupril	TABLET;ORAL	EQ 5MG BASE	QUINAPRIL HYDROCHLORIDE	Aciphex
Accupril	TABLET;ORAL	EQ 10MG BASE	QUINAPRIL HYDROCHLORIDE	Aciphex
Accupril	TABLET;ORAL	EQ 20MG BASE	QUINAPRIL HYDROCHLORIDE	Aciphex
Accupril	TABLET;ORAL	EQ 40MG BASE	QUINAPRIL HYDROCHLORIDE	Aciphex

SQL Query: SELECT drugname, form, strength, genericname, dconfusedname
FROM confusedname, genall
WHERE (confusedname.drugname = genall.brandname)
AND
(genall.brandname = ACCUPRIL);

Test Case 4 A	**4.2.6. 1.3 Select Drug Name ZOVIRAX from Search by Name**			
Entered by :	S. I.		**Date Entered:**	09/18/2017
Steps in Test Case	**Name Entered**	**Expected Output**	**Actual Output**	**Comments**
User Entered a Drug Name	**ZOVIRAX**			
		Info about " ZOVIRAX "	Info about " ZOVIRAX "	**Passed: System displays Names**



Test Case 4 B	4.2.6. 1.4 Select Drug Name ZOVIRAX from Search by Name			
Entered by :	S. I.		**Date Entered:**	09/18/2017
Steps in Test Case	**Name Entered**	**Expected Output**	**Actual Output**	**Comments**
User Entered a Drug Name	**ZOVIRAX**			
Click on ZOVIRAX for Prescription		Info about " ZOVIRAX "	Info about " ZOVIRAX "	**Passed: System displays Names**



Number of Items (27)				
Drug Name	**Form**	**Strength**	**Generic Name**	**Confused Name**
Zovirax	INJECTABLE;INJECTION	EQ 500MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Doribax
Zovirax	INJECTABLE;INJECTION	EQ 1GM BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Doribax
Zovirax	INJECTABLE;INJECTION	EQ 250MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Doribax
Zovirax	OINTMENT;TOPICAL	5%	ACYCLOVIR	Doribax
Zovirax	CAPSULE;ORAL	200MG	ACYCLOVIR	Doribax
Zovirax	SUSPENSION;ORAL	200MG/5ML	ACYCLOVIR	Doribax
Zovirax	TABLET;ORAL	400MG	ACYCLOVIR	Doribax
Zovirax	TABLET;ORAL	800MG	ACYCLOVIR	Doribax
Zovirax	CREAM;TOPICAL	5%	ACYCLOVIR	Doribax

Zovirax	INJECTABLE;INJECTION	EQ 500MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zyvox
Zovirax	INJECTABLE;INJECTION	EQ 1GM BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zyvox
Zovirax	INJECTABLE;INJECTION	EQ 250MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zyvox
Zovirax	OINTMENT;TOPICAL	5%	ACYCLOVIR	Zyvox
Zovirax	CAPSULE;ORAL	200MG	ACYCLOVIR	Zyvox
Zovirax	SUSPENSION;ORAL	200MG/5ML	ACYCLOVIR	Zyvox
Zovirax	TABLET;ORAL	400MG	ACYCLOVIR	Zyvox
Zovirax	TABLET;ORAL	800MG	ACYCLOVIR	Zyvox
Zovirax	CREAM;TOPICAL	5%	ACYCLOVIR	Zyvox
Zovirax	INJECTABLE;INJECTION	EQ 500MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zostrix
Zovirax	INJECTABLE;INJECTION	EQ 1GM BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zostrix
Zovirax	INJECTABLE;INJECTION	EQ 250MG BASE/VIAL **Federal Register determination that product was not discontinued or withdrawn for safety or efficacy reasons**	ACYCLOVIR SODIUM	Zostrix
Zovirax	OINTMENT;TOPICAL	5%	ACYCLOVIR	Zostrix
Zovirax	CAPSULE;ORAL	200MG	ACYCLOVIR	Zostrix
Zovirax	SUSPENSION;ORAL	200MG/5ML	ACYCLOVIR	Zostrix
Zovirax	TABLET;ORAL	400MG	ACYCLOVIR	Zostrix
Zovirax	TABLET;ORAL	800MG	ACYCLOVIR	Zostrix
Zovirax	CREAM;TOPICAL	5%	ACYCLOVIR	Zostrix

SQL Query: SELECT drugname, form, strength, genericname, dconfusedname
FROM confusedname, genall
WHERE (confusedname.drugname = genall.brandname)
AND
(genall.brandname = ZOVIRAX);

Test Case 5	**4.2.6. 1.5 Search ABELCET Drug with no Confused Name**			
Entered by :	S. I.		**Date Entered:**	09/18/2017
Steps in Test Case	**Name Entered**	**Expected Output**	**Actual Output**	**Comments**
User Entered a Drug Name	**ABELCET**			
Search by letter A or type Name in the search field Click on ABELCET for Prescription		Info about " ABELCET "	Info about " ABELCET "	**Passed: System displays Names**

Number of Items (1)	
Brand Name	Generic Name
ABELCET	AMPHOTERICIN B

PRESCRIBE ABELCET by clicking the drug name : The result shows **ZERO** (NULL) confused drug name(s)

Number of Items (10)				
Drug Name	Form	Strength	Generic Name	Confused Name
ABELCET	INJECTABLE, LIPID COMPLEX;INJECTION	5MG/ML	AMPHOTERICIN B	NULL
AMBISOME	INJECTABLE, LIPOSOMAL;INJECTION	50MG/VIAL	AMPHOTERICIN B	NULL
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	ABELCET
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	AMBISOME
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	ABELCET
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	AMBISOME
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	ABELCET
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	AMBISOME
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	ABELCET
AMPHOTERICIN B	INJECTABLE;INJECTION	50MG/VIAL	AMPHOTERICIN B	AMBISOME

4.2.6.2 Unit Testing

NDA system consists of two main modules:

- Drug Name Search by Name
- Drug Name Search by letter

and several sub modules. Unit testing was performed on each of them to find out if they are error free, and not accepting unwanted characters, and producing the expected results.

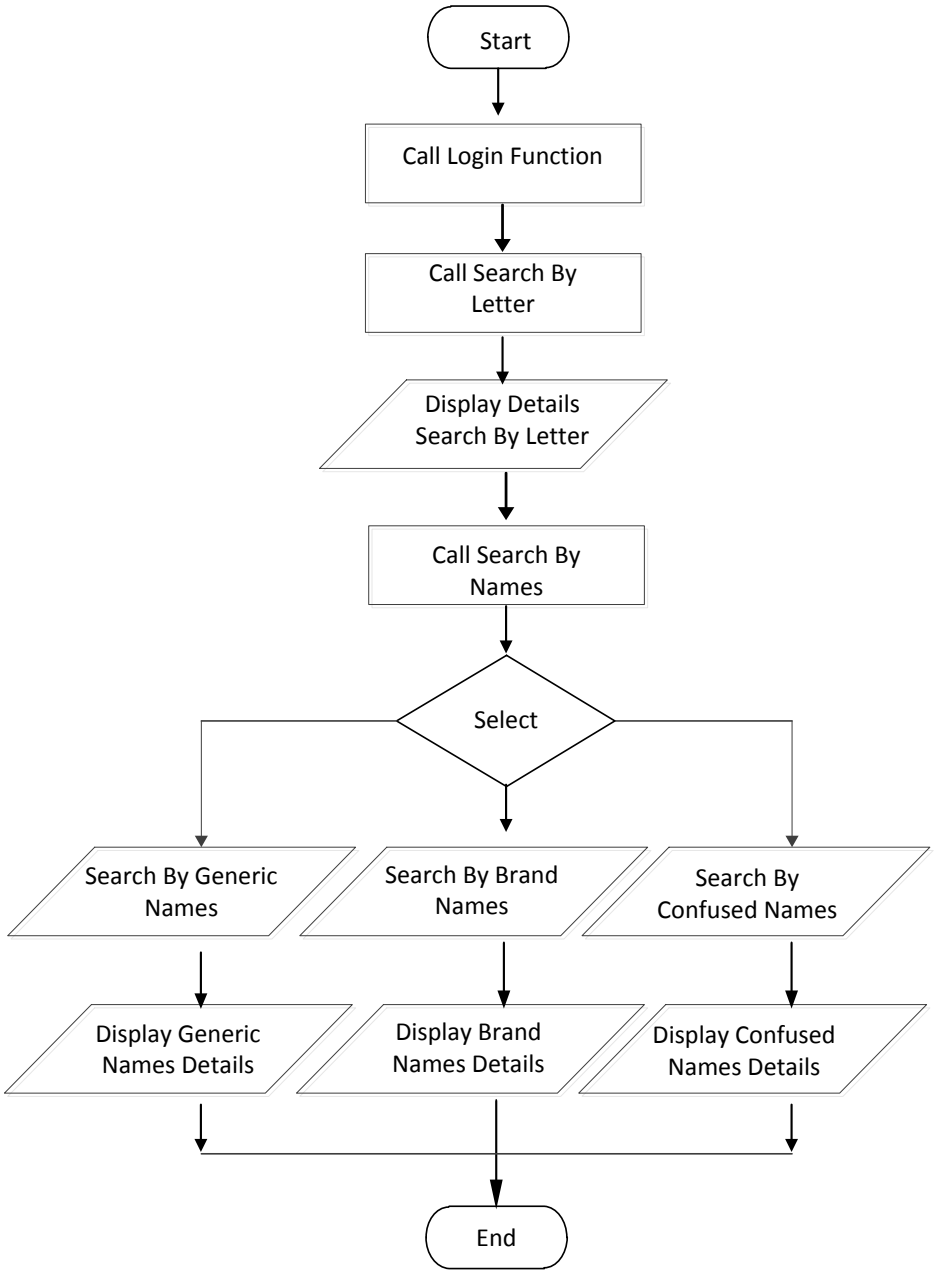
4.2.6.3 Integration Testing

This test takes place after all modules are put together, the goal being to check whether or not the two components while passing variables to each other and using shared resources can still produce the expected results. **e.g.** Module Search by letter " **A** " lists drug names starting with letter " A ". Because this module does not perform Search by Drug Name, the system has to pass those drug names starting with letter " **A** " to the other module (Search by Drug Names) so that they can be evaluated.

4.2.6.4 Integration Programming Code:

The below ALGORITHM programming code written in PHP is used to integrate all modules of this application. This code is called by "USER_LOGIN.php" once user has logged in successfully.

Figure 30: Algorithm for Integration Module



4.2.6.5 System Testing

System Testing was perform locally so, Performance Testing, Security & Portability of the NDA cannot be evaluated in the appropriate manner.

CHAPTER V

CONTRASTING EXISTING AND PROPOSED SYSTEMS

5.1 Introduction

This chapter presents and discusses the main differences between the existing system and the **Novel Decision Algorithm** (NDA). We assume that all basics functionalities of the two systems are the same, therefore the focus will be on analyzing the impact of the added (new tool) **NDA** during the drug prescribing process. In this chapter we also use **Inferential Statistics** to draw conclusions from data used to evaluate the credibility or refutability of the **NDA** theory.

Table 33: Overall Comparison of Existing and Proposed Systems

Criteria	Current System	Proposed System	Comments
Capability of Searching for Brand & Confused Drug Name	NO	YES	The proposed system minimizes the risk of confusion on Brand Drug Names by displaying known confused drug names and Brand Names
Capability of Searching for Generic & Confused Drug	NO	YES	The proposed system minimizes the risk of

Name			confusion on Generic Drug Names by displaying known confused drug names and Generic Names
Capability of Searching for Brand LASA	NO	YES	The proposed system minimizes the risk of confusion on Generic Look-Alike and Sound-Alike Names by displaying known Brand LASA confused drug names
Capability of Searching for Generic LASA	NO	YES	The proposed system minimizes the risk of confusion on Generic Look-Alike and Sound-Alike Names by displaying known Brand LASA confused drug names
Capability of Displaying Pop-Up Alert on Brand Drug Names	NO	YES	The proposed system displays a Pop-Up Alert when this Brand drug is selected to warn the prescriber on an eventual risk when prescribing the specified drug name that looks or sounds alike with another drug name..
Capability of Displaying Pop-Up Alert on Generic			The proposed system displays a Pop-Up Alert

Drug Names	NO	YES	when this Generic drug is selected to warn the prescriber on an eventual risk when prescribing the specified drug name that looks or sounds alike with another drug name..
Capability of Displaying Pop-Up Alert on LASA Drug Names	NO	YES	The proposed system displays a Pop-Up Alert when this LASA drug is selected to warn the prescriber on an eventual risk when prescribing the specified drug name that looks or sounds alike with another drug name..

5.2 Statistics

In this rubric we present three main tables: PRODUCTS, LASA, and Drug Confused Names that were used in the calculation or production of some aggregates.

5.2.1 Description of Tables

5.2.1.1 Products:

This table contains all the drug names approved by the US Food and Drug Administration (FDA.) that are available to the public.

5.2.1.2 LASA

This table contains a list of Look-Alike / Sound-Alike drug names approved by the US Food and Drug Administration (FDA.).

5.2.1.3 Confused Drug Names

This table contains a list of Drug Names reported by the public to the FDA or ISMP.

5.2.1.4 Quantitative Relation Between Tables

This table below shows the ratio between Products and LASA, which is relatively low. This is a good indicator in reducing medication errors. On the other hand, the ratio between LASA and Drug Confused Names is very high, this tells us how cautious we should be when dealing with LASA Drug Names.

Table Names	Nbr. Rows	Ratio to Products	Ration to LASA
Products	34739		
LASA	342	0.0098	
Drug Confused. Names	798		2.3333

Table 34: List of LASA with Number of Occurrences of Drug Confusion

LASA	Frequency	LASA Confused Names		LASA	Frequency	LASA Confused Names
Accolate	1	Accutane		Calciferol	1	Calcitriol
Accupril	2	Accutane		Calcitriol	1	Calciferol
Accutane	2	Accolate		Captopril	1	Carvedilol
Acetazolamide	1	Acetohexamide		Carafate	1	Cafergot
Acetohexamide	1	Acetazolamide		Carboplatin	1	Cisplatin
Actonel	1	Actos		Cardene	3	Cardizem
Actos	1	Actonel		Cardene SR	1	Cardizem SR
Adderall	1	Inderal		Cardizem	2	Cardene
Adriamycin	1	Aredia		Cardizem CD	1	Cardizem SR
Aggrastat	2	Aggrenox		Cardizem SR	1	Cardizem CD
Alkeran	1	Leukeran		Cardura	1	Cardene
Alprazolam	1	Lorazepam		Carvedilol	1	Captopril
Altace	1	Artane		Cataflam	1	Catapres

Alupent	1	Atrovent		Catapres	1	Cataflam
Amantadine	2	Ranitidine		Celebrex	2	Celexa
Amicar	1	Amikin		Celexa	1	Celebrex
Amiloride	1	Amlodipine		Cerebyx	1	Celebrex
Amiodarone	1	Amrinone		Chlorpromazine	2	Chlorpropamide
Amlodipine	1	Amiloride		Chlorpropamide	1	Chlorpromazine
Amrinone	1	Amiodarone		Cisplatin	1	Carboplatin
Aredia	1	Adriamycin		Clinoril	1	Clozaril
Argatroban	1	Aggrastat		Clonazepam	2	Clonidine
Artane	1	Altace		Clonidine	1	Clonazepam
Asacol	1	Os-Cal		Clozaril	1	Clinoril
Atrovent	1	Alupent		Codeine	2	Cardene
Avandia	2	Coumadin		Colace	1	Calan
Azithromycin	1	Erythromycin		Combivir	1	Epivir
Bacitracin	1	Bactroban		Coumadin	1	Avandia
Bactroban	1	Bacitracin		Covera	1	Provera
Bepridil	1	Prepidil		Cozaar	1	Hyzaar
Betagan	1	Betoptic		Cyclobenzaprine	1	Cyproheptadine
Betoptic	2	Betagan		Cyproheptadine	1	Cyclobenzaprine
Brevibloc	1	Brevital		Cytotec	1	Cytoxan
Brevital	1	Brevibloc		Cytoxan	1	Cytotec
Bumex	1	Permax		Danazol	1	Dantrium
Bupivicaine	1	Ropivicaine		Dantrium	1	Danazol
Buprenex	1	Bumex		Darvon	1	Diovan
Bupropion	1	Buspirone		Daunorubicin	1	Doxorubicin
Buspirone	1	Bupropion		Demerol	1	Desyrel
Cafergot	1	Carafate		Denavir	1	Indinavir
Calan	1	Colace		Depakote	1	Depakote ER
Depo-Medrol	1	Solu-Medrol		Hydromorphone	1	Morphine
Desipramine	1	Imipramine		Hydroxyzine	1	Hydralazine
Desyrel	1	Demerol		Hyzaar	1	Cozaar
DiaBeta	1	Zebeta		Imdur	2	Imuran
Diovan	1	Darvon		Imipenem	1	Omnipen
Diprivan	1	Ditropan		Imuran	1	Imdur
Ditropan	1	Diprivan		Inderal	2	Adderall
Dobutamine	1	Dopamine		Isordil	1	Inderal
Dolobid	1	Slo-bid		K-Dur	1	Imdur
Donepizil	1	Doxepin		K-Phos-Neutral	1	Neutra-Phos-K
Dopamine	1	Dobutamine		Klonopin	1	Clonidine
Doxepin	1	Donepizil		Labetalol	1	Lamisil
Doxorubicin	2	Daunorubicin		Lamictal	4	Lamisil
Edecrin	1	Eulexin		Lamisil	2	Lamictal

Efudex	1	Eurax		Lamivudine	1	Lamotrigine
Eldepryl	1	Enalapril		Lamotrigine	1	Lamivudine
Eloxatin	1	Fluoxetene		Lanoxin	1	Lonox
Enalapril	1	Eldepryl		Lantus	1	Lente
Epivir	1	Combivir		Lasix	1	Luvox
Erythromycin	1	Azithromycin		Leukeran	1	Alkeran
Etidronate	1	Etomidate		Levbid	3	Lithobid
Etomidate	1	Etidronate		Levodopa	1	Methyldopa
Eurax	1	Efudex		Levoxyl	1	Luvox
Fentanyl	1	Sufentanil		Lithobid	1	Levbid
Fioricet	1	Fiorinal		Lodine	1	Codeine
Fiorinal	1	Fioricet		Lomotil	2	Lamictal
Flomax	2	Fosamax		Loniten	1	Lotensin
Fluoxetene	1	Eloxatin		Lonox	1	Lanoxin
Foradil	1	Toradol		Lopid	3	Levbid
Fosamax	1	Flomax		Lorabid	2	Levbid
Glipizide	1	Glyburide		Lorazepam	1	Alprazolam
Glucotrol	1	Glucotrol XL		Lortab	1	Lorabid
Glyburide	1	Glipizide		Losartan	1	Valsartan
Haldol	1	Stadol		Lotensin	1	Loniten
Heparin	1	Hespan		Lotrimin	1	Lotrisone
Hespan	1	Heparin		Lotrisone	1	Lotrimin
Humalog	1	Humulin		Lotronex	2	Lovenox
Hydralazine	1	Hydroxyzine		Lovenox	1	Lotronex
Hydrocodone	1	ydrocortisone		Ludiomil	1	Lamictal
Hydrocortisone	1	Hydrocodone		Luvox	1	Lasix
Medroxyprogesterone	1	Methylprednisolone		Pentobarbital	1	Phenobarbital
Methyldopa	1	Levodopa		Percocet	1	Percodan
Methylprednisolone	1	Medroxyprogesterone		Percodan	1	Percocet
Metoprolol	1	Misoprostol		Phenobarbital	1	Pentobarbital
Micro-K	1	Micronase		Pindolol	2	Parlodel
Micronase	1	Micro-K		Pitocin	1	Pitressin
Minoxidil	1	Monopril		Pitressin	1	Pitocin
MiraLax	1	Mirapex		Plavix	1	Paxil
Mirapex	1	MiraLax		Plendil	3	Pindolol
Misoprostol	1	Metoprolol		Pletal	1	Plendil
Mitomycin	1	Natamycin		Pravachol	1	Propranolol
Monoket	1	Monopril		Prednisone	1	Primidone
Monopril	3	Accupril		Prepidil	1	Bepridil
Morphine	1	Hydromorphone		Prilosec	1	Prednisone
Nasalcrom	1	Nasalide		Prinivil	2	Plendil
Nasalide	1	Nasalcrom		Probenecid	1	Procanbid
Nasarel	1	Nizoral		Procanbid	1	Probenicid

Natamycin	1	Mitomycin		Prochloperazine	1	Chlorpromazine
Navane	1	Norvasc		Propranolol	1	Pravachol
Neoral	2	Neurontin		Protonix	1	Lotronex
Neurontin	2	Neoral		Provera	1	Covera
Neutra-Phos-K	1	K-Phos-Neutral		Prozac	1	Prilosec
Nizoral	2	Neoral		Quinidine	1	Quinine
Noroxin	1	Neurontin		Quinine	1	Quinidine
Norpramin	1	Nortriptyline		Ranitidine	1	Amantadine
Nortriptyline	1	Norpramin		Retrovir	1	Ritonavir
Norvasc	1	Navane		Rifabutin	1	Rifampin
Omnipen	1	Imipenem		Rifampin	1	Rifabutin
Os-Cal	1	Asacol		Rimantidine	1	Amantadine
Oxybutynin	1	OxyContin		Ritonavir	1	Retrovir
Oxycodone IR	1	OxyContin		Ropivicaine	1	Bupivicaine
OxyContin	2	Oxybutynin		Roxanol	1	Roxicet
Paraplatin	1	Platinol		Roxicet	1	Roxanol
Parlodel	1	Pindolol		Serentil	3	Seroquel
Paxil	1	Plavix		Seroquel	4	Serentil
Pediapred	1	Pediazole		Serzone	4	Seroquel
Pediazole	1	Pediapred		Sinequan	2	Singulair
Penicillamine	1	Penicillin		Singulair	2	Sinequan
Penicillin	1	Penicillamine		Slo-bid	4	Dolobid
Penicillin G Potassium	1	Penicillin G Procaine		Solu-Medrol	2	Depo-Medrol
Stadol	2	Haldol		Valganciclovir	1	Valacyclovir
Sufentanil	2	Fentanyl		Valsartan	1	Losartan
Sulfadiazine	2	Sulfasalazine		Valtrex	1	Valcyte
Sulfasalazine	2	Sulfadiazine		Vancenase	1	Vanceril
Taxol	1	Taxotere		Vanceril	1	Vancenase
Taxotere	1	Taxol		Vinblastine	1	Vincristine
Tegretol	1	Toradol		Vincristine	1	Vinblastine
Tiagabine	1	Tizanidine		Vioxx	1	Zyvox
Tiazac	1	Ziac		Viracept	1	Viracept
Tizanidine	1	Tiagabine		Volmax	1	Flomax
TobraDex	1	Tobrex		Xanax	1	Zantac
Tobrex	1	TobraDex		Zantac	2	Xanax
Topamax	1	Toprol XL		Zebeta	1	DiaBeta
Toprol XL	1	Topamax		Ziac	1	Tiazac
Toradol	3	Foradil		Zovirax	1	Zyvox
Torsemide	1	Furosemide		Zyprexa	1	Zyrtec
Tramadol	2	Trazodone		Zyrtec	2	Zantac
Trazodone	1	Tramadol		Zyvox	2	Vioxx
Valacyclovir	1	Valganciclovir				

Script for Frequency:

```
SELECT lasadrugname, COUNT(*) Freq FROM lasaname
        GROUP BY lasadrugname HAVING Freq > = 1;
```

5.2.1.6 Frequency Distribution Table

Table 35

Number Of Drug Names Per Frequency	Frequency	Cumulative Number of Drugs	Cumulative frequency
233	1	233	1
36	2	269	3
7	3	276	6
4	4	280	10
280			

5.2.1.7 Descriptive Statistics

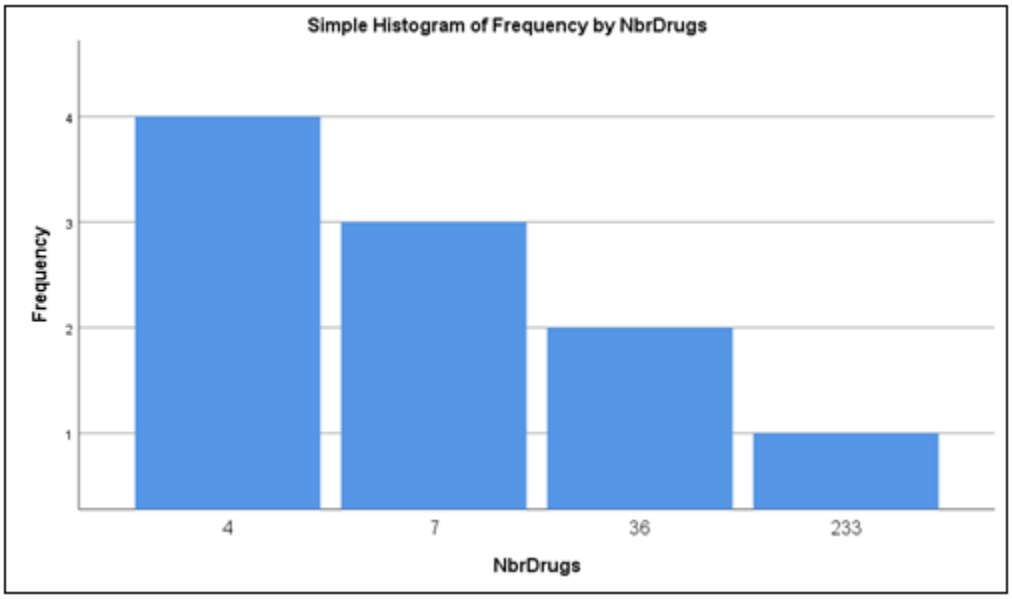
Descriptive Statistics

Table 36:

	N	Minimum	Maximum	Mean	Std. Deviation
Nbr of Drugs Per Frequency	4	4	233	70.00	109.621
Probability With Replacement	4	.2	.2	.200	.0000
Probability Without Replacement	4	.4	1.0	.700	.2582
Valid N (listwise)	4				

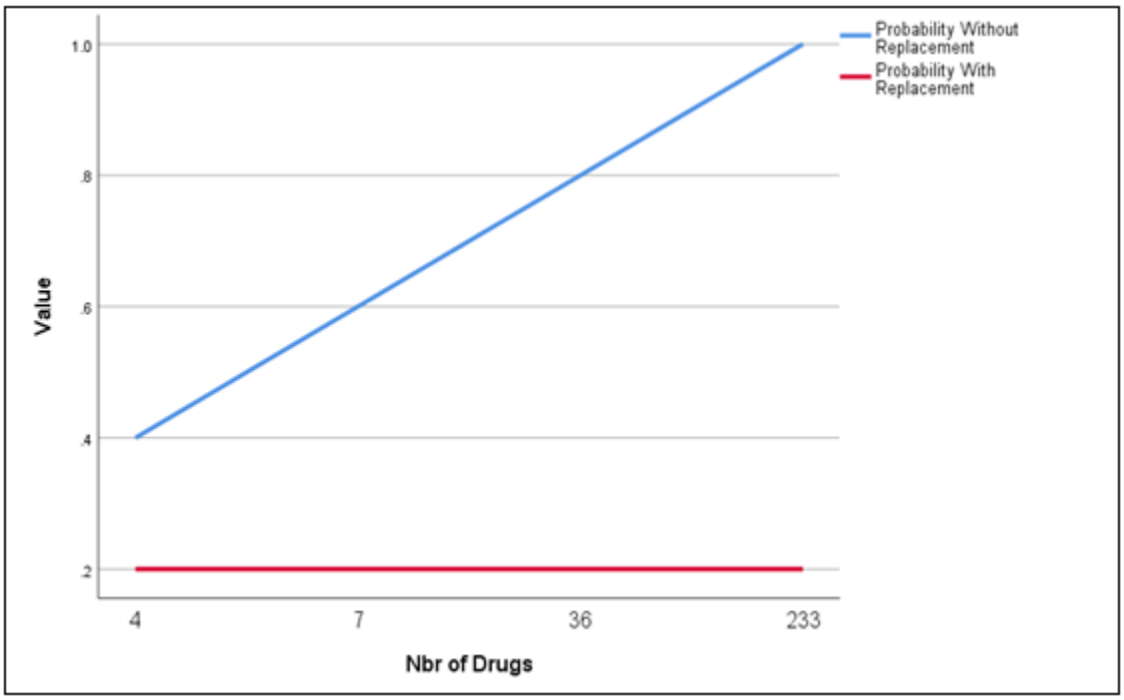
5.2.1.8 Depiction of Frequency

Figure 31



5.2.1.9 Drug Names and Probability

Figure 32



5.2.2.0 Depiction of the NDA

The final goal of the NDA is to prevent any error replication of known confused drug names or a combination of " LASA and Drug Confused Names " .

With the actual system, the same medication error can happen again as many times as possible because of a none existing preventive mechanism.

Statistically speaking, this might be stated as solving a Probability problem ***WITH Replacement*** where : If you select a first Confused Drug Name from the list, this selection doesn't affect the Probability of obtaining the SAME Confused Drug Name twice, just because the sample data didn't change thus the probability of selecting a Confused Drug Name still **1 / Total number of Confused Drug Names**.

Ex:: Given **5** Confused Drug Names, the new sample data numbered from 1 to 5.

What is the probability of selecting a Drug Name you have previously selected ?

Table 37 Table of Probability with Replacement

Numbers	Probability	Ratio	Product
1	1/5	0.2	0.2
2	1/5	0.2	0.04
3	1/5	0.2	0.008
4	1/5	0.2	0.0016
5	1/5	0.2	0.00032
P(A) = 0.00032			

The philosophy or approach in the use of the NDA is to select a Drug Confused Name or a combination LASA, Drug Confused Names ***WITHOUT Replacement*** so that the same Drug or combination of Drugs cannot be used again. Given the same problem above:

Table 38 Table of Probability Without Replacement

Numbers	Probability	Ratio	Product
1	5/5	1	1
2	4/5	0.8	0.8
3	3/5	0.6	0.48
4	2/5	0.4	0.192
5	1/5	0.2	0.0384
P(B) = 0.0384			

5.2.2.1 Statistically Evaluating Prescription Drug Errors Through NDA

Based on the following theorems:

- If P(X) is **CLOSE** to **One**, There is a strong chance that Event will Occur
- If P(X) is **CLOSE** to **Zero**, There is only a small chance that Event will Occur

From those theorems we can deduct that:

- **P(A) = 0.00032** is **CLOSE** to **Zero**, and a chance that Event will Occur is small
- **P(B) = 0.0384** is **CLOSE** to **One** , Therefore a strong chance that Event (**Displaying Pop-Up Alert**) will Occur during the Drug search.
- The gap between the two Probabilities is Statistically Significant suggesting the Effectiveness of the **NDA**

CHAPTER VI

DISCUSSION

Sound-Alike Drug Name Errors:
Could a CDSS, a "CPOE with Embedded "Novel Decision Algorithm" coupled with Confused Drug Names, Generic drug names and Doses" improve health care providers decisions with a lower prescribing error rate?

6.1 Introduction

This chapter discusses the hypothesis whether or not the **Novel Decision Algorithm** (NDA) as presented and described in this research could lower medication errors caused by LASA and Drug Confused Names.

6.2 Presenting LASA & Confused Drug Names

In the following section we comment on Look-Alike / Sound-Alike and Confused Drug Names to better understand the problematic when writing a prescription drug or dispensing drugs.

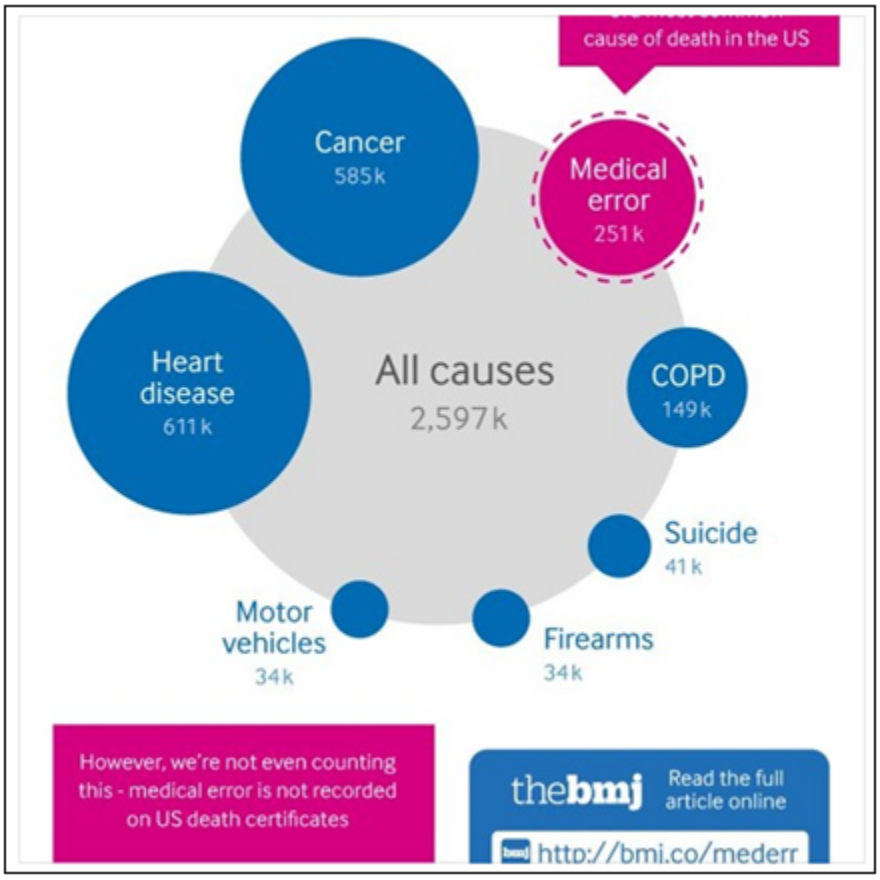
According to the Institute for Safe Medication Practices (ISMP), "LASA drug names are drug names that sound or appear to be similar to other drugs when written or spoken. "

On the other hand Confused drug names are medications that were reported to FDA or ISMP through the National Medication Errors Reporting Program (MERP)

because they were confused to other drugs. The ISMP then publishes those drug names so that the list can be used to avoid similar mistakes.

Generally speaking, progress in reducing medication errors have been made through the use of Clinical Decision Support Systems (CDSS), Computerized Physician Order Entry (CPOE), the use of Tall Man Lettering to list a few, but a lot is still needed to be done. As a result, the number of medication errors is still high in the US as shown in the graph below

Figure 33 Medical Error The Third Leading Cause of Death in The US



http://www.bmj.com/content/353/bmj.i2139.full

6.3 Could the Novel Decision Algorithm (NDA) Lower Medication Error Rate Caused by LASA and Drug Confused Names ?

With the use of the NDA, we are adding another layer of security, prevention, warning to the existing techniques used in order to reduce medication errors.

The NDA combines and uses :

- Known Confused Drug Names (to Avoid Error Replication)
- Known LASA Drug Names (to Prevent and Avoid Error Replication)
- Combined Brand and Generic Names (for Drug Names Uniqueness)

to guide medical professional when selecting and /or prescribing medications.

Based on number of successful test results obtained when testing the NDA System, we strongly believe that the use of this application will help prevent and reduce the number of errors caused by Confused Drug Names.

CHAPTER VII

ADVERSE DRUG EVENTS (ADEs)

7.1 Introduction:

This chapter presents a statistical analysis of Adverse Drug Events (ADEs) in U.S. Hospitals. The data used for this endeavor is from the Nationwide Inpatient Sample (NIS) 2014, one of the largest database of the Healthcare Cost and Utilization Project (HCUP) .

Due to a high volume of data, we deliberately partitioned the NIS 2014 in four quarters: Quarter1, Quarter 2, Quarter 3, and Quarter 4. The benefits of doing this can be performance improvement when running queries, manageability, but more precisely to investigate how data and all its implications vary from one period of time to another.

We set the statistics sample size to **21%** of the total number (**145**) of distinct E_Codes involved in this study, which corresponds to the "**31**" largest E_Codes; these E_Codes will be used from Quarter 1 through Quarter 4.

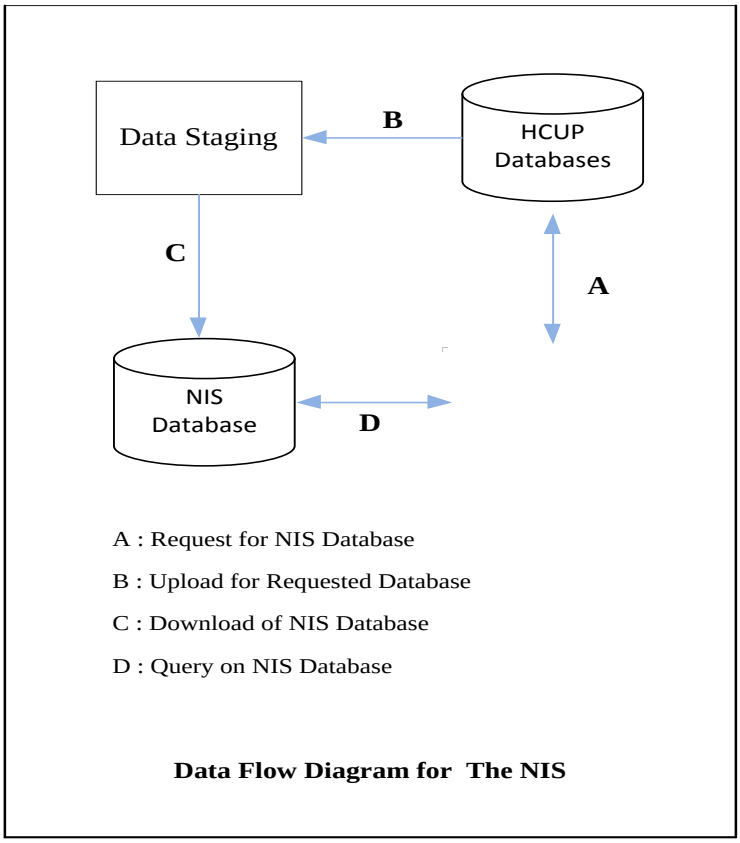
We also provide in this chapter, a brief definition of key terms and produce various statistics generated from SPSS statistical software, and Microsoft Excel.

The statistical analysis of Drug Events (ADEs) in this chapter doesn't cover all External Cause of Injury Codes, see figures : 34; 35; 36; 37; Instead it only focuses on ADEs (**2617 E_Codes**), a type of medication errors that converges with the subject of our study.

7.2 Data Flow Diagram of the NIS

The figure below shows the migration of data from the HCUP to the ADE Relational Database.

Figure 34 : Data flow Diagram of the NIS



7.3 Converting data from ASCII into SPSS file format :

In order to successfully convert the data from HCUP, it is required to complete the execution of the following tasks :

1. Download SPSS Zipped files from HCUP NIS Database
2. Double Click to open the files with extension .SPS

3. The first line of the file looks like :

   DATA LIST FILE = NIS_2014_Core.ASC FIXED

4. Copy the Path where the downloaded file are stored

5. Add it in front of NIS_2014_Core.ASC FIXED

6. You get: Path\NIS_2014_Core.ASC FIXED

7. The last line of the opened file looks like:

   SAVE OUTFILE = NIS_2014_Core.SAV COMPRESSED

8. Add the path in front of NIS_2014_Core.SAV COMPRESSED

9. You get : Path\NIS_2014_Core.SAV COMPRESSED

10. Press Ctrl + A to select all the code

11. Click RUN in the Menu Bar to execute the selection

12. The **new file** with **.SAV** extension is saved in your repertory.

7.4 Download the Nationwide Inpatient Sample (NIS) Database

At the end of data conversion, four tables are created as shown in **table 39**. The NIS contains more than seven million hospital stays and is the largest inpatient care database from the Healthcare Cost and Utilization Project (HCUP).

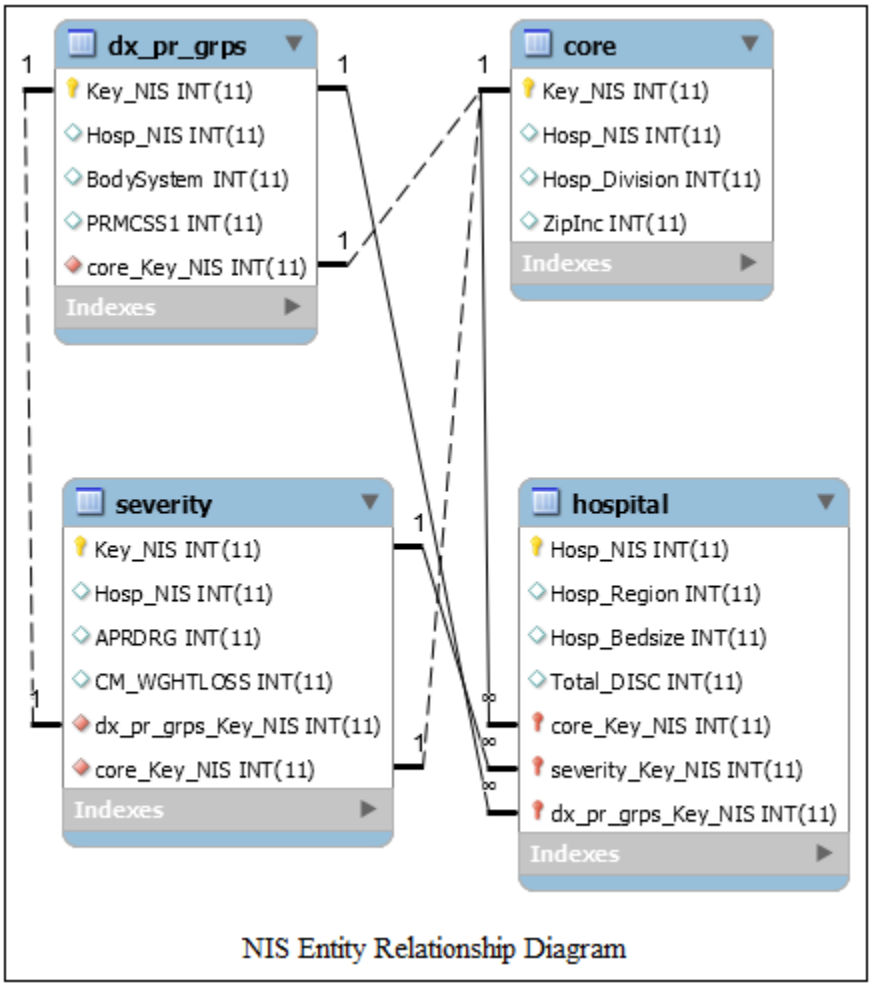
Table 39: NIS list of Tables

File Specifications	Table Name	Num. Columns	Num. Rows
Core File	Core	152	7,071,762
Hospital Weights File	Hospital	14	4,411
Severity Measures File	Severity	34	7,071,762
Diagnosis and Procedure Groups File	DX_PR_GRPS	80	7,071,762

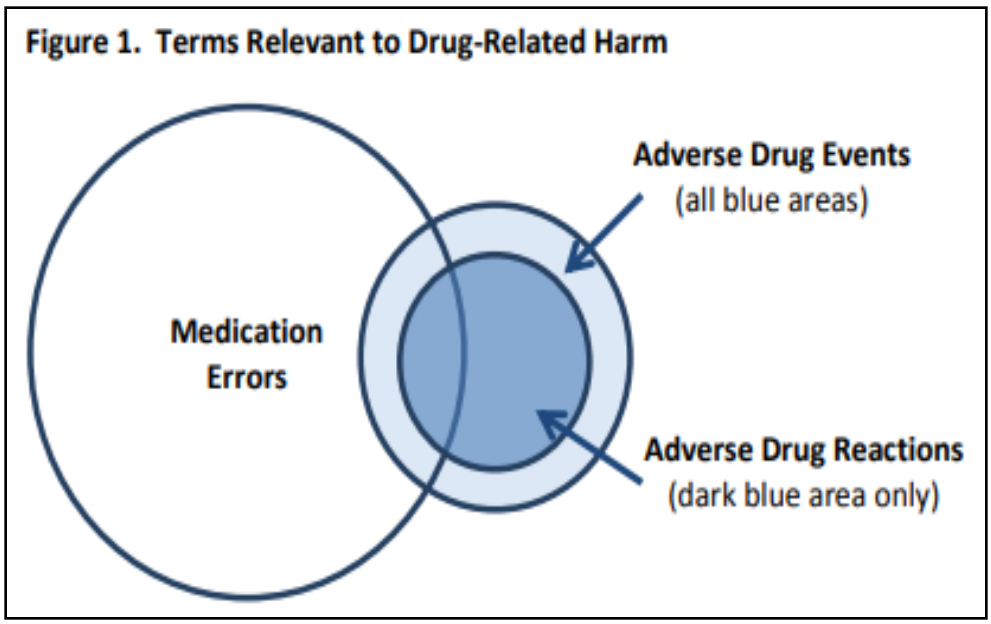
7.5 Entity Relationship Diagram of the NIS :

The following figure shows how tables are interconnected in the NIS 2014 database

Figure 35 : NIS Entity Relationship Diagram (ERD)



7.6 Presenting Adverse Drug Events (ADEs) :



[108]

7.7 ADE Definition:

According to David W. Bates, Adverse drug events (ADEs) are defined as injuries resulting from medical interventions related to a drug. ADEs may result from medication errors or from adverse drug reaction in which there was no error [**99**].

7.8 Introduction to Medication Classes

Specific codes from the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) are used to classify (ADEs).

Previously called CCHPR (Clinical Classification for Health Policy Research), the CCS is a tool for clustering patient diagnoses and procedures into a manageable number of clinically meaningful categories [106].

7.9 Characteristics of Clinical Classification Software

The CCS consists of two related classification systems

- Single-Level diagnosis categories
- Multi-Level diagnosis categories

7.9.1 Single - Level CCS

The Single-Level diagnosis CCS aggregates (groups) illnesses and conditions into 285 mutually exclusive categories [106] .

Table 1: Examples of single-level CCS diagnosis categories

Description	ICD-9-CM[1] diagnosis Codes used to map	CCS category
Essential Hypertension	4011 4019	98
Hypertension with complications and secondary hypertension	4010 40200 40201 40210 40211 40290 40291 4030 40300 40301 4031 40310 40311 4039 40390 40391 4040 40400 40401 40402 40403 4041 40410 40411 40412 40413 4049 40490 40491 40492 40493 40501 40509 40511 40519	99

7.9.2 Multi - Level CCS

The Multi-Level diagnosis CCS expands the Single-Level into a hierarchical structure [106] .

Table 3: Examples of multi-level CCS diagnosis categories			
Multi-level CCS category	Description	ICD-9-CM diagnoses used to map	Single-level CCS used to map
7	Diseases of the circulatory system	--	96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121
7.1	Hypertension	--	98 99
7.1.1	Essential hypertension	--	98
7.1.2	Hypertension with complications and secondary hypertension	--	99
7.1.2.1	Hypertensive heart and/or renal disease	40200 40201 40210 40211 40290 40291 4030 40300 40301 4031 40310 40311 4039 40390 40391 4040	--

7.10 Example of Clinical Classification Software - DIAGNOSES

Clinical Classification Software categories start from number : 1 to 2621 **[106]** .

- 1 Codes: Tuberculosis
- ……
- 2613 E Codes: Poisoning
- 2616 E Codes: Adverse effects of medical care
- **2617 E Codes: Adverse effects of medical drugs**
- 2618 E Codes: Poisoning by other medications and drugs
- ……

  2621E Codes: Place of Occurrence

In the following section, detailed External causes of injury codes and Single Level CCS (Clinical Classifications Software) for ICD-9-CM are listed [**105**]

Figure 39:

2617 E Codes: Adverse effects of medical drugs

E9300 E9301 E9302 E9303 E9304 E9305 E9306 E9307 E9308 E9309 E9310 E9311 E9312 E9313 E9314 E9315 E9316 E9317 E9318 E9319 E9320 E9321 E9322 E9323 E9324 E9325 E9326 E9327 E9328 E9329 E9330 E9331 E9332 E9333 E9334 E9335 E9336 E9337 E9338 E9339 E9340 E9341 E9342 E9343 E9344 E9345 E9346 E9347 E9348 E9349 E9350 E9351 E9352 E9353 E9354 E9355 E9356 E9357 E9358 E9359 E9360 E9361 E9362 E9363 E9364 E9370 E9371 E9372 E9373 E9374 E9375 E9376 E9378 E9379 E9380 E9381 E9382 E9383 E9384 E9385 E9386 E9387 E9389 E9390 E9391 E9392 E9393 E9394 E9395 E9396 E9397 E9398 E9399 E9400 E9401 E9408 E9409 E9410 E9411 E9412 E9413 E9419 E9420 E9421 E9422 E9423 E9424 E9425 E9426 E9427 E9428 E9429 E9430 E9431 E9432 E9433 E9434 E9435 E9436 E9438 E9439 E9440 E9441 E9442 E9443 E9444 E9445 E9446 E9447 E9450 E9451 E9452 E9453 E9454 E9455 E9456 E9457 E9458 E9460 E9461 E9462 E9463 E9464 E9465 E9466 E9467 E9468 E9469 E9470 E9471 E9472 E9473 E9474 E9478 E9479 E9480 E9481 E9482 E9483 E9484 E9485 E9486 E9488 E9489 E9490 E9491 E9492 E9493 E9494 E9495 E9496 E9497 E9499

As noted in section : **7.1 Introduction** of this chapter, our study will only focus on (**2617 E_Codes**) ***Adverse Effects of Medical Drugs***, because this type of medication errors converges with the subject of our study.

The following table provides the attributes of each **ECode** (External Causes of injury Code)

7.11 CCS for ICD-9-CM - Adverse effects of medical drugs

Figure 40: List of **CCS** (Clinical Classifications Software)

ECode1	ECCS1	Description	Adverse Type
E9300	2617	E Codes: Adverse effects of medical drugs	ADV EFF PENICILLINS
E9301	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIFUNG ANTBIOT
E9302	2617	E Codes: Adverse effects of medical drugs	ADV EFF CHLORAMPHENICOL
E9303	2617	E Codes: Adverse effects of medical drugs	ADV EFF ERYTHROMYCIN
E9304	2617	E Codes: Adverse effects of medical drugs	ADV EFF TETRACYCLINE
E9305	2617	E Codes: Adverse effects of medical drugs	ADV EFF CEPHALOSPORIN
E9306	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTMYCOB

			ANTBIOT
E9307	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTINEOP ANTBIOT
E9308	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIBIOTICS NEC
E9309	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIBIOTIC NOS
E9310	2617	E Codes: Adverse effects of medical drugs	ADV EFF SULFONAMIDES
E9311	2617	E Codes: Adverse effects of medical drugs	ADV EFF ARSENIC ANTI-INF
E9312	2617	E Codes: Adverse effects of medical drugs	ADV EFF METAL ANTI-INF
E9313	2617	E Codes: Adverse effects of medical drugs	ADV EFF QUINOLINE
E9314	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIMALARIALS
E9315	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTPROTAZOAL NEC
E9316	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTHELMINTICS
E9317	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIVIRAL DRUGS
E9318	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIMYCOBAC NEC
E9319	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTINFCT NEC/NOS
E9320	2617	E Codes: Adverse effects of medical drugs	ADV EFF CORTICOSTEROIDS
E9321	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANDROGENS
E9322	2617	E Codes: Adverse effects of medical drugs	ADV EFF OVARIAN HORMONES
E9323	2617	E Codes: Adverse effects of medical drugs	ADV EFF INSULIN/ANTIDIAB
E9324	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANT PITUITARY
E9325	2617	E Codes: Adverse effects of medical drugs	ADV EFF POST PITUITARY
E9326	2617	E Codes: Adverse effects of medical drugs	ADV EFF PARATHYROID
E9327	2617	E Codes: Adverse effects of medical drugs	ADV EFF THYROID & DERIV
E9328	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTITHYROID AGNT
E9329	2617	E Codes: Adverse effects of medical drugs	ADV EFF HORMONES NEC/NOS
E9330	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANALLRG/ANTEMET
E9331	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTINEOPLASTIC
E9332	2617	E Codes: Adverse effects of medical drugs	ADV EFF ACIDIFYING AGENT
E9333	2617	E Codes: Adverse effects of medical drugs	ADV EFF ALKALIZING AGENT

E9334	2617	E Codes: Adverse effects of medical drugs	ADV EFF ENZYMES NEC
E9335	2617	E Codes: Adverse effects of medical drugs	ADV EFF VITAMINS NEC
E9336	2617	E Codes: Adverse effects of medical drugs	ORAL BISPHOSPHONATES (Begin 2007)
E9337	2617	E Codes: Adverse effects of medical drugs	IV BISPHOSPHONATES (Begin 2007)
E9338	2617	E Codes: Adverse effects of medical drugs	ADV EFF SYSTEMIC AGT NEC
E9339	2617	E Codes: Adverse effects of medical drugs	ADV EFF SYSTEMIC AGT NOS
E9340	2617	E Codes: Adverse effects of medical drugs	ADV EFF IRON & COMPOUNDS
E9341	2617	E Codes: Adverse effects of medical drugs	ADV EFF LIVER/ANTIANEMIC
E9342	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTICOAGULANTS
E9343	2617	E Codes: Adverse effects of medical drugs	ADV EFF VITAMIN K
E9344	2617	E Codes: Adverse effects of medical drugs	ADV EFF FIBRINOLYSIS AGT
E9345	2617	E Codes: Adverse effects of medical drugs	ADV EFF COAGULANTS
E9346	2617	E Codes: Adverse effects of medical drugs	ADV EFF GAMMA GLOBULIN
E9347	2617	E Codes: Adverse effects of medical drugs	ADV EFF BLOOD PRODUCTS
E9348	2617	E Codes: Adverse effects of medical drugs	ADV EFF BLOOD AGENT NEC
E9349	2617	E Codes: Adverse effects of medical drugs	ADV EFF BLOOD AGENT NOS
E9350	2617	E Codes: Adverse effects of medical drugs	ADV EFF HEROIN
E9351	2617	E Codes: Adverse effects of medical drugs	ADV EFF METHADONE
E9352	2617	E Codes: Adverse effects of medical drugs	ADV EFF OPIATES
E9353	2617	E Codes: Adverse effects of medical drugs	ADV EFF SALICYLATES
E9354	2617	E Codes: Adverse effects of medical drugs	ADV EFF AROM ANALGSC NEC
E9355	2617	E Codes: Adverse effects of medical drugs	ADV EFF PYRAZOLE DERIV
E9356	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIRHEUMATICS
E9357	2617	E Codes: Adverse effects of medical drugs	ADV EFF NON-NARC ANALGSC
E9358	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANALGESICS NEC
E9359	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANALGESIC NOS

E9360	2617	E Codes: Adverse effects of medical drugs	ADV EFF OXAZOLIDIN DERIV
E9361	2617	E Codes: Adverse effects of medical drugs	ADV EFF HYDANTOIN DERIV
E9362	2617	E Codes: Adverse effects of medical drugs	ADV EFF SUCCINIMIDES
E9363	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTCONVL NEC/NOS
E9364	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTI-PARKINSON
E9370	2617	E Codes: Adverse effects of medical drugs	ADV EFF BARBITURATES
E9371	2617	E Codes: Adverse effects of medical drugs	ADV EFF CHLORAL HYDRATE
E9372	2617	E Codes: Adverse effects of medical drugs	ADV EFF PARALDEHYDE
E9373	2617	E Codes: Adverse effects of medical drugs	ADV EFF BROMINE COMPNDS
E9374	2617	E Codes: Adverse effects of medical drugs	ADV EFF METHAQUALONE
E9375	2617	E Codes: Adverse effects of medical drugs	ADV EFF GLUTETHIMIDE
E9376	2617	E Codes: Adverse effects of medical drugs	ADV EFF MIX SEDATIVE
E9378	2617	E Codes: Adverse effects of medical drugs	ADV EFF SEDAT/HYPNOT NEC
E9379	2617	E Codes: Adverse effects of medical drugs	ADV EFF SEDAT/HYPNOT NOS
E9380	2617	E Codes: Adverse effects of medical drugs	ADV EFF CNS MUSCL DEPRES
E9381	2617	E Codes: Adverse effects of medical drugs	ADV EFF HALOTHANE
E9382	2617	E Codes: Adverse effects of medical drugs	ADV EFF GAS ANESTHET NEC
E9383	2617	E Codes: Adverse effects of medical drugs	ADV EFF INTRAVEN ANESTH
E9384	2617	E Codes: Adverse effects of medical drugs	ADV EFF GEN ANES NEC/NOS
E9385	2617	E Codes: Adverse effects of medical drugs	ADV EFF TOPIC/INFIL ANES
E9386	2617	E Codes: Adverse effects of medical drugs	ADV EFF NERVE-BLOCK ANES
E9387	2617	E Codes: Adverse effects of medical drugs	ADV EFF SPINAL ANESTHET
E9389	2617	E Codes: Adverse effects of medical drugs	ADV EFF LOC ANES NEC/NOS
E9390	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIDEPRESSANTS
E9391	2617	E Codes: Adverse effects of medical drugs	ADV EFF PHENOTHIAZ TRANQ
E9392	2617	E Codes: Adverse effects of medical drugs	ADV EFF BUTYROPHEN TRANQ
E9393	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIPSYCHOTC NEC

E9394	2617	E Codes: Adverse effects of medical drugs	ADV EFF BENZODIAZ TRANQ
E9395	2617	E Codes: Adverse effects of medical drugs	ADV EFF TRANQUILIZER NEC
E9396	2617	E Codes: Adverse effects of medical drugs	ADV EFF HALLUCINOGENS
E9397	2617	E Codes: Adverse effects of medical drugs	ADV EFF PSYCHOSTIMULANTS
E9398	2617	E Codes: Adverse effects of medical drugs	ADV EFF PSYCHOTROPIC NEC
E9399	2617	E Codes: Adverse effects of medical drugs	ADV EFF PSYCHOTROPIC NOS
E9400	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANALEPTICS
E9401	2617	E Codes: Adverse effects of medical drugs	ADV EFF OPIAT ANTAGONIST
E9408	2617	E Codes: Adverse effects of medical drugs	ADV EFF CNS STIMULNT NEC
E9409	2617	E Codes: Adverse effects of medical drugs	ADV EFF CNS STIMULNT NOS
E9410	2617	E Codes: Adverse effects of medical drugs	ADV EFF CHOLINERGICS
E9411	2617	E Codes: Adverse effects of medical drugs	ADV EFF PARASYMPATHOLYTC
E9412	2617	E Codes: Adverse effects of medical drugs	ADV EFF SYMPATHOMIMETICS
E9413	2617	E Codes: Adverse effects of medical drugs	ADV EFF SYMPATHOLYTICS
E9419	2617	E Codes: Adverse effects of medical drugs	ADV EFF AUTONOM AGNT NOS
E9420	2617	E Codes: Adverse effects of medical drugs	ADV EFF CARD RHYTH REGUL
E9421	2617	E Codes: Adverse effects of medical drugs	ADV EFF CARDIOTONICS
E9422	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTILIPEMICS
E9423	2617	E Codes: Adverse effects of medical drugs	ADV EFF GANGLION-BLOCK
E9424	2617	E Codes: Adverse effects of medical drugs	ADV EFF CORONARY VASODIL
E9425	2617	E Codes: Adverse effects of medical drugs	ADV EFF VASODILATORS NEC
E9426	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIHYPERTEN AGT
E9427	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIVARICOSE
E9428	2617	E Codes: Adverse effects of medical drugs	ADV EFF CAPILLARY-ACT
E9429	2617	E Codes: Adverse effects of medical drugs	ADV EFF CARDIOVASC NEC
E9430	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTACIDS
E9431	2617	E Codes: Adverse effects of medical drugs	ADV EFF IRRIT CATHARTIC

E9432	2617	E Codes: Adverse effects of medical drugs	ADV EFF EMOLL CATHARTICS
E9433	2617	E Codes: Adverse effects of medical drugs	ADV EFF CATHARTICS NEC
E9434	2617	E Codes: Adverse effects of medical drugs	ADV EFF DIGESTANTS
E9435	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIDIARRHEA AGT
E9436	2617	E Codes: Adverse effects of medical drugs	ADV EFF EMETICS
E9438	2617	E Codes: Adverse effects of medical drugs	ADV EFF GI AGENT NEC
E9439	2617	E Codes: Adverse effects of medical drugs	ADV EFF GI AGENT NOS
E9440	2617	E Codes: Adverse effects of medical drugs	ADV EFF MERCURY DIURETIC
E9441	2617	E Codes: Adverse effects of medical drugs	ADV EFF PURINE DIURETICS
E9442	2617	E Codes: Adverse effects of medical drugs	ADV EFF ACETAZOLAMIDE
E9443	2617	E Codes: Adverse effects of medical drugs	ADV EFF SALURETICS
E9444	2617	E Codes: Adverse effects of medical drugs	ADV EFF DIURETICS NEC
E9445	2617	E Codes: Adverse effects of medical drugs	ADV EFF ELECTROLYTE AGNT
E9446	2617	E Codes: Adverse effects of medical drugs	ADV EFF MINERAL SALT NEC
E9447	2617	E Codes: Adverse effects of medical drugs	ADV EFF URIC ACID METAB
E9450	2617	E Codes: Adverse effects of medical drugs	ADV EFF OXYTOCIC AGENTS
E9451	2617	E Codes: Adverse effects of medical drugs	ADV EFF SMOOTH MUSC RELX
E9452	2617	E Codes: Adverse effects of medical drugs	ADV EFF SKELET MUSC RELX
E9453	2617	E Codes: Adverse effects of medical drugs	ADV EFF MUSC AGT NEC/NOS
E9454	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTITUSSIVES
E9455	2617	E Codes: Adverse effects of medical drugs	ADV EFF EXPECTORANTS
E9456	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTI-COMMON COLD
E9457	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIASTHMATICS
E9458	2617	E Codes: Adverse effects of medical drugs	ADV EFF RESP DRG NEC/NOS
E9460	2617	E Codes: Adverse effects of medical drugs	ADV EFF LOC ANTI-INFECTV
E9461	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIPRURITICS
E9462	2617	E Codes: Adverse effects of medical drugs	ADV EFF LOCAL ASTRINGENT
E9463	2617	E Codes: Adverse effects of medical drugs	ADV EFF EMOLLIENT/DEMULC

E9464	2617	E Codes: Adverse effects of medical drugs	ADV EFF HAIR/SCALP PREP
E9465	2617	E Codes: Adverse effects of medical drugs	ADV EFF EYE ANTI-INF/DRG
E9466	2617	E Codes: Adverse effects of medical drugs	ADV EFF ENT ANTI-INF/DRG
E9467	2617	E Codes: Adverse effects of medical drugs	ADV EFF TOPIC DENTAL DRG
E9468	2617	E Codes: Adverse effects of medical drugs	ADV EFF SKIN AGENT NEC
E9469	2617	E Codes: Adverse effects of medical drugs	ADV EFF SKIN AGENT NOS
E9470	2617	E Codes: Adverse effects of medical drugs	ADV EFF DIETETICS
E9471	2617	E Codes: Adverse effects of medical drugs	ADV EFF LIPOTROPIC DRUGS
E9472	2617	E Codes: Adverse effects of medical drugs	ADV EFF ANTIDOTES NEC
E9473	2617	E Codes: Adverse effects of medical drugs	ADV EFF ALCOHOL DETER
E9474	2617	E Codes: Adverse effects of medical drugs	ADV EFF PHARMACEUT EXCIP
E9478	2617	E Codes: Adverse effects of medical drugs	ADV EFF MEDICINAL NEC
E9479	2617	E Codes: Adverse effects of medical drugs	ADV EFF MEDICINAL NOS
E9480	2617	E Codes: Adverse effects of medical drugs	ADV EFF BCG VACCINE
E9481	2617	E Codes: Adverse effects of medical drugs	ADV EFF TYPHOID VACCINE
E9482	2617	E Codes: Adverse effects of medical drugs	ADV EFF CHOLERA VACCINE
E9483	2617	E Codes: Adverse effects of medical drugs	ADV EFF PLAGUE VACCINE
E9484	2617	E Codes: Adverse effects of medical drugs	ADV EFF TETANUS VACCINE
E9485	2617	E Codes: Adverse effects of medical drugs	ADV EFF DIPHTHER VACCINE
E9486	2617	E Codes: Adverse effects of medical drugs	ADV EFF PERTUSSIS VACCIN
E9488	2617	E Codes: Adverse effects of medical drugs	ADV EFF BACT VAC NEC/NOS
E9489	2617	E Codes: Adverse effects of medical drugs	ADV EFF MIX BACT VACCINE
E9490	2617	E Codes: Adverse effects of medical drugs	ADV EFF SMALLPOX VACCINE
E9491	2617	E Codes: Adverse effects of medical drugs	ADV EFF RABIES VACCINE
E9492	2617	E Codes: Adverse effects of medical drugs	ADV EFF TYPHUS VACCINE
E9493	2617	E Codes: Adverse effects of medical drugs	ADV EFF YELLOW FEVER VAC
E9494	2617	E Codes: Adverse effects of medical drugs	ADV EFF MEASLES VACCINE
E9495	2617	E Codes: Adverse effects of medical drugs	ADV EFF POLIO VACCINE
E9496	2617	E Codes: Adverse effects of medical drugs	ADV EFF VIRAL VACC NEC
E9497	2617	E Codes: Adverse effects of medical drugs	ADV EFF MIXED VIRAL-BACT
E9499	2617	E Codes: Adverse effects of medical drugs	ADV EFF BIOLOGIC NEC/NOS

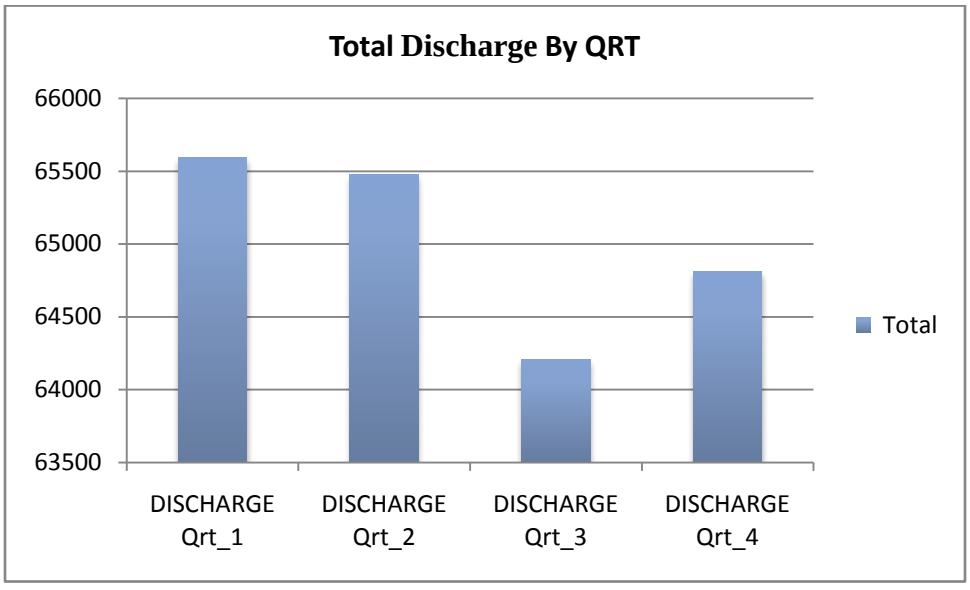
7.12 Statistics Analysis of the NIS 2014 Database:

This section of the study presents the statistics on adverse drug events performed against the National Inpatients Sample (NIS) 2014 database, more specifically on the data sample which is a set of thirty one selected **ECodes**. The following graphs and tables summarize the characteristics of inpatients and hospitals involving adverse drug events (ADEs) .

HIGHLIGHTS

- The overall number of hospitals discharges involving adverse drug events (ADEs) from the first to the fourth quarter on year 2014

Figure 41: Total discharge by Quarter



- In the inpatient setting, the following E Codes : E9320 (Corticosteroids), E9331 (Antineoplastic), and E9342 (Anticoagulants) represent **47.64 percent** of all discharges of the statistic sample (**260087** events), accounting for more than **50 percent** of the total yearly charges of the statistic sample (**$15,093,974,949.00**).
- More than **45 percent** of all inpatients (**260087** events), with adverse drug events (ADEs) were for patients in age group **0-16** and E Code **E9331** (Antineoplastic).
- Division **#5** (South Atlantic) is ranked number one with the highest Length Of Stay (LOS) **24.32%** (**260299** events), as well as the highest Total Charges Amount **22.07%** of (**$15,093,974,949.00**).
- In terms of Length Of Stay by region, the South (**Region #3**) is ranked number one with **37.31%** (**134** events**)**.
- Over the four quarters of 2014, more than **46 percent** of patients (**252553** events) died during hospitalization from E Codes : **E9320** (Corticosteroids), **E9331** (Antineoplastic), and **E9342** (Anticoagulants).
- More than **47 percent** of Income (**255207** events) for ZipCodes: 1, 2, 3, and 4 during the four quarters (Qtr1, Qtr2, Qtr3, and Qtr4) were generated by inpatients from E Codes : **E9320** (Corticosteroids), **E9331** (Antineoplastic), and **E9342** (Anticoagulants).
- **53.50** percent of all inpatients (**260074** events) with adverse drug events were patients in age group **56-90**, followed by age group **41-64** with a percentage of **34.45**.

- Corticosteroids (**E9320**) **17.52** percent of events, Antineoplastic (**E9331**) **17.22** percent , and Anticoagulants (**E9342**) **12.91** percent of events were the most common causes of adverse drug events (ADEs).
- Among all inpatients, there was **55.52** percent of females and **44.48** of males (**260060** events).
- Four tables (Summary Quarter 1, Summary Quarter 2, Summary Quarter 3, and Summary Quarter 4) give a general overview of all statistics performed on the National Inpatient Sample (NIS) 2014 database.

- **Table 40 : Summary of Statistical Analysis for Quarter One**

ECodel	Dis-charge	Died	Alive	Total Income	Sex		LOS	Age Group				Census Div	Total Charge
					Male	Female		0-16	17-40	41-64	65-90		
E9300	694	673	20	681	319	375	694	92	99	232	271	694	$48,113,388.0
E9305	611	603	8	603	278	333	611	72	87	187	265	611	$35,782,536.0
E9308	2178	2118	59	2142	941	1236	2178	90	399	800	888	2178	$146,330,467.0
E9309	1069	1047	22	1048	447	622	1069	79	100	343	547	1069	$60,283,864.0
E9310	695	687	7	679	282	413	695	31	117	220	327	695	$28,009,993.0
E9320	12450	12146	301	12236	5257	7193	12450	222	1277	5074	5877	12450	$774,192,224.0
E9323	1079	1060	18	1056	510	569	1079	7	64	356	652	1079	$40,848,899.0
E9331	10410	9937	473	10219	4940	5469	10410	756	957	4164	4532	10410	$703,876,706.0
E9342	9161	8676	481	9015	4606	4554	9161	9	230	1880	7042	9161	$513,350,634.0
E9348	409	395	14	403	226	183	409	3	14	131	261	409	$24,744,100.0
E9352	3932	3841	90	3868	1526	2406	3932	110	494	1488	1840	3932	$212,022,881.0
E9356	511	503	8	503	225	286	511	19	75	178	239	511	$23,522,407.0
E9358	828	812	16	813	334	494	828	7	90	302	429	828	$52,066,171.0
E9359	1535	1517	18	1501	711	824	1535	16	163	607	749	1535	$66,379,710.0
E9361	478	466	12	465	238	240	478	9	58	204	207	478	$19,832,160.0
E9363	980	973	7	963	417	563	980	50	149	379	402	980	$44,526,565.0
E9378	405	390	15	394	171	234	405	11	34	120	240	405	$26,710,616.0
E9379	1789	1750	39	1766	739	1050	1789	19	202	676	891	1789	$118,815,684.0
E9384	406	402	4	403	199	207	406	12	33	128	232	406	$30,343,490.0
E9390	550	542	5	537	195	355	550	16	72	168	294	550	$21,549,737.0
E9393	744	728	16	725	327	417	744	15	154	294	281	744	$33,768,160.0
E9394	885	857	27	864	386	498	885	30	70	282	503	885	$54,286,723.0
E9413	655	651	3	643	363	292	655	4	19	129	503	655	$25,544,703.0
E9420	724	694	30	715	384	340	724	6	16	161	541	724	$50,849,190.0
E9421	733	682	51	724	263	470	733	4	11	82	636	733	$36,608,083.0
E9426	1311	1297	13	1287	603	708	1311	10	52	394	855	1311	$48,432,404.0
E9429	1132	1119	13	1123	516	616	1132	4	51	426	651	1132	$43,059,446.0
E9443	866	855	11	853	298	568	866	1	19	251	595	866	$31,743,944.0
E9444	3068	2993	74	3015	1370	1698	3068	40	69	824	2135	3068	$159,724,190.0
E9478	2843	2753	90	2787	1345	1498	2843	56	260	973	1554	2843	$216,816,535.0
E9479	2463	2404	58	2416	1008	1455	2463	64	239	917	1242	2463	$148,628,646.0
Total	65594	63571	2003	64447	29424	36166	65594	1864	5674	22370	35681	65594	$3,840,764,256.0

- **Table 41 : Summary of Statistical Analysis for Quarter Two**

ECodel	Dis-charge	Died	Alive	Total Income	Sex		LOS	Age Group				Census Div	Total Charge
					Male	Female		0-16	17-40	41-64	65-90		
E9300	733	716	17	717	356	377	733	77	117	243	296	733	$50,810,789.0
E9305	630	622	8	614	261	369	630	48	94	193	295	630	$33,107,495.0
E9308	2180	2134	43	2141	832	1348	2179	113	381	758	928	2180	$143,937,755.0
E9309	1038	1022	16	1018	422	616	1038	70	104	315	549	1038	$60,872,885.0
E9310	740	730	10	728	325	415	740	23	111	234	372	740	$25,484,652.0
E9320	11320	11066	254	11114	4737	6582	11320	212	1231	4541	5335	11320	$688,574,199.0
E9323	1066	1049	15	1041	511	555	1066	6	65	370	625	1066	$37,277,437.0
E9331	11320	10861	457	11064	5314	6002	11320	836	1010	4628	4845	11320	$754,424,753.0
E9342	8400	7951	445	8273	4171	4227	8400	8	220	1780	6392	8400	$465,390,282.0
E9348	417	408	9	411	189	228	417	1	25	130	261	417	$23,082,752.0
E9352	3897	3833	63	3834	1521	2376	3897	106	495	1433	1863	3897	$215,252,420.0
E9356	483	477	6	476	233	249	483	11	64	191	217	483	$18,695,840.0
E9358	825	812	13	813	323	502	825	9	86	328	402	825	$48,215,871.0
E9359	1720	1696	24	1676	814	906	1720	18	195	706	801	1720	$70,306,211.0
E9361	502	490	12	491	249	253	502	5	61	217	219	502	$20,700,914.0
E9363	1032	1024	7	1010	424	607	1031	47	166	406	413	1032	$48,609,389.0
E9378	385	375	9	374	169	216	385	7	37	116	225	385	$23,949,236.0
E9379	1815	1778	37	1790	691	1124	1815	18	198	705	894	1815	$113,053,745.0
E9384	392	387	5	391	168	224	392	20	26	137	209	392	$28,720,480.0
E9390	544	540	3	539	181	363	544	10	70	204	260	544	$20,790,744.0
E9393	672	666	6	657	316	356	671	31	122	256	263	672	$28,930,617.0
E9394	892	874	18	876	379	513	892	33	71	315	473	892	$48,225,240.0
E9413	747	738	9	735	354	393	747	6	16	175	550	747	$30,746,240.0
E9420	716	685	31	704	382	334	716	6	13	157	540	716	$49,042,163.0
E9421	778	738	40	760	286	492	778	2	5	87	684	778	$36,923,466.0
E9426	1381	1371	10	1355	611	770	1381	9	63	442	867	1381	$49,691,879.0
E9429	1258	1241	17	1235	596	662	1258	5	66	456	731	1258	$43,683,821.0
E9443	1100	1092	7	1077	398	702	1100	1	24	315	760	1100	$36,257,700.0
E9444	3026	2955	70	2982	1342	1683	3026	21	79	820	2106	3026	$149,830,078.0
E9478	2790	2693	97	2734	1262	1528	2790	48	260	1017	1465	2790	$200,761,514.0
E9479	2676	2618	56	2642	1100	1576	2676	54	291	990	1341	2676	$146,867,091.0
Total	65475	63642	1814	64272	28917	36548	65472	1861	5766	22665	35181	65475	**$3,712,217,658.0**

- **Table 42 : Summary of Statistical Analysis for Quarter Three**

ECodel	Dis-charge	Died	Alive	Total Income	Sex		LOS	Age Group				Census Div	Total Charge
					Male	Female		0-16	17-40	41-64	65-90		
E9300	742	721	21	724	359	383	742	62	142	245	293	742	$55,822,087.0(
E9305	574	561	12	566	247	327	574	36	100	194	244	574	$35,034,628.0(
E9308	2204	2163	39	2152	931	1273	2204	114	456	779	854	2204	$142,950,147.0(
E9309	949	933	16	926	370	579	949	53	97	279	520	949	$50,950,663.0(
E9310	807	797	10	793	346	461	807	28	140	239	400	807	$35,304,574.0(
E9320	10334	10112	216	10131	4350	5983	10334	236	1291	4143	4663	10334	$659,149,826.0(
E9323	1073	1058	15	1052	490	583	1073	4	81	371	617	1073	$37,400,869.0(
E9331	11504	11032	468	11288	5438	6065	11504	900	1130	4570	4903	11504	$790,731,819.0(
E9342	7875	7490	384	7753	3886	3988	7875	2	221	1706	5946	7875	$435,475,661.0(
E9348	431	420	11	426	206	225	431	0	23	114	294	431	$22,777,828.0(
E9352	4089	4007	80	4011	1542	2546	4089	114	576	1531	1868	4089	$226,341,209.0(
E9356	500	496	4	492	260	240	500	20	67	207	206	500	$20,587,707.0(
E9358	841	828	12	824	343	496	841	10	102	309	420	841	$43,349,313.0(
E9359	1753	1728	23	1721	822	931	1753	10	215	704	824	1753	$71,505,346.0(
E9361	477	470	7	469	248	229	477	5	75	200	197	477	$21,556,015.0(
E9363	1042	1032	10	1020	445	597	1042	42	171	398	431	1042	$46,482,758.0(
E9378	393	383	10	387	164	229	393	10	38	128	217	393	$26,221,218.0(
E9379	1809	1772	37	1782	683	1125	1809	25	193	728	863	1809	$106,720,891.0(
E9384	426	421	5	422	190	236	426	16	46	129	235	426	$30,620,547.0(
E9390	567	559	7	561	196	371	567	8	60	203	296	567	$19,478,728.0(
E9393	694	681	12	679	338	356	694	13	128	271	282	694	$29,994,799.0(
E9394	849	822	27	834	395	454	849	22	51	308	468	849	$50,406,215.0(
E9413	741	734	7	728	377	364	741	3	28	170	540	741	$28,918,965.0(
E9420	724	697	27	711	379	345	724	8	25	166	525	724	$47,680,912.0(
E9421	665	631	34	646	241	424	665	2	3	69	591	665	$34,961,667.0(
E9426	1413	1390	21	1380	630	783	1413	9	67	463	874	1413	$50,314,148.0(
E9429	1284	1272	12	1249	611	673	1284	3	57	510	714	1284	$47,735,497.0(
E9443	1094	1087	7	1073	338	756	1094	1	28	317	748	1094	$40,191,684.0(
E9444	3040	2982	56	2988	1353	1687	3040	24	90	877	2049	3040	$165,100,556.0(
E9478	2807	2718	89	2763	1318	1488	2807	41	254	967	1545	2807	$202,193,449.0(
E9479	2504	2446	56	2450	1037	1466	2504	64	234	926	1280	2504	$139,393,587.0(
Total	64205	62443	1735	63001	28533	35663	64205	1885	6189	22221	33907	64205	**$3,715,353,313.0(**

- **Table 43 : Summary of Statistical Analysis for Quarter Four**

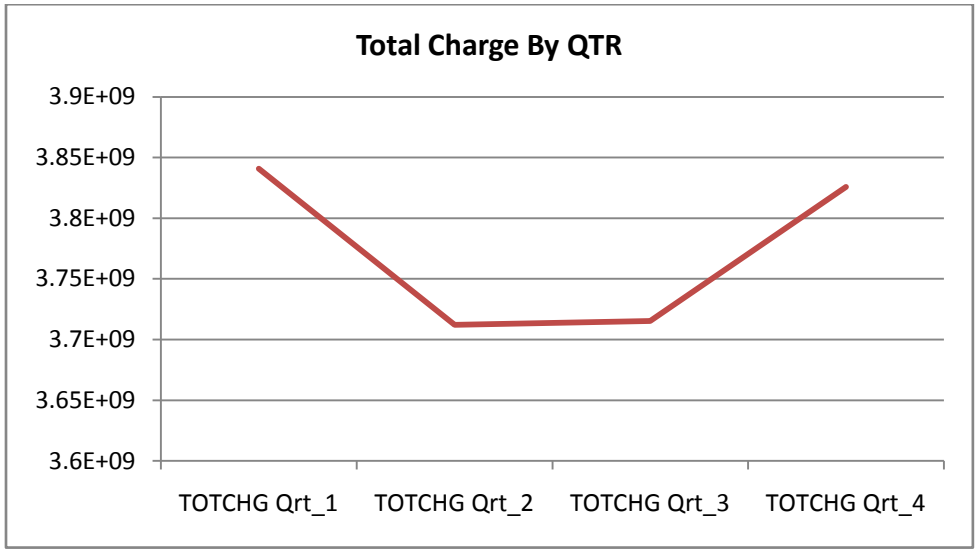
ECode 1	Dis-charge	Died	Alive	Total Income	Sex		LOS	Age Group				Census Div	Total Charge
					Male	Female		0-16	17-40	41-64	65-90		
E9300	723	706	17	707	345	378	723	64	136	255	268	723	$45,790,903.00
E9305	609	596	12	598	261	348	608	49	101	196	262	609	$36,281,321.00
E9308	2125	2077	48	2080	899	1226	2125	106	387	776	856	2125	$137,173,737.00
E9309	1049	1037	12	1021	431	618	1049	72	108	334	535	1049	$62,627,902.00
E9310	760	748	12	744	354	406	760	26	111	240	382	760	$30,617,436.00
E9320	11469	11194	272	11238	4953	6516	11468	236	1336	4686	5211	11469	$716,602,892.00
E9323	1027	1016	11	1002	474	553	1027	4	76	312	635	1027	$38,966,420.00
E9331	11558	11081	475	11285	5453	6105	11558	938	1089	4555	4976	11558	$812,784,675.00
E9342	8128	7643	485	7997	3969	4159	8128	12	211	1718	6187	8128	$458,721,018.00
E9348	413	401	12	405	211	202	413	1	18	147	247	413	$25,279,209.00
E9352	4126	4059	67	4039	1565	2561	4126	106	590	1535	1895	4126	$241,204,808.00
E9356	473	468	5	462	211	262	473	12	71	184	206	473	$21,609,554.00
E9358	779	763	16	765	296	483	779	9	105	293	372	779	$44,355,984.00
E9359	1712	1689	23	1678	759	952	1712	16	208	673	814	1712	$72,005,274.00
E9361	397	390	7	391	202	195	397	5	51	170	171	397	$16,523,118.00
E9363	1044	1030	13	1025	436	607	1044	69	160	382	433	1044	$44,861,683.00
E9378	346	339	7	340	156	190	346	14	33	108	191	346	$22,368,485.00
E9379	1813	1776	36	1785	716	1097	1813	36	204	683	890	1813	$113,982,057.00
E9384	415	407	8	401	198	217	415	13	30	145	227	415	$30,997,686.00
E9390	560	558	2	547	189	371	560	15	79	180	286	560	$21,228,111.00
E9393	663	660	2	641	311	352	662	20	127	252	264	663	$32,737,272.00
E9394	871	850	21	856	378	492	871	26	67	305	473	871	$53,052,287.00
E9413	651	642	8	635	320	331	651	5	24	168	454	651	$25,379,503.00
E9420	715	681	33	701	357	358	715	9	18	134	554	715	$46,647,187.00
E9421	596	563	33	585	219	377	596	0	4	57	535	596	$28,006,407.00
E9426	1210	1194	16	1181	556	654	1209	11	45	364	790	1210	$49,361,363.00
E9429	1138	1128	10	1115	530	607	1138	4	57	429	648	1138	$42,839,130.00
E9443	920	910	10	907	316	604	920	1	26	269	624	920	$33,050,632.00
E9444	3133	3053	80	3086	1365	1768	3133	37	89	848	2159	3133	$163,470,496.00
E9478	2742	2648	94	2673	1252	1490	2742	46	260	962	1474	2742	$201,961,608.00
E9479	2648	2590	58	2597	1119	1529	2646	58	259	988	1343	2648	$155,151,564.00
Total	64813	62897	1905	63487	28801	36008	64807	2020	6080	22348	34362	64813	$3,825,639,722.00

- **Table 44 : Total Charges by Quarter**

  (Note: Missing Charges account for : $ 14, 061,492.00)

	TOTCHG Qtr_1	TOTCHG Qtr_2	TOTCHG Qtr_3	TOTCHG Qtr_4	GRAND TOTCHG	PERCENTAGE
E9300	$48,113,388.00	$50,810,789.00	$55,822,087.00	$45,790,903.00	$200,537,167.00	1.33%
E9305	$35,782,536.00	$33,107,495.00	$35,034,628.00	$36,281,321.00	$140,205,980.00	0.93%
E9308	$146,330,467.00	$143,937,755.00	$142,950,147.00	$137,173,737.00	$570,392,106.00	3.78%
E9309	$60,283,864.00	$60,872,885.00	$50,950,663.00	$62,627,902.00	$234,735,314.00	1.56%
E9310	$28,009,993.00	$25,484,652.00	$35,304,574.00	$30,617,436.00	$119,416,655.00	0.79%
E9320	$774,192,224.00	$688,574,199.00	$659,149,826.00	$716,602,892.00	$2,838,519,141.00	18.81%
E9323	$40,848,899.00	$37,277,437.00	$37,400,869.00	$38,966,420.00	$154,493,625.00	1.02%
E9331	$703,876,706.00	$754,424,753.00	$790,731,819.00	$812,784,675.00	$3,061,817,953.00	20.29%
E9342	$513,350,634.00	$465,390,282.00	$435,475,661.00	$458,721,018.00	$1,872,937,595.00	12.41%
E9348	$24,744,100.00	$23,082,752.00	$22,777,828.00	$25,279,209.00	$95,883,889.00	0.64%
E9352	$212,022,881.00	$215,252,420.00	$226,341,209.00	$241,204,808.00	$894,821,318.00	5.93%
E9356	$23,522,407.00	$18,695,840.00	$20,587,707.00	$21,609,554.00	$84,415,508.00	0.56%
E9358	$52,066,171.00	$48,215,871.00	$43,349,313.00	$44,355,984.00	$187,987,339.00	1.25%
E9359	$66,379,710.00	$70,306,211.00	$71,505,346.00	$72,005,274.00	$280,196,541.00	1.86%
E9361	$19,832,160.00	$20,700,914.00	$21,556,015.00	$16,523,118.00	$78,612,207.00	0.52%
E9363	$44,526,565.00	$48,609,389.00	$46,482,758.00	$44,861,683.00	$184,480,395.00	1.22%
E9378	$26,710,616.00	$23,949,236.00	$26,221,218.00	$22,368,485.00	$99,249,555.00	0.66%
E9379	$118,815,684.00	$113,053,745.00	$106,720,891.00	$113,982,057.00	$452,572,377.00	3.00%
E9384	$30,343,490.00	$28,720,480.00	$30,620,547.00	$30,997,686.00	$120,682,203.00	0.80%
E9390	$21,549,737.00	$20,790,744.00	$19,478,728.00	$21,228,111.00	$83,047,320.00	0.55%
E9393	$33,768,160.00	$28,930,617.00	$29,994,799.00	$32,737,272.00	$125,430,848.00	0.83%
E9394	$54,286,723.00	$48,225,240.00	$50,406,215.00	$53,052,287.00	$205,970,465.00	1.36%
E9413	$25,544,703.00	$30,746,240.00	$28,918,965.00	$25,379,503.00	$110,589,411.00	0.73%
E9420	$50,849,190.00	$49,042,163.00	$47,680,912.00	$46,647,187.00	$194,219,452.00	1.29%
E9421	$36,608,083.00	$36,923,466.00	$34,961,667.00	$28,006,407.00	$136,499,623.00	0.90%
E9426	$48,432,404.00	$49,691,879.00	$50,314,148.00	$49,361,363.00	$197,799,794.00	1.31%
E9429	$43,059,446.00	$43,683,821.00	$47,735,497.00	$42,839,130.00	$177,317,894.00	1.17%
E9443	$31,743,944.00	$36,257,700.00	$40,191,684.00	$33,050,632.00	$141,243,960.00	0.94%
E9444	$159,724,190.00	$149,830,078.00	$165,100,556.00	$163,470,496.00	$638,125,320.00	4.23%
E9478	$216,816,535.00	$200,761,514.00	$202,193,449.00	$201,961,608.00	$821,733,106.00	5.44%
E9479	$148,628,646.00	$146,867,091.00	$139,393,587.00	$155,151,564.00	$590,040,888.00	3.91%
	$3,840,764,256.00	**$3,712,217,658.00**	**$3,715,353,313.00**	**$3,825,639,722.00**	**$15,093,974,949.00**	100.00%

Figure 42 : Total charges by Quarter



FINDINGS

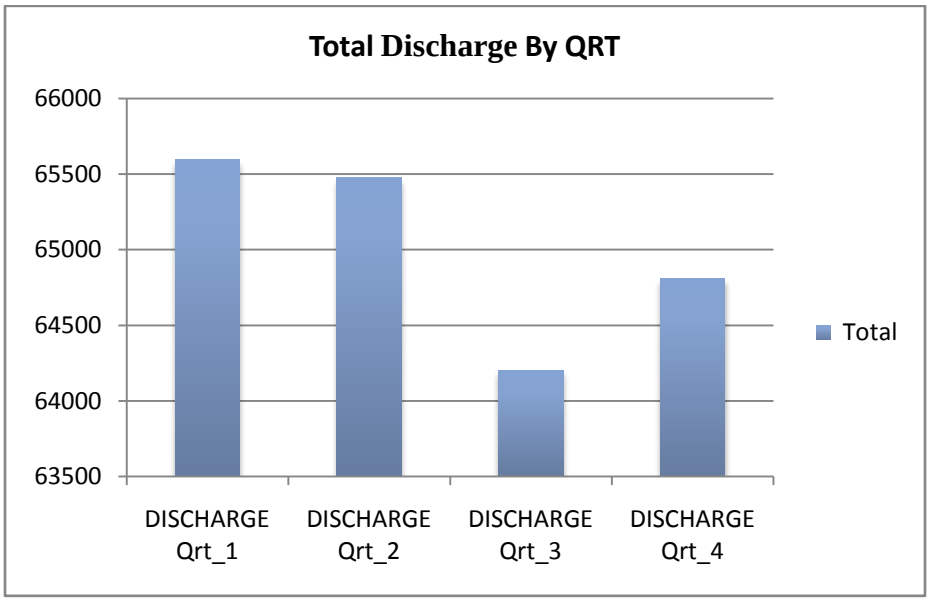
CHARACTERISTICS OF INPATIENTS:

7.12.2.1.1: Inpatients Discharges - Table 45

Ecode	DISCH Qtr_1	DISCH Qtr_2	DISCH Qtr_3	DISCH Qtr_4	TOTAL DISCH	DISCH TOTCH G	DISCH TOTCH G %
E9300	694	733	742	723	2892	2,892	1.11%
E9305	611	630	574	609	2424	2,424	0.93%
E9308	2178	2180	2204	2125	8687	8,687	3.34%
E9309	1069	1038	949	1049	4105	4,105	1.58%
E9310	695	740	807	760	3002	3,002	1.15%
E9320	12450	11320	10334	11469	45573	45,573	17.52%
E9323	1079	1066	1073	1027	4245	4,245	1.63%
E9331	10410	11320	11504	11558	44792	44,792	17.22%
E9342	9161	8400	7875	8128	33564	33,564	12.90%
E9348	409	417	431	413	1670	1,670	0.64%

E9352	3932	3897	4089	4126	16044	16,044	6.17%
E9356	511	483	500	473	1967	1,967	0.76%
E9358	828	825	841	779	3273	3,273	1.26%
E9359	1535	1720	1753	1712	6720	6,720	2.58%
E9361	478	502	477	397	1854	1,854	0.71%
E9363	980	1032	1042	1044	4098	4,098	1.58%
E9378	405	385	393	346	1529	1,529	0.59%
E9379	1789	1815	1809	1813	7226	7,226	2.78%
E9384	406	392	426	415	1639	1,639	0.63%
E9390	550	544	567	560	2221	2,221	0.85%
E9393	744	672	694	663	2773	2,773	1.07%
E9394	885	892	849	871	3497	3,497	1.34%
E9413	655	747	741	651	2794	2,794	1.07%
E9420	724	716	724	715	2879	2,879	1.11%
E9421	733	778	665	596	2772	2,772	1.07%
E9426	1311	1381	1413	1210	5315	5,315	2.04%
E9429	1132	1258	1284	1138	4812	4,812	1.85%
E9443	866	1100	1094	920	3980	3,980	1.53%
E9444	3068	3026	3040	3133	12267	12,267	4.72%
E9478	2843	2790	2807	2742	11182	11,182	4.30%
E9479	2463	2676	2504	2648	10291	10,291	3.96%
	65594	65475	64205	64813	**260087**	**520,174**	100.00%

Figure 43: Inpatients Discharged by Quarter



The table 45 and Figure 43 above show the distribution of patient discharges over quarter one throughout quarter four. The number of inpatients discharged from one quarter to another is not significant: **25.22%** for quarter one, **25.17%** for quarter two, **24.68%** for quarter three and **24.93%** for quarter four. When ECodes are taken individually into account, we can notice that their values between all four quarters are so diverse and vary from 1529 to 45573 inpatients.

7.12.2.1.2 Characteristics of Inpatients Discharged by Race:

Race (uniform) * Discharge quarter Cross tabulation

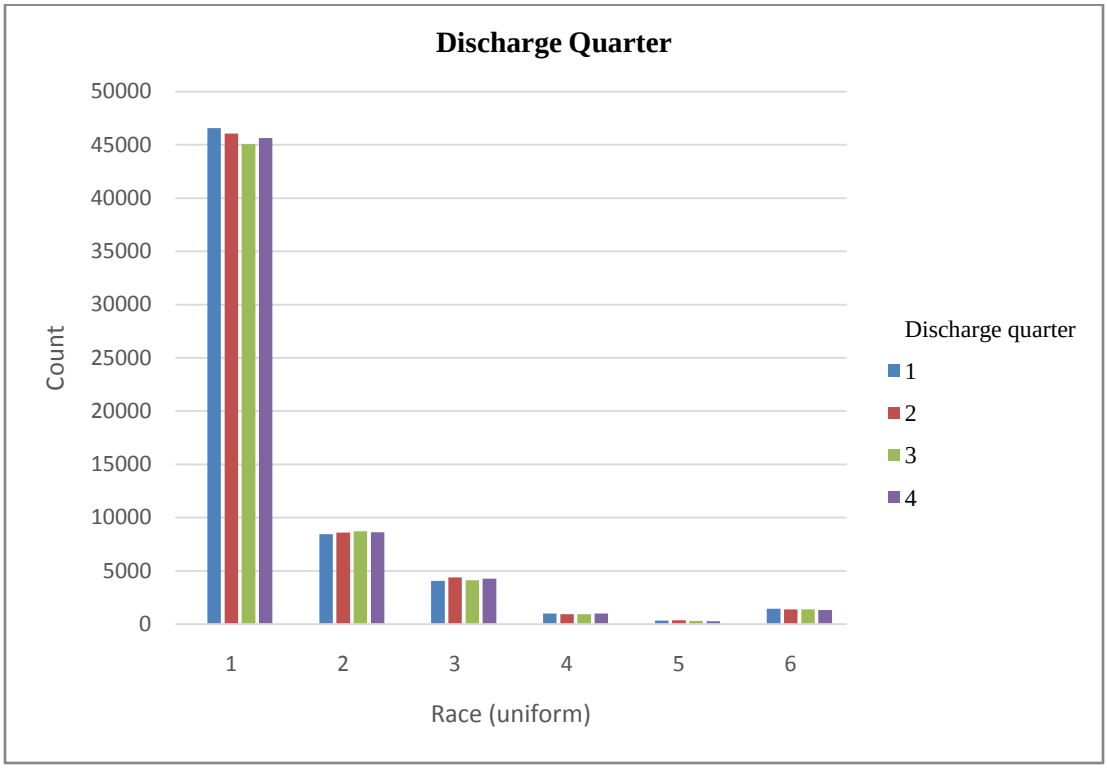
Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Race (uniform) * Discharge quarter	245235	94.2%	15074	5.8%	260309	100.0%

Table 46: Inpatients discharged by Race

		Discharge quarter				Total
		1	2	3	4	
Race (uniform)	1) White	46583	46076	45083	45637	183379
	2) Black	8440	8588	8726	8629	34383
	3) Hispanic	4058	4391	4107	4268	16824
	4) Asian or Pacific Islander	987	946	924	1005	3862
	5) Native American	318	362	295	274	1249
	6) Other	1448	1369	1392	1329	5538
Total		61834	61732	60527	61142	245235

Figure 44: Discharge Quarter by Race



The number of inpatients by race varies from one race to another also from one quarter to another. The population of Black inpatients slightly increased by **1.33** percent during the first three quarters in opposite of the white one, regardless of its high number of inpatients **74.77** percent (245235 events)

7.12.2.1.3 Characteristics of Inpatients Died by Race :

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Race (uniform) * Died during hospitalization	245386	94.3%	14923	5.7%	260309	100.0%

Race (Uniform) * Died during hospitalization Cross Tabulation

Table 47 : Count Inpatients Died by Race

		Died during hospitalization		
		0 (Died)	1 (Alive)	Total
Race (uniform)	1	178014	5362	183376
	2	33611	854	34465
	3	16414	453	16867
	4	3726	137	3863
	5	1207	42	1249
	6	5384	182	5566
Total		238356	7030	245386

The number of inpatients died regardless of the race is extremely high. More than **97.13** percent (245386 events) of all inpatients died from adverse drug events (ADEs). These numbers corroborate with the assertion that medication errors is one of the top causes of death nationwide .

The following graph shows the number of inpatients by race died (Blue) and alive (Red) during hospitalization

Figure 45 : Graph Inpatients Died by Race

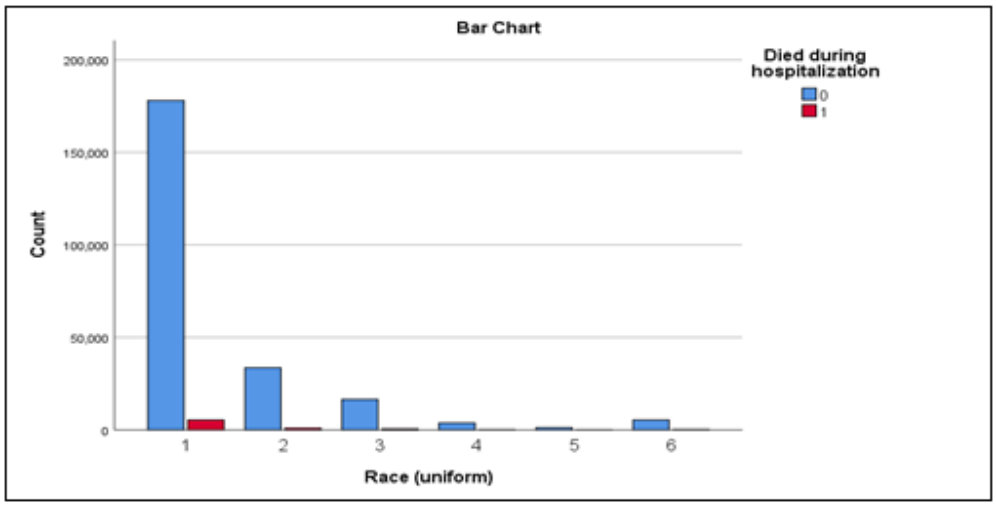


Table 48 : E code 1 * Race (uniform) Cross tabulation

	Race (uniform)						
	1	2	3	4	5	6	Total
E9300	1967	305	268	61	20	82	2703
E9305	1769	207	162	49	15	61	2263
E9308	6144	895	700	145	65	205	8154
E9309	2929	449	287	59	16	91	3831
E9310	2101	409	185	46	20	64	2825
E9320	31386	6941	3136	615	205	1019	43302
E9323	2438	997	391	82	27	116	4051
E9331	31248	5107	3423	898	162	1122	41960
E9342	25449	3890	1744	350	134	558	32125
E9348	1226	185	118	30	12	27	1598
E9352	11250	1980	921	232	103	333	14819
E9356	1332	239	154	42	13	51	1831
E9358	2415	332	162	37	23	64	3033
E9359	4684	964	409	108	49	130	6344
E9361	1047	530	133	14	9	32	1765
E9363	2865	566	244	53	23	97	3848
E9378	1154	134	87	26	5	28	1434
E9379	5334	814	366	71	25	107	6717
E9384	1176	178	94	26	8	40	1522
E9390	1715	180	114	14	8	36	2067
E9393	1853	429	152	45	17	72	2568
E9394	2665	300	203	32	21	63	3284
E9413	1987	383	158	52	13	62	2655
E9420	2253	263	115	41	6	28	2706
E9421	2176	260	139	36	8	42	2661
E9426	3397	1070	349	79	34	113	5042
E9429	2923	1181	285	73	20	94	4576
E9443	2847	522	224	99	20	77	3789
E9444	8719	1793	704	155	75	224	11670
E9478	7665	1611	787	177	46	296	10582
E9479	7312	1366	656	118	47	233	9732
	183426	34480	16870	3865	1249	5567	245457

1 White
2 Black
3 Hispanic
4 Asian or Pacific Islander
5 Native American
6 Other

Below is a representation of all inpatients by race for each ECode

Figure 46 : Graph of Race by E Codes

7.12.2.1.4

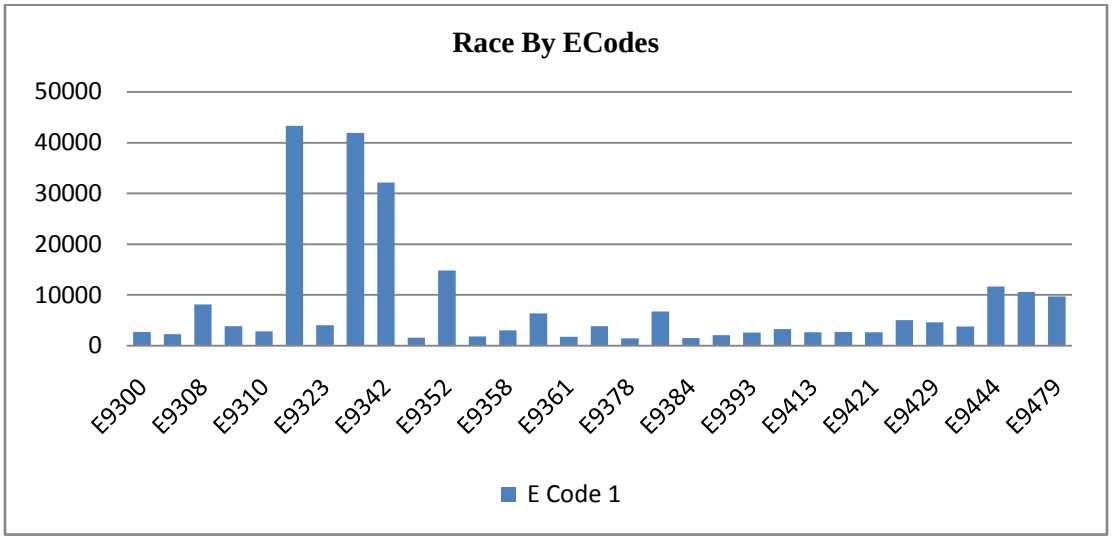


Figure 47 : Graph of Number of Inpatients by Race

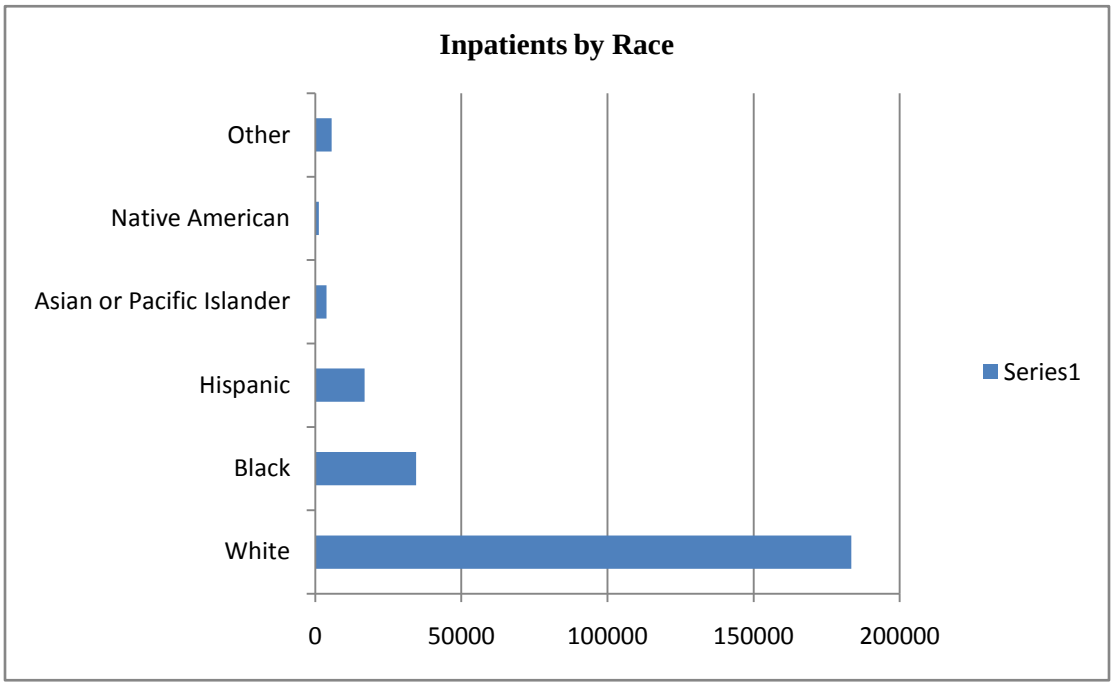
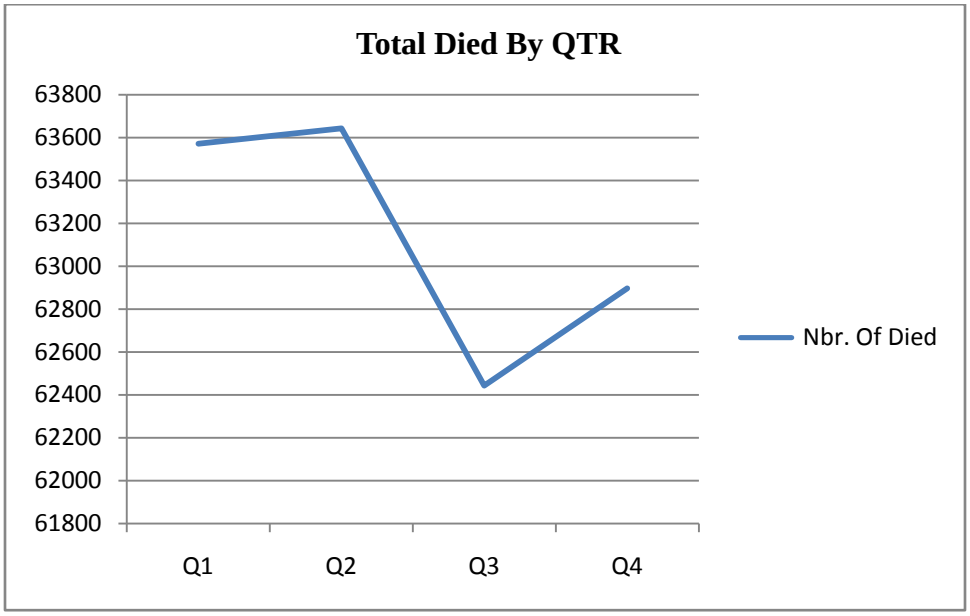


Table 49 : Characteristics of Inpatients Died by ECode :

7.12.2.1.5

	Died during hospitalization				Total	Prct
	Q1	Q2	Q3	Q4		
E9300	673	716	721	706	2816	1.12%
E9305	603	622	561	596	2382	0.94%
E9308	2118	2134	2163	2077	8492	3.36%
E9309	1047	1022	933	1037	4039	1.60%
E9310	687	730	797	748	2962	1.17%
E9320	12146	11066	10112	11194	44518	17.63%
E9323	1060	1049	1058	1016	4183	1.66%
E9331	9937	10861	11032	11081	42911	16.99%
E9342	8676	7951	7490	7643	31760	12.58%
E9348	395	408	420	401	1624	0.64%
E9352	3841	3833	4007	4059	15740	6.23%
E9356	503	477	496	468	1944	0.77%
E9358	812	812	828	763	3215	1.27%
E9359	1517	1696	1728	1689	6630	2.63%
E9361	466	490	470	390	1816	0.72%
E9363	973	1024	1032	1030	4059	1.61%
E9378	390	375	383	339	1487	0.59%
E9379	1750	1778	1772	1776	7076	2.80%
E9384	402	387	421	407	1617	0.64%
E9390	542	540	559	558	2199	0.87%
E9393	728	666	681	660	2735	1.08%
E9394	857	874	822	850	3403	1.35%
E9413	651	738	734	642	2765	1.09%
E9420	694	685	697	681	2757	1.09%
E9421	682	738	631	563	2614	1.04%
E9426	1297	1371	1390	1194	5252	2.08%
E9429	1119	1241	1272	1128	4760	1.88%
E9443	855	1092	1087	910	3944	1.56%
E9444	2993	2955	2982	3053	11983	4.74%
E9478	2753	2693	2718	2648	10812	4.28%
E9479	2404	2618	2446	2590	10058	3.98%
Total	63571	63642	62443	62897	**252553**	100.00%
Prct	**25.17%**	**25.20%**	**24.72%**	**24.91%**		

Figure 48 : Number of Inpatients Died by Quarter



The number of inpatients died from adverse drug event (ADEs) in 2014 was high and it still growing up year after year. In the second quarter of 2014 we noticed an increase of 0.03% of death rate followed by a decrease of 0.48% in the third. Of the three causes of death from the Corticosteroids (E9320), Antineoplastic (E9331), and Anticoagulants (E9342), the Antineoplastic (E9331) constantly showed an increase from one quarter to another as presented in the table 50 below.

Table 50 : Inpatients died by Top E Code for each Quarter

	Died during hospitalization					
	Qtr1	Qtr2	Qtr3	Qtr4	Total	Prct
E9320	12146	11066	10112	11194	44518	17.63%
E9331	9937	10861	11032	11081	42911	16.99%
E9342	8676	7951	7490	7643	31760	12.58%

7.12.2.1.6 Characteristics of Inpatients by Region:

The graph and table below show the distribution of all inpatients by region and by quarter. Region 3, the biggest of all four regions has more than **37** percent (134 events) of all discharges .This number of events is low because **99.9** percent of cases were missing We also can notice a constant decrease of discharges from quarter one to quarter four

List of Regions :

1:	NorthEast	(ME , NH, VT, MA, RI, CT, NY, NJ, PA)
2:	MidWest or North Central	(OH, IN, IL, MI, MN, IA, MO, ND, SD, NE, KS)
3:	South	(DE, MD, DC, VA, WV, NC, SC, GA, FL, KY, TN, AL, MS, AR, LA, OK, TX)
4:	West	(MT, ID, WY, CO, NM, AZ, UT, NV, WA, OR, CA, AK, HI)

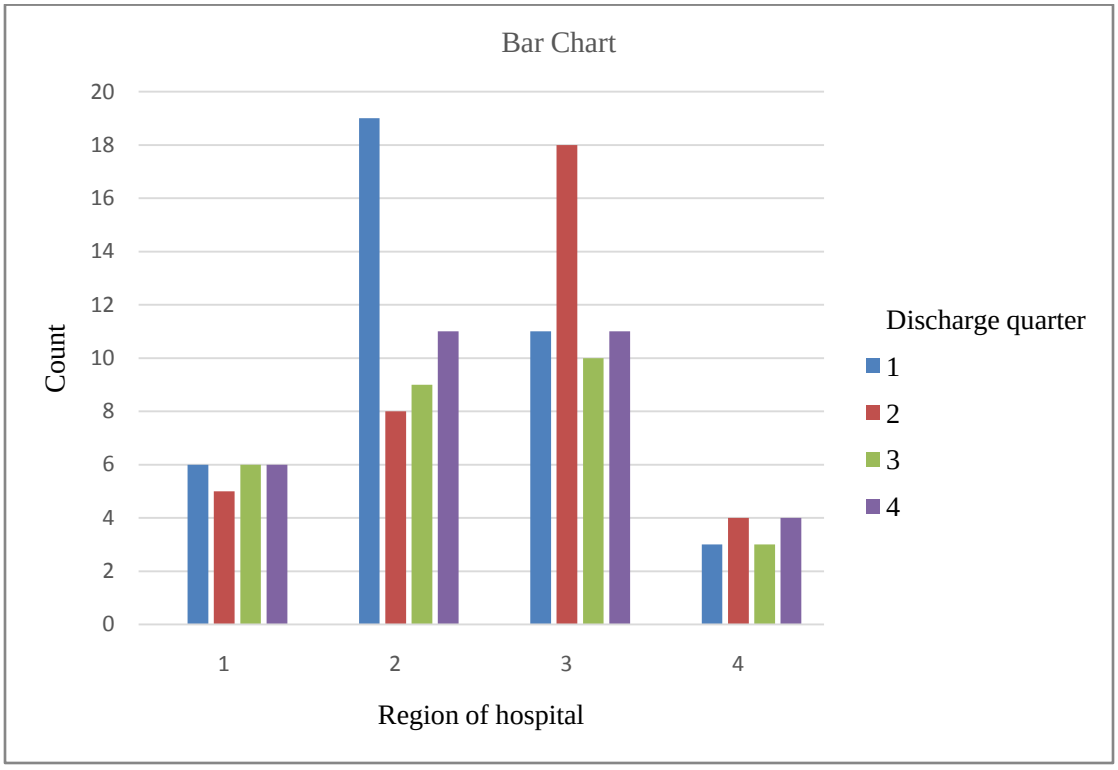
Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Region of hospital * Discharge quarter	134	0.1%	260175	99.9%	260309	100.0%

Region of hospital * Discharge quarter Cross tabulation

Table 51 : Count Inpatients by Region

		Discharge quarter				Total
		Qtr1	Qtr2	Qtr3	Qtr4	
Region of hospital	1	6	5	6	6	23
	2	19	8	9	11	47
	3	11	18	10	11	50
	4	3	4	3	4	14
Total		39	35	28	32	134

Figure 49: Graph Region of Hospital - Discharge by Quarter



7.12.2.1.7 Characteristics of Inpatients by Age :

Age differences:

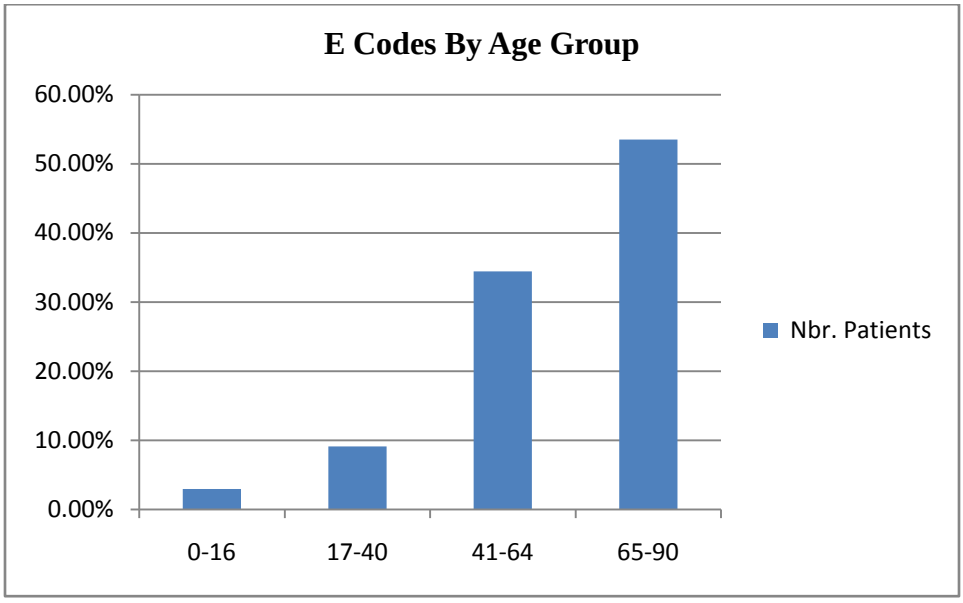
As shown in Table 52, during the four quarters the highest percentage of inpatients with drug adverse events **53.50** percent: ((139131 / 260074) * 100) were age group 65-90, followed by age group 41-64 (**34.45** percent) . At the same time, only (**2.94** percent) a low percentage rate was accounted for patients less than 17 years old.

We can also notice from this table that, regardless of the type of ECode , the number of inpatients with drug adverse events (ADEs) increases as we go from the lowest age group (**0-16**) to the highest one (**65-90**). See graph below.

Table 52 : Inpatients by Age Group for each E Code

ECode1	Age Group				Total	Prct
	0-16	17-40	41-64	65-90		
E9300	295	494	975	1128	2892	1.11%
E9305	205	382	770	1066	2423	0.93%
E9308	423	1623	3113	3526	8685	3.34%
E9309	274	409	1271	2151	4105	1.58%
E9310	108	479	933	1481	3001	1.15%
E9320	906	5135	18444	21086	45571	17.52%
E9323	21	286	1409	2529	4245	1.63%
E9331	3430	4186	17917	19256	44789	17.22%
E9342	31	882	7084	25567	33564	12.91%
E9348	5	80	522	1063	1670	0.64%
E9352	436	2155	5987	7466	16044	6.17%
E9356	62	277	760	868	1967	0.76%
E9358	35	383	1232	1623	3273	1.26%
E9359	60	781	2690	3188	6719	2.58%
E9361	24	245	791	794	1854	0.71%
E9363	208	646	1565	1679	4098	1.58%
E9378	42	142	472	873	1529	0.59%
E9379	98	797	2792	3538	7225	2.78%
E9384	61	135	539	903	1638	0.63%
E9390	49	281	755	1136	2221	0.85%
E9393	79	531	1073	1090	2773	1.07%
E9394	111	259	1210	1917	3497	1.34%
E9413	18	87	642	2047	2794	1.07%
E9420	29	72	618	2160	2879	1.11%
E9421	8	23	295	2446	2772	1.07%
E9426	39	227	1663	3386	5315	2.04%
E9429	16	231	1821	2744	4812	1.85%
E9443	4	97	1152	2727	3980	1.53%
E9444	122	327	3369	8449	12267	4.72%
E9478	191	1034	3919	6038	11182	4.30%
E9479	240	1023	3821	5206	10290	3.96%
SUM	7630	23709	89604	139131	260074	100%
Prct	2.94%	9.11%	34.45%	53.50%	100%	

Figure 50 : Graph E Code by Age Group



7.12.2.1.8 Characteristics of Inpatients by Age at admission * Length of stay :

In the following section the length of stay of inpatients by age is presented. Because of the large size of data, we only worked with the first ten (from 0 to 9), the last variable (343th), and the total count of the length of stay (LOS) for each inpatient's age.

Age 90 has the highest number of inpatients: 10074 (260,285 events) **3.87** percent, followed by Age 67 : 8514 (260,285 events) **3.27** percent (260,285 events).

Age 11 has the lowest number of inpatients: 283 (260,285 events) **0.10** percent, Three days is the top length of stay and accounts for **15.72** percent of all stays (260,285 events)

Table 53 : Inpatients by Age and by Length Of Stay (LOS)

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Age in years at admission * Length of stay (cleaned)	260285	100.0%	24	0.0%	260309	100.0%

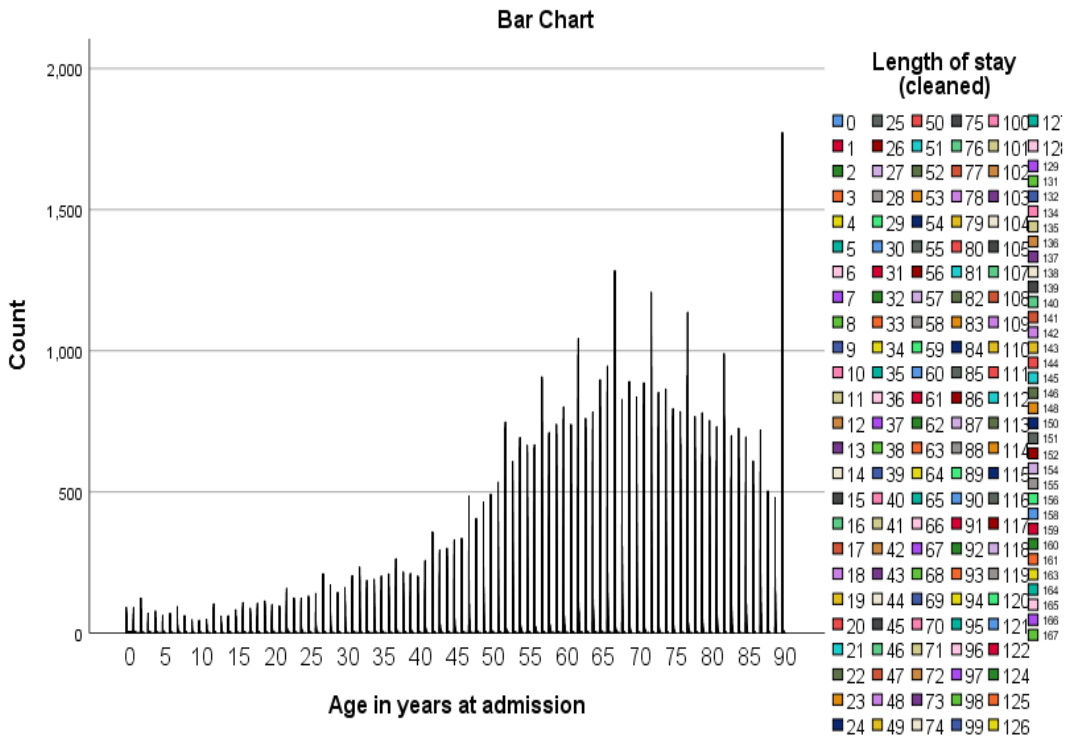
Age in years at admission * Length of stay (cleaned) Cross tabulation

		Length of stay (cleaned)								
		0	1	2	3	4	5	...	343	Total
Age in years at admission	0	6	63	90	74	60	36	...	0	805
	1	9	68	89	50	47	32	...	0	449
	2	13	80	123	86	80	45	...	0	656
	3	2	41	70	33	52	43	...	0	402
	4	2	51	78	48	55	28	...	0	365
	5	4	41	62	49	44	33	...	0	337
	6	5	38	70	54	42	19	...	0	337
	7	3	58	84	93	58	47	...	0	548
	8	2	37	62	42	35	27	...	0	327
	9	1	39	40	46	39	25	...	0	285
	10	2	34	45	42	32	34	...	0	295
	11	5	31	29	47	27	34	...	0	283
	12	5	66	103	91	90	57	...	0	618
	13	3	28	42	59	40	35	...	0	347
	14	10	44	57	61	49	48	...	0	442
	15	6	48	82	59	60	55	...	0	472
	16	9	61	94	108	85	79	...	0	661
	17	6	44	88	76	66	39	...	0	497
	18	9	58	105	89	62	48	...	0	556
	19	4	62	113	104	93	62	...	0	686
	20	7	59	100	76	80	46	...	0	610
	21	6	62	92	96	87	67	...	0	619
	22	8	71	144	158	114	99	...	0	980
	23	5	63	124	119	82	84	...	0	752
	24	10	77	123	112	96	64	...	0	763
	25	11	87	131	124	92	70	...	0	814
	26	17	74	140	116	105	83	...	0	810

	27	11	93	183	210	133	117	...	0	1229
	28	13	92	170	123	92	72	...	0	879
	29	16	94	139	144	118	80	...	0	928
	30	10	87	161	135	112	100	...	0	953
	31	8	110	203	188	144	110	...	0	1278
	32	13	150	233	202	188	144	...	0	1463
	33	16	98	186	160	136	93	...	0	1048
	34	8	104	170	190	142	92	...	0	1085
	35	18	115	202	152	151	118	...	0	1158
	36	11	121	209	164	133	111	...	0	1176
	37	26	165	260	263	228	161	...	0	1680
	38	14	129	216	177	147	107	...	0	1204
	39	12	130	207	211	146	128	...	0	1288
	40	14	131	201	199	141	111	...	0	1294
	41	24	154	253	257	179	131	...	0	1514
	42	27	202	355	358	243	199	...	0	2231
	43	24	204	294	283	216	159	...	0	1793
	44	19	181	300	272	227	167	...	0	1867
	45	13	193	329	278	223	166	...	0	1863
	46	26	202	334	334	258	181	...	0	2034
	47	27	292	442	485	354	275	...	0	3027
	48	24	222	406	382	306	218	...	0	2516
	49	22	275	463	442	309	231	...	0	2736
	50	24	275	477	492	349	283	...	0	2999
	51	38	252	511	534	395	304	...	0	3288
	52	43	420	728	747	547	470	...	0	4723
	53	46	299	608	540	428	321	...	0	3701
	54	52	390	659	692	533	412	...	0	4607
	55	46	337	664	641	481	411	...	0	4084
	56	24	369	656	666	462	431	...	0	4304
	57	55	470	898	907	748	545	...	0	6128
	58	47	392	702	710	558	412	...	0	4539
	59	31	381	705	739	594	468	...	0	4838
	60	44	380	758	801	582	445	...	0	4959
	61	35	360	738	737	530	461	...	0	4840
	62	51	514	985	1042	832	657	...	0	7009
	63	34	323	729	760	651	456	...	0	4983
	64	40	381	722	782	608	502	...	0	5166
	65	50	409	801	897	679	517	...	0	5516

	66	47	447	855	945	650	606	...	1	5900
	67	69	566	1178	1284	997	816	...	0	8514
	68	38	386	744	827	660	461	...	0	5241
	69	50	415	802	891	709	495	...	0	5660
	70	46	387	811	836	695	528	...	0	5513
	71	55	410	810	886	768	585	...	0	5990
	72	73	548	1051	1207	944	729	...	0	7654
	73	33	361	730	852	633	517	...	0	5211
	74	41	351	718	864	672	476	...	0	5254
	75	47	389	769	795	676	545	...	0	5504
	76	43	371	692	784	669	545	...	0	5177
	77	56	454	912	1136	881	655	...	0	6845
	78	43	317	657	766	610	494	...	0	4887
	79	36	354	604	780	633	514	...	0	4889
	80	32	304	619	753	626	415	...	0	4473
	81	40	310	610	731	587	440	...	0	4481
	82	43	396	769	989	755	635	...	0	6032
	83	32	265	552	699	540	473	...	0	4342
	84	31	275	536	725	619	461	...	0	4344
	85	38	239	487	694	533	391	...	0	3902
	86	13	212	482	609	526	381	...	0	3687
	87	26	296	571	719	595	467	...	0	4428
	88	21	179	352	503	407	358	...	0	2996
	89	21	160	329	480	360	300	...	0	2643
	90	68	609	1247	1773	1516	1128	....	0	10074
Total		2268	19982	37524	40936	32336	25120		1	260285

Figure 51 : Graph Length of Stay by Age



7.12.2.1.9 Characteristics of Inpatients by Sex and E Code:

Case Processing Summary

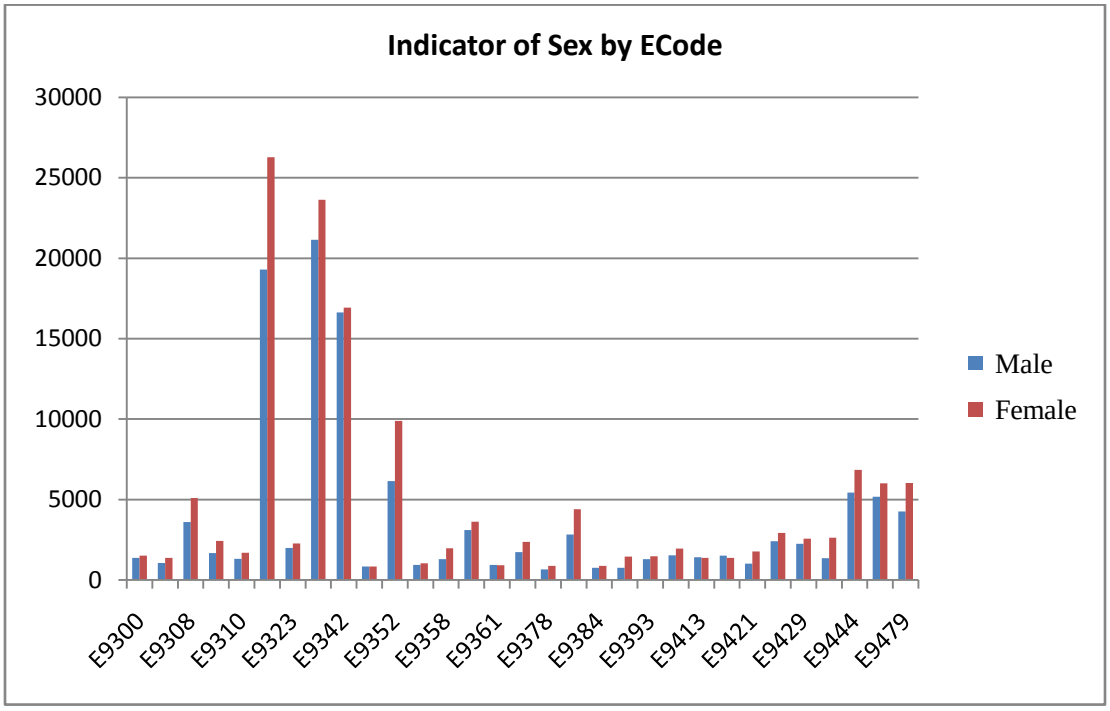
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
E code 1 * Indicator of sex	260282	100.0%	27	0.0%	260309	100.0%

Based on the repartition by sex presented in the following table, we can say that the population of female is large and represents **55.50** percent of all discharges (260282 events) in opposite to **44.50** percent for male. We observe the same tendency when comes to the repartition by ECode, excluding the **CORTICOSTEROIDS** (E9320), **SYMPATHOLYTICS** (E9413), and **HYDANTOIN DERIV** (E9361) where the number of inpatient males is greater.

Table 54 : Inpatients by Sex and by E Code

E code 1 * Indicator of sex Cross tabulation				
Count				
		Indicator of sex		
		M	F	Total
E code 1	E9300	1383	1518	2901
	E9305	1047	1378	2425
	E9308	3605	5088	8693
	E9309	1673	2437	4110
	E9310	1314	1700	3014
	E9320	19321	26286	45607
	E9323	1988	2262	4250
	E9331	21185	23663	44848
	E9342	16640	16935	33575
	E9348	832	839	1671
	E9352	6162	9892	16054
	E9356	930	1037	1967
	E9358	1297	1975	3272
	E9359	3110	3615	6725
	E9361	937	917	1854
	E9363	1723	2374	4097
	E9378	660	870	1530
	E9379	2829	4397	7226
	E9384	755	884	1639
	E9390	762	1461	2223
	E9393	1294	1482	2776
	E9394	1538	1958	3496
	E9413	1416	1380	2796
	E9420	1503	1377	2880
	E9421	1009	1764	2773
	E9426	2401	2916	5317
	E9429	2256	2560	4816
	E9443	1350	2630	3980
	E9444	5434	6838	12272
	E9478	5188	6012	11200
	E9479	4268	6027	10295
Total		115810	144472	260282

Figure 52 : Graph Sex by E Code

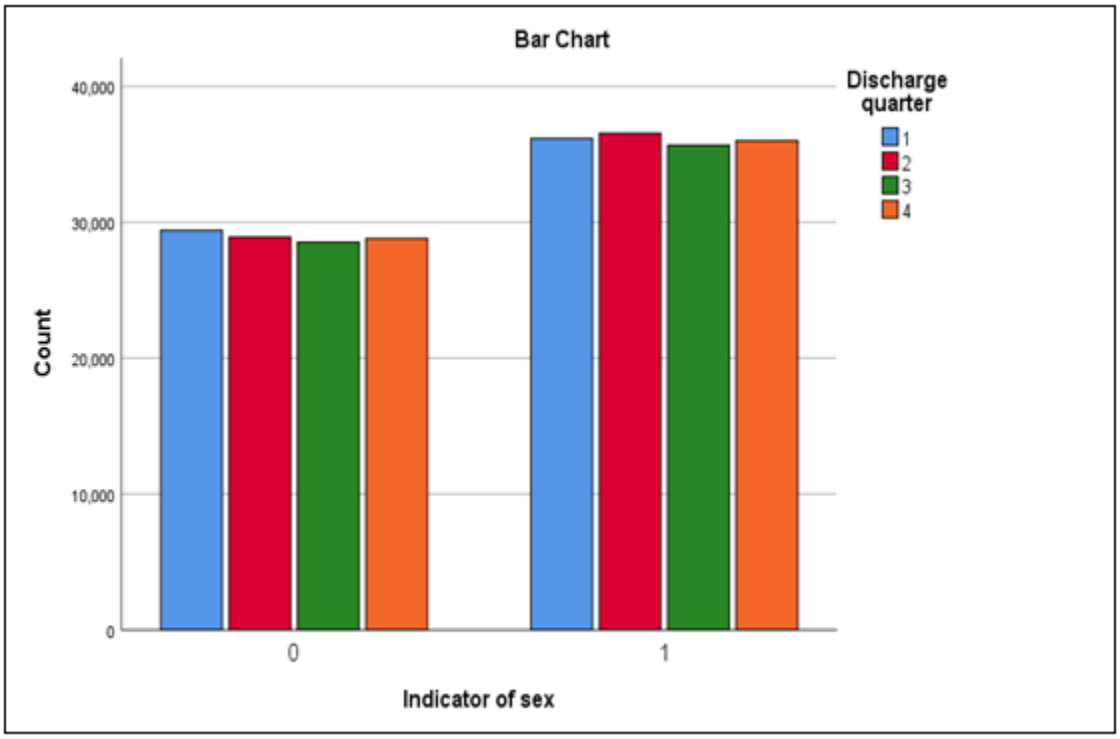


7.12.2.1.10 Characteristics of Inpatients by Sex and by QTR:

Table 55 : Indicator of sex * Discharge quarter Cross tabulation

		Discharge quarter				
		Qtr1	Qtr2	Qtr3	Qtr4	Total
Indicator of sex	Male	29424	28917	28533	28801	115675
	Female	36166	36548	35663	36008	144385
Total		65590	65465	64196	64809	260060

Figure 53: Graph Discharge by Sex and by Quarter



0 = Male **1 = Female**

Both the number of inpatient males and females independently vary with no patterns from one quarter to another, making trends and estimates of inpatients more difficult. Quarter one for males and females combined has a higher number of inpatients **25.22** percent of all events.

7.12.2.1.11 Characteristics of Inpatients Died, and by Sex:

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Indicator of sex * Died during hospitalization	260212	100.0%	97	0.0%	260309	100.0%

Table 56 : Inpatients Died by Sex

		Died during hospitalization		
		0	1	Total
Indicator of sex	0 = Male	111931	3835	115766
	1 = Female	140819	3627	144446
Total		252750	7462	260212

Figure 54: Graph Inpatients Died by Sex

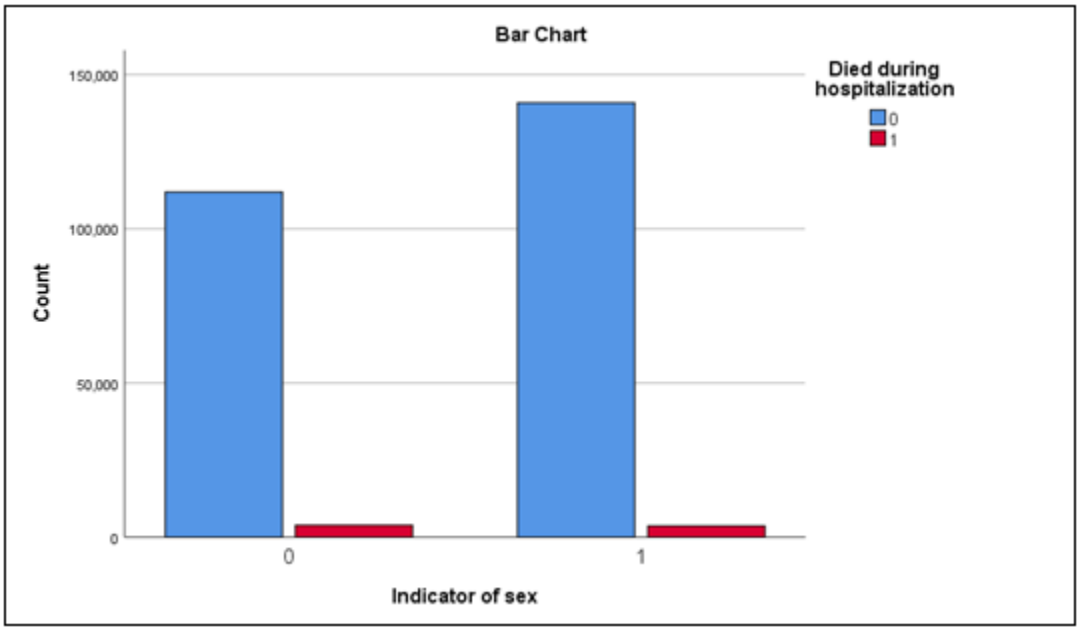


Table 57 : Characteristics of Inpatients by Median household income :

7.12.2.1.12 Inpatients by Median household Income

	Median household income national quartile for patient ZIP Code Cross tabulation				
	INCOME Qtr1	INCOME Qtr 2	INCOME Qtr 3	INCOME Qtr 4	Total
E9300	720	793	668	648	2829
E9305	602	682	554	543	2381
E9308	2422	2354	2033	1706	8515
E9309	1084	1168	956	805	4013
E9310	773	818	711	642	2944
E9320	13523	12601	10051	8544	44719

E9323	1471	1146	863	671	4151
E9331	10969	11707	10838	10342	43856
E9342	9559	9246	7890	6343	33038
E9348	431	438	410	366	1645
E9352	4079	4368	3901	3404	15752
E9356	501	525	496	411	1933
E9358	736	905	885	689	3215
E9359	1858	1839	1531	1348	6576
E9361	773	476	346	221	1816
E9363	1150	1088	955	825	4018
E9378	402	412	368	313	1495
E9379	1850	2043	1737	1493	7123
E9384	371	436	428	382	1617
E9390	550	596	571	467	2184
E9393	823	734	632	513	2702
E9394	970	1026	786	648	3430
E9413	752	820	645	524	2741
E9420	727	804	679	621	2831
E9421	867	801	596	451	2715
E9426	1677	1447	1164	915	5203
E9429	1602	1343	992	785	4722
E9443	1079	1066	960	805	3910
E9444	3574	3418	2770	2309	12071
E9478	3262	3103	2420	2172	10957
E9479	3326	2910	2206	1663	10105
Total	72483	71113	60042	51569	255207

7.12.2.1.13 The following is the corresponding median household income national quartile for patient ZIP Code for year 2014 :

Table 58 : Median household Income by ZipCode

ZipCode Number	Income Range
1	$1 - 39,999
2	$40,000 - 50.999
3	$51,000 - 65,999
4	$66,000 +

When referring to **table 58**, we can tell that zip code one has the lowest income range and the highest number of inpatients in the median household income table above. On the other hand, we cannot for example establish any correlation between income range and inpatients died, nor income range and inpatients of a specific ECode because of the nature of data available in the NIS 2014.

The graph below shows a distribution of ECode by all four ZipCodes .

Figure 55: Median household Income by ZipCode of Inpatients

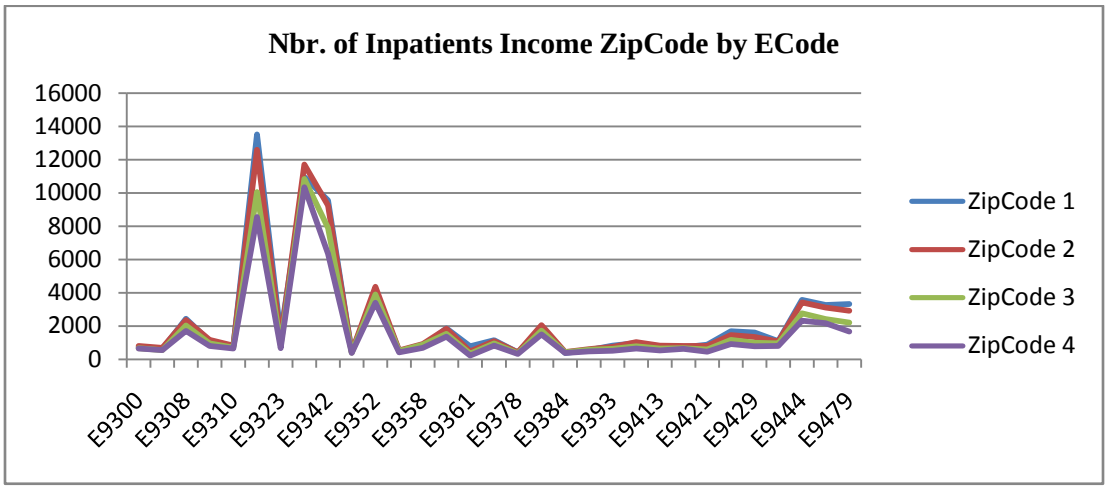
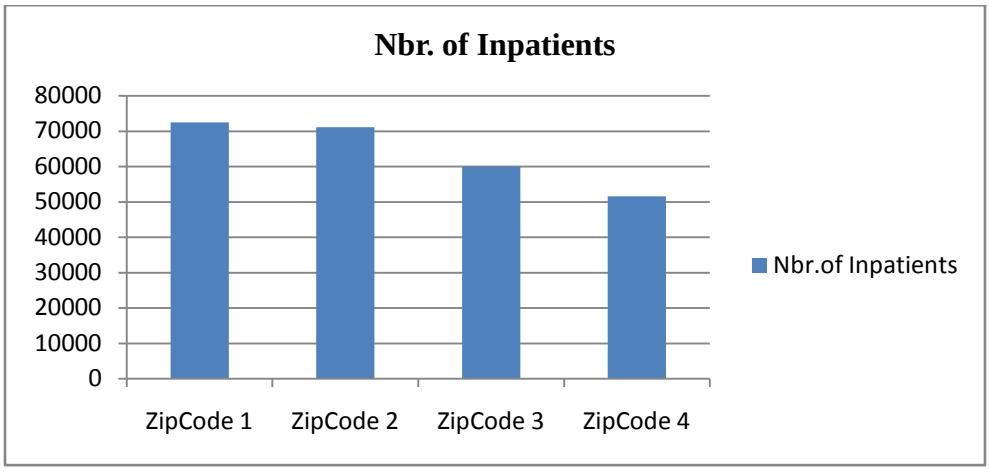


Figure 56 : Number of Inpatients by Median household Income



CHARACTERISTICS OF HOSPITALS:

Table 59 : Hospital Census for all Divisions * ECode

7.12.2.2.1

	Census Division of hospital									Total
	1	2	3	4	5	6	7	8	9	
E9300	223	425	497	251	624	163	290	220	199	2892
E9305	207	344	398	214	488	160	230	152	231	2424
E9308	635	1144	1409	677	2046	658	1026	556	536	8687
E9309	270	471	764	328	1050	299	486	218	219	4105
E9310	225	412	513	247	729	218	343	143	172	3002
E9320	2203	6093	8458	3041	12109	3404	5072	3146	2047	45573
E9323	277	618	656	262	1147	271	555	264	195	4245
E9331	2372	6277	7553	3948	9895	3587	5746	2932	2482	44792
E9342	1714	4846	6533	1761	8699	2686	3454	2346	1525	33564
E9348	89	234	273	99	420	108	212	106	129	1670
E9352	1180	1924	2884	1508	3326	922	1589	1297	1414	16044
E9356	135	301	383	142	402	100	175	131	198	1967
E9358	182	411	612	347	748	170	287	251	265	3273
E9359	462	766	1119	547	1688	473	796	506	363	6720
E9361	83	230	315	98	513	180	252	110	73	1854
E9363	321	575	765	324	902	321	419	244	227	4098
E9378	103	155	220	122	364	146	201	118	100	1529
E9379	309	645	1438	726	1723	513	721	672	479	7226
E9384	89	213	302	152	387	121	162	137	76	1639
E9390	224	312	357	207	479	142	199	131	170	2221
E9393	274	478	449	272	605	157	225	155	158	2773
E9394	276	400	581	269	862	228	343	224	314	3497
E9413	191	335	480	215	691	172	289	178	243	2794
E9420	222	373	569	254	624	249	283	147	158	2879
E9421	141	378	418	175	658	344	356	162	140	2772
E9426	341	750	956	352	1277	365	585	304	385	5315
E9429	335	566	816	334	1322	310	537	267	325	4812
E9443	257	536	611	274	1004	235	474	313	276	3980
E9444	783	1485	2189	796	3092	782	1437	918	785	12267
E9478	653	1663	1811	747	2855	878	1316	725	534	11182
E9479	466	1037	1784	848	2580	1071	1412	681	412	10291
Total	15242	34397	46113	19537	63309	19433	29472	17754	14830	260087

Table 59 above summarizes the hospital census (the total number of patients admitted to the hospital by midnight) for all nine divisions as follows :

7.12.2.2.2 List of States by Division of Hospital

Table 60

Division #	Division Name	List of States
1	New England	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut
2	Middle Atlantic	New York, Pennsylvania, New Jersey
3	East North Central	Wisconsin, Michigan, Illinois, Indiana, Ohio
4	West North Central	Missouri, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa
5	South Atlantic	Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida
6	East South Central	Kentucky, Tennessee, Mississippi, Alabama
7	West South Central	Oklahoma, Texas, Arkansas, Louisiana
8	Mountain	Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico
9	Pacific	Alaska, Washington, Oregon, California, Hawaii

Division #5 takes the lead with **24.34** percent of the total number of census (260087 events), followed by Division #3 **17.72** percent. The Corticosteroids (E9320) in all nine Divisions were the most common drug adverse events with **17.52** percent (260087 events) , followed by Antineoplastic (E9331) **17.22** percent, and Anticoagulants (E9342) **12.90** percent.

The following graphs show the distribution of census by Division and census by ECode.

Figure 57: Graph Census by Division

7.12.2.2.3

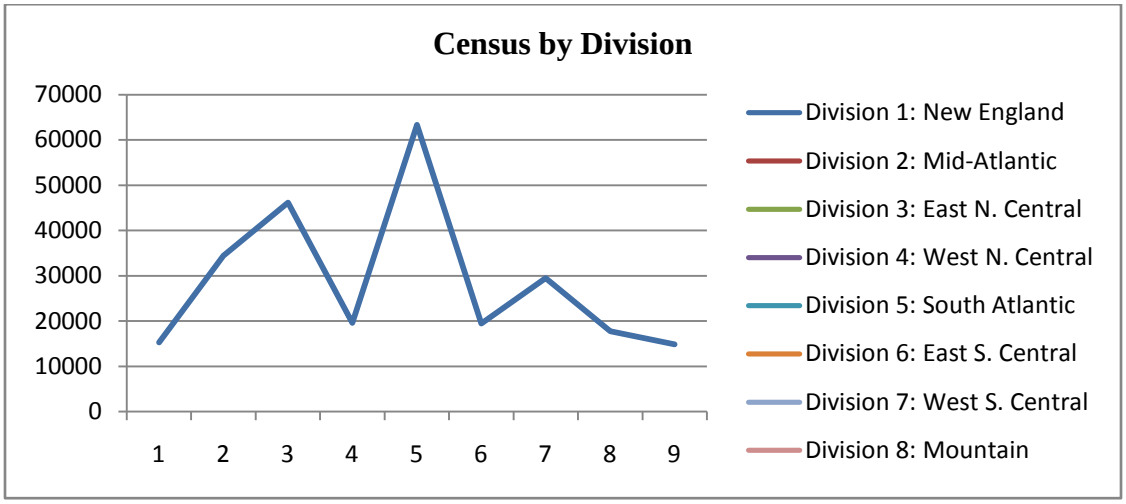
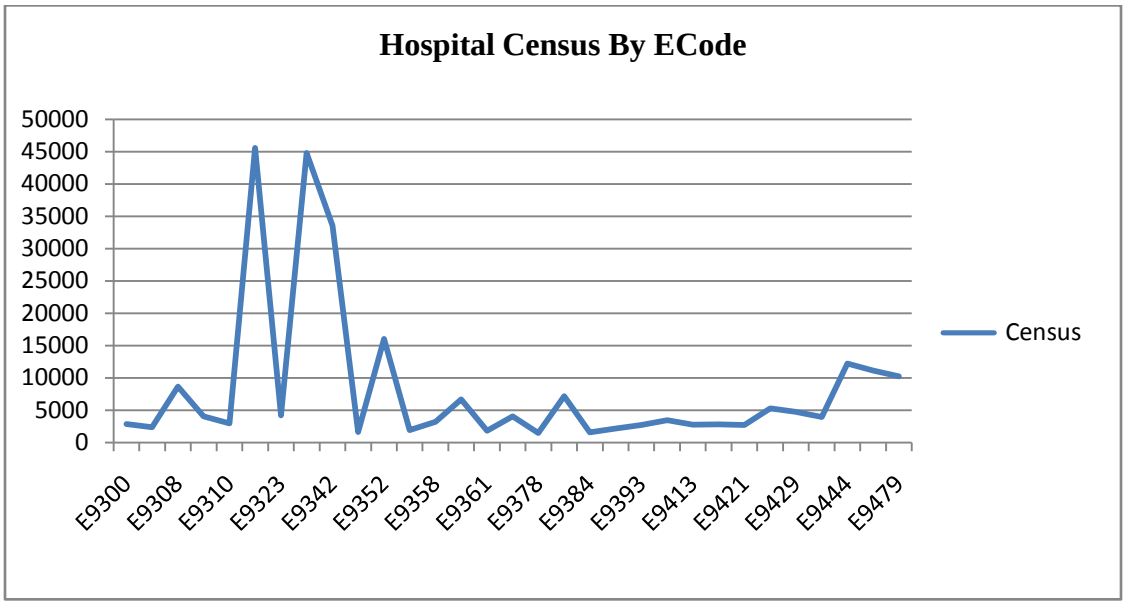


Figure 58: Graph Hospital Census by E Code

7.12.2.2.4



Characteristics of Hospitals:

Table 61 : Division of hospital * Died during hospitalization

7.12.2.2.5

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Census Division of hospital * Died during hospitalization	260232	100.0%	77	0.0%	260309	100.0%

Cross tabulation

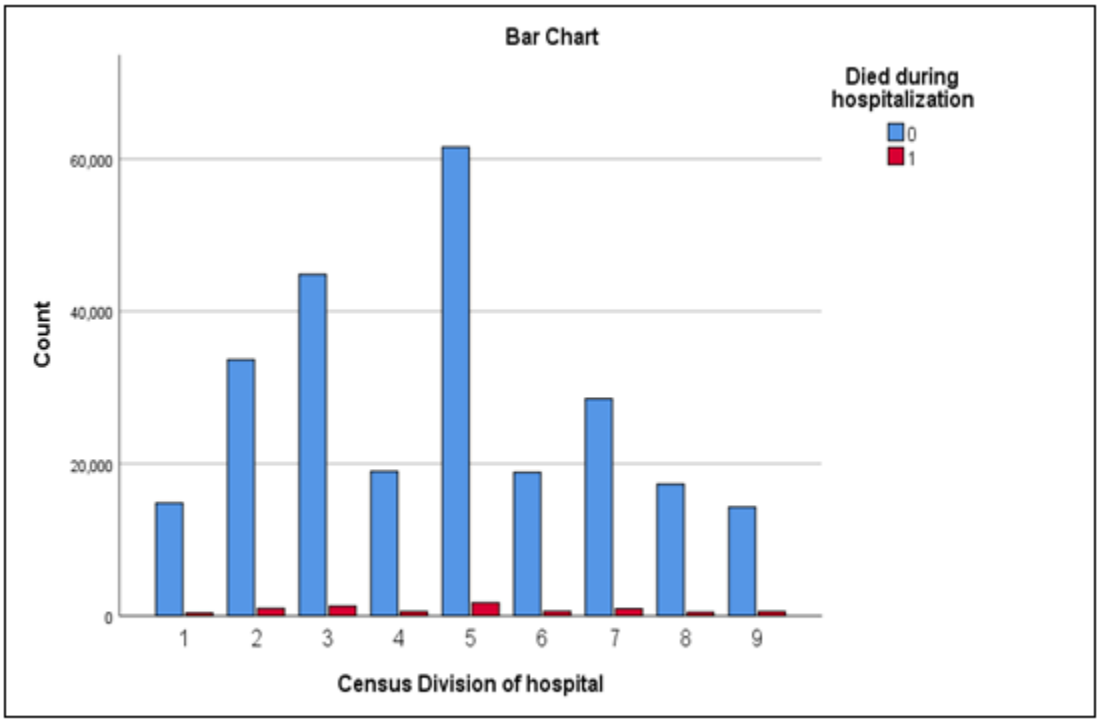
Count

		Died during hospitalization		Total
		0	1	
Census Division of hospital	1	14822	403	15225
	2	33642	976	34618
	3	44850	1263	46113
	4	18963	560	19523
	5	61574	1716	63290
	6	18835	598	19433
	7	28514	938	29452
	8	17293	456	17749
	9	14275	554	14829
Total		252768	7464	260232

0 = Died
1 = Alive

In the table above, the statistics show that the number of inpatient died during hospitalization is high in Division #5 with a rate of **24.35** percent (252768 events) followed by Division #3 **17.74** percent and **13.30** percent for Division #2. The following graph shows the distribution of inpatients died during hospitalization or alive .

Figure 59: Inpatients Died by Division



0 = Died 1 = Alive

Table 62 : Census Division of hospital * Total Charges

7.12.2.2.6

Census Division of hospital	1	$609,232,758.00
	2	$2,501,532,229.00
	3	$2,281,263,821.00
	4	$996,405,051.00
	5	$3,334,624,519.00
	6	$900,460,534.00
	7	$2,033,731,054.00
	8	$1,179,674,686.00
	9	$1,271,111,789.00
Total		**$15,108,036,441.00**

The repartition of total charges by division shows Division # 5 as the leader of all nine divisions in generating the highest healthcare cost **22.07** percent of ($15,108,036,441.00).

Characteristics of Hospitals:

Hospital Region

List of Regions :

1:	NorthEast	(ME , NH, VT, MA, RI, CT, NY, NJ, PA)
2:	MidWest or North Central	(OH, IN, IL, MI, MN, IA, MO, ND, SD, NE, KS)
3:	South	(DE, MD, DC, VA, WV, NC, SC, GA, FL, KY, TN, AL, MS, AR, LA, OK, TX)
4:	West	(MT, ID, WY, CO, NM, AZ, UT, NV, WA, OR, CA, AK, HI)

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Region of hospital * Discharge quarter	134	0.1%	260175	99.9%	260309	100.0%

Table 63 : Region of hospital * Discharge quarter Cross tabulation

7.12.2.2.7

		Discharge quarter				Total
		1	2	3	4	
Region of hospital	1	6	5	6	6	23
	2	19	8	9	11	47
	3	11	18	10	11	50
	4	3	4	3	4	14
Total		39	35	28	32	134

The case processing summary of discharges for all four regions shows a **99.9** percent of missing cases (discharges) so based on the **0.1** percent of data available, we can say that region #3 (South) has the higher number of inpatient discharge, and that there was a constant decrease of the number of discharge during the first three quarters as shown in the graph below:

Figure 60: Discharge by Region of Hospital and by Quarter

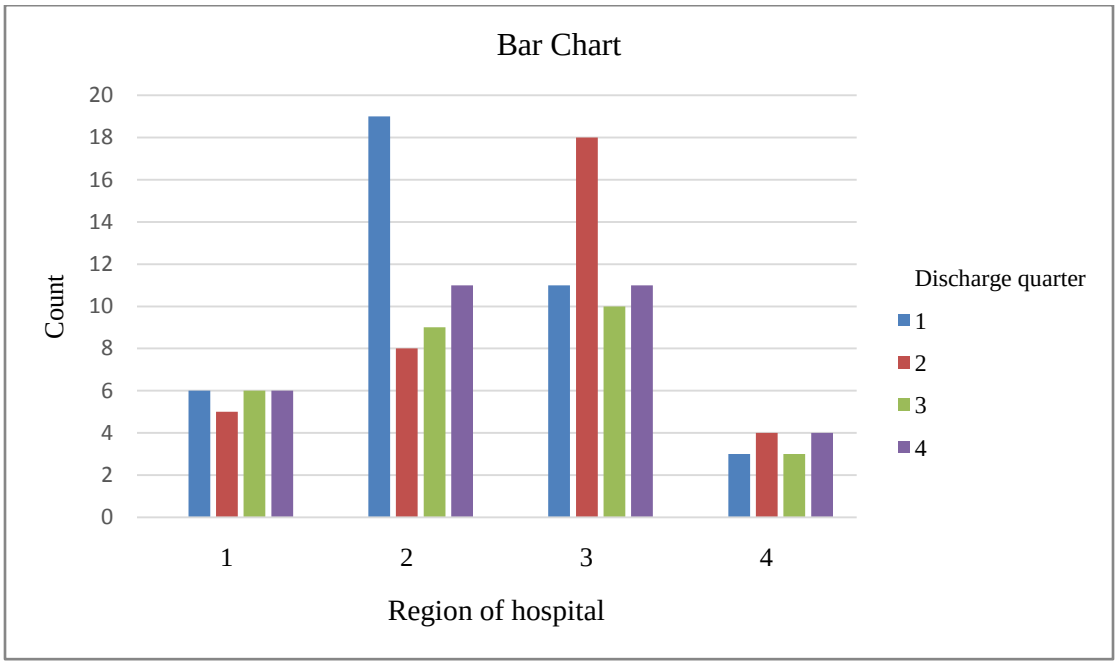


Figure 61: Total Discharge by Quarter for all Regions

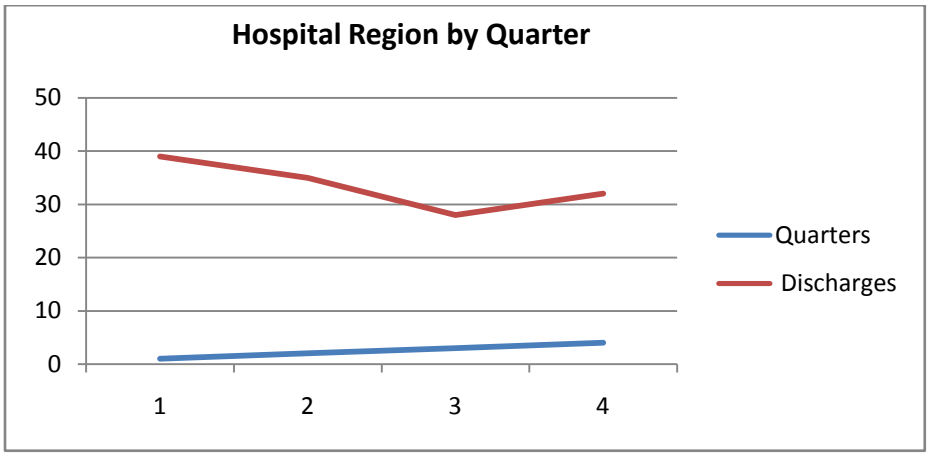


Table 64 : E code 1 * Region of hospital Cross tabulation

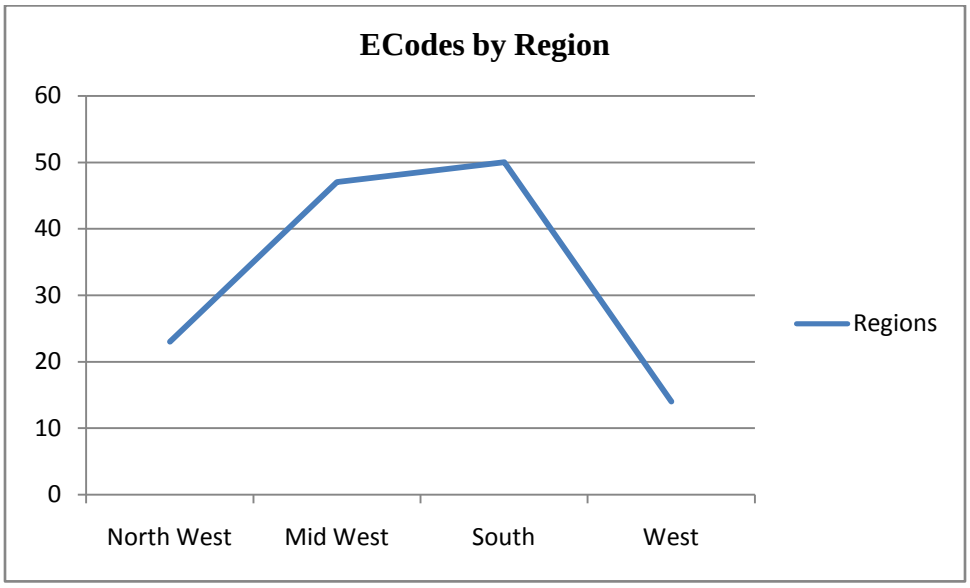
7.12.2.2.8

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
E code 1 * Region of hospital	134	0.1%	260175	99.9%	260309	100.0%

	Region of hospital				Total
	North East	MidWest	South	West	
E9305	1	0	0	0	1
E9308	0	2	4	1	7
E9309	0	1	3	0	4
E9310	0	0	3	0	3
E9320	4	9	7	5	25
E9323	2	1	2	0	5
E9331	5	5	6	6	22
E9342	4	5	5	0	14
E9352	0	5	2	0	7
E9356	0	0	1	0	1
E9358	1	0	0	1	2
E9359	0	1	2	0	3
E9361	1	0	1	0	2
E9363	0	1	2	0	3
E9378	0	1	0	0	1
E9379	0	2	0	0	2
E9394	1	0	2	0	3
E9421	0	0	2	0	2
E9426	0	3	0	0	3
E9429	0	1	1	0	2
E9443	1	1	0	0	2
E9444	0	5	0	0	5
E9478	2	1	1	0	4
E9479	1	3	6	1	11
	23	**47**	**50**	**14**	**134**

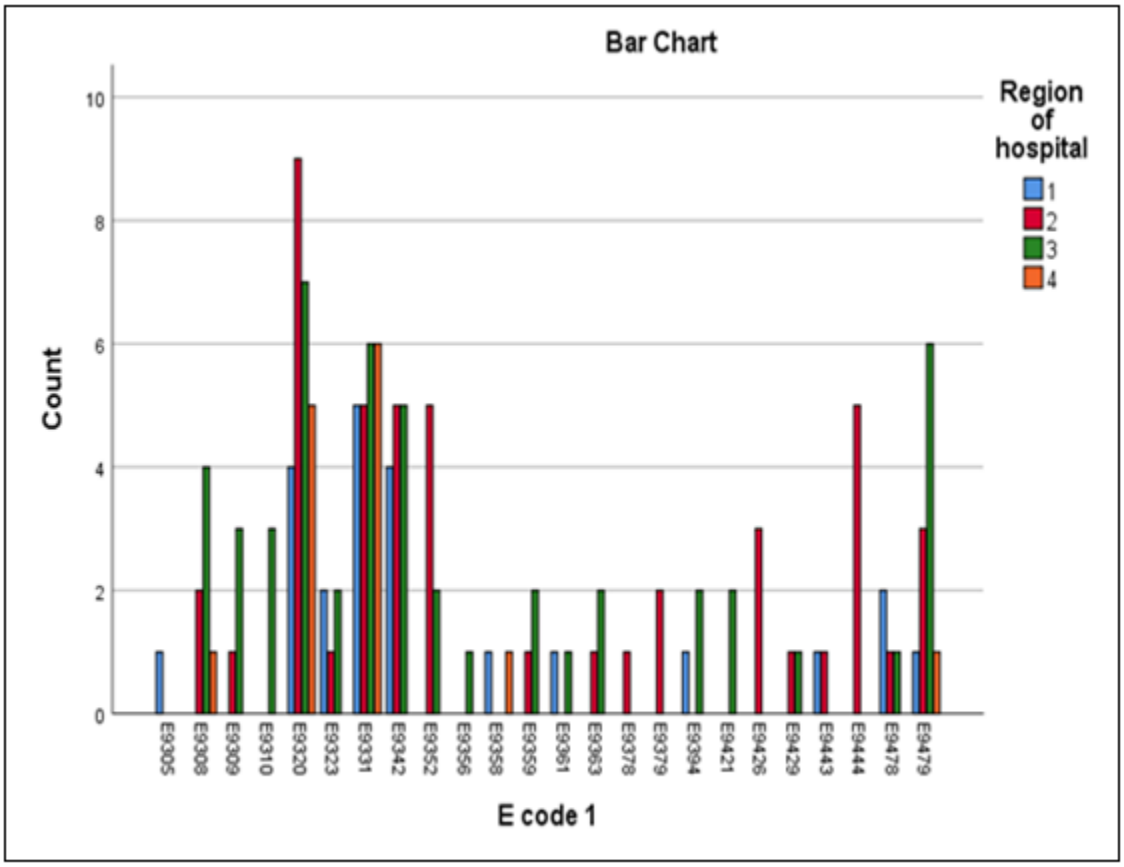
Figure 62: Graph of E Code by Region



The case processing summary of E code 1 * Region of hospital Cross tabulation shows a **99.9** percent of missing cases so based on the **0.1** percent of data available, we can say that region #3 (South) has the higher number of cases of drug adverse events. We can also notice that region #2 (MidWest or North Central) is where the Corticosteroids (E9320) had a high number of cases followed by region #3.

The graph below shows the distribution of region of hospital by ECode

Figure 63: Distribution of region of hospital by ECode



1 = North East **2 = Mid West** **3 = South** **4 = West**

7.12.2.2.9 Hospital Length Of Stay by Division:

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Length of stay (cleaned) * Census Division of hospital	260299	100.0%	10	0.0%	260309	100.0%

Table 65 : Census Division of hospital * Length of stay (cleaned) Cross tabulation

Count

		Length of stay (cleaned)								Total
		0	1	2	3	4	5	. . .	343	
Census Division of hospital	1	150	1115	2105	2506	1967	1522		0	15242
	2	276	2479	4635	5186	4276	3373		0	34616
	3	383	3414	6623	7434	5825	4500		0	46113
	4	169	1502	2958	3277	2586	1930		0	19536
	5	600	4974	9158	9859	7751	6087		0	63307
	6	151	1420	2912	3127	2487	1940		0	19432
	7	268	2220	3974	4434	3449	2834		0	29472
	8	185	1522	2931	2927	2206	1607		0	17753
	9	86	1338	2233	2187	1790	1329		1	14828
Total		2268	19984	37529	40937	32337	25122		1	260299

Division #5 as shown in the above table comes ahead of all nine divisions with a **24.32** percent of inpatients (260299 events). We can also notice that the length of stay of three days was the most used and represents **15.72** percent of inpatients (260299 events). For the length of stay of three days category, division #5 once again takes the lead with **24.08** percent of inpatients (40937 events).

The following table presents the most frequent lengths of stay used quarterly as well as the most common drug adverse events for each period.

7.12.2.2.10 Top Lengths Of Stay :

Table 66 : Top Length of Stay by Div. of Hospital and by Quarter

Quarters	Total Number of days	Total Number of Inpatients	Causes
1	3	10084	E9320, E0331, E9342
2	3	10354	E9320, E0331, E9342
3	3	10258	E9320, E0331, E9342
4	3	10221	E9320, E0331, E9342

Three (3) days is the top **LOS** that accounts for a maximum number of inpatients. Quarter 1 has the highest number of inpatients (10354) followed by 10258 inpatients for Quarter 3. The common causes of hospitalization are: E9320, E0331, E9342

7.12.2.2.11 Hospital Length Of Stay by Region:

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Length of stay (cleaned) * Region of hospital	134	0.1%	260175	99.9%	260309	100.0%

Table 67 : Length of stay (cleaned) * Region of hospital Cross tabulation

Count		Region of hospital				Total
		1 **North East**	2 **Mid West**	3 **South**	4 **West**	
Length of stay (cleaned)	1	1	6	6	1	14
	2	2	9	6	5	22
	3	3	6	7	2	18

	4	6	8	6	2	22
	5	6	2	4	1	13
	6	1	3	4	0	8
	7	1	2	3	0	6
	8	0	3	0	0	3
	9	0	2	1	0	3
	10	0	1	1	0	2
	11	0	0	1	1	2
	12	1	1	2	0	4
	13	0	1	0	0	1
	14	0	0	1	0	1
	15	0	0	1	0	1
	16	0	1	0	0	1
	19	1	0	0	0	1
	20	1	0	1	0	2
	21	0	0	1	0	1
	22	0	0	2	1	3
	25	0	1	1	0	2
	27	0	0	1	0	1
	28	0	0	0	1	1
	30	0	0	1	0	1
	44	0	1	0	0	1
Total		**23**	**47**	**50**	**14**	**134**

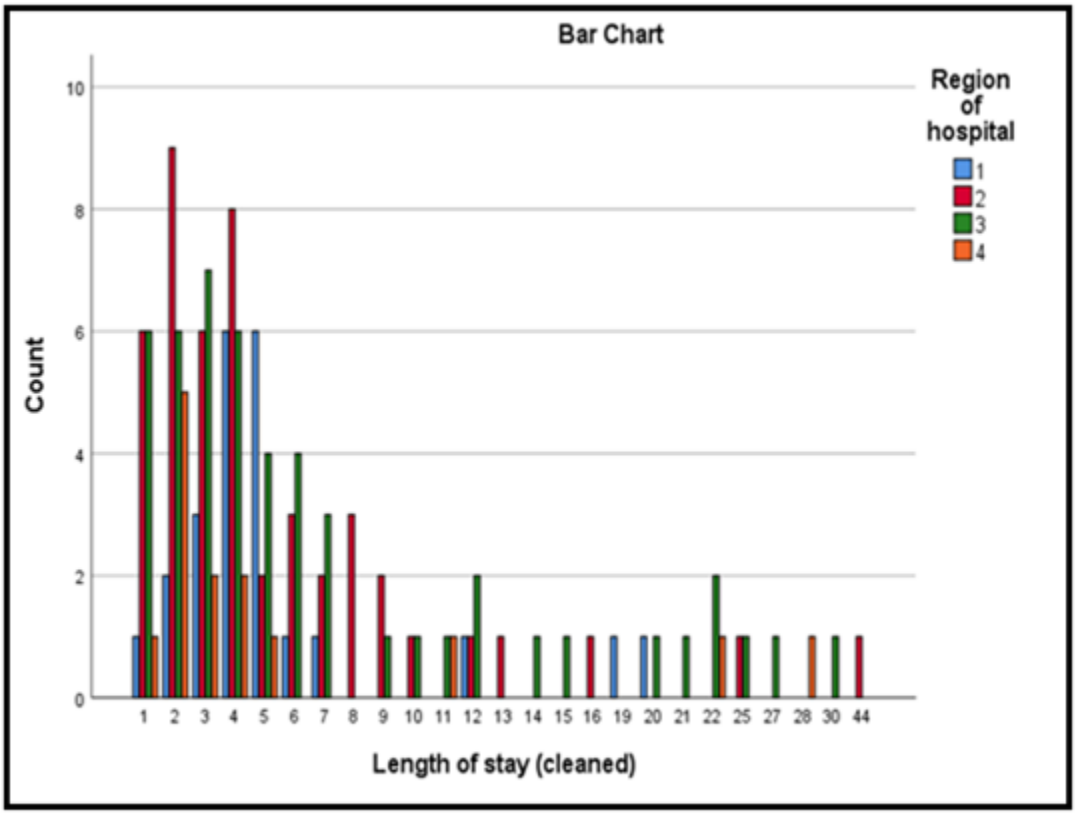
According to Healthcare Cost and Utilization Project (HCUP) **[109]** and a study conducted by Knickman JR, Foltz AM **[110], [111],** hospitals practice patterns significantly vary from one region to another. As a fact, in the NIS 2014, lengths of stay tend to be longer in East Coast hospitals than in West Coast hospitals. The reasons of that difference are not well known but could be a combination of socioeconomic characteristics (Education, Income, Employment, and Housing to list a few) and the characteristics of health care systems.

Because of a large amount of missing data, **99.9** percent of (260.309 events) as shown in the above table, any analysis performed on the **0.1** percent of valid data will not

be informative. Nevertheless we can notice that the length of stay in region 1 (NorthEast) 23 events is greater than the one in region 4 (West) 14 events.

The graph below shows a representation of length of stays for each region of hospital:

Figure 64: Length Of Stay for each Region of Hospital



1 = North East **2 = Mid West** **3 = South** **4 = West**

DISCUSSION

The number of death caused by medication errors along with adverse drug events is still growing year after year, The statistics analysis performed on the National Inpatient Sample confirm that phenomena and show that among all those medication errors and adverse drug events, Corticosteroids, and Antineoplastic, and Anticoagulants were the most common causes responsible for **53.2** percent of all deaths from medication errors (252,553 events) and the most costly accounting for **51.51** percent of all total charges for inpatients ($15,093,974,949.00).

This statistic analysis doesn't show the drug names (within the Corticosteroids, and Antineoplastic, and Anticoagulants categories) that were passed to inpatients, and doesn't say neither if they were the main cause of death.

A **list of confused drug names** published by the Food and Drug Administration (FDA) contains some drug names that are being used for the Corticosteroids, and Antineoplastic, and Anticoagulants treatments. Based on this assertion we suggest and recommend the use of the "**Novel Decision Algorithm**" (NDA) software to prevent from reproducing the same medication errors.

As for the maintenance of the NDA and NDA Database, the use of Computerized Maintenance Management System (CMMS) is not appropriate if there are both embedded in an existing system. On the other hand, the actual NDA system and NDA database Standalone version doesn't meet the FDA's CMMS certification criteria but can be customized to automatically connect to FDA's database and update the NDA database with new drug names, start scheduled backups, produce performance report for hardware and software to list a few.

CHAPTER VIII

CONCLUSION

8.1 Introduction:

This chapter elaborates on our personal statement based on the conclusions we have reached from this research, it also talks about Limitations of our study, as well as Recommendations and Future Research.

8.2 Final Statement:

Over the past decades, we have seen with the use of information technology enormous advancements leading to costs reduction, improved patient care when utilizing Clinical Decision Support Systems (CDSS).

Paradoxically we have also seen an increasing number of medication errors in the US as shown in figure 30. Causes have their origins from different sources therefore, working on decreasing medication errors rate requires input from Researchers, Doctors and medical personal, Patients, Law and policy makers as well as CDSS vendors.

The aim of this research was to propose a new concept: "*Displaying Pop-Up Alerts that warns the prescribers by listing LASA Drug Names that require more attention while they are being prescribed*" in the hope of reducing medication errors rate.

The test results prove that this concept is working fine and can be used and applied everywhere.

There is no one size fits all, the NDA is a proof of concept that has limitations. Recommendations have been made and can be used as valuable inputs for future research.

8.3 Research Limitations:

Medical errors, Medication errors are top sensitive topics no healthcare leaders wants to talk about. Conducting this research was not an easy thing. The following are key limitations of this research.

1. This research only looked at the data collected from the **FDA** and **ISMP**. However the positive results of this research might still be widely applicable in all institutions, Healthcare facilities with their respective own set of data.

2. Vendors and Healthcare facilities were unable to offer a demo or Screenshots of the application used for drug prescription. This would have been a key point in building the NDA .

3. Because of Data Privacy and Security Policy, Lack of cleaned data, Multiple data sources, and data types we were unable to obtain desired data to refine the development of the NDA database.

4. Lack of literature review on the subject : ***"CPOE with Embedded Prescribing Pop-Up Alerts coupled with Confused Drug Names, Generic drug names and Doses"*** , limiting therefore the possibility to view the problem in a different angle.

8.4 Recommendations:

Table 68:

ISSUE	RECOMMENDATION
Alert Fatigue	The pop-Up screen generated by the NDA system is part of the drug search process signaling the presence of a hazard requiring attention; Therefore we believe this alert in opposite to other irrelevant medical alerts shouldn't lead to alert fatigue.
Efficiency	Add a descriptive column in the Table PRODUCTS . This information indicates the purpose of the medication while minimizing the risk of confusion
Multiples data sources	Need of centralized data access point at the facility (Hospital) or regional level to ensure data consistency, data accuracy and availability
Obsolete database	Check FDA and ISMP for new updates to avoid querying obsolete database as some drugs may be discontinued or added to the list
Errors Collection in the facility hosting the NDA	Create a table in the database, or Add a column in an existing one to **collect** new Confused Drug Names. The NDA will use that table to update the existing list.
Data retrieval	Because MySQL is case sensitive, Convert all searchable (Text) columns in Upper-Case to avoid queries returning Zero data .
Education and Training	Key employees with WRITE privileges should be trained to support (perform minor changes) the system

8.5 Future Research:

In the future work, implementation of t the NDA in a healthcare facility is needed in order to check the replication **rate** of known (reported) Confused Drug Names errors.

This implementation will also help discover and analyze other factors than Confused Drug Names leading to medication errors such as :

- Lack of Training
- Long shifts and workloads that impair healthcare personal performance
- Bad work environment

. Lastly but not the least, the implementation of the NDA in a healthcare facility will help understand what were the motivations for installing on:

- Standalone
- Embedded in existing CPOE

Draw conclusion including resistance of change factors then make recommendation

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Appendices

1. Suboptimal Drug Use

Authors	Alldred DP, Raynor DK, Hughes C, Barber N, Chen TF, Spoor P. Interventions to optimize prescribing for older people in care homes. Cochrane Database of Systematic Reviews 2013, Issue 2. Art. No.: CD009095. DOI: 10.1002/14651858.CD009095.pub2.
Purpose	To determine the effect of interventions to optimize prescribing for older people living in care homes.
Design	Comprehensive Narrative review of the literature
Setting	262 nursing homes
Patients	7653 from 6 countries
Results	Eight randomized controlled trials were included. A meta—analysis could not be performed due to heterogeneity. One intervention used computerized order entry and decision support systems, three used multidisciplinary education, and four used a pharmacist intervention. None of the studies showed improvements in primary outcomes of adverse drug events, hospital admissions, or death. Some improvement was however seen in secondary outcomes of drug-related problems resolved, medication appropriateness improved and cost of medications reduced.
Conclusion	There is a need for high-quality cluster-randomized controlled trials testing clinical decision support systems and multidisciplinary interventions that measure well-defined, important resident-related outcomes.

Authors	Cheung WY, Levin R, Setoguchi S. Appropriateness of cardiovascular care in elderly adult cancer survivors. Med Oncol.2013;30:561.
Purpose	To assess the utilization of and adherence to medications and treatments for the secondary prevention of myocardial infarction (MI) in cancer survivors (CS) versus non-cancer patients (NCP) and to compare temporal trends in cardiovascular care between these two

	patient cohorts.
Design	Retrospective cohort study linking data from Medicare, pharmacy assistance programs, and cancer registries. Outcomes included the percentage of individuals receiving preventive medications (statins, β-blockers, angiotensin-converting enzyme inhibitors) and revascularization interventions (angioplasty, stent, bypass surgery) within 90 days after acute MI in CS and propensity score-matched NCP.
Setting	New Jersey and Pennsylvania
Patients	Cancer survivors and non-cancer patients 65 years and older discharged from hospital for acute MI
Results	There were 1,119 CS and 7,886 NCP. Compared to NCP, more survivors received statins (38 vs. 31 %) and β-blockers (67 vs. 59 %), but fewer underwent bypass surgery (1.5 vs. 2.8 %) after MI. From 1997 to 2004, both survivors and NCP were increasingly prescribed medications to prevent future coronary events. Over the same time period, receipt of bypass surgery was significantly lower among survivors. Depression, lung disease, advanced age and being female were associated with underuse of preventive care among survivors when compared to NCP
Conclusion	Use of preventive medications and procedures was similar between CS and NCP and generally improved, but uptake of bypass surgery among CS lags behind NCP.

Authors	Olesen C, Harbig P, Barat L, Damsgaard EM. Absence of over-the-counter medicinal products in on-line prescription records: a risk factor of overlooking interactions in the elderly. PharmacoepidemiolDrug Safe.2013;22:145-50.
Purpose	To assess possible origins of harmful interactions in elderly patients arising from the current absence of information on over-the-counter (OTC) medicines in the Danish on-line prescription record.
Design	Cross-sectional
Setting	city in Denmark
Patients	309 who were 65+ taking 5+ medications and enrolled in previously reported pharmaceutical care intervention trial

Results	74% used OTC medications as determined by in-home visit. Information about the use of 33% of OTC medications was not included in on-line record. Overall 114/309 had evidence of a drug interaction involving an OTC medication. Nearly 1/4 of those with a drug interaction were rated as can be used with certain precautions.
Conclusion	The absence of information on OTC products in an on-line prescription record entails a risk of overlooking interactions in elderly patients.

Authors	Quato DM, Trivedi AN. Receipt of high risk medications among elderly enrollees in Medicare Advantage plans. J Gen Intern Med. 2013;28:546-53.
Purpose	To determine predictors of high risk medication (HRM) as per NCQA HEDIS quality indicator
Design	Cross-sectional
Data Source	415 Medicare Advantage Plans Medication Files for 2009
Patients	6,204,824 enrollees 65+
Results	Approximately 21 % of MA enrollees received at least one HRM and 4.8 % received at least two. Factors with at least a 10% risk-difference with HRM use were female gender, Southern region, Higher rates also seen with low personal income, living in a low socioeconomic area, being 65-84 years of age, and being white.
Conclusion	Use of HRMs among MA enrollees varies widely by geographic region. Persons living in the Southern region of the U.S., whites, women, and persons of low personal income and socioeconomic status are more likely to receive HRMs.

Authors	Rognstad S, Brekke M, Fetveit A, Dalen I, Straand J. Prescription peer academic detailing to reduce inappropriate prescribing for older patients: a cluster randomized controlled trial. Br J Gen Pract. 2013;63:e554-622.
Purpose	To study the effects of a multifaceted educational intervention on potentially inappropriate prescribing (PIP) for older patients by general practitioners (GPs)

Design	Cluster randomized educational intervention using academic detailing by GPs within CME groups
Setting	Norwegian general practice
Patients	Norwegian general practitioners and older outpatients
Results	A total of 449 GPs (96.6%) completed the study; 250 in the intervention group and 199 in the control group. After adjusting for baseline differences and clustering effects, a reduction relative to baseline of 10.3% (95% confidence interval = 5.9 to 15.0) PIPs per 100 patients aged ≥70 years was obtained.
Conclusion	Educational outreach visits with feedback and audit, using GPs as academic detailers in GPs CME groups, reduced PIPs for older patients aged ≥70 years in general practice.

2. Medication Administration Errors

Authors	Young HM, Sikma SK, Reinhard SC, McCormick WC, Cartwright JC. Strategies to promote safe medication administration in assisted living settings. Res GerontolNurs. 2013;6:161-70.
Purpose	To described assisted living (AL) provider views on medication safety and strategies used to promote safety in medication administration
Design	Qualitative Survey
Participants	96 persons representing all parties involved in medication administration (i.e., medication aides, administrators, RNs, consulting pharmacists, primary care providers) in 12 AL settings in three states.
Results	Core themes were the importance of medication safety, unique contextual factors in AL, and strategies used to promote medication safety.
Conclusion	This study has implications for research on interventions to improve medication safety at the individual, facility, and policy levels

3. Medication Adherence/Knowledge

Authors	Kwint HF, Stolk G, Faber A, Gussekloo J, Bouvy ML. Medication adherence and knowledge of older patients with and without multidose drug dispensing. Age Ageing. 2013;42:620-626.
Purpose	To compare self-reported medication adherence and knowledge of older patients receiving their drugs via multidose machine dispensed medications in a disposable sachet (MDD users) with patients receiving manually dispensed drugs (non-MDD users).
Design	Cross-sectional
Patients	Random sample of those 65+ using MDD (n=119) and taking 5+ drugs matched by age and gender with non-MDD elders taking 5+ drugs (n=96)
Results	Percent adherent as per the Medication Adherence Reporting Scale was higher in MDD users than non MDD users (81% vs 58% respectively; $p<0.001$). The percentage of patients with adequate knowledge was lower for MDD users (40%) compared with non-MDD users (79%, $P < 0.001$).
Conclusion	This study shows that older patients receiving their drugs via MDD reported a higher medication adherence compared with patients receiving manually dispensed drugs, despite a lower knowledge and lower cognitive function among patients receiving MDD.

Authors	Marek KD, Stetzer F, Ryan PA, Bub LD, Adams SJ, Schlidt A, Lancaster R, OBrien AM. Nurse care coordination and technology effects on health status of frail older adults via enhanced self-management of medication: randomized clinical trial to test efficacy. Nurs Res. 2013;62:269-78.
Purpose	To evaluate health status outcomes of frail older adults receiving a home-based support program that emphasized self-management of medications using both care coordination and technology.
Design	randomized controlled trial with three arms-control, or intervention with nurse care coordination and medication-dispensing machine (MD.2) or nurse care coordination and Mediplanner (simple box with separate compartments for individual medication times)
Setting	Community
Patients	414 older adults having trouble managing medications

Results	In both theMD.2 and Mediplanner groups, the average percent of correct doses per month was very high, at 98.8% and 97.4%, respectively. Compared to the control group, those with nurse coordination and Mediplanner showed improvement in health outcomes (SF-36, geriatric depression scale, mini mental status exam, physical performance test). There was no difference between the MD.2 and Mediplanner groups on any of the four outcomes).
Conclusion	Addition of the MD.2 machine to nurse care coordination did not result in better health status outcomes

Authors	Martin P, Tamblyn R, Ahmed S, Tannenbaum C. A drug education tool developed for older adults changes knowledge, beliefs and risk perceptions about inappropriate benzodiazepine prescriptions in the elderly. Patient Ed Counsel.2013; 92:81-7.
Purpose	To develop and test an educational tool for older adults that increases risk perception about benzodiazepines through knowledge acquisition and change in beliefs
Design	Before-after intervention survey of knowledge and beliefs about inappropriate prescriptions. Patients:144 community dwelling consumers of benzodiazepines 65+ taking 5+ medications from Montreal.
Results	Post-intervention, 65 (45.1%) participants perceived increased risk. Increased risk perceptions were explained by better knowledge acquisition (mean change score 0.9, 95% CI (0.5, 1.3)), and a change in beliefs (BMQ differential mean change score −5.03, 95% CI (−6.4, −3.6)), suggesting elicitation of cognitive dissonance. Self-efficacy for tapering, (mean change score 31.2, 95% CI (17.9, 44.6)), and intent to discuss discontinuation of benzodiazepine with a doctor (83.1% vs 44.3%, $p < 0.001$) were higher among participants who perceived increased risk.
Conclusion	Risk perception surrounding inappropriate prescriptions can be altered through direct delivery of an educational tool to aging consumers.

Authors	Mochizuki H, Nanjo Y, Takahashi H. Better adherence to a transdermal tulobuterol patch than inhaled salmeterol in elderly chronic obstructive pulmonary disease patients. GeriatrGerontolInt. 2013;13:398-404.

Purpose	To compare adherence and effects on health outcomes between transdermal and inhaled LABA in elderly patients.
Design	Randomized cross-over trialof 44 treatment-naïve, elderly patients with moderate-to-severe COPD. Patients were treated with a transdermal tulobuterol patch (TP; 2 mg, once a day) or inhaled salmeterol (50 μg, twice a day). Primary outcomes were adherence to the LABA medications and changes in QOL measured by the St Georges Respiratory Questionnaire
Setting	Outpatient
Patients	Elderly Japanese patients
Results	The adherence rate was 90.3 ± 1.6% for TP and 75.5 ± 2.9% for salmeterol ($P < 0.001$). Adherence to salmeterol was correlated with age and Mini-Mental State Examination (MMSE) score ($P < 0.05$ and $P < 0.01$, respectively). Adherence to TP was relatively constant regardless of age and MMSE score. QOL scores were significantly improved from baseline after TP, but not after salmeterol treatment ($P < 0.05$).
Conclusion	Adherence levels were higher with TP than with inhaled salmeterol, and more stable across age groups and MMSE levels. TP might be a favorable treatment option for COPD patients with poor adherence to an inhaled LABA.

4. Medication Monitoring

Authors	BilottaC,FranchiC,NobiliA,NicoliniP,DjadeCD,TettamantiM,FortinoI,BortolottiA,MerlinoL,VerganiC.New prescriptions of spironolactone associated with angiotensin-converting-enzyme inhibitors and/or angiotensin receptor blockers and their laboratory monitoring from 2001 to 2008: a population study on older people living in the community in Italy. Eur J ClinPharmacol. 2013;69:909-17.
Purpose	To analyze8-year trends in new use and monitoring of spironolactone co-prescribed with angiotensin-converting-enzyme inhibitors (ACE-Is) and/or angiotensin receptor blockers (ARBs).

Design	Retrospective administrative health database analysis. The frequency of subjects 65 years and older who received co-prescription from 2001 to 2008 was measured. Multivariate analyses were adjusted for age, sex, local health unit, treatment with beta-blockers, drugs for diabetes, and polypharmacy (i.e., exposure to five or more different drugs)
Setting	Italys Lombardy region
Patients	Community dwelling elders
Results	Only new users of spironolactone co-prescribed with ARBs increased from 2001 to 2008 ($P < 0.001$). In the 6 months before starting the co-prescriptions 96 to 100% of patients measured serum creatinine (mean 99.3%), sodium (97.3%) and potassium (98.6%). Within 3 months after starting the co-prescriptions 96 to 99% of patients measured serum sodium (mean 97.3%) and potassium (98.6%), but on average only 48% of them (range 43 to 53%) measured serum creatinine. Multivariate analysis showed polypharmacy to be the only independent predictor of such creatinine monitoring ($P < 0.001$).
Conclusion	Creatinine monitoring was inadequate after the co-prescription of spironolactone with ACE-Is and/or ARBs.

B. ADVERSE DRUG EVENTS

Authors	Basaria S, Davda MN, Travison TG, Ulloor J, Singh R, Bhasin S. Risk factors associated with cardiovascular events during testosterone administration in older men with mobility limitation. J Gerontol: Med Sci. 2013;68:153-60.
Purpose	To evaluate changes in gonadal hormones and markers of inflammation and coagulation to elucidate risk factors associated with cardiovascular events.
Setting	3 academic medical centers
Patients	179 men 65+ with mobility limitations enrolled in clinical trial.
Results	Within the testosterone group, the 6-month increase in free testosterone was significantly greater in men who experienced cardiovascular events than in those who did not [mean (95%

	confidence interval), 10.6 (4.6–16.7) vs 5.2 (3.0–7.5) ng/dL, p = .05]. In multivariable logistic regression analysis, the change in the serum levels of free testosterone was associated with cardiovascular events.
Conclusion	Mobility-limited older men who experienced cardiovascular events had greater increases in serum free testosterone levels than those who did not.

Authors	De PaepeP, PetrovicM, Outtier L, Van MaeleG, Buylaert W. Drug interactions and adverse drug reactions in the older patients admitted to the emergency department. ActaClinica Belgica.2013;68:15-21.
Purpose	To prospectively evaluate drug interactions and adverse drug reactions (ADRs) in older patients in the emergency department (ED) and to characterize risk factors
Design	Prospective evaluation of medical records for ADRs by an expert panel which also evaluated avoidability and causality. An interaction program was used to search for potential drug interactions followed by assessment for clinical significance.
Setting	Emergency department in a tertiary referral medical center in Belgium
Patients	80 ED patients aged 65 and older
Results	Eighty seven ADRs were identified in 37 patients; 18 were the result of an interaction (15 patients). Causality was assessed as definite (n=11), probable (n=62) and possible (n=24). The reason for admission was definitely and probably related to an ADR in 6 and 18 patients respectively. Only 17 (20%) of the ADRs were assessed as unavoidable, while 23 (26%) and 47 (54%) were classified as definitely and possibly avoidable, respectively. ADRs were related with female gender (p=0.023) and number of drugs (p=0.004). Clinically relevant interactions were related with older age (p=0.032) and number of drugs (p=0.003).
Conclusion	ADRs frequently occur in the older patients who present to the ED and are an important cause of hospital admissions with a substantial contribution of adverse drug interactions.

Authors	Dionne PA, Vasiliadis HM, Latimer E, Berbiche D, Preville M. Economic impact of inappropriate benzodiazepine prescribing and related drug interactions among elderly persons. Psychiatr Serv.

	2013;64:331-8.
Purpose	To describe, from a health care system perspective, potentially inappropriate benzodiazepine (BZD)prescribing among elderly persons and associated health service use and costs
Design	12 month longitudinal study
Setting	Quebec Canada
Patients	744 subjects 65+ from 2006 ESA study taking a BZD.
Results	44% of BZD users received at least one potentially inappropriate prescription due to a drug interaction, use of a long half-life agent or excessive dosage of a short half-life agent. These participants compared to other BZD users had a greater risk of hospitalizations (Adjusted Odds Ratio [AOR]-1.95), and emergency department visits (AOR- 3.50) and higher health care costs ($3,076 higher per year, p<.001).
Conclusion	A significant association was found between inappropriate benzodiazepine use and some health services use resulting in higher health care costs.

Authors	KlopotowskaJE,WierengaPC,SmorenburgSM,StuijtCC,AriszL,Kuks PF,Dijkgraaf MG, Lie-A-Huen L, de Rooij SE. WINGS study group. Recognition of adverse drug events in older hospitalized medical patients. Eur J ClinPharmacol. 2013;69:75-85.
Purpose	To assess medical teams ability to recognize adverse drug events (ADEs) in older inpatients.
Setting	3 Internal Medicine wards in three Netherland Hospitals
Patients	250 consecutively admitted 65+
Results	Using a standardized approach a physician/clinical pharmacist pair identified 269 ADEs at admission or during hospital stay in 164 patients. Approximately, 20% of these ADEs were not recognized by the medical team. Unrecognized ADEs were significantly more often ADEs with possible causality (p=0.014, ADEs caused by medication errors (p<0.001), and ADEs not manifesting as new symptoms (p<0.001). The recognition of ADEs varied with event type.

Conclusion	The recognition of ADEs by medical teams was substantial for those ADEs with evident causality and with clinically apparent and severe consequences.

Authors	Lapi F, Azoulay L, Yin H, Nessim SJ, Suissa S. Concurrent use of diuretics, angiotensin converting enzyme inhibitors, and angiotensin receptor blockers with non-steroidal anti-inflammatory drugs and risk of acute kidney injury: nested case-control study. BMJ. 2013;346:e8525
Purpose	To assess whether a double therapy combination consisting of diuretics or angiotensin converting enzyme inhibitors or angiotensin receptor blockers with addition of non-steroidal anti-inflammatory drugs (NSAIDs) and the triple therapy combination of two of the aforementioned antihypertensive drugs to which NSAIDs are added are associated with an increased risk of acute kidney injury.
Design	Retrospective cohort study using nested case-control analysis. Outcomes rate ratios with 95% confidence intervals of acute kidney injury associated with current use of double and triple therapy combinations of antihypertensive drugs with NSAIDs.
Setting	General practices contributing data to the UK Clinical Practice Research Datalink linked to the Hospital Episodes Statistics database
Patients	A cohort of 487,372 users of antihypertensive drugs. Cases were first ever occurrence of a hospital admission for acute kidney injury. Controls without acute kidney injury were randomly selected from the database and match on year of birth, sex, calendar year of cohort entry, duration of follow-up.
Results	During a mean follow-up of 5.9 (SD 3.4) years, 2215 cases of acute kidney injury were identified (incidence rate 7/10,000 person years) with a mean age of 76.9 years (SD 10.9). There were 21,993 controls with mean age of 76.9 years (SD 10.7). Current use of a double therapy combination containing either diuretics or angiotensin converting enzyme inhibitors or angiotensin receptor blockers with NSAIDs was not associated with an increased rate of acute kidney injury. Current use of a triple therapy combination was associated with an increased rate of acute kidney injury (rate ratio 1.31, 95% confidence interval 1.12 to 1.53). In secondary analyses, the highest risk was observed in the first 30 days of use (rate ratio 1.82, 1.35 to 2.46).

Conclusion	A triple therapy combination consisting of diuretics with angiotensin converting enzyme inhibitors or angiotensin receptor blockers and NSAIDs was associated with an increased risk of acute kidney injury. The risk was greatest at the start of treatment.

Authors	Nickel CH, Ruedinger JM, Messmer AS, Maile S, Peng A, Bodmer M, Kressig RW, Kraehenbuehl S, BingisserR.Drug-related emergency department visits by elderly patients presenting with non-specific complaints. Scand J Trauma ResuscEmerg Med. 2013;21:15.
Purpose	To identify the frequency of drug-related problems (DRPs) among patients presenting with non-specific complaints and to evaluate responsible drug classes.
Design	One month longitudinal study
Setting	Single Emergency Department (ED) in Switzerland
Patients	633 patients with median age of 81 years of age.
Results	77 (12.2%) were determined by agreement of two ED physicians to have a DRP. Only 40% of the DRPs were correctly identified by staff that provided care for these patients. Polypharmacy and certain drug classes (thiazides, antidepressants, benzodiazepines, anticonvulsants) were associated with DRPs.
Conclusion	Elderly patients with non-specific complaints need to be screened systematically for drug-related problems.
Authors	Nurminen J, Puustinen J, PiirtolaM, Vahlberg T, Lyles A, Kivela SL. Opioids, antiepileptic and anticholinergic drugs and the risk of fractures in patients 65 years of age and older: a prospective population-based study. Age Ageing 2013;42:318-24.
Purpose	To determine if there are gender-specific risk of fractures 65+ population associated with the use of an opioid, antiepileptic or anticholinergic drug individually or combined;
Design	Longitudinal
Participants	488 men and 708 women 65+ from Finland

Results	At the 3 year follow-up, in men, concomitant use of an opioid and an antipsychotic and a benzodiazepine and opioid increased the risk of fracture (Adjusted RR 21.1, 95% CI 1.7–256.9; and Adjusted RR 3.8,95% CI 0.7–21.1, respectively. No increased risk was seen in men with other drug classes or in women with any drug classes.
Conclusion	The concomitant use of an opioid with an antipsychotic, or with a benzodiazepine may increase the risk of fractures in men aged 65 years and older.

Authors	Patel AM, Shariff S, Bailey DG, Juurlink DN, Gandhi S, Mamdani M, Gomes T, Fleet J, Hwang YJ, Garg AX. Satin toxicity from macrodile antibiotic coprescription: a population-based cohort study. Ann Intern Med. 2013;158:869-76.
Purpose	To measure the frequency of statin toxicity after coprescription of a statin with clarithromycin or erythromycin.
Design	Population-based cohort study.
Patients	Continuous statin users older than 65 years from Ontario Canada who were prescribed clarithromycin (n = 72,591) or erythromycin (n = 3267) compared with those prescribed azithromycin (n = 68,478).
Results	Compared with azithromycin, coprescription of a statin with clarithromycin or erythromycin was associated with a higher risk for hospitalization with rhabdomyolysis (absolute risk increase, 0.02% [95% CI, 0.01% to 0.03%]; relative risk [RR], 2.17 [CI, 1.04 to 4.53])
Conclusion	In older adults, coprescription of clarithromycin or erythromycin with a statin that is metabolized by CYP3A4 (i.e., atorvastatin, simvastatin, lovastatin) increases the risk for statin toxicity.

Authors	Quach L, Yang FM, Berry SD, Newton E, Jones RN, Burr JA, Lipsitz LA. Depression, antidepressants, and falls among community-dwelling elderly people: the MOBILIZE Boston study. J Gerontol Med Sci. 2013;68:1575-81.
Purpose	To examine the association between depression and antidepressants, with indoor and outdoor falls, and to investigate how antidepressants mediate this relationship.

Design	Longitudinal
Patients	763 men and women aged 70 from Boston MA
Results	Antidepressant use increased the risk of outdoor falls by 70% compared with participants who did not use antidepressants (IRR = 1.70, 95% CI = 1.16–2.49, $p < .05$). Antidepressant use was not associated with indoor falls (IRR = 0.94, 95% CI = 0.64–1.37, $p = .74$).
Conclusion	Clinicians should carefully consider the role of antidepressants among older adults with depression and their potential increase for the risk of outdoor falls.

- = Compiled and abstracted by Drs. Hanlon, Semla and Schmader

IMPORT AND LOAD DATA

3.4.4.1 Import the data (Text File Format) from the FDA database

1 Extract the data (Text format) from FDA website

https://www.fda.gov/downloads/Drugs/InformationOnDrugs/UCM527389.zip

2 Unzip files

Table 26: Listing of Zipped Files

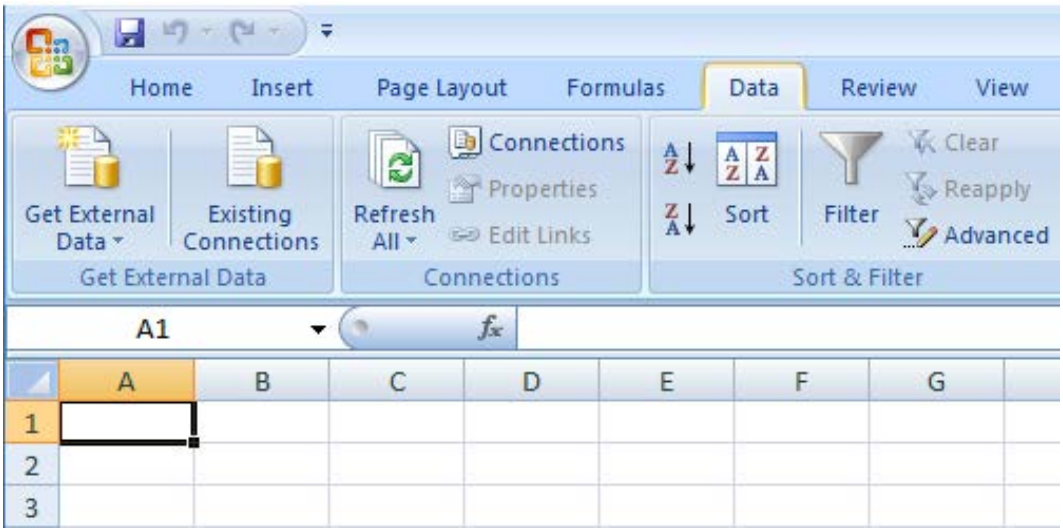
Name	Type	Compressed size	Password protected	Size	Ratio	Date modified
AppDoc	Text Document	566 KB	No	5,668 KB	91%	11/18/2015 1:30 PM
AppDocType_Lookup	Text Document	1 KB	No	1 KB	41%	11/18/2015 1:30 PM
application	Text Document	115 KB	No	1,586 KB	93%	11/18/2015 1:30 PM
ChemTypeLookup	Text Document	1 KB	No	1 KB	41%	11/18/2015 1:30 PM
DocType_lookup	Text Document	1 KB	No	2 KB	58%	11/18/2015 1:30 PM
Product	Text Document	355 KB	No	2,812 KB	88%	11/18/2015 1:30 PM
Product_tecode	Text Document	39 KB	No	270 KB	86%	11/18/2015 1:30 PM
RegActionDate	Text Document	708 KB	No	4,984 KB	86%	11/18/2015 1:30 PM
ReviewClass_Lookup	Text Document	1 KB	No	1 KB	37%	11/18/2015 1:30 PM

3.4.4.2 Convert the data from Text File to Excel File format

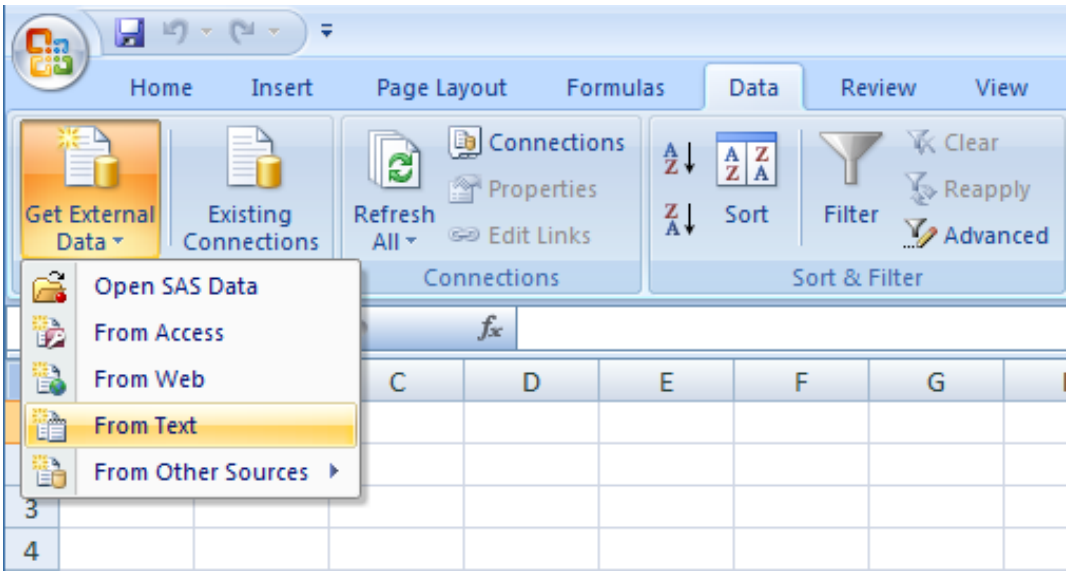
1 Open Ms Excel

a) Click Data from the menu bar

Figure 24: Steps for Extracting and Converting Files to Excel (CSV)



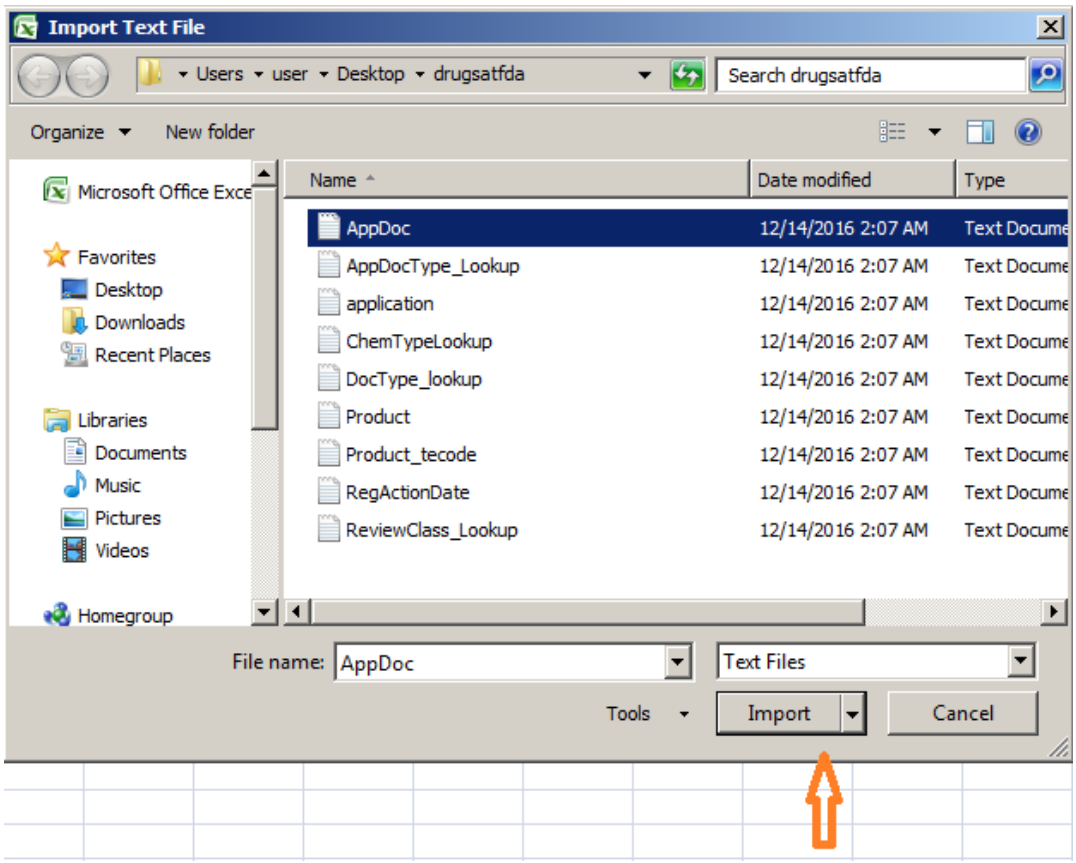
b) Click Get External Data



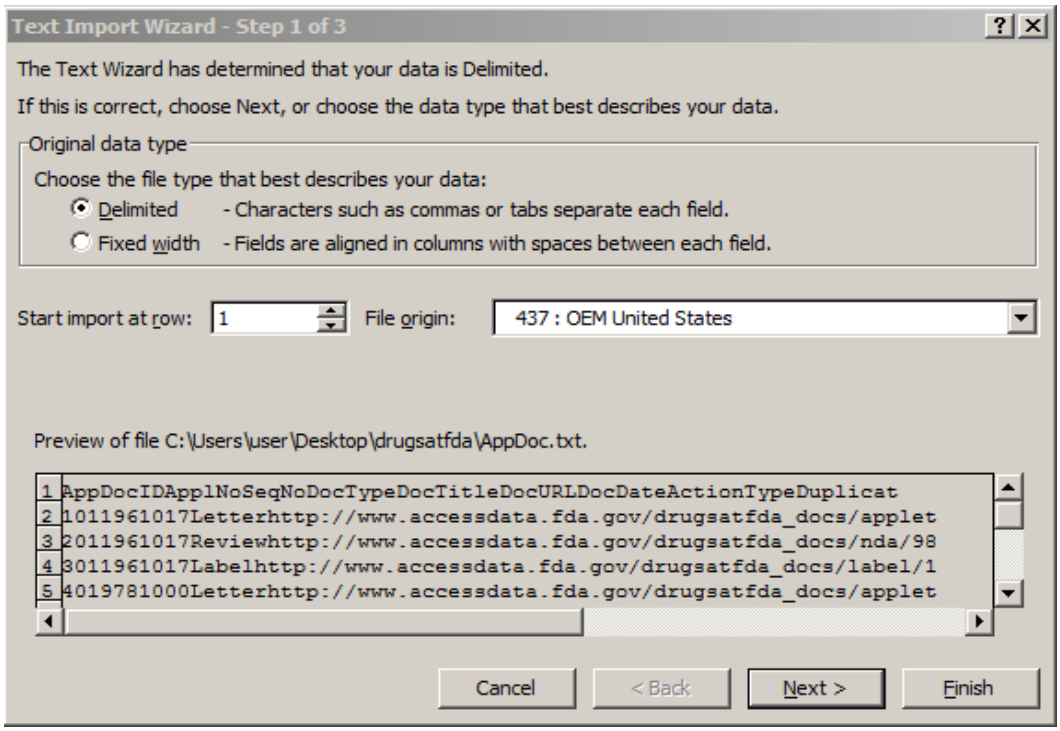
c) Select From Text

d) Browse then select the desired Text File

e) Select Import

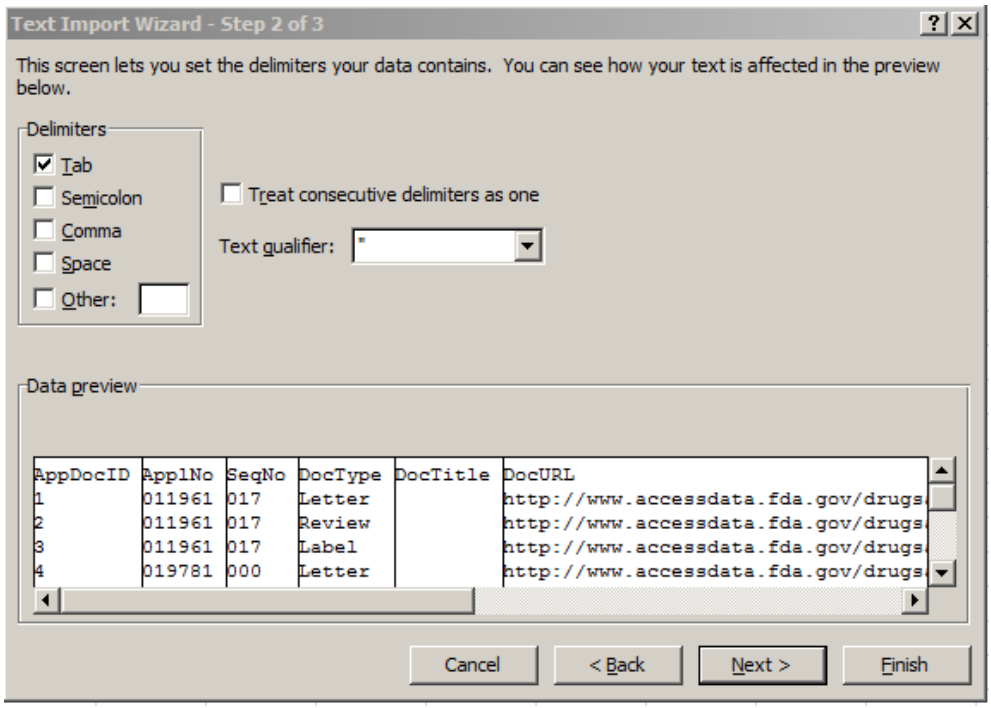


f) Click Delimited



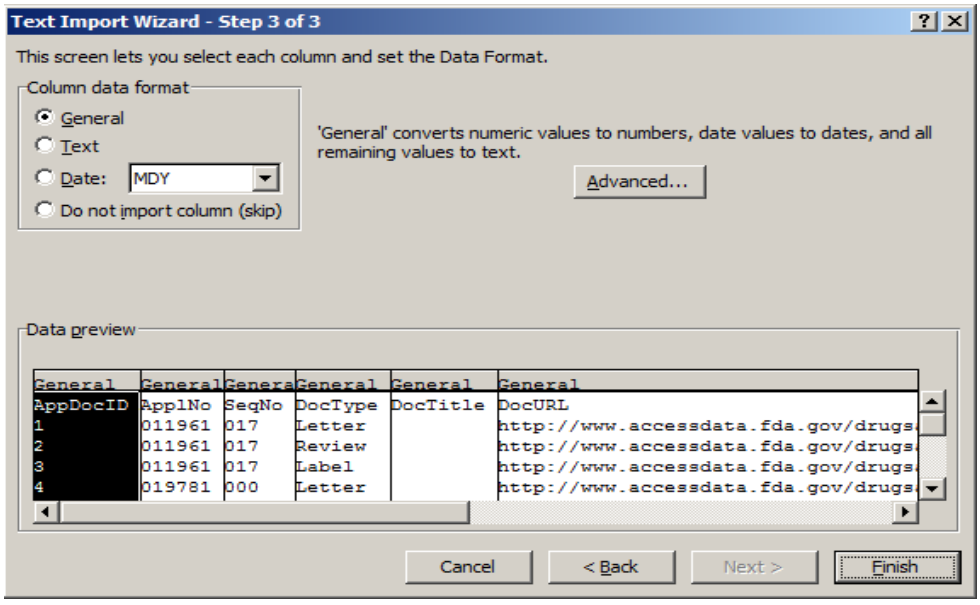
g) Then Click Next

h) Select Tab



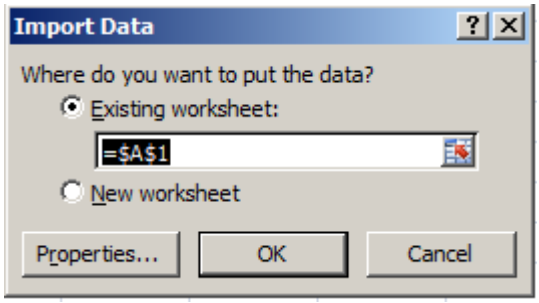
i) Click Next

j) Click General (Column data format)



k) Click Finish

l) Click OK



2 Click Save As

a) Browse then select the location where to save the Excel File

b) Give the same Text File name to the Excel File

3.4.4.3 Convert the data from Excel CSV to SQL

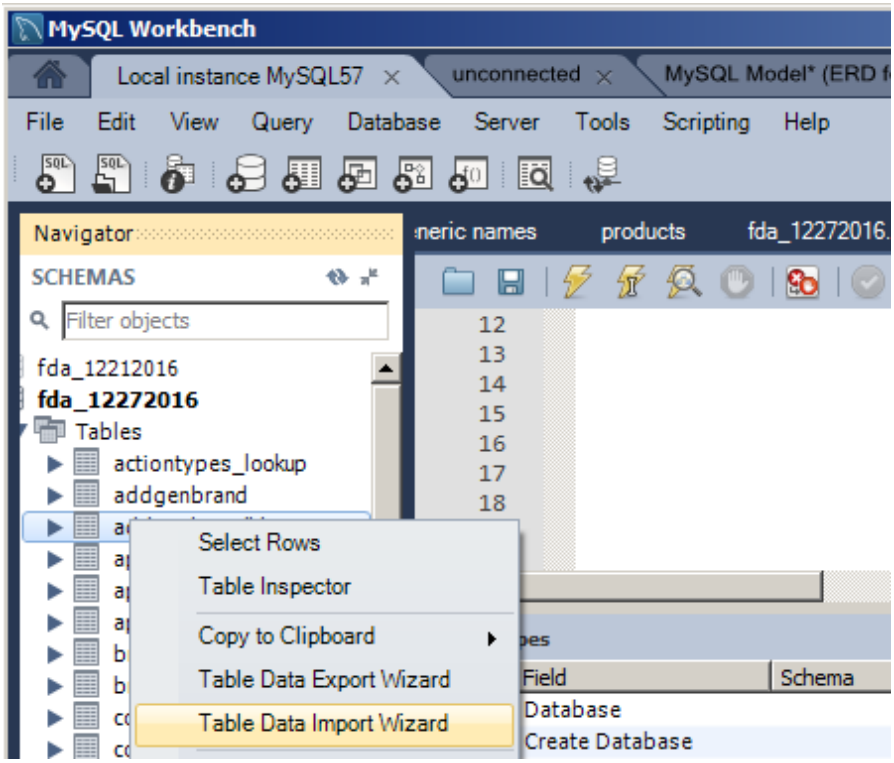
Do the following to load data from Excel into the database:

1) In Excel, save all files with CSV Extension

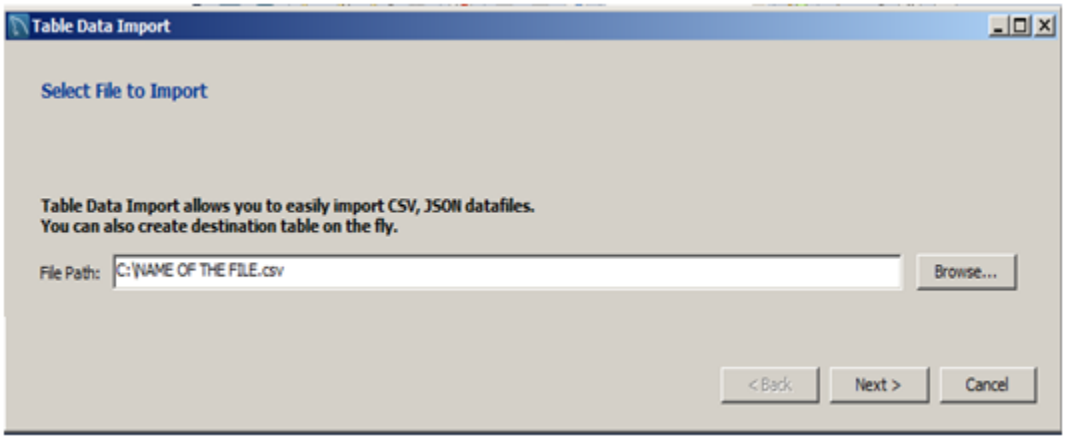
2) Open MySQL

3) Right Click any TABLE then Select **Table Data Import Wizard**

Figure 25: Steps for Extracting and Converting files from CSV to MySQL

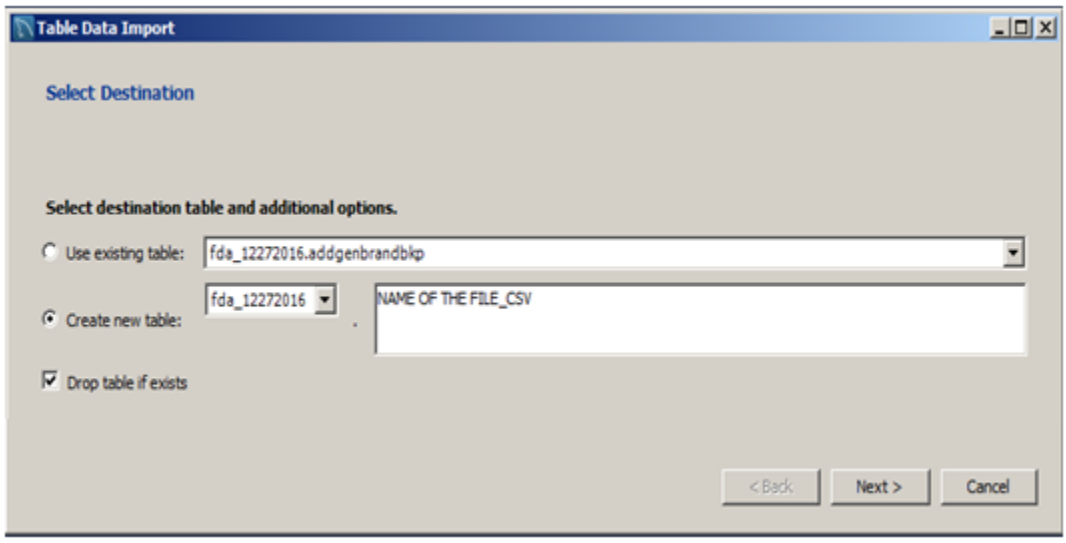


4) Click Browse to select the desired file with CSV format



5) Click Next

6) **Check** : Create new table and Drop table if exists



7) Click Next

8) Follow Wizard Instructions Until Finish **!!**

9) **Right Click** any table then Click Refresh all to view the mew table

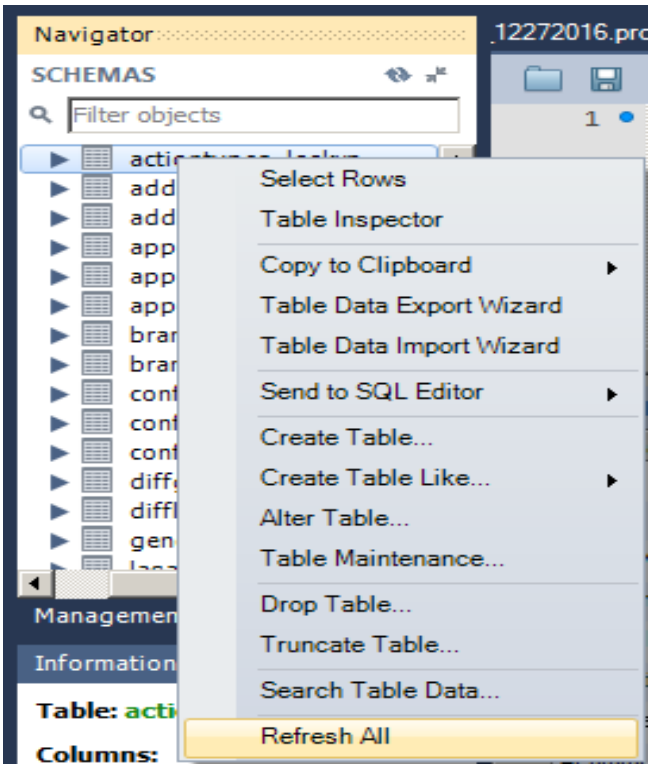


Figure 36:

2618 E Codes: Poisoning by other medications and drugs

52801 52802 9090 9095 9600 9601 9602 9603 9604 9605 9606 9607 9608 9609 9610 9611 9612 9613 9614 9615 9616 9617 9618 9619 9620 9621 9622 9623 9624 9625 9626 9627 9628 9629 9630 9631 9632 9633 9634 9635 9638 9639 9640 9641 9642 9643 9644 9645 9646 9647 9648 9649 9651 9654 9655 9656 96561 96569 9657 9658 9659 9660 9661 9662 9663 9664 9670 9671 9672 9673 9674 9675 9676 9678 9679 9680 9681 9682 9683 9684 9685 9686 9687 9689 9700 9701 9708 97081 97089 9709 9710 9711 9712 9713 9719 9720 9721 9722 9723 9724 9725 9726 9727 9728 9729 9730 9731 9732 9733 9734 9735 9736 9738 9739 9740 9741 9742 9743 9744 9745 9746 9747 9750 9751 9752 9753 9754 9755 9756 9757 9758 9760 9761 9762 9763 9764 9765 9766 9767 9768 9769 9770 9771 9772 9773 9774 9778 9779 9780 9781 9782 9783 9784 9785 9786 9788 9789 9790 9791 9792 9793 9794 9795 9796 9797 9799 9952 99520 99521 99522 99523 99527 99529

Figure 37:

2613 E Codes: Poisoning

E8500 E8501 E8502 E8503 E8504 E8505 E8506 E8507 E8508 E8509 E851 E8520 E8521 E8522 E8523 E8524 E8525 E8528 E8529 E8530 E8531 E8532 E8538 E8539 E8540 E8541 E8542 E8543 E8548 E8550 E8551 E8552 E8553 E8554 E8555 E8556 E8558 E8559 E856 E857 E8580 E8581 E8582 E8583 E8584 E8585 E8586 E8587 E8588 E8589 E8600 E8601 E8602 E8603 E8604 E8608 E8609 E8610 E8611 E8612 E8613 E8614 E8615 E8616 E8619 E8620 E8621 E8622 E8623 E8624 E8629 E8630 E8631 E8632 E8633 E8634 E8635 E8636 E8637 E8638 E8639 E8640 E8641 E8642 E8643 E8644 E8650 E8651 E8652 E8653 E8654 E8655 E8658 E8659 E8660 E8661 E8662 E8663 E8664 E8665 E8666 E8667 E8668 E8669 E867 E8680 E8681 E8682 E8683 E8688 E8689 E8690 E8691 E8692 E8693 E8694 E8698 E8699 E9620 E9621 E9622 E9629 E972 E9800 E9801 E9802 E9803 E9804 E9805 E9806 E9807 E9808 E9809 E9810 E9811 E9818 E9820 E9821 E9828 E9829

Figure 38:

2616 E Codes: Adverse effects of medical care

E8700 E8701 E8702 E8703 E8704 E8705 E8706 E8707 E8708 E8709 E8710 E8711 E8712 E8713 E8714 E8715 E8716 E8717 E8718 E8719 E8720 E8721 E8722 E8723 E8724 E8725 E8726 E8728 E8729 E8730 E8731 E8732 E8733 E8734 E8735 E8736 E8738 E8739 E8740 E8741 E8742 E8743 E8744 E8745 E8748 E8749 E8750 E8751 E8752 E8758 E8759 E8760 E8761 E8762 E8763 E8764 E8765 E8766 E8767 E8768 E8769 E8780 E8781 E8782 E8783 E8784 E8785 E8786 E8788 E8789 E8790 E8791 E8792 E8793 E8794 E8795 E8796 E8797 E8798 E8799