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Polypharmacy, the Electronic Medical Record, and Adverse Drug Events

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has been found to be complete and satisfactory in all respects,
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Abstract

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by

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MS, Tennessee State University, 2010

BS, Tennessee State University, 2005

Project Submitted in Partial Fulfillment

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Abstract

Polypharmacy, a concurrent chronic use of multiple prescribed and over-the-counter medications by the same individual, is one of the clinical problems facing primary care providers. Polypharmacy creates the potential for adverse drug-related events, especially in the elderly. The advent of electronic medical records (EMR) may help identify and respond to these potential adverse events. The purpose of this project was to investigate the relationship between the total number of medication taken by elderly, 65 years and older, and the severity of drug-drug and drug-disease interactions triggered by the EMR system. The study used a retrospective chart review of the EMRs. Three independent variables (age, gender, and number of medications) and 4 dependent variables (major drug-drug, moderate drug-drug, major drug-drug, and moderate drug-drug interactions) were analyzed a sample size of 247 individuals, ranging in age from 65 to 98 years. The total number of medications ranged from 2 to 27 medications, with 177 (71.7%) patients using 2 to 9 medications, and 70 (28.3%) using 10 or more medications. Correlational showed a positive relationship between number of medication and major drug-drug, moderate drug-drug, major drug-disease, and moderate drug-disease interactions (r = 0.240, p = 0.0001; r = .596, p = 0.0001; r = 464, p =0.0001; r = 669, p = 0.0001, respectively). However, there was no significant relationship between age and major and moderate drug-drug and drug disease interactions. The results of this study contribute to positive social change by increasing primary care providers' understanding of the role the EMR can play in the identification and management of patients with polypharmacy.

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Table of Contents

List of Tables

List of Figures

Section 1: Nature of the Project

Introduction

The advent of health information technology (HIT) has played a critical role in the advancement of the U.S. health care delivery system and medication safety. However, its full potential in improving patients' outcomes such as decreasing polypharmacy in elderly is yet to be seen as many elderly are still taking too many medications with potential adverse events. Decreasing polypharmacy in elderly may not be actualized unless there is a change in the prescribing culture of clinicians. To achieve this, prescribers need to embrace and meaningfully use the HIT to change a prescribing culture that has proven to be harmful to the elderly population. This could be done by utilizing the electronic medical record (EMR) automated trigger system. This system is one of the HIT innovative capabilities that can assist clinicians at the point-of-care to make the best clinical decision in terms of prescription writing based on up-to-date information on the EMR. The EMR automated trigger system alerts the providers of the potential drug-drug interactions, drug-food interactions, drug-disease interactions, and drug-alcohol interactions (eClinicalWorks, 2013). This gives the providers an opportunity to review patients' medications and discontinue any medication with potential adverse drug-drug drug-drug interactions, eliminating potential consequence of polypharmacy at the-point-of-care, and enhancing medication adherence and safety.

The prevalence and problem of polypharmacy in elderly has been widely documented throughout literature. Johnston (2007, p. 259) noted that although "the elderly make up less than 15% of the U.S population; they use about 30% of all prescribed medications and 40% of the OTC drugs". Terrie (2004, p. 1) also reported that "Older individuals account for > $3 billion in annual prescription drug sales; 61% of elderly are taking one prescription drug, and most of them take an average of 3 to 5 medications, and nearly 46% of all elderly individuals admitted to hospitals in the United States may be taking seven medications". Adverse drug-related events (ADREs) present a challenging and expensive public health problem (Hohl, Dankoff, Colacome, & Afilaloet, 2001). They account for 3% to 23% of hospital admissions, prolonged hospital stays, and increase morbidity and mortality (Classen, Pestotnik, Evans, Lloyd, & Burke, 1997). In 2001, the National Service Framework for Older People showed that 5% to 17% of hospital admissions were caused by adverse reactions to medicines, and 6% to 17% of older patients in the hospital experienced adverse drug reactions (Bretherton, Day, & Lewis, 2003). Therefore, decreasing polypharmacy should be every provider's priority in any clinical practice as this will not only promote quality of care for the elderly, but also decrease the overall healthcare cost.

Problem Statement

The relatively high incidence of polypharmacy in elderly aged 65 years and older is one of the clinical problems facing NPs' practice in primary care today. Many researchers have shown that our elderly patients are receiving several prescriptions from different physicians which may increase their risk for adverse drug events (Junius-Walker, Theile, & Hummers-Pradier, 2007; & Weng, Tsai, Sheu et al., 2013). Elderly patients, because of age, are also known to have multiple or complex illnesses, and are often cared for by multiple providers who may not be aware of clinical decisions taken by the other prescribers (Linjakumpu et al., 2002). This can lead to polypharmacy, which in turn leads to adverse drug interactions, medication errors, and non-adherence issues which are preventable (Linjakumpu et al., 2002). Furthermore, the problem of polypharmacy has since been recognized as the principal medication issue by the United States Department of Health and Human services (DHHS) report “Healthy People 2000” that medication safety was noted as an objective of the Healthy People 2010 agenda with it recommendations including: “close monitoring for adverse medical events, linking information systems to prevent errors, having physicians and pharmacists regularly review the medications a patient is taking, and counseling the patient about prescriptions” (USDHHS, 2000, p.236). Institute of Medicine’s (IOM, 2006, p. 10) chasm series also recommended to health care organizations to “take advantage of the latest information technologies” in improving medication safety, hence the significance of this project. This project therefore has utilized the EMR automated trigger system to investigate the association between the number of medications prescribed and the severity levels of drug-drug and drug-disease interactions. The results could then be used to plan interventions to decrease polypharmacy and eliminate potential adverse drug-related events in elderly.

Purpose statement and Project objectives

The purpose of this project is to investigate the relationship between the total number of medication taken by elderly patients 65 years or older and the severity of drug-drug interactions and drug-disease interactions. The objective of this project is to determine if there is a relationship between the number of medications prescribed and the level of severity of these interactions triggered by the EMR. The EMR automated trigger system is one of the HIT innovative capabilities which alerts provider of the potential drug-drug interactions, drug-disease interaction, drug-food interactions, and drug-alcohol interactions. There are two levels of severity of drug-drug interactions and two levels of severity of drug- disease interactions triggered by the EMR automated trigger system (eClinicalWorks, 2013). These severity levels are major (red color-code) and moderate (orange color-code) drug-drug or drug-disease interactions. Hence, the EMR automated trigger system categorized the severity level of drug-drug interactions into major drug-drug interactions (red color-code) and moderate drug-drug interactions (orange color-code). Similarly, the severity level of drug-disease interactions is categorized into major drug-disease interactions (red color-code) and moderate drug-disease interactions (orange color-code). This will be discussed in details in Section 3 of this project.

Project Hypothesis

The hypothesis of this project is that there will be a positive relationship between the number of medications and the number of major severity and moderate severity of drug-drug and drug-disease interactions.

Significance/Relevance to Practice

One of the major practice issues facing NP practice in primary care is the relatively high incidence of polypharmacy in elderly individuals aged 65 years and older. Elderly seen in primary care settings come in with multiple prescription, over-the-counter (OTC) and herbal medications. Many of these elderly have to rely on their primary care providers to review these medications and give them direction on how to self-manage these medications to avoid potential adverse-reactions. Primary care NPs are in a unique position to monitor and potentially eliminate adverse effects of a complex medication regimen and decrease incidence of polypharmacy in the elderly population by using the EMR automated trigger system to eliminate inappropriate and unnecessary medications during office visits. The results of this research project will also have effects on nursing-sensitive outcomes, which will help define guidelines for intervention and prevention of ADREs.

Swanson (1991, p. 161) defined caring as, "a nurturing way of relating to a valued other, toward whom one feels a personal sense of commitment and responsibility" Swanson stated that five processes characterize caring: knowing, being with, doing for, enabling, and maintaining belief. Because NPs are an extension of nursing, not medicine, NPs practice knowing (empathy), being with (presence), doing for (evidence-based practice), enabling (empowerment), and maintaining belief (instilling hope) (Hagedorn & Quinn, 2005). Finally because NPs are guided by nursing theory, the success of NPs depends on practicing evidence-based care with competency in assessment, diagnosing, and managing patients (including writing prescriptions) and maintaining a caring practice (Hagedorn & Quinn, 2005). This implies among other measures that NPs meaningfully used the available health information technology to prudently write prescriptions to their elderly patients.

Evidence-based Significance of the Project

The results of this study will add to the plethora of evidence in managing patients with chronic illness who are potentially susceptible to polypharmacy. Evidence-based practice (EBP) is a problem-solving approach for the delivery of healthcare that integrates the best evidence from studies and patient care data with clinical expertise and patient preferences and values (Fineout-Overholt, 2010). It places emphasis not just on best practices but rather on a decision-making process in which decisions are made on a case-by-case basis using the best evidence available. Although polypharmacy in elderly poses a significant challenge to primary care providers, only three studies reviewed associated the number of medications to increase risk of adverse effect. The first study was conducted by (Williams, 2002, p. 1917), who reported that "taking only two drugs increases the risk of an adverse effect by 6%, eight medications raise risk by 100%". The second study conducted by Goldberg, Mabee, Chan, & Wong (1996, p. 447), found that "the probability of an ADR increases from 13% for two drugs to 82% for more than seven drugs". The third study by Frazier (2005, p. 5) reported that "the potential of an ADR nears 100% when 10 medications are use". However, these studies did not specify the type or the severity of these interactions. This study will help close the gap in the literature and show the association between the total number of medications and type and severity of each interaction. According to Rollason & Vogt, (2003, p. 817), "polypharmacy in the elderly complicates therapy, increases cost, and is a challenge for healthcare agencies". Pharmacological therapy in the elderly is difficult due to physiological changes associated with aging, such as poor absorption and decreased metabolism, and these changes may contribute to adverse drug reactions (Trotter, 2001). Because the effects of one medication may potentiate or inhibit the action of another medication (Fulton & Allen, 2005), polypharmacy complicates drug therapy and needs to be addressed. The utilization of HIT innovative capability, such as the automated trigger system, to assist in eliminating inappropriate prescriptions in the elderly population will not only reduce potential adverse events, but also reduce overall healthcare cost for this population.

Implications for Social Change

The potential benefit of Health Information Technology (HIT) is to increase patient safety by minimizing medication errors. Studies have shown that increased safety would result mostly from the alerts or triggers or reminders generated by the EHR systems for medications (Center for Medicare Advocacy, 2009). These triggers not only warn the providers of potential adverse drug interactions with other drugs the patient is taking, but also provide recommendations that would prevent such adverse outcomes. Rand reports estimated that if hospital used an HIT system with electronic prescribing, around 200, 000 adverse drug reactions could be eliminated each year, with annual savings of about $1 billion (Center for Medicare Advocacy, 2009). NPs must take advantage of the advanced information technology such as electronic prescribing, electronic medical records, and electronic laboratory record, and explore ways to use them to decrease the risk of adverse drug reactions.

Electronic script systems are very effective in alerting the providers of potential adverse reactions or interactions but this system requires the discipline of the users to review them and make the necessary changes based on the alerts recommendations. All providers should facilitate and enhance the self-care of all patients, especially the elderly, who potentially are the most affected by polypharmacy or excessive prescribing. The key to enhancing self-care and reducing non-adherence include information, instructions, and organization. Each office visit should give NPs the opportunity to enhance client's self-care potential by giving appropriate information concerning each prescribed medication, such as what the drug is used for, side effects to report, duration of therapy, drug-drug interactions, drug-food interactions, and immediate action a client can take in case of severe reactions.

Definition of Terms

Polypharmacy: There is no clear definition of polypharmacy throughout the literature reviewed, except that it indicates the use of multiple medications (prescriptions/OTCs) by a patient. Some definitions of polypharmacy include "excessive or unnecessary use of prescription or nonprescription medications" (Jones, 1997, p. 627), "use of six or more medications" (Bushardt et al., 2008, p. 383), others consider it as the prescription, administration, or use of more medications than are clinically indicated in a given patient (Larsen et al., 1999; Montamat and Cusack, 1992). The Center for Medicare and Medicaid Services (CMS) defines polypharmacy as treatment with nine or more medications. For the purpose of this project, polypharmacy is defined as the concurrent chronic use of two or more medications (prescribed/OTCs) by the same individual. This definition is appropriate for this study because the EMR automated trigger system produces alerts once the clinician enters at least two medications into the patient's medication record.

Electronic Medical Record (EMR): An Electronic Medical Record (EMR), also called the Electronic Health Record (EHR) is a digital version of paper charting, which contains links to other databases that assist the providers in diagnosis and treatment, referrals to other providers, and billing (CMS, 2013).

Meaningful Use: Meaningful Use is a term used to set standards or criteria to promote the spread of electronic health records and health information in the United States. It is a set of standards defined by the Center for Medicare and Medicaid services (CMS). The CMS (2013) defines 'Meaningful Use' as a "set of standards defined by the Centers for Medicare & Medicaid Services (CMS) Incentive Programs that governs the use of electronic health records and allows eligible providers and hospitals to earn incentive payments by meeting specific criteria".

Adverse Drug Reactions (ADRs): The World Health Organization (1992) defines adverse drug reaction as "a response to a drug which is noxious and unintended, and which occurs at doses normally used in man for the prophylaxis, diagnosis, or therapy of disease, or for the modifications of physiological function". Edwards and Aronson (2000, p. 1256) also defined adverse drug reaction as "an appreciably harmful or unpleasant reaction, resulting from an intervention related to the use of a medicinal product, which predicts hazard from future administration and warrants prevention or specific treatment, or alteration of the dosage regimen, or withdrawal of the product."

Limitations

This project is limited to one particular primary care office and a single EMR system, which may affect the result. Further research needs to be conducted using multiple healthcare organizations and EMRs. Sample size may also be a limitation. A convenient sample was used which may affect the results. A review of this EMR system during my practicum showed this primary care has over 400 patients 65 years and older, however some of these charts will not be used due to inclusion criteria of using only charts with two or more medications.

Summary

This section has established the significance of this project to improvement of care delivery in primary care settings. The results of this study will lead to health promotion of this target population, the elderly, who are the most susceptible to effects of polypharmacy. A need to determine the relationship between the total numbers of medications prescribed and the severity of drug-drug interactions and other interactions will allow nursing researchers to use the results for development of guidelines or tools that prescribers can use to eliminate inappropriate or unnecessary prescriptions. Some of the recommendations from IOM (2011) report include a call to health care organizations to “promote health care that is safe, effective, client-centered, timely, efficient, and equitable; that health professionals should be educated to deliver patient-centered care as members of an interdisciplinary team, emphasizing evidence-based practice, quality improvement, and informatics”. This project is responding to the IOM report by attempting to answer this important research question with the hope of using the results to promote the health of this target population.

Section 2: Background and Context

Specific Literature Review

Electronic Health Records (EHRs)

The government has developed many policies to promote wider adoption of electronic medical records (EMRs) with the hope that they will improve quality of care, improve care coordination, and reduce healthcare costs. However, Layman (2008, p. 165) noted that research “has not consistently demonstrated access for disadvantaged persons, the accuracy of EHRs, their positive effects on productivity, nor decrease costs”. Furthermore, Harrington, Kennerly, Johnson, and Snyder (2011, p.31) asserted that “While healthcare information technology (HIT) is intended to relieve some of the burden by reducing errors, several aspects of the systems such as the electronic medical record (EMR) may actually increase the incidence of certain types of errors or produce new safety risks that result in harm”. According to CMS (2013) the EHRs “are builds to share information with other health providers and everyone involved in patient care and patients themselves should be able to access their records at any time to meet the criteria for stage one of ‘meaningful use’”. This continues to raise concerns regarding safety of patients’ information across a complex health care system as each health organization involved in patients’ care navigate the system to comply with the government regulations on the use of EHR.

The EMR provides the potential benefits in improving patients quality of care in primary care by tracking patients’ data over time, identifying patients who need preventive visits or screening, and monitoring how patients measure up to quality indicators (eClinicalWorks, 2013). It allows patients to access their records. Currently, there is a debate in the nation whether patients should be able to edit their medical records via the patient portal. Meanwhile, health care organizations continue to rely on Health Insurance Portability and Accountability Act (HIPPA) rule which allows patients to request that inaccurate information be corrected, but not to demand changes for other reasons (USDHHS, 1996).

Barriers to full utilization of EMR system include time constraints and lack of interoperability of HIT systems. In a study conducted by Houser and Johnson (2008, p.6) which aimed at identifying the main barriers to EHRs implementation, they found that "the most significant barriers were lack of national information standards and code sets (62 %), lack of available funding (59 %), concern about physician (51 %), and lack of interoperability (50 %)". Clinicians in primary care faced a greater challenge in balancing efficiency and quality of care. A physician who sees an average of 25 patients a day may not have time to review the EMR automated trigger system for recommendations before writing a prescription. In a study conducted by Tai-Seale, McGuire, and Zhang (2007, p. 1871) on "time allocation in primary care office", they found that "the median visit length was 15.7 minutes during elderly patients' visits to primary care, and the length of visit overall varied little even when contents of visit varied widely" They concluded that "a highly regimented schedule might interfere with having sufficient time for patients with complex or multiple problems". Again, in a systemic review study conducted by Boostra & Broekhuis (2010) which involved review of 22 previous published studies, concluded that physicians cited most often financial barriers, technical barriers, and time constraints as barriers to EHR adoption. Ball, Douglas, and Walker (2011, p 252) also reported that “one of the major barriers to EBP is the constraint of time”. Providers are constantly under pressure to practice based on current evidence. However, the organizational demand for efficiency does not always allow a clinician to meet both demands. This is a major barrier in translating evidence into practice. As Ball et al. (2011, p. 247) noted, “access is not usually the prevailing issue; it is the time constraints of searching and appraising that become one of the biggest challenges of EBP decision making at the point of care”. Providers therefore need to develop strategies to accomplish both tasks of practicing based on current evidence and meeting the demand for efficiency.

Lack of interoperability may also present a major barrier to full utilization of the EMR system. Interoperability is the ability of separate systems to convey information to each other in a computer-recognizable format (Ball et al. 2011). Review of this same EMR system revealed lack of interoperability with other systems which would have increased efficiency. Providers and some pharmacies were still faxing patients’ records which had to be manually retrieved and reviewed by clinicians before attaching it to patients’ charts. This process takes time and delay valuable information that clinicians could have used to make the best clinical decision at the point-of-care (Ball et al. 2011).

Meaningful Use

Meaningful use is concerned with capturing the way providers used their EHR, comparing it to the measures defined by CMS (eClinicalWorks, 2013). It was meant to ensure complete and accurate patients information especially in improving health care delivery in the United States. Its aim is to promote the best possible care as providers may be able to access patient health history at the point of care. This was supposed to enhance easy information sharing among practitioners, promotes better coordination of care, and empowers patients to play more active role in their care and health information of self and families. In effect this should potentially improve overall health care quality, safety and efficiency through the promotion of health information technology and secure health information. The CMS (2013) defines ‘Meaningful Use’ as a “set of standards defined by the Center for Medicare & Medicaid Services (CMS) Incentive Programs that governs the use of electronic health records and allows eligible providers and hospitals to earn incentive payments by meeting specific criteria”. Meaningful use is concerned with capturing the way providers used their EHR, comparing it to the measures defined by CMS (eClinicalWorks, 2013). However, the provider or practice has the option to register for attestation for the incentive program on the CMS website.

The process involves three stages over a five year period that started in 2011. The first stage is data capturing and storage (2011-2012), second stage involves advance clinical process (2014) and third stage in 2016 will involve improved outcomes (evaluation) (CMS, 2013). The table below shows the three stages of Meaningful Use set criteria.

Table 1

EHR Incentive Program (CMS.gov, 2013)

Stage 1: Meaningful use criteria focus on:	Stage 2: Meaningful use criteria focus on:	Stage 3: Meaningful use criteria focus on:
Electronically capturing health information in a standardized format	More rigorous health information exchange (HIE)	Improving quality, safety, and efficiency, leading to improved health outcomes
Using that information to track key clinical conditions	Increased requirements for e-prescribing and incorporating lab results	Decision support for national high-priority conditions
Communicating that information for care coordination processes	Electronic transmission of patient care summaries across multiple settings	Patient access to self-management tools
Initiating the reporting of clinical quality measures and public health information	More patient-controlled data	Access to comprehensive patient data through patient-centered HIE
Using information to engage patients and their families in their care		Improving population health

General Literature

Incidence of polypharmacy in the elderly: Many researchers over the years have documented on increasing high incidence of polypharmacy in the elderly population in the United States. This is not surprising because as the geriatric population continues to rise, so does the incidence of polypharmacy. In a study of patients randomly chosen from an outpatient clinic at a VA Hospital (primarily a geriatric population), the mean number of medications was five, and 65% were taking more than four drugs (Jensen et al., 2002).

Another VA study found that 42% of geriatric patients admitted to a facility were taking five or more medications (Good, 2002). A study of Swedish elderly found that 39% were taking five or more drugs concomitantly (Jorgensen et al., 2001). Again, in a study conducted by Steinman et al. (2006), non-institutionalized elderly individuals were found to use an average of four drugs, 41% to 65% of elderly individuals used more than four drugs daily (Jensen et al., 2002), and elderly individuals receiving home care were found to use an average of five and a half medications (Flaherty et al., 2000). In another study conducted by Jyrkka et al. (2006) in Finland, the prevalence of polypharmacy (>5 medicines) increased from 54% in 1998 to 67% in 2003; and excessive polypharmacy (>or=10 medicines) also increased from 19% to 28% in the same period. The same study also found that persons in institutional care used significantly more medicines (10.9) than community-dwelling elderly persons (7.0, $p<0.001$). Other studies and surveys (Routledge et al., 2004; Johnston, 2007) have shown that ambulatory elderly persons fill between nine to 13 prescriptions per year; the average prescription per ambulatory patients were 5.7 and 7 for nursing home patients; and individuals over age 65 used two to six prescription drugs and one to more than three OTC drugs.

Effects of polypharmacy in the elderly: Many studies have documented several negative consequences of polypharmacy. For example, the use of multiple medications have been found to increase the risk of medication-related adverse events and drug interactions, and creates a more complicated drug regimen for the patient making compliance more difficult (Dayer-Berenson & Martinez, 2008). IOM (2006, p.10) “concludes that there are at least 1.5 million preventable ADEs that occur in the United

States each year". Other clinical consequences of polypharmacy include non-adherence, increased risk of hospitalizations and medication errors (Rollason et al, 2003). In 2001, the National Service Framework for Older People showed that 5% to 17% of hospital admissions were caused by adverse reactions to medicines and 6% to 17% of older patients in the hospital experienced adverse drug reactions (Bretherton et al., 2003). The Centers for Education and Research Therapeutics also reports that 100,000 deaths occur yearly due to adverse drug reactions, and as the 4th leading cause of death ahead of pulmonary disease, diabetes, AIDS, and automobile deaths (FDA, 2008).

Hohl, et al. (2001) also reported the relationship between polypharmacy, adverse drug-related events, and potential adverse drug interactions in elderly patients presenting to an emergency department. The result of this study revealed that adverse drug-related events (ADREs) account for 10.6% of all emergency department visits, 31% of patients had at least one potential adverse drug interaction (PADI) in their medication lists, and 50% had at least one PADI in their medication list that was unrelated to the ADRE with which they presented. The study concluded that ADREs are an important cause of emergency department visits in the elderly and PADIs were found in significant proportion of medication lists.

An increase in the number of medications dramatically increases the number of drug combinations, thereby increasing the risk adverse drug reactions (ADRs) and drug-drug interactions (Jones, 1997). According to the study by Goldberg, Mabee, Chan, & Wong (1996, p. 447), "the probability of an ADR increases from 13% for two drugs to

82% for more than seven drugs”. Furthermore, Frazier (2005, p. 5) reported that “the potential of an ADR nears 100% when 10 medications are used”.

Another effect of polypharmacy on the elderly is increased risk for falls. Although falls are common occurrences in elderly, one study on the relationship between polypharmacy and falls in elderly found that the risk of fall increased significantly with the number of drugs used per day. In a univariate analysis, 28 drugs were associated with falling (Ziere et al., 2006). The study therefore concluded that fall risk is associated with the use of polypharmacy, but only when at least one established fall risk-increasing drug was part of the daily regimen. These drugs include diuretics, antiarrhythmics, psychotropics, which are prescribed to many elderly patients.

Polypharmacy may also increase healthcare cost, either from increase in cost of unnecessary medications or from the cost of treatment from adverse drug reactions. Visits to specialists, emergency care, and hospital admissions contribute to polypharmacy because of multiple prescribers and account for an annual cost of $76.6 billion (Prybys et al., 2002). Prybys et al. also reported that up to 28% of hospital admissions are secondary to an adverse drug event, and the incidence of events in patients over-65 years is more than double than in patients 45 years and younger. Sullivan et al. (1992) estimated the direct cost of hospitalization due to nonadherence to be $US 85 billion. They also suggested that $US 17-25 billion could be attributed to the indirect costs of polypharmacy. When polypharmacy is reduced, patients tend to save money. In an article on the cost effectiveness of pharmacists’ drug regimen reviews, Sullivan et al. (2001) estimated potential savings resulting from a reduction in medications to be &US 81 million a year, saving averted hospitalizations to be $US 224 million annually and savings from reduced drug administration time in nursing homes to be $US 154 million.

The elderly are more at risk of medication errors because of their exposure to a greater number of drugs and the complexity of their drug regimen. In a report on mortality associated with medication errors, 48.6% of the deaths occurred in patients aged over 60 years, and 55% of these patients were taking more than one drug (Phillips et al., 2001).

Factors contributing to polypharmacy in elderly: Researches have shown many factors contribute to polypharmacy in elderly. These include age, chronic medical condition, self-medication due to direct advertisement to patients, non-compliance/non-adherence issues, multiple providers, use of multiple pharmacies, excessive prescribing culture of some physicians, and lack of care coordination (Good, 2002; Hume, 2005). Elderly are prone to chronic medical conditions such as arthritis, hypertension, diabetes, heart disease, etc. that necessitate the use of multiple medications. Self-medication has increased polypharmacy incidence due to increased direct-advertisement to patients of OTCs/Herbal medications (Good, 2002). Prybys et al. (2002) reported that complementary and alternative therapies are more popular as demonstrated by a significant increase in sales. Patients most often do not consider herbal and OTC supplements or remedies as medications and hence do not usually report use of these medications to their healthcare providers (Good, 2002). In addition, the elderly sometimes have knowledge deficit regarding the medications that they are taking. (Linjakumpu et al., 2002, p. 809) reports that “elderly are more likely to have cognitive or sensory disorders that increase the chance of miscommunication with their clinicians about how to take their medications and their doses”. This may complicate therapy due to non-adherence.

Aging is also known to increase the risks of medication problems due to chronic illnesses such as heart disease, hypertension, diabetes, chronic renal failure and arthritis (Veehof et al., 2000). Hence, the symptoms of polypharmacy can be missed or confused with another illness making physicians to prescribe more medications instead of discontinuing or changing the medication that causes the symptoms in the first place. Many authors (Bedell et al., 2000; Kaufman et al., 2002; Linjakumpu et al., 2002; Veehof et al., 2000) reported that advanced age was a factor in the development of polypharmacy. Furthermore, Veehof et al. (2000) reported that the predictors of polypharmacy were (a) numbers of medications at the start of the study, (b) age, (c) cardiovascular conditions (i.e. hypertension, coronary ischemic diseases, atrial fibrillation, and heart failure), (d) diabetes, (e) stomach disorder, and (f) medication use without a clear indication. Hume (2005) reported many patients have multiple providers and use more than one pharmacy which creates a situation where neither a single provider nor pharmacist knows all the medications prescribed.

Patient’s non-adherence or noncompliance to medication therapy increases risk for physician to prescribe more medications to treat the same illness leading to duplication of medications. The rate of non-adherence has been estimated to be between 25% and 59% in the elderly and 50% in the aged with chronic conditions (Spina & Scordo, 2002). Changes in the drug regimen may be made by patients to increase convenience, reduce adverse effects, or decrease refill expenses. Factors contributing to non-adherence include large number of medications, expensive medications, complex or frequently changing schedule, adverse reactions, confusion about brand/trade name, difficult-to-open containers, limited patient understanding and route of administration (rectal, vaginal, subcutaneous , etc.) (Spina and Scordo, 2002). Also, elderly are more likely to have cognitive or sensory disorders that increase the chance of miscommunication with their clinicians about how to take their medications and their doses (Linjakumpu et al., 2002). Elderly may also keep old medications that have been discontinued for future use because of cost, but may later start to use these medications with the new ones because of cognitive impairment. These contribute to polypharmacy which may increase the risk for serious drug interactions and adverse reactions and hospitalizations.

Interventions to reduce polypharmacy in elderly: Health care providers have used various methods to assess and decrease the incidence of polypharmacy. These interventions include the utilization of the Beers criteria (Beers, 1997), the “brown bag” approach (Prybys et al., 2002), using mnemonics such as SAIL or TIDE (Werder & Preskorn, 2003), and the “10-step approach” (Carlson, 1996). In 1997, Beers and colleagues established criteria to determine inappropriate medications prescribed for the elderly and developed a “provider friendly” list to use when determining what medication to prescribe for the older client. Example of recommendation in this list is to use benzodiazepines in small doses in older individuals because of their increased sensitivity to these substances. There is a significant gap in literature of the effectiveness of these interventions. No research was identified that addressed the most effective interventions to utilize when decreasing medications, but many researches addressed inappropriate prescribing.

Prybys et al. coined the term “brown bag syndrome” when clients arrive at the emergency room or primary care provider’s office with a lunch bag filled with various prescription and nonprescription medications. It is the providers’ responsibility to review and determine contents of these bags before writing another prescription for these patients. Bikowski et al. (2001) recommended the brown bag approach, computerized medication regimens, and online communications to decrease medication regimen discrepancies. Frequent medication reviews at every visit with the elderly are necessary to determine regimen compliance and if medications have been added by another provider. Barat et al. (2001) recommended improved patient education (i.e., regarding dosage, indication, benefits, risks), the use of “compliance aids” such as pill boxes, medication calendars, and careful evaluation of each drug by primary care providers to reduce the number of medications prescribed and to increase drug regimen compliance.

Werder and Preskorn (2003) advocated the use of the SAIL and TIDE mnemonics to avoid polypharmacy. The acronym SAIL represents keeping the prescribed regimen as simple as possible, being aware of the potential adverse effects, exploring the indication for a prescribed medication, and listing each drug (including name and dosage) on the chart and providing a copy to the client. TIDE is another helpful mnemonic for prescribers. Werder & Preskorn (2003) identified the importance of scheduling time during an office visit to address medications, ensure the prescriber awareness of individual response to medications, avoidance of potential drug-drug interactions, and most importantly education of the client.

Carlson (1996) advocates the “10-steps to prudent prescribing”. The 10 steps include (a) disclosing medication, (b) identifying drugs by generic name and class, (c) using the right drug for the right reason, (f) eliminating agents with no benefit, (g) eliminating drugs with no indication, (h) substituting a less toxic drug, (i) avoiding cycle of “double dipping”, and (j) utilizing the motto of “one disease, one cure, once-a-day”. According to Carlson (1996), skillful prescribing habits are beneficial to both the provider and the client: side effects of medications can be reduce, drug-drug interactions can be avoided, cost effectiveness improved as well as improvement in client compliance, and quality of life.

Polypharmacy, as well as inappropriate prescribing, for the elderly is a major problem and a challenge that contributes to costs, adverse drug events, confusion, compliance issues, and errors in management. A systematic approach to drug monitoring is an important aspect of appropriate prescribing. Attention to prescribing of medications, consistent review of medication lists, and reevaluation of indications and outcomes of prescribing are essential to ensure that polypharmacy is minimized and safety for patients is maximized (Ballentine, 2008). A randomized trial in which residents caring for inpatients received a simple medication grid of all the patients’ medications and times of the administration led to a significant decrease in the number of medications in the intervention group (Muir et al., 2001). However, despite numerous reports of successful interventions to alter prescribing for elderly patients by decreasing either polypharmacy or inappropriate prescribing, there is little evidence documenting an impact on health outcomes. Another randomized trial of elderly outpatients at a VA medical center involved having a clinical pharmacist meet with intervention patients to make recommendations to patients and clinicians concerning drug regimens. Although there was a significant decrease in inappropriate prescribing in the intervention group, there was no difference in health-related quality of life (Hanlon, et al., 1996). In another report of the same trial, investigators found that 26% of drugs stopped as part of the intervention (involving nearly one-third of the patients) resulted in adverse drug withdrawal events. Unfortunately, approximately one-third of these events resulted in hospitalization, an emergency room visit, or an urgent care visit (Graves et al., 1997).

Despite the plethora of research on polypharmacy, there is still a gap in literature on the association between the number of medications taken by elderly and the severity of drug-drug interactions. This study will attempt to investigate and answer the research question by utilizing the EMR medication automated trigger system to collect data on elderly 65 years and older in relation to medication utilization and potential drug-drug and drug-disease interactions.

Conceptual Model

The use of conceptual model can be explored to assess how change related to implementation of technology can be applied to improve patient outcomes. To decrease polypharmacy through application and meaningful use of HIT innovative capabilities such as the automated medication trigger system, Technology Acceptance Model (TAM) will be explored. Technology Acceptance Model (TAM) is an information system theory developed by Davis et al. (1989) to show how people come to accept and use technology. TAM suggests a number of factors influence people decisions in acceptance of new technology, including perceived usefulness, perceived ease of use, subjective norms, attitudes and related variables. Karsh (2004) suggested the use of theoretical models to guide and facilitate adoption of health care systems and technologies, citing motivational theories such as Maslow's needs' classification and decision-making theories such as Social Cognitive Theory. TAM is based on human factors engineering science, which include the study of technology design and evaluation and has been used effectively to assess usability and acceptability of technology (Ball, Douglas, & Walker, 2011).

Understanding the impact of new technologies on users, organizations, and work processes is important (Karsh, 2004). TAM explored the ease of use and usefulness of technology which plays a critical role in acceptance. Researchers have identified technology characteristic that have a direct and indirect impact on acceptance such as response time, flexibility, and breakdown (Karsh, 2004), trust and management support (Wu et al., 2008). Although the government policy and incentives ensured the adoption and implementation of certified EHR technology, the prescribing culture of some clinicians actually does not reflect the meaningful use of this technology. According to CMS (2013), meaningful use is a set of standards that will potentially improve overall health care quality, safety and efficiency through the promotion of health Information Technology and secure health information. However, few researches show the successful implementation of this system as it was intended by the government, especially in improving the health of the elderly population, which medication management is a major component of health promotion for this population. Although clinicians may have access to fully functional EHRs which allows them to translate evidence to practice at point of care, its functions are not fully utilized due to time constraint. A familiar culture in primary care practice is for a provider to see an average of 25 to 30 patients per day. Hence, patients are scheduled every 15 minutes which is not enough time for physician to evaluate patient, review chart for any alerts, and review patient's current medication in order to make the best clinical decision. For example, Tamblyn et al. (1997, p. 430) in a study on "unnecessary prescribing of NSAIDs and the management of NSAIDs-related gastropathy in medical practice" concluded that shorter visits, especially those less than 15 minutes, were a risk factor for inappropriate prescribing and management of gastrointestinal side effects". This implies the need for increase visit time for the elderly population, who are susceptible to polypharmacy, requiring ample time for physician to review their medications at the point-of-care before writing another prescription.

Section 3: Collection and Analysis of Evidence

Project Design/Methods

A correlative study design was adopted for this study. A correlative method is appropriate for this study because it is non-experimental. According to Polit (2010, p. 216), “the primary use of correlation procedure is for answering research questions and testing hypotheses”. This study is non-experimental and therefore this design is appropriate for this study.

Sampling

The study sample was collected from one single EMR system used by one primary care organization with a total of 497 elderly aged 65 and older. Inclusion criteria included patients aged 65 years and older and taking at least two or more medications (prescription and OTCs). Exclusion criteria included all patients below 65 years and taking zero to one medication. Sample size used was 247 that meet the inclusion criteria out of a total of 497 elderly patients. Ethical considerations for collecting research data from my clients is the issue of conflict of interest and HIPPA/privacy issues. Chart reviews were utilized, removing any identifying information after accessing the EMR system to collect data. Although the elderly is the target population, their treatments were not altered by this study.

Data Collection Techniques

- Created a Data Collection Sheet (Appendix A)
- Used EMR to select all patients 65 years and older

- Manually reviewed the medication records of all selected charts to select charts that meet the inclusion criteria to be used in the study and to determine sample size.
- Opened each selected chart to activate each patient medication automated trigger system to count and record the number of major drug-drug interactions (red color), moderate drug-drug interactions (orange color), major drug-disease interactions (red color), and moderate drug-disease interactions (orange color). Age, gender, and total number of medications were also obtained.

Study Variables

The study used three independent variables which included number of medications, age, and gender. The total number of medications was obtained by counting all medications (both OTCs and prescribed) that is on the patient's medication list in the EMR at the time of data collection. Age was obtained in terms of years and only patients 65 years and older were included. Gender was obtained as either male or female**.**

Dependent variables used included major drug-drug interactions, moderate drug-drug interactions, major drug-disease interactions, and moderate drug-disease interactions. Each color trigger in each category of interaction was assigned the number 1. All red color triggers under drug-drug interactions category were added to obtain the total number of major drug-drug interactions. All orange color triggers under drug-drug interactions category were added to obtain the total number of moderate drug-drug interactions. Similarly, all red color triggers under drug-disease interactions category were added to obtain the total number of major drug-disease interactions. All orange color triggers under drug-disease category were added to obtain the total number of moderate drug-disease interactions. Data collection form is included in Appendix A.

EMR Medication Automated Trigger System

The EMR medication automated trigger is color-coded to alert prescribers on the severity level of drug-drug interactions, drug-disease interactions, drug-food interactions, and drug-alcohol interactions. For example, the color red means major drug-drug interaction or major drug-disease interaction. The color orange means moderate drug-drug interaction, or moderate drug-disease interaction, or moderate drug-food interaction, or moderate drug-alcohol interaction. Yellow color means minor drug-food interaction, or minor drug-alcohol interaction. With these capabilities, this study will attempt to answer the research question, and show if there is any relationship between the total number of medications the elderly takes and the severity of these interactions. For the purpose of this study, drug-food interactions and drug-alcohol interactions triggers were excluded from the sample.

Tables 2-3 below show a typical alerts triggered by the EMR automated system. Not all alerts are included in the tables. A complete list of alerts for this patient, who is on 14 medications, is seven pages long with one moderate drug-drug interaction, one minor (yellow) drug-food interaction, one moderate (orange) drug-food interaction, one moderate (orange) drug-alcohol interaction, 28 moderate (orange) drug-disease interactions, and 13 major (red) drug-disease interactions. A prescriber may adjust the severity of each alert after reviewing the recommendations.

Table 2

Drug-Drug Interactions

Drug 1	Drug 2	Severity	Drug To Drug Interaction Description	Adjust Severity
Oxybutynin Chloride Oral Tablet 5 MG	Micro-K Oral Capsule Extended Release 10 MEQ	Moderate	Coadministration of Oxybutynin Chloride Oral Tablet 5 MG and solid dosage forms of potassium chloride may increase the risk of potassium-induced gastrointestinal mucosal damage. Coadministration of Oxybutynin Chloride Oral Tablet 5 MG and solid dosage forms of potassium chloride is contraindicated. The clinical significance of this interaction is unknown.	○ Major ○ Moderate ○ Minor Reset

Source: EMR Automated System Alerts – eClinicalWorks, 2014

Table 3

Drug-Disease Interactions

Drug	Condition	Severity	Precaution Description
Lovastatin Oral Tablet 40 MG	Bell's Palsy	Not recommended	Lovastatin Oral Tablet 40 MG is not recommended in Myopathy. Since Bell's Palsy is a more specific form of Myopathy, the same precaution may apply.
Lovastatin Oral Tablet 40 MG	Facial Paralysis	Not recommended	Lovastatin Oral Tablet 40 MG is not recommended in Myopathy. Since Facial Paralysis is a more specific form of Myopathy, the same precaution may apply.
Imitrex Oral Tablet 100 MG	Hypertension	Not recommended	Imitrex Oral Tablet 100 MG is not recommended in Hypertension.
Imitrex Oral Tablet 100 MG	Severe Hypertension	Not recommended	Imitrex Oral Tablet 100 MG is not recommended in Hypertension. Since Severe Hypertension is a more specific form of Hypertension, the same precaution may apply.
Imitrex Oral Tablet 100 MG	Moderate to Severe Hypertension	Not recommended	Imitrex Oral Tablet 100 MG is not recommended in Hypertension. Since Moderate to Severe Hypertension is a more specific form of Hypertension, the same precaution may apply.
Imitrex Oral Tablet 100 MG	Paradoxical Pressor Response	Not recommended	Imitrex Oral Tablet 100 MG is not recommended in Hypertension. Since Paradoxical Pressor Response is a more specific form of Hypertension, the same precaution may apply.

Source: EMR Automated System Alerts – eClinicalWorks, 2014

Data Collection

All data were collected from the electronic medical records. Each patient's medication record was reviewed to collect the number of alerts produced by the EMR medication automated trigger system for each severity category of drug-drug and drug-disease interactions. Again, drug-food and drug-alcohol interactions were not collected. Demographic information such as age and gender were also collected. However patient's name or diagnosis, and other information that may identify the patient were not used during data collection in order to protect the human subject and maintain patients' confidentiality. The IRB approval number for this study is 05-04-15-0381390.

Data Analysis

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 18.0. First, correlation analysis was used to determine the existence of a relationship between the dependent variables (major drug-drug interactions, moderate drug-drug interactions, major drug-disease interactions, and moderate drug-disease interactions) and the independent variables (age and total number of medications). Gender, which is a dichotomous variable, was initially included in the analysis by coding (female = 0, male = 1) as dummy variable and then excluded from the second analysis. Both analyses yielded similar results so I chose to use the second analysis. Finally, a multiple regression analysis was used to determine the effect of the independent variables on the dependent variables and to test the hypothesis.

Summary/Conclusion

The objective of this study was to determine the relationship between the total number of medication taken by the elderly aged 65 and older and the severity of drug-drug interactions and drug-disease interactions by utilizing the EMR automated trigger system which has the capacity to alert clinicians of the severity of these interactions. Therefore HIT with it innovative capabilities such as the EMR automated trigger system can assist clinicians in eliminating medications with potential adverse events, thereby decreasing polypharmacy at the point of care.

Section 4: Findings and Recommendations

Introduction

This section describes and analyses the data collected and presents the results relating to the research hypothesis. A correlation analysis was used to determine the existence of a relationship between the dependent variables (major drug-drug interactions, moderate drug-drug interactions, major drug-disease interactions, and moderate drug-disease interactions) and the independent variables (age and total number of medications). Gender which is a dichotomous variable was initially included in the analysis by coding (female = 0, male = 1) as dummy variable and then excluded from the second analysis. Both analysis yielded similar results, so I chose to use the second analysis. Finally, a multiple regression analysis was used to determine the effect of the independent variables on the dependent variables and to test the hypothesis.

Results

Samples: A total of 497 medication records of all patients 65 and older were first selected and reviewed from a single EMR system from one primary care office. The selected medication records were manually reviewed to select patients' medication records that met the inclusion criteria to be used in the study. Out of 497 records, 247 charts met the inclusion criteria and were selected for the study. The final sample size was N = 247, which is about 49.7% of the target population. The explanation for the remaining 250 records (50.3%) that did not meet the inclusion criteria were mostly patients coming for immigration physical and travel medicine consultations who were not required to complete their medication history.

Demographics: The demographics of the study sample (*n* = 247) (Table 4) ranged in age from 65-98 years. Females (*n* =179) encompassed 72.5% of the samples. Males (*n* = 68) comprised 27.5% of the sample. Total number of medications used ranged from two-27 medications, with 177 (71.7%) patients using two-nine medications, and 70 (28.3%) used 10 or more medications, which is considered excessive polypharmacy.

Table 4

Sample Demographics

Sample (%)		Number of Sample N = 247	Percentage of N = 247
Age	65-75	151	61.1
	76-86	73	29.6
	>86 to 98	23	9.3
Gender	Male	68	27.5
	Female	179	72.5
Total # of Med	2-9	177	71.7
	10 & more	70	28.3

Table 5

Descriptive Statistics for Study Variables

Variable	Mean (M)	Standard Deviation (SD)	N
Age of Patients	74.41	7.589	247
Total Number of Medications	7.41	5.170	247
Major Drug-Drug Interactions	0.40	1.139	247
Moderate Drug-Drug Interactions	1.83	2.687	247
Major Drug-Disease Interactions	1.34	3.344	247
Moderate Drug-Disease Interactions	18.77	28.220	247

A summary of the descriptive statistics for the study variables is shown above. Age of patients studied ranged from 65 to 98 years (M= 74.41, SD= 7.6) (Tables 4 and 5). Total number of medications taken by patients ranged from 2-27 (M=7.41, SD= 5.170) (Tables 4 and5). The highest number of interactions produced by the EMR automated trigger system came from moderate drug-disease interactions (M= 18.77, SD= 28.220) (Table 5). Major drug-drug interactions has the lowest number of interactions (M= 0.40, SD= 1.139) (Table 5). Moderate drug-drug and major drug-disease interactions were closed in the number of interactions produced (M= 1.83, SD= 2.687 and M= 1.34, SD= 3.344, respectively) (Table 5).

Table 6

Summary of Correlations Analysis of Independent Variables and Dependent Variables (N=24)

Independent Variables	Dependent Variables	Pearson *r*	p-value
Age	Major drug-drug	-.032	.620
Total # of Med	Major drug-drug	.240	.000**
Age	Moderate drug-drug	-.059	.357
Total # of Med	Moderate drug-drug	.596	.000**
Age	Major drug-disease	.039	.543
Total # of Med	Major drug-disease	.464	.000**
Age	Moderate drug-disease	-.054	.398
Total # of Med	Moderate drug-disease	.669	.000**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The Pearson correlation statistics revealed that as the number of medication increased, major drug-drug, moderate drug-drug, major drug-disease and moderate drug-disease interactions also increased (*r = 0.240, p = 0.000; r = .596, p = 0.000; r = 464, p = 0.000; r = 669, p = 0.000,* respectively). Therefore, the findings are significant. The Pearson correlations (*r* = -0.032, -0.059, 0.39, -0.054) do not depict significant relationship between age and major drug-drug, moderate drug-drug, major drug-disease, and moderate drug-disease interactions (table 6).

Table 7

Summary of Regression Analysis Using Age and Total Number of Medications as Independent Variables and Major drug-drug, Moderate drug-drug, Major-drug disease, and Moderate drug-disease as Dependent Variables.

	ANOVA MODEL	Sum of Squares	df	Mean Square	F	Sig.	R	R^2	Adj. R^2	Std. Error of Est.
Major Drug-Drug	Regression	18.906	2	9.453	7.678	.001	.243	.059	.051	1.110
	Residual	300.414	244	1.231						
	Total	319.320	246							
Mod. Drug-Drug	Regression	640.661	2	320.305	68.823	.000	.601	.361	.355	2.157
	Residual	1135.584	244	4.654						
	Total	1776.194	246							
Major Drug-Disease	Regression	594.546	2	297.273	33.629	.000	.465	.216	.210	2.973
	Residual	2156.887	244	8.840						
	Total	2751.433	246							
Mod. Drug-Disease	Regression	88755.286	2	44377.64	101.05	.000	.673	.453	.449	20.96
	Residual	107157.094	244	439.168						
	Total	195912.381	246							

	Coefficients	Unstandardized Coefficients		Standardized Coefficients				
		B	Std. Error	Beta	T	Sig.	95% CI LB for B	95% CI UB for B
Major Drug-Drug	(Constant)	.439	.702		.625	.533	-.944	1.821
	Total No. of medications	.053	.014	.241	3.885	.000	.026	.080
	Age of Patient	-.006	.009	-.039	-.623	.534	-.024	.013
Mod. Drug-Drug	(Constant)	1.535	1.365		1.125	.262	-1.153	4.223
	Total No. of medications	.311	.027	.598	11.676	.000	.258	.363
	Age of Patient	-.027	.018	-.076	-1.486	.139	-.063	.009
Major Drug-Disease	(Constant)	-1.718	1.881		-.914	.362	-5.423	1.987
	Total No. of medications	.300	.037	.463	8.172	.000	.228	.372
	Age of Patient	.011	.025	.026	.450	.653	-.038	.060
Mod. Drug-Disease	(Constant)	11.903	13.26		.898	.370	-14.21	38.02
	Total No. of medications	3.664	.259	.671	14.170	.000	3.154	4.173
	Age of Patient	-.273	.176	-.073	-1.549	.123	-.620	.074

In the regression analysis summary (Table 7), the effects of independent variables on the dependent variables are summarized. The number of medications explains only 5.9 % (r^2= .059) of the variations in the major severity level of drug-drug interactions. This result was unexpected because 94% of the variation in major drug-drug interactions cannot be explained by the total number of medications. Total number of medications is significant at (p =0.001). Age was not significant. For beta coefficients, the total number of medications is nearly six times as much weight as age in predicting major drug-drug interactions. The number of medications also explains 36.1% (r^2= .0361) of the variations in the moderate severity level of drug-drug interactions. The number of medications was significant at p-value of 0.000. Age was not significant. Like major drug-drug interactions, moderate drug-drug interactions are not significantly related with age. In comparing beta coefficients, the total number of medications has eight times as much weight on moderate severity of drug-drug interactions as age. The number of medications also explains only 22.0% (r^2= .216) of the variations in the major severity of drug-disease interactions. Total number of medications was significant at p-value of 0.000. Beta values, or in comparing coefficients, the total number of medications is nearly 18 times a stronger predictor than age. That means total number of medications has 18 times as much weight or impact as age in predicting moderate severity of drug-disease interactions. The number of medications explains nearly 45.3% (r^2= .453) of the variations in the moderate severity level of drug-disease interactions. Like other interactions in the sample, the total number of medications is significant predictor of moderate drug-disease interactions. In comparing the coefficients, total number of medications has nine times as much weight as age in predicting moderate severity level of drug-disease interactions.

Discussion

The results of the analysis consistently revealed a positive correlation between the number of medications and the severity levels of drug-drug or drug-disease interactions. Correlation statistics revealed that as the number of medication increased, the severity level of each interaction increased. The number of medications had the strongest effect on moderate drug-drug and moderate drug-disease interactions, explaining 36.1% (r^2= .0361) and 45.3% (r^2= .453) of the variations respectively. However, while the total number of medications did have a positive correlation with major drug-drug/drug-disease interactions, the effects were not very strong, explaining only 5.9% (r^2= .059) and 22.0% (r^2= .216) of the variations respectively.

Other independent variable (age) showed no relationship with all severity levels of drug-drug and drug-disease interactions throughout the analysis. This was unexpected because according to previous study, advanced in age increases the potential of drug-drug interactions due to age physiologic changes (Cusack, B.J., 2004). Since positive correlation in the analysis is only seen between the number of medications and all severity levels of drug-drug and drug-disease interactions, the hypothesis that there will be a positive relationship between the number of medications and the number of major severity and moderate severity of drug-drug and drug-disease interactions is accepted.

The findings of this study are similar to other previous studies which associated an increase in the number of medications taken by elderly to an increase in drug-drug interactions. For example, three studies found associated the increase number of medications to increase risk of adverse effect or drug-drug interactions. The first study conducted by (Williams, 2002, p. 1917) concluded that “taking only two drugs increases the risk of an adverse effect by 6%, eight medications raise risk by 100%”. The second study conducted by Goldberg, Mabee, Chan, & Wong (1996, p.447), found that “the probability of an ADR increases from 13% for two drugs to 82% for more than seven drugs”. The third study by Frazier (2005, p. 5) reported that “the potential of an ADR nears 100% when 10 medications are use”. Although these studies only examined the relationship between the number of medications and drug-drug interactions without looking at the severity levels of these interactions, they at least pointed to the same conclusion that an increase in the number of medication prescribed is associated with an increase in adverse drug-drug interactions. This study has therefore expanded on this knowledge by looking at the association between the number of medication and the severity of these interactions and concluded that there is a significant positive correlation between the number of medications taken by elderly and the severity levels of drug-drug and drug-disease interactions.

The results of this study also revealed that increase in number of medications does not always result in increase in drug-drug/drug-disease interactions. A number of unusual cases in the data showed the existence of polypharmacy without any or very few corresponding increase in the number of various interactions as one would expect

(Appendix B). For example, a 76 y/o female with 10 medications and a 75 y/o female with eight medications resulted in zero alerts which mean zero drug-drug and zero drug-disease interactions (Appendix B). This raises an important clinical question whether the class of drug combination may be responsible for drug-drug/drug-disease interactions and not always the number of medications taken. Studies have shown that certain classes of drugs more than others often cause adverse reactions in the elderly (Nobel, 2001). Such drugs include but not limited to psychotropics, anti-hypertensives, diuretics, nonsteriod anti-inflammatory drugs (NSAIDS), and corticosteroids, as well as particular drugs, such as digoxin and warfarin (Nobel, 2001). Other drugs to be taken with caution by elderly include anti-cholinergic and sedative/hypnotic agents (may cause changes in mental status), OTC sleep /cold remedies such as Benadryl, H2 receptor antagonists (ranitidine), and beta blockers (atenolol) as they may cause confusion in elderly (Dayer-Bereson &Martinez, 2008). This therefore revealed the need for exploration of the implications of the study.

Implications

This study showed no relationship between age and the various severity levels of drug-drug/drug-disease interactions as one would expect and as found in literature. Therefore further research is needed to explore why no relationship exist between age and drug-drug/drug-disease interactions in elderly population aged 65 years and older. Another profound result of this study that needs further research is the existence of polypharmacy without any corresponding increase in drug-drug/drug-disease interactions. Polypharmacy in elderly has remained a major problem for NP practice. Therefore, the ability to utilize health information technology to determine the association between the number of medications and the severity of drug-drug and drug-disease interactions should guide the NP in quality improvement initiative planning that will chart the course of change in the way providers prescribe to this population. The process of completing this study has also exposed some organizational factors such as time constraint and demand for efficiency that sometimes act as barriers to full utilization of the available health information technology (HIT) in improving quality of care. These two factors require an organizational approach and a transformative leadership to chart the course for change.

Recommendations

NP practice should ensure full utilization of the EMR automated trigger system which has the capability of alerting prescribers of potential drug-drug and drug disease interaction. Since this study has shown that polypharmacy does not always result in drug-drug/drug-disease interactions, implementation of initiative to examine the evidence relating to the effect of drug class on potential interactions is needed. As time constraint continues to present a major barrier to full utilization of EMR automated trigger system at the point of care, an evaluation of the usefulness of existing toolkit and development of a toolkit to assist prescribers to know which classes of medications to be eliminated in elderly or which combination of medications that should not be prescribed to this population is recommended. Every NP in primary care with HIT should lead in evaluation of the EMR automated trigger system to determine classes of medications that caused the alerts and review the evidence-based recommendations to determine safer alternatives. NP collaboration with physician, pharmacy, and other stakeholders in designing any clinical tool that will assist clinicians to stop or change medications with potential adverse events when prescribing for elderly will ensure sustainability of such initiative. Primary care providers should find a way to utilize the available clinical tools, such as the BEERS, STOPP and START criteria, and to incorporate these criteria into the toolkit, which can be used as part of orientation to the EMR system utilization for newly hired providers. The targeted class of medications should be those that trigger major drug-drug or major drug-disease interactions to eliminate or not start them on elderly. Safer alternatives should also be created for these classes of medications if they cannot be avoided. These should be available to providers inside the toolkit so that it will eliminate time the providers could have used to search for alternatives before prescribing.

In order to overcome some of the usability challenges facing health information technology implementation, NPs should be aware of the principles of HIT usability so that they can give input in the design selection, testing, training end user, and implementation process where it affects end users and patient care. Before any system is selected, the clinicians should be involved early in the project with system requirements development and system selection.

Primary care NPs should explore the potential benefits of increase in visit time from 15 minutes to 30 minutes for elderly population to give the providers ample time to review patient's medications, review the EMR automated trigger system for any potential drug-drug or drug-disease interactions, and review evidence-based recommendations before writing medications for the elderly. NP should take the leadership role in implementing these changes as they are in a unique position to provide leadership in the evaluation of the health information system to determine how to use it to eliminate inappropriate prescribing. This may involve employing collaborative and leadership skills to create change in the prescribing culture of clinician that has proven to be detrimental to the elderly population.

Strength and Limitations

Strength: The significance of this project is the ability to cause improvement of care delivery in primary care settings. This project has led to evaluation of this organization's current EMR system for the first time. The evaluation exposed system failure which has therefore resulted in two ongoing quality improvement initiatives: increase in office visit time for elderly from 15 to 30 minutes and the development of a toolkit to assist clinicians eliminate inappropriate and unnecessary prescription at the point of care. In moving forward, the goal is to achieve a total practice transformation through HIT application by meaningfully using the evidences that are already there to produce a better, safer, more efficient, cost effective care to the elderly population.

Limitations: This project is limited to one particular primary care office and a single EMR system, which may affects the result. Therefore, further research needs to be conducted using multiple healthcare organizations and EMRs. Sample size may also be a limitation. A small sample size was used which may affect the results.

Analysis of Self

As scholar: The process of completing this project has allowed me to develop as a scholar through the tedious and elaborate process that causes one to engage in development of a final project (Capstone). This process exposed me to important areas of being a successful DNP scholar which involve critical analysis, synthesis of literature, and application of theory and research to nursing-practice problem in any practice setting. At the completion of this process, I can truly see how much I have grown and actually embrace research as part of my continuous education goals. Since the inception of the program, I have gotten involved in collection of data from my practice for our nursing organizations and colleagues who are engaged in one research project or the other. I have also mapped out plan to continue this project as future goals after graduation.

As practitioner: The DNP project process and the DNP program as a whole as increased my skills as a clinician. Practicing based on evidence is no longer optional for me but an obligation I have since cultivated in order to provide my patients the best possible care. One example of this development is in the area of health information system application. Before the start of this program, the electronic health record system was nothing but another tool I thought was given to us to increase our workload. However, through the practicum experience I soon discovered how much we have missed in not fully utilizing and meaningfully using the EMR system as it was intended. The exposure through the DNP project/practicum process has led to not only evaluation of this system for the first time since its inception, but also exposure to the flaws in the system. This in turn led to the development of two ongoing quality improvement initiatives that if successfully implemented have the potential to produce a better, safer, more efficient, cost effective care to the elderly population.

As Project developer: The process of conducting a DNP project has increased my knowledge in the areas of need assessment, strategy mapping, data collection and analysis. Methodology that was used in conducting need assessment for decreasing polypharmacy in elderly included using resource inventories. This involved mapping strategy to gather all information to identify every agency or stakeholder that provided services directly or indirectly to this population such as the pharmacists, specialists, home health agencies, EHR vendors. This progress therefore increased my communication and leadership skills which was helpful in getting my organization embraced change which would ultimately improve outcomes for this target population.

What does this Project mean for future professional development?

The experience gained from this project has opened my vision about future projects and research work that I planned to embark on in the future. With the DNP preparation, I now have a firm grasp of how to be a catalyst for change which is required in our fast changing health care delivery system. As the nation's healthcare delivery system changes, so is the demand on DNP- prepared nurses who are in a unique position to rethink and re-evaluate many processes in both micro and macro levels, plan and implement interventions that would not only impact the system positively but also lead to improve patient outcomes.

Summary and Conclusion

The findings of this study are similar to other studies revealing the association between increased number of medications and drug-drug/drug-disease interactions. This study has added to research knowledge on polypharmacy by showing a positive correlation between the number of medications and the severity level of each interaction. Therefore, health information technology with its innovative capabilities such as the

EMR automated trigger system potentials in decreasing medication errors, increasing safety, improving care coordination may not be realized until healthcare organizations fully take advantage of its capabilities and meaningfully use it at the point of care as it was intended. With the capability of the EMR automated trigger system in alerting prescribers of the potential drug-drug, drug-disease, drug-food, and drug-alcohol, a prescriber therefore can utilize its evidence-based recommendations in prescribing safely thereby eliminating drug combinations with potential adverse drug interactions.

The following clinical tools are also available in assisting providers in reducing the risk of drug-drug interactions: The BEERS, STOPP and START criteria. The Beers criteria are accessible on the American Geriatrics Society website at http://www.americangeriatrics.org. They can also be printed as a pocket card and downloaded as a smartphone app by providers to be used at the point of care. The STOPP criteria are designed to be used in tandem with the START (screening tool to alert doctors to right treatment criteria (Ryan, O'Mahony, Kennedy, Weedle, & Byrne, 2009). Both are available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2810806/.

Section 5: Scholarly Product

A Project Summary and Evaluation Report

Title

Polypharmacy, the Electronic Medical Record, and Adverse Drug Events

Introduction

The advent of health information technology (HIT) has played a critical role in the advancement of the U.S. health care delivery system and medication safety. HIT has the potential to improve medication safety and decrease adverse drug events in elderly 65 years and older who are at risk for polypharmacy. Decreasing polypharmacy needs utilization of HIT innovative capability, EMR automated trigger system at the point-of-care. The EMR automated trigger system alerts the providers of the potential drug-drug interactions, drug-food interactions, drug-disease interactions, and drug-alcohol interactions. There is increased in use of electronic medical records in the U.S. since the introduction of the government incentive money, although still behind other developing nations like the Netherland and United Kingdom (Figure 1).

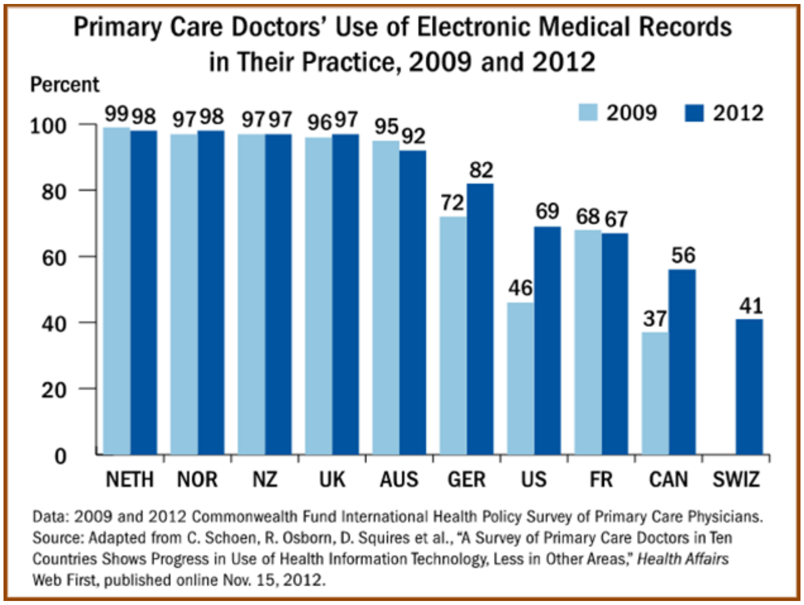

Figure 1

One of the major practice issues facing NP practice in primary care is the relatively high incidence of polypharmacy in elderly individuals aged 65 years and older. Elderly seen today in primary care settings come in with brown bags or grocery bags full of not just prescription medications, but also over-the-counter (OTC) and herbal medications. Many of these elderly have to rely on their primary care providers to review these medications and give them direction on how to self-manage these medications to avoid potential adverse-reaction. Primary care NPs are therefore in a unique position to monitor and potentially eliminate adverse effects of a complex medication regimen and decrease incidence of polypharmacy in the elderly population by taking advantage of the EMR automated trigger system to eliminate inappropriate and unnecessary medications during office visits.

The purpose of this project therefore was to investigate the relationship between the total number of medication taken by elderly 65 years and older and the severity of drug-drug interactions and drug-disease interactions using the EMR automated trigger system. There are two levels of severity of drug-drug interactions and two levels of severity of drug-disease interactions as triggered by the EMR automated trigger system. These severity levels are color-coded as: major (red color-code) and moderate (orange color-code) drug-drug or drug-disease interactions (Figure 2).

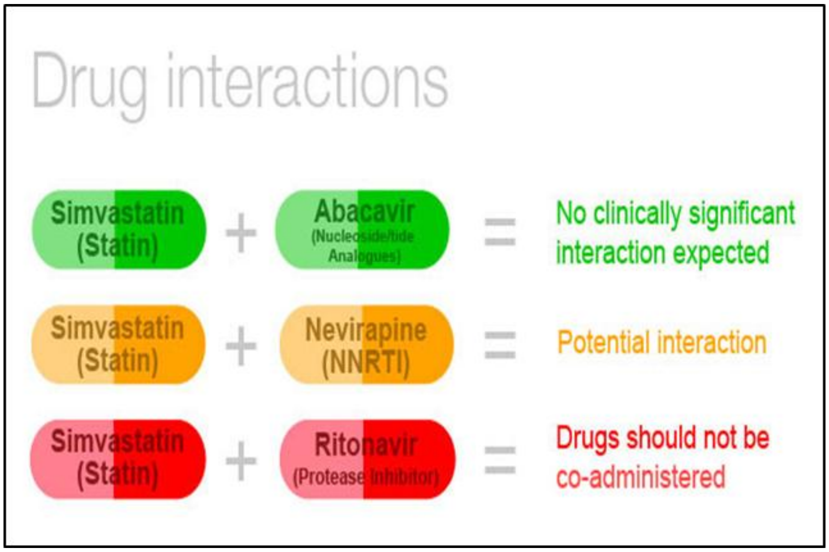

Figure 2: Drug-Drug Interaction Triggers

Literature Review

The relatively high incidence of polypharmacy in elderly aged 65 years and older is one of the clinical problems facing NPs' practice in primary care today. Many researches have shown that our elderly patients are receiving several prescriptions from different physicians which may increase their risk for adverse drug events (Weng, Tsai, Sheu et al., 2013; Junius-Walker, Theile, & Hummers-Pradier, 2007). "The elderly make up less than 15% of the U.S population; they use about 30% of all prescribed medications and 40% of the OTC drugs" (Johnston, 2007, p.259). "Older individuals account for > $3 billion in annual prescription drug sales; 61% of elderly are taking one prescription drug, and most of them take an average of 3 to 5 medications, and nearly 46% of all elderly individuals admitted to hospitals in the United States may be taking seven medications" (Terrie, 2004, p.1). Adverse drug-related events (ADREs) present a challenging and expensive public health problem (Hohl et al., 2001). They account for 3% to 23% of hospital admissions, prolonged hospital stays, and increase morbidity and mortality (Classen et al., 1997). Other clinical consequences of polypharmacy include non-adherence, increased risk of hospitalizations and medication errors (Rollason et al., 2003).

Institute of Medicine (IOM, 2006, p.10) chasm series also recommended to health care organizations to "take advantage of the latest information technologies" in improving medication safety, hence the significance of this project. Studies have shown that increased safety would result mostly from the alerts or triggers or reminders generated by the EHR systems for medications (Center for Medicare Advocacy, 2009). Rand reports estimated that if hospital used an HIT system with electronic prescribing, around 200, 000 adverse drug reactions could be eliminated each year, with annual savings of about $1 billion (Center for Medicare Advocacy, 2009).

Methodology

This study required an IRB approval which was obtained before data collection. A correlative study design was adopted for this study. Data collection was done in one primary care setting with over 400 elderly patients 65 years and older with a single EHR system. Inclusion criteria included all elderly 65 years and older taking two or more medications (prescribed/OTC). A total number of medication records that met the inclusion criteria were 247. A data collection form which included three independent variables: number of medications, age and gender; and four independent variables: major drug-drug interactions, moderate drug-drug interactions, major drug-disease interactions, and moderate drug-disease interactions was created and used in recording the data. All data were collected from the patients' electronic medication records after removing patient's identifiers such as name, address, and diagnosis in order to protect the human subject and maintain patients' confidentiality. The number of alerts produced by the EMR medication automated trigger system for each severity category of drug-drug and drug-disease interactions was obtained.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 18.0. First, correlation analysis was used to determine the existence of a relationship between the dependent variables (major drug-drug interactions, moderate drug-drug interactions, major drug-disease interactions, and moderate drug-disease interactions) and the independent variables (age and total number of medications). Gender which is a dichotomous variable was initially included in the analysis by coding (female = 0, male = 1) as dummy variable and then excluded from the second analysis. Finally, a multiple regression analysis was used to determine the effect of the independent variables on the dependent variables and to test the hypothesis.

Results

Table 6

Summary of Correlations Analysis of Independent Variables and Dependent Variables (N=247)

Independent Variables	Dependent Variables	Pearson *r*	p-value
Age	Major drug-drug	-.032	.620
Total # of Med	Major drug-drug	.240	.000**
Age	Moderate drug-drug	-.059	.357
Total # of Med	Moderate drug-drug	.596	.000**
Age	Major drug-disease	.039	.543
Total # of Med	Major drug-disease	.464	.000**
Age	Moderate drug-disease	-.054	.398
Total # of Med	Moderate drug-disease	.669	.000**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The results of data analysis showed an existence of a positive relationship between number of medication and major drug-drug, moderate drug-drug, major drug-disease and moderate drug-disease interactions (r = 0.240, p = 0.000; r = .596, p = 0.000; r = 464, p = 0.000; r = *669*, p = 0.000, respectively) (table 6). Therefore, the findings were significant. However, the Pearson correlations (r = -0.032, -0.059, 0.39, -0.054) (table 6) did not depict significant relationship between age and major drug-drug, moderate drug-drug, major drug-disease, and moderate drug-disease interactions.

Table 7

Summary of Regression Analysis using Age and Total Number of Medications as Independent Variables and Major drug-drug, Moderate drug-drug, Major drug-disease, and Moderate drug-disease as Dependent Variables

	ANOVA MODEL	Sum of Squares	df	Mean Square	F	Sig.	R	R^2	Adj. R^2	Std. Error of Est.
Major Drug-Drug	Regression	18.906	2	9.453	7.678	.001	.243	.059	.051	1.110
	Residual	300.414	244	1.231						
	Total	319.320	246							
Mod. Drug-Drug	Regression	640.661	2	320.305	68.823	.000	.601	.361	.355	2.157
	Residual	1135.584	244	4.654						
	Total	1776.194	246							
Major Drug-Disease	Regression	594.546	2	297.273	33.629	.000	.465	.216	.210	2.973
	Residual	2156.887	244	8.840						
	Total	2751.433	246							
Mod. Drug-Disease	Regression	88755.286	2	44377.64	101.05	.000	.673	.453	.449	20.96
	Residual	107157.094	244	439.168						
	Total	195912.381	246							

The results of the regression analysis also consistently revealed a positive correlation between the number of medications and the severity levels of drug-drug or drug-disease interactions. The results showed that as the number of medication increased, the severity level of each interaction increased. The number of medications had the strongest effect on moderate drug-drug and moderate drug-disease interactions, explaining 36.1% (r^2= .0361) and 45.3% (r^2= .453) of the variations respectively.

However, while the number of medications did have a positive correlation with major drug-drug/drug-disease interactions, the effects were not very strong, explaining only 5.9% (r^2= .059) and 22.0% (r^2= .216) of the variations respectively (table 7). Again, age showed no relationship with all severity levels of drug-drug and drug-disease interactions throughout the analysis. This was unexpected because according to previous study, advanced in age increases the potential of drug-drug interactions due to age physiologic changes (Cusack, B.J., 2004). Therefore, additional study is needed to understand this unusual occurrence.

Evaluation

The evaluation of this study was done in terms of its implications to clinical practice and social change. This study showed no relationship between age and the various severity levels of drug-drug/drug-disease interactions as one would expect and as found in literature. Therefore further research is needed to explore why no relationship exist between age and drug-drug/drug-disease interactions in elderly population aged 65 years and older. Another profound result of this study that needs further research is the existence of polypharmacy without any corresponding increase in drug-drug/drug-disease interactions. A number of unusual cases in the data showed the existence of polypharmacy without any or very few corresponding increase in the number of various interactions as one would expect. For example, a 76 y/o female with 10 medications and a 75 y/o female with eight medications resulted in zero alerts which mean zero drug-drug and zero drug-disease interactions (Appendix B).

Polypharmacy in elderly has remained a major problem for NP practice. Therefore, the ability to utilize health information technology to determine the association between the number of medications and the severity of drug-drug and drug-disease interactions may guide the NP in quality improvement initiative planning that may chart the course of change in the way providers prescribe to this population. For example, the results can be used in development of a toolkit to assist prescribers to know which classes of medications to be eliminated in elderly or which combination of medications that should not be prescribed to this population. The process of completing this study has also exposed some organizational factors such as time constraint and demand for efficiency that sometimes act as barriers to full utilization of the available health information technology (HIT) in improving quality of care. These two factors require an organizational approach and a transformative leadership to chart the course for change. NPs should take the leadership role in implementing changes in their organizations as they are in a unique position to provide leadership in the evaluation of the health information system and employ collaborative and leadership skills to create change in the prescribing culture of clinician that has proven to be detrimental to the elderly population.

Conclusion

The objective of this study was to determine the relationship between the total number of medication taken by the elderly aged 65 and older and the severity of drug-drug interactions and drug-disease interactions by utilizing the EMR automated trigger system which has the capacity to alert clinicians of the severity of these interactions. The findings of this study are similar to other studies revealing the association between increased number of medications and drug-drug/drug-disease interactions. This study therefore has added to research knowledge on polypharmacy by showing a positive correlation between the number of medications and the severity level of each interaction. Therefore HIT with it innovative capabilities such as the EMR automated trigger system can assist clinicians in eliminating medications with potential adverse events, thereby decreasing polypharmacy at the point-of-care if fully utilized as it was intended.

Dissemination

My plan for dissemination this study is to have either a Poster or Podium Presentation during the AANP National Conference likely in 2017. My initial plan was to have a poster presentation during the AANP 2016 national conference at San Antonio, Texas in June. This is no longer possible as I could not meet the date line for abstract submission. AANP conference has offered novice and seasoned researchers alike a wider forum to showcase their work and to network with colleagues in fostering professional growth. Finding the right medium to disseminate research findings is always as important as the research itself. Dissemination of my DNP project is essential for development as a scholar-practitioner and a nurse leader. Being able to contribute to nursing knowledge through dissemination of my DNP project to a wider audience is crucial for my professional development.

References

Ball, M. J., Douglas, J. V., & Walker, P. H. (2011). *Nursing Informatics, where technology and caring meet (4^{th} Ed.).* New York, NY: Springer.

Ballentine, N. H. (2008). Polypharmacy in the elderly: Maximizing benefit, minimizing harm, *Critical Care Nurse Quarterly*, *31*(1), 40-45.

Barat, I., Andreasen, F., & Damsgaard, E. (2001). Drug therapy in the elderly: What doctors believe and patients actually do. *British Journal of Clinical Pharmacology, 51*(6), 615-622.

Bedell, S., Jabbour, S., Goldberg, R., Glaser, H., Gobble, S., Young-Xu, Y. et al. (2000). Discrepancies in the use of medications (electronic version). *Archives of internal Medicine*, *760*(14).

Beers, M. (1997). Explicit criteria for determining potentially inappropriate medication use in the elderly: An update. *Archives of Internal Medicine*, *757*(14), 1531-1537.

Bikowski, R., Ripsin, C., & Lorraine, V. (2001). Physician-patient congruence regarding medication regimens. *Journal of the American Geriatric Society*, 49 (10), 1353-1537.

Boostra, A. & Broekhuis, M. (2010). Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. *BMC Health Services Research, 10,* 231. doi:10.1186/1472-6963-10-231.

Bretherton, A., Day, L., & Lewis, G. (2003). Polypharmacy and older people. *Nurse Times, 99*(17), 54-55.

Bushardt, R. L., Massey, E. B., Simpson, T. W., Ariail, J. C., & Simpson, K. N. (2008).

Polypharmacy: Misleading, but manageable. *Clinical Interventions in Aging, 3*(2), 383-389.

Carlson, J. E. (1996). Perils of polypharmacy: 10 steps to prudent prescribing. *Geriatrics*, *51*(7), 26-32. Center for Medicare Advocacy (2009). Health information technology as a health care reform tool. Retrieved from http://www.medicareadvocacy.org/InfoByTopic/Reform/Reform_09_06.04.HIT.htm#_ednref8

Center for Medicare and Medicaid Services (CMS, 2013). Meaningful Use. Retrieved from http://www.healthit.gov/policy-researchers-implementers/meaningful-use

Classen, D. C., Pestotnik, S. L., Evans, R. S., Lloyd, J. F., & Burke, J. P. (1997). Adverse drug events in hospitalized patients: Excess length of stay, extra cost, and attributable mortality. *Journal of American Medical Association*, *277*(4), 301-306.

Cusack, B. J. (2004). Pharmacokinetics in older persons. *The American Journal of Geriatric Pharmacotherapy*, *2*(4), 274-302.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Dayer-Berenson, L. & Martinez, Y. Q. (2008). Polypharmacy in the elderly, *Nursing Spectrum*, Retrieved from www.ncbi.nlm.nih.gov/pubmed?cmd=Link&db=pubmed...

eClinicalWorks (2013). Retrieved from www.eclinicalworks. com

eClinicalWorks (2014). Retrieved from www.eclinicalworks.com

Edwards, R. & Aronson, J. K. (2000). Adverse drug reactions: definitions, diagnosis, and management. *The Lancet, 356*, 1255-1257.

FDA (2008). Preventable adverse drug reactions: A focus on drug interactions. Retrieved from: www.fda.gov/cder/drugReactions

Fineout-Overholt, E. (2010). Evidence-Based practice, step by step: Critical appraisal of the evidence part III. *American Journal of Nursing*, *110*(11), 43-51

Flaherty, J. H., Perry III, H., Lynchard, G. S., & Morley, J. E. (2000). Polypharmacy and hospitalization among older home care patients: Retrospective chart review. *Journal of Gerontology, 55*(10), 554-559. Retrieved from www.ncbi.nlm.nih.gov/pubmed/11034227.

Fulton, M. M., & Allen, E. R. (2005). Polypharmacy in the elderly: A literature review. *Journal of the American Academy of Nurse Practitioners*, *17*,123–132.

Frazier, S.C. (2005). Health outcomes and polypharmacy in elderly individuals: an integrated literature review. *Journal of Gerontology Nursing*, *31*(9), 4-11. PMID:16190007.

Good, C. B. (2002) Polypharmacy in elderly patients with diabetes. *Diabetes Spectrum*, *15*(4), 240-249. Retrieved from http://spectrum.diabetesjournals.org/content/15/4/240.full

Goldberg, R. M., Mabee, J., Chan, L., & Wong, S. (1996).Drug-drug and drug-disease interactions in the ED: analysis of a high-risk population. *American Journal of Emergency Medicine, 14*(5), 447–450.

Graves, T., Hanlon, J. T., Schmader, K. E., Landsman, P. B., Samsa, G. P., Pieper, C. F.,

& Weinberger, M, (1997). Adverse events after discontinuing medications in Elderly outpatients. *Archives of Internal Medicine*, *157* (19), *2205*–2210.

Hagedorn, S. & Quinn, A.A. (2005). Theory-based nurse practitioner practice: The advanced practice role. Retrieved from www.medscape.com/viewarticle/496718_4

Hanlon, J. T., Weinberger, M., Samsa, G. P., Schmader, K. M., Lewis, I. K., Cowper, P. … Feussner, J. R. (1996). A randomized, controlled trial of a clinical pharmacist intervention to improve inappropriate prescribing in elderly outpatients with polypharmacy. *The American Journal of Medicine, 100*(4), 428-437. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8610730.

Harrington, L., Kennerly, D., Johnson, C., & Snyder, D. A. (2011), Safety issues related to the Electronic Medical Record (EMR): Synthesis of the literature from the last decade, 2000-2009/practitioner application. *Journal of Healthcare Management, 56*(1), 31-43. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21323026.

Hohl, C. M., Dankoff, J., Colacome, A., & Afilalo, M. (2001). Polypharmacy, adverse drug-related events, and potential adverse drug interactions in elderly patients presenting to an emergency department, *Journal of Emergency Medicine, 38*(6), 666-671.

Houser, S. H. & Johnson, L. A. (2008).Perceptions regarding electronic health record implementation among health information management professionals in Alabama: A statewide survey and analysis. *Perspectives in Health Information*

Management, 16(5),6. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18504505/

Hume, A. L. (2005). Safe and effective drug therapy in older adults. *Medical Health, 88*(1), 15-17.

Institute of Medicine (2011). *The future of nursing: Leading change, advancing health.* Retrieved from http://www.iom.edu/~/media/Files/Report

Institute of Medicine (2006). Preventing medication error: Quality chasm series. Retrieved from http://www.iom.edu/Reports/2006/Preventing-Medication-Errors-Quality-Chasm-series. aspx.

Jensen, J., Lundin-Olsson, L., Nyberg, L., & Gustafson, Y. (2002). Fall and injury prevention in older people living in residential care facilities: A cluster randomized trial**.** *Annals of Internal Medicine, 136*(10)**,** 733-741. doi:10.7326/0003-4819-136-10-200205210-00008.

Johnston, C. B. (2007). Drugs and the elderly: practical considerations. USCF Primary Care Lecture Series Website. Retrieved from http://www.ucop.edu/agrp/docs/sf_drugs.ppt#256,1

Jones, B. (1997). Decreasing polypharmacy in clients most at risk. *AACN Clinical Issues, 8*, 627-634. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9392719

Jorgensen T., Johansson S., Kennerfalk A., Wallander M., & Svardsudd K. (2001). Prescription use, diagnoses, and healthcare utilization among the elderly. *Annual Pharmacotherapy, 35*, 1004–*1009.*

Junius-Walker, U., Theile, G., & Hummers-Pradier, E. (2007). Prevalence and predictors of polypharmacy among older primary care patients in Germany. *Family Practice, 24*, 14-19

Jyrkka, J. Vartiainen, L., Hartikainen, S., Sulkaya, R., & Enlund, H. (2006). Increasing use of medicines in elderly persons: A five-year follow-up of the Kuopio 75+ study. *Europian Journal of Clinical Pharmacology, 62*(2), 151-158.

Karsh, B. T. (2004). Beyond usability: Designing effective technology implementation systems to promote patient safety. *Quality and Safety in Health Care, 13*(5), 388-394.

Kaufman, D., Kelly, J., Rosenberg, L., Anderson, T., & Mitchell, A. (2002). Recent patterns of medication use in the ambulatory adult population of the United States: The Slone Survey. *Journal of the American Medical Association*, *257*(3), 337-344.

Larsen, P., & Hoot M.J. (1999). Polypharmacy and the elderly patients (electronic version). *Association of Operating Room Nurses Journal*, *63*(3), 619-625.

Layman, E. J. (2008), Ethical issues and the electronic health record. *Health Care Manager*, *27*(2), 165-176.

Linjakumpu T., Hartikainen S., Klaukka T., Veijola J., Kivela S., Isoaho R. (2002). Use of medications and polypharmacy are increasing among the elderly. *Journal of Clinical Epidemiology*, *5,* 809-817

Montamat, S. & Cusack B. (1992). Overcoming problems with polypharmacy and drug misuse in the elderly. *Clinical Geriatric Medicine, 8(*1), 143–*158.*

Muir, A. J., Sanders, L.L., Wilkinson, W. E., & Schmader, K. (2001). Reducing

Medication regimen complexity: A controlled trial. *Journal of General Internal Medicine, 16*(2), 77-82.

Phillips, J., Beams, S., Brinker, A., Holquist, C., Honig, P., Lee, L. Y., & Pamer, C. (2001). Retrospective analysis of mortalities associated with medication errors. *American Journal of Health-System Pharmacy, 58*(19), 1835-1841.

Polit, D. F. (2010*). Statistics and data analysis for nursing research (2nd ed.).* Upper Saddle River, NJ: Pearson Education Inc.

Prybys, K., Melville, K., Hanna, J., Gee, A., & Chyka, P. (2002). Polypharmacy in the elderly: Clinical challenges in emergency practice: Part 1: Overview, etiology, and drug interactions. *Emergency Medicine Reports*, *23*(11), 145-153.

Rollason, V., & Vogt, N. (2003). Reduction of polypharmacy in the elderly: A systematic review of the role of the pharmacist. *Drugs and Aging, 20,* 817–832.

Routledge, P. A., O'Mahony, M.S., & Woodhouse, K. W. (2004). Adverse drug reactions in elderly patients. *British Journal of Clinical Pharmacology, 57*(2), 121-126. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14748810

Spina, E. & Scordo, M. G. (2002). Clinically significant drug interactions with antidepressants in the elderly. *Drugs and Aging*, *19*, 299-320.

Sullivan, S. D., Kreling, D. H., & Hazlet, T. K. (1992). Noncompliance with medication regimens and subsequent hospitalization: a literature analysis and cost of hospitalization estimate. *Journal of Research in Pharmaceutical Economic, 2,* 19-33.

Steinman, M. A., Landefeld, C. S., Rosenthal, G. E., Berthenthal, D., Sen, S., & Kaboli,

P. J. (2006). Polypharmacy and Prescribing Quality in Older People. The *American Geriatrics Society, 54*(10), 1516–1523.

Swanson K.M. (1991). Empirical development of middle range theory of caring. *Nursing Research, 40*(3), 161-166. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2030995

Tai-Seale, M., McGuire, T. G., & Zhang, W. (2007). Time allocation in primary care office visits. *Health Services Research, 42*(5), 1871-1894. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17850524.

Tamblyn, R., Berkson, L., Dauphinee, W. D., Gayton, D., Grad, R., Huang, A., Isaac, L., McLeod, P., & Snell, L. (1997). Unnecessary prescribing of NSAIDs and the management of NSAIDs-related gastropathy in medical practice. *Annals of Internal Medicine, 127*(6), 429-438.

Terrie, Y.C. (2004). Understanding and managing polypharmacy in the elderly. *Pharmacy Times, 12.* Retrieved from http://www.pharmacytimes.com/publications/issue/2004/2004-12/2004-12-9094

Trotter, J. M. (2001). Geriatric pharmacy issues for rehabilitation. *Topics in Geriatric Rehabilitation*, *17*(2), 1–17. Retrieved from http://www.aafp.org/afp/2002/1115/p1917.html#abstract

United States Department of Health and Human Services (1996). Personal health records and the HIPPA privacy rule. Retrieved from http://www.hhs.gov/ocr/privacy/hipaa/understanding/special/healthit/phrs.pdf

United States Department of Health and Human Services. (2000). *Healthy people 2010*.

McLean, VA: International Medical Publishing.

Veehof, L., Stewart, R., Haaijer-Ruskamp, F., & Meyboom-de Jong, B. (2000). The Development of polypharmacy: A longitudinal study. *Family Practice*, *17* (3), 261-267.

Weng, M. C., Tsai, C. F., Sheu, K. L., Lee, Y. T., Lee , H. C., Tzeng, S. L. … Chen, S. C. (2013). The impact of number of drugs prescribed on the risk of potentially inappropriate medication among outpatient older adults with chronic diseases Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23836694

Werder, S., & Preskorn, S. (2003). Managing polypharmacy: Walking the fine line between help and harm [electronic version]. Current Psychiatry online, *2* (2). Retrieved from http://0-proquest.umi.com.sultan.tnstate.edu.

Williams C.M. (2002). Using medications appropriately in older people. *American Family Physician*, *66*(10),1917-1924.

World Health Organization (WHO, 1992). *International monitoring of adverse reactions to drugs: Adverse reaction terminology.* WHO Collaborating Center for International Drug Monitoring, Uppsala, Sweden.

Wu, J. H., Shen, W. S., Lin, L. M., Greenes, R. A., & Bates, D. W. (2008). Testing the technology acceptance model for evaluating healthcare professionals' intention to use an adverse event reporting systems. *International Journal for Quality in Health Care*, *20*(2), 123-129.

Ziere, G., Dieleman, J. P., Pols, H.A., van der Cammen, T. J. & Stricker, B. H. (2006).

Polypharmacy and falls in the middle age and elderly population. *British Journal of Clinical Pharmacology*, *61*(2), 218-223. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1885000/

Appendices

Appendix A: Sample Data Collection Sheet

Sample of data collection sheet

Chart #	Age	Gender	Total # of med	DD Major (red)	DD Moderate (orange)	DS Major (red)	DS Moderate (orange)
1	75	M	14	1	1	14	28
2	65	F	10	2	8	1	10
3							
4							
5							
6							
7							
8							
9							
10							

Key: DD= drug-drug interactions; DS= drug-disease interactions

Appendix B: Data Collection Form (*N*= *247*)

Age	Gender	Total# of med	DD_Red	DD_Orange	DS_Red	DS_Orange	Gender1
72	F	3	0	11	0	9	1
73	F	4	2	6	0	0	1
65	F	4	1	1	0	0	1
80	F	7	0	0	0	0	1
67	F	4	0	0	0	0	1
78	M	2	0	0	0	0	0
70	F	2	2	2	0	9	1
78	F	23	2	10	2	83	1
73	F	17	0	0	11	51	1
81	M	7	0	0	1	2	0
78	M	2	0	0	0	0	0
79	F	3	0	1	0	0	1
71	F	5	0	0	0	2	1
82	F	8	0	1	0	0	1
76	F	10	0	0	0	0	1
69	F	9	0	0	0	1	1
71	M	2	0	0	0	0	0
70	M	3	0	0	0	0	0
76	F	17	1	0	2	38	1
87	M	6	0	0	0	0	0
69	F	2	0	0	0	11	1
75	F	5	0	3	5	52	1
70	F	14	2	6	0	29	1
85	M	6	0	0	0	0	0
76	F	13	0	0	0	0	1
78	F	13	0	1	5	45	1
76	F	22	0	0	0	0	1
68	F	5	0	0	0	0	1
85	F	13	6	1	10	35	1
70	F	4	0	0	0	0	1
73	M	6	0	0	0	0	0
66	M	4	0	0	0	0	0
67	M	5	0	1	0	14	0
67	F	2	0	0	0	0	1
73	F	2	0	0	0	1	1

72	M	2	0	0	0	0	0
84	F	18	0	0	0	2	1
86	M	7	0	0	0	0	0
73	F	8	0	0	0	0	1
77	F	4	0	0	0	0	1
75	F	5	0	0	0	0	1
71	F	3	0	0	0	7	1
67	F	9	1	0	1	14	1
77	F	7	1	2	2	8	1
87	M	10	0	1	0	6	0
66	F	8	1	4	0	2	1
72	F	2	0	0	0	0	1
66	M	5	0	0	0	36	0
69	M	3	0	6	0	1	0
69	M	5	0	1	0	15	0
66	M	5	0	2	0	0	0
67	F	4	0	0	0	0	1
86	M	8	0	1	0	23	0
74	F	10	0	1	0	0	1
69	F	11	0	0	0	0	1
88	F	15	0	0	0	17	1
67	F	8	1	0	1	14	1
65	F	12	0	2	0	0	1
74	F	10	1	4	0	25	1
84	F	11	2	0	0	15	1
68	M	6	0	0	0	0	0
69	F	10	1	1	0	36	1
84	M	12	4	2	7	58	0
66	F	11	0	0	0	0	1
84	M	6	4	0	0	23	0
85	F	5	0	0	0	0	1
86	F	4	0	0	0	0	1
68	F	13	0	4	1	110	1
87	M	5	0	2	0	4	0
65	F	27	0	6	12	144	1
67	F	14	0	4	0	21	1
80	F	7	0	0	0	18	1
67	F	2	0	0	0	1	1
90	F	3	0	0	1	13	1
69	F	8	0	2	0	2	1

67	F	5	0	0	0	3	1
71	F	8	0	2	0	13	1
70	F	7	0	3	0	29	1
74	F	7	0	0	0	0	1
88	F	6	0	2	0	2	1
66	F	5	0	1	0	5	1
84	F	20	2	6	4	54	1
67	F	4	0	0	0	0	1
76	F	18	1	6	1	74	1
76	M	4	0	0	0	3	0
83	F	5	0	0	0	20	1
69	M	3	0	0	0	0	0
69	F	3	0	0	0	2	1
70	M	2	0	1	0	26	0
70	F	8	1	3	0	43	1
85	M	3	0	0	0	0	0
89	F	13	0	5	5	9	1
78	F	4	0	2	7	15	1
66	M	7	2	5	0	12	0
92	F	5	0	0	0	6	1
89	F	2	0	0	0	0	1
69	M	10	0	5	1	14	0
66	F	7	0	10	12	11	1
71	F	4	0	0	0	10	1
71	M	2	0	0	0	10	0
76	M	8	0	0	0	0	0
72	F	5	0	1	0	0	1
73	M	10	4	7	0	0	0
65	M	3	1	0	0	8	0
65	F	6	0	0	0	5	1
72	F	2	0	0	0	2	1
79	F	8	1	1	0	32	1
71	F	17	2	5	0	0	1
72	F	12	1	4	0	12	1
73	F	10	0	1	9	62	1
66	F	5	0	0	0	32	1
66	M	9	0	1	1	61	0
72	F	2	0	0	0	0	1
68	M	13	1	4	5	108	0
70	F	7	0	0	0	0	1

73	F	10	1	8	3	63	1
66	F	9	0	1	0	8	1
73	M	4	0	2	0	2	0
66	F	3	0	0	0	1	1
71	F	5	0	0	2	0	1
68	F	3	0	0	0	1	1
77	F	8	0	4	0	22	1
83	F	8	0	7	2	43	1
69	M	11	0	1	1	56	0
88	F	2	0	0	0	13	1
71	F	13	2	14	16	67	1
81	F	8	0	4	0	24	1
68	M	3	0	0	1	0	0
66	F	22	0	4	8	53	1
83	F	15	0	3	5	50	1
72	F	3	0	0	0	5	1
79	F	13	1	6	3	32	1
83	F	2	0	0	0	0	1
93	F	12	0	4	2	13	1
66	F	12	0	6	2	54	1
66	M	3	0	0	0	2	0
80	F	2	0	0	0	0	1
71	F	24	1	10	2	82	1
67	F	13	0	2	0	38	1
65	F	8	0	0	0	4	1
69	F	2	0	0	0	10	1
80	F	16	0	13	5	88	1
66	M	5	0	0	0	0	0
70	F	3	0	0	0	5	1
75	F	3	0	1	0	12	1
79	M	23	0	8	12	83	0
76	M	4	1	2	0	0	0
76	F	14	1	4	5	57	1
78	F	3	0	0	0	7	1
76	F	4	0	0	0	3	1
73	F	4	0	2	0	2	1
65	F	4	0	0	0	2	1
65	F	4	0	3	2	10	1
77	F	4	0	0	0	4	1
75	F	8	0	6	0	16	1

68	F	5	2	0	0	14	1
83	F	7	1	2	0	37	1
89	F	5	0	1	0	24	1
68	F	23	1	8	5	113	1
74	F	2	0	0	0	0	1
78	F	2	0	0	0	0	1
95	F	6	1	2	0	2	1
66	F	9	0	1	0	4	1
72	F	5	0	0	0	16	1
67	F	2	0	0	0	20	1
74	M	7	0	1	0	0	0
92	F	10	0	2	16	38	1
70	F	5	0	1	0	22	1
77	M	7	1	4	0	22	0
66	M	2	0	0	0	1	0
66	M	11	0	3	11	17	0
87	M	4	0	0	0	0	0
69	F	4	0	0	0	0	1
87	F	5	0	0	0	19	1
82	F	9	0	4	0	2	1
67	F	11	0	2	0	5	1
72	F	12	0	7	0	0	1
78	F	17	2	9	0	7	1
68	M	10	3	6	0	41	0
66	M	2	0	0	0	0	0
65	F	5	0	2	3	56	1
73	M	2	0	0	0	0	0
73	M	13	0	4	2	50	0
88	F	2	0	0	0	1	1
71	F	3	0	0	0	25	1
69	F	4	0	1	0	0	1
75	F	8	0	0	0	0	1
98	F	2	0	0	0	0	1
85	F	3	0	1	0	14	1
66	F	2	0	0	0	2	1
72	M	10	0	4	14	50	0
74	M	5	0	0	0	43	0
66	F	10	7	3	0	70	1
75	F	3	0	0	0	20	1
68	M	6	10	6	0	13	0

73	M	11	0	8	3	30	0
83	F	14	0	3	0	63	1
66	F	22	5	8	20	164	1
77	M	5	0	1	2	6	0
68	F	18	0	6	0	20	1
74	M	18	0	5	2	48	0
85	F	19	0	5	12	93	1
74	F	12	4	7	2	56	1
70	F	8	0	4	0	11	1
67	M	6	0	0	0	29	0
83	M	4	0	0	0	10	0
85	F	7	0	3	0	17	1
76	M	17	0	5	14	177	0
65	M	2	0	0	1	0	0
66	F	3	0	1	0	6	1
86	F	8	1	0	0	14	1
66	F	4	0	0	0	0	1
75	M	2	0	0	0	0	0
82	F	13	0	0	0	30	1
88	F	3	0	0	0	2	1
90	F	5	0	1	0	2	1
72	F	3	0	0	0	1	1
77	M	7	0	2	0	0	0
66	F	17	1	8	2	28	1
65	F	7	0	1	2	35	1
83	F	10	1	5	12	28	1
75	M	4	1	1	2	16	0
70	F	2	0	0	0	0	1
74	F	4	0	0	0	2	1
68	M	2	0	2	0	0	0
91	F	14	0	2	0	28	1
78	F	7	0	0	1	17	1
83	F	6	0	2	0	12	1
82	M	7	0	2	0	5	0
78	M	3	0	0	0	11	0
77	F	3	0	0	0	0	1
71	F	8	0	3	12	58	1
66	F	2	0	0	0	0	1
68	F	10	1	5	1	9	1
70	M	10	0	1	0	15	0

76	F	3	0	0	0	1	1
65	M	3	0	0	0	0	0
80	M	8	2	3	0	7	0
66	F	7	0	2	0	33	1
83	M	5	0	0	3	23	0
77	M	3	0	0	10	3	0
89	F	3	0	0	0	0	1
67	F	16	0	0	0	80	1
88	F	5	0	0	2	10	1
70	F	7	0	4	0	0	1
79	F	8	0	0	0	48	1
66	F	3	0	0	0	27	1

Key: DD= drug-drug interactions; DS= drug-disease interactions

Appendix C: SPSS Output Correlation

i. Major drug-drug interactions

Correlations

		Age of patient	Total number of medications	Major drug-drug	Recoded gender
Age of patient	Pearson Correlation	1	.029	-.032	.051
	Sig. (2-tailed)		.652	.620	.426
	N	247	247	247	247
Total number of medications	Pearson Correlation	.029	1	.240**	.150*
	Sig. (2-tailed)	.652		.000	.019
	N	247	247	247	247
Major drug-drug	Pearson Correlation	-.032	.240**	1	-.044
	Sig. (2-tailed)	.620	.000		.495
	N	247	247	247	247
Recoded gender	Pearson Correlation	.051	.150*	-.044	1
	Sig. (2-tailed)	.426	.019	.495	
	N	247	247	247	247

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

ii. Moderate drug-drug interaction

Correlations

		Age of patient	Total number of medications	Recoded gender	Moderate drug-drug
Age of patient	Pearson Correlation	1	.029	.051	-.059
	Sig. (2-tailed)		.652	.426	.357
	N	247	247	247	247
Total number of medications	Pearson Correlation	.029	1	.150*	.596**
	Sig. (2-tailed)	.652		.019	.000
	N	247	247	247	247
Recoded gender	Pearson Correlation	.051	.150*	1	.067
	Sig. (2-tailed)	.426	.019		.291
	N	247	247	247	247
Moderate drug-drug	Pearson Correlation	-.059	.596**	.067	1
	Sig. (2-tailed)	.357	.000	.291	
	N	247	247	247	247

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

iii. Major drug-disease interaction

Correlations

		Age of patient	Total number of medications	Recoded gender	Major drug disease
Age of patient	Pearson Correlation	1	.029	.051	.039
	Sig. (2-tailed)		.652	.426	.543
	N	247	247	247	247
Total number of medications	Pearson Correlation	.029	1	.150*	.464**
	Sig. (2-tailed)	.652		.019	.000
	N	247	247	247	247
Recoded gender	Pearson Correlation	.051	.150*	1	.006
	Sig. (2-tailed)	.426	.019		.928
	N	247	247	247	247
Major drug disease	Pearson Correlation	.039	.464**	.006	1
	Sig. (2-tailed)	.543	.000	.928	
	N	247	247	247	247

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

iv. Moderate Drug-Drug Correlation

Correlations

		Age of patient	Total number of medications	Recoded gender	Moderate drug disease
Age of patient	Pearson Correlation	1	.029	.051	-.054
	Sig. (2-tailed)		.652	.426	.398
	N	247	247	247	247
Total number of medications	Pearson Correlation	.029	1	.150*	.669**
	Sig. (2-tailed)	.652		.019	.000
	N	247	247	247	247
Recoded gender	Pearson Correlation	.051	.150*	1	.047
	Sig. (2-tailed)	.426	.019		.461
	N	247	247	247	247
Moderate drug disease	Pearson Correlation	-.054	.669**	.047	1
	Sig. (2-tailed)	.398	.000	.461	
	N	247	247	247	247

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX D: SPSS REGRESSIONS OUTPUT

i. Major Drug-Drug Interactions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.256[a]	0.065	0.054	1.108

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.886	3	6.962	5.669	.001[a]
	Residual	298.434	243	1.228		
	Total	319.320	246			

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

b. Dependent Variable: Major drug-drug

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.521	.704		.739	.460
	Age of patient	-.005	.009	-.035	-.563	.574
	Total number of medications	.056	.014	.253	4.035	.000
	Recoded gender	-.200	.158	-.080	-1.270	.205

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.521	.704		.739	.460
	Age of patient	-.005	.009	-.035	-.563	.574
	Total number of medications	.056	.014	.253	4.035	.000
	Recoded gender	-.200	.158	-.080	-1.270	.205

a. Dependent Variable: Major drug-drug

ii. Major Drug-Disease Interactions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469a	0.220	0.211	2.971

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	606.426	3	202.142	22.900	.000[a]
	Residual	2145.007	243	8.827		
	Total	2751.433	246			

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

b. Dependent Variable: Major drug disease

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-1.517	1.887		-.804	.422
	Age of patient	.013	.025	.029	.504	.615
	Total number of medications	.306	.037	.473	8.260	.000
	Recoded gender	-.491	.423	-.067	-1.160	.247

a. Dependent Variable: Major drug disease

iii. Moderate Drug-Drug Interactions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.601a	0.361	0.353	2.161

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	641.213	3	213.738	45.761	.000[a]
	Residual	1134.982	243	4.671		
	Total	1776.194	246			

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

b. Dependent Variable: Moderate drug-drug

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.580	1.373		1.151	.251
	Age of patient	-.027	.018	-.075	-1.465	.144
	Total number of medications	.312	.027	.601	11.579	.000
	Recoded gender	-.110	.308	-.019	-.359	.720

a. Dependent Variable: Moderate drug-drug

iv. Moderate Drug-Disease Interactions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.675a	0.456	0.449	20.951

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	89249.503	3	29749.834	67.776	.000[a]
	Residual	106662.877	243	438.942		
	Total	195912.381	246			

a. Predictors: (Constant), Recoded gender, Age of patient, Total number of medications

b. Dependent Variable: Moderate drug disease

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	13.198	13.310		.992	.322
	Age of patient	-.264	.176	-.071	-1.497	.136
	Total number of medications	3.705	.261	.679	14.174	.000
	Recoded gender	-3.165	2.982	-.051	-1.061	.290

a. Dependent Variable: Moderate drug disease