THE ASSOCIATION OF STRUCTURAL AND PROCESS FACTORS WITH MEDICATION ERRORS FOR RESIDENTS ENTERING A NURSING HOME

by

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ABSTRACT

SANDI JEANNE LANE**.** The association of structural and process factors with medication errors for residents entering a nursing home. (Under the direction of DR. JACQUELINE DIENEMANN and DR. JENNIFER TROYER)

Objective: The purpose of the study is to elucidate the relationships and inter-relatedness of specific structure, process, and outcome elements contributing to harmful medication errors for the vulnerable people who reside in nursing homes by exploring the inter-relationships between structure and process factors in relationship to medication errors and medication errors associated with harm.

Methods: The Medication Error Quality Initiative-Individual Error (MEQI-IE) Data for North Carolina nursing homes for FY 2007 was used for analysis. A multivariable model was used which controlled for facility and resident characteristics, phases of the medication use process, reported causes of the error, primary type of error, personnel involved, and number of medications.

Results: Ownership status does not directly impact the number of medication errors reported or a more harmful error being reported. Chain affiliation was found to interact with ownership status; a not-for-profit nursing home that is a member of a chain is predicted to have half the rate of medication errors that a for-profit nursing home that is not part of a chain has. Prescribing errors are associated with harm more often than administering errors during the medication use process; and a dose omission error is less likely to be associated with harm than a wrong dose error.

Conclusions: Over two-thirds of the nursing homes reported a medication error during the first seven days of a resident's admission. Chain affiliation interacts with ownership status and is associated with a decrease in incidence rate of reported

medication errors. Medication errors during the administration phase account for one third of the errors, but prescribing errors, which account for only 4.8% of all errors, are associated with more harmful events. Wrong dose errors are associated with harm twice as often as dose omissions even though dose omissions were reported in over one third of the errors. Almost one half of the wrong dose errors occurred during the documenting phase with 42.7% a recording issue. The processes surrounding and related to documentation and recording of the medication use process are critical to medication safety for residents during their first seven days of admission into the SNF.

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CHAPTER 1: INTRODUCTION

Specific Aims

Older adults are especially susceptible to adverse drug events due to their frail condition, multiple physical and cognitive aliments, complex drug regimens and frequent transitions throughout the health care continuum. Documented adverse drug events with individuals 65 years of age or more were 25.3% of all emergency department visits. Of those adverse drug events requiring hospitalization, 48.9% involved those 65 and older[1]. Brennan et al. reported that residents 65 or older had greater than twice the risk of an adverse drug event than residents 16-44 years of age[2].

These findings are of added importance as older persons, those age 65 and over, are a growing proportion of our population. Population projections indicate that in 2010, 13% of the US population will be 65 and older and by 2050 this will increase to 20%[3]. Of the almost 1.5 million people living in nursing homes in 2004, 1.3 million were over 65 years of age with women out numbering men two to one; 174,100 of the 1.3 million were 65-74, 468,700 were aged 75-84, and 674,500 were over 85 years of age[4].

Many of those aged 65 and over will have at least one nursing home admission. The five leading nursing home admission diagnosis were diseases of the circulatory system (23.7%), mental disorders (20.6%), diseases of the nervous system and sense organs (14%), Alzheimer's disease (8.5%), and heart disease (8.3%)[5]. A nursing home is a long-term care facility certified by Medicare and Medicaid that provides skilled nursing

services, often times referred to as a skilled nursing facility (SNF).

Considerable research and attention has been focused on medication errors in the acute care setting, much less effort has been focused on errors in long-term care settings. Yet, North Carolina SNFs report 13,551-15,145 medication errors and potential medication errors (circumstances or events that have the capacity to cause an error[6]) each year[7-9]. More importantly, studies estimate that approximately 800,000 preventable adverse drug events occur in U.S. long-term care facilities annually with an estimated 350,000 in SNFs[10].

Studies of medication errors in SNFs have identified the transition period at initial admission, re-admission after a hospitalization or when changing medical providers as particularly risk prone[11, 12]. Upwards of 46% of medication errors occurred during transition between levels of care or providers, a time when orders are frequently updated and changed[13]. This period is vulnerable to medication errors primarily due to poor communication between care teams[14-16].

Consideration of resident level medication error data in the context of a modified Donabedian model of structure, process, and outcome (SPO) would provide an opportunity to evaluate the degree of adjacent interactions, as well as the proportion of root causes of errors due to structure, process or the interaction between the two. For example, although structure can impact process and directly impact outcome, it does not ensure specific processes take place nor specific outcomes occur.

Previous nursing home research using the structure variable of profit status found that for-profit SNFs provide lower quality care[17-23]. This study will examine if this results in residents in for-profit SNFs experiencing more medication errors and more medication

errors associated with harm than residents in not-for-profit SNFs using a cross sectional analysis of medication errors from North Carolina.

Hypothesis 1a: For-profit nursing homes will report a higher rate of medication errors during the seven days following admission than not-for-profit nursing homes.

Hypothesis 1b: A harmful medication error is more likely to be reported by a for-profit nursing home than not-for-profit nursing home during the seven days following admission.

Previous nursing home studies of process variables include adequacy of care plans, use of restraints[24, 25], urinary catheters[26, 27], feeding tubes[28] and the medication use process[29-31]. Studies of medication errors during the various phases of the medication use process indicate variable results regarding the relationships between process measures and medication errors. However, several studies indicate that 34-55 % of the errors occurred during administration of the medication use phase[8, 9, 29-31].

Hypothesis 2: Medication errors are more likely to be harmful when administering is reported as the medication use phase compared to any other phase in the medication use process during the seven days following admission.

Studies of the primary medication error type indicate dose omission is often the primary error type (23%-53% of errors), often followed by wrong dose (7%-21% of errors)[8, 29-31]. We theorize that wrong dose (under dose or over dose) is more likely to do harm than omitting a dose or other type of medication error.

Hypothesis 3: Medication errors are more likely to be harmful when wrong dose is reported as the error type compared to any other type of error during the seven days following admission.

The purpose of the study is to elucidate the relationships and inter-relatedness of specific SPO elements contributing to harmful medication errors for the vulnerable people who reside in SNFs. Toward this end, this study will explore the inter-relationships between structure and process factors in relationship to medication errors and medication errors associated with harm. These findings, it is hoped, will contribute to identification of opportunities for improvements in systematic processes of medication use. For many of these residents an adverse drug event contributes to a downward cascade of health, making prevention of the utmost importance[32, 33].

CHAPTER 2: LITERATURE REVIEW

Background and Significance

The Institute of Medicine defines a medical error as "the failure of a planned action to be completed as intended (i.e, error of execution) or the use of a wrong plan to achieve an aim (i.e, error of planning)"[34]. Medical errors may cause injury and may also result in costly medical care and human suffering. Adverse events are limited to when injury occurs from a medical error or there is an idiopathic patient response that is harmful. Brennan and associates defined adverse events as an injury caused by medical management as opposed to the disease process [2].

Previous studies of medication safety and adverse drug events in SNFs have evaluated the prevalence of medication errors, use of inappropriate medications for the older adults [35-38], categories of medications involved[10, 33, 39-41], contributing risk factors[10, 39, 42-46], impact of monitoring and medication reconciliation programs[39, 42, 47], and adverse drug events during resident transfers between hospitals and nursing homes.

Using data from the 1996 Medical Expenditure Panel Survey Nursing Home Component, Lau et al. reported at least 50% of all residents aged 65 and older received at least one potentially inappropriate medication during a three month nursing home stay [38]. The criteria used most often to assess medication appropriateness was published by Beers and colleagues in 1991 and updated in 1997 [48, 49]. Beers himself reported 40% of

residents in nursing homes received at least one potentially inappropriate medication [50]. A study conducted in 15 Georgia nursing homes identified 519 (46.5%) patients received at least one inappropriate medication and 143 experienced an adverse health outcome [51]. A study of inappropriate prescribing before and after nursing home admission found residents receiving at least one inappropriate drug decreased from 25.4% before admission to 20.8% after admission [35]. Nursing homes reporting potentially inappropriate medications among their 10 most common medication errors also reported a greater number of medication errors [41].

Medication error and adverse drug event studies in nursing homes report conflicting findings for the most prevalent drugs and drug classes involved in medication errors. North Carolina nursing homes reported warfarin, horazepam, insulin, and hydrocodone as the drugs most frequently involved as medication errors for the four year period 2004-2007[8, 52]. Two recent (2001 & 2003) studies report similar findings of central nervous system, anticoagulants, and electrolytic, caloric and water balance agents, drugs as the most prevalent class of drugs involved in adverse drug events or medication errors [10, 29]. Whereas, findings from earlier (1991-1995, 1988-1989) studies identified cardiovascular drugs and central nervous system drugs as the most frequently reported [43, 46, 47]. Another study reported diuretics and anticoagulants as the drug categories most frequently involved in adverse drug events [42]. Differences in data collection methods and year when the study occurred contribute to the variation in the most prevalent class reported. The earlier studies used chart reviews whereas, the more recent studies interviewed staff in addition to chart reviews. Substantial changes in pharmaceutical

regimes and new drug development along with increased resident acuity also contribute to the differences in study results.

Studies of risk factors contributing to a medication error or adverse drug event pinpoint a number of potential risk factors. For instance, an early study identified age, being female and an increase in the number of medications as risk factors for an adverse drug event [47]; few other subsequent studies found age or gender to be risk factors [42-46]. Many studies identified an increase in the number of medications or medications from multiple drug classes [10, 43-47], an increase in the number of medical diagnoses [45, 46], being a new resident [44] or recently hospitalized [46], and having experienced a prior adverse drug event [45] as risk factors. Gurwitz et al. identified several drug categories as risk factors for adverse drug events; antipsychotic agents, anticoagulants, diuretics, and antiepileptics [10].

Programs to monitor and reduce adverse drug events indicate their benefit. Soon (1985) implemented a two phase program involving pharmacist medical record review, staff education, and physician communication resulting in fewer drug reactions and fewer residents experiencing more than one reaction. The author attributes the reductions to the education and monitoring program. A multidisciplinary monitoring program implemented in a 465 bed not-for-profit SNF increased the number of adverse drug reactions documented from 21 to 216 in an eighteen month period [42]. Boockvar et al studied the effect of medication reconciliation on return to the nursing home from an acute care stay. The odds of having an adverse drug event were significantly reduced after implementation of medication reconciliation [53]. To improve communication of patient-specific information for new SNF admissions, a group of medical directors implemented a multi-facility communication system which improved the flow of inter-

facility information[54]. Various uses of information technology in acute care indicate benefit in the reduction of medication errors and adverse drug events in long term care[55], including; computerized physician order entry[56-58], on-line decision support systems[59], alert and warning systems for allergies or drug interactions[60], and automating the prescribing process[61].

The transfer process between hospitals and SNFs has been identified as a time of increased risk of an adverse drug event. Field et al. (2001) reported that being a newly admitted resident increased the odds of an adverse drug event by 2.8 (95% CI 1.5-5.2)[44], Gerety et al. (1993) reported similar findings in that hospitalization during the study period was strongly correlated with adverse drug event incidence[46]. Boockvar et al. (2004) studied the iatrogenic harm from medication changes during resident transfer and identified an overall risk of adverse drug event per drug changed to be 4.4%[62].

Studies of medication error and adverse drug event often employ varying methods of error detection due to the variability of error occurrence, differences in definitions, complexity of the medication use process (e.g. administering errors are detected via observation whereas prescribing errors are detected through chart review), and outcome being measured[63]. The chart review method has been used in several research studies including the landmark Harvard Medical Practice Studies I[2] and II[64], Thomas's study of negligent care in Utah and Colorado[65], and many studies smaller in scope[1, 66]. Chart reviews entail retrospective data collection by trained data collectors. In addition to chart reviews other documents such as incident reports and pharmacy logs are reviewed for potential identification of an error or adverse event. Review of submitted incident reports has also been used to evaluate medication error and adverse drug event. MEDMARX is a

voluntary, anonymous, confidential database owned by United States Pharmacopeia where member hospitals report medication errors and can track and share medication error data with other providers in a standardized format. Santell et al. used this method in his analysis of reported medication errors[30, 31] . A third error detection method, observation, is reported to best estimate the true frequency of medication errors especially administration errors[67]. Direct observation entails the observation of preparation and administration of medication to the patient. The observer then compares the dose given to the dose ordered, if there is a difference an error is noted[68]. One study reported that of the 318 medication errors reported using direct observation only 1 was detected by an error report[67]. Studies indicate that underreporting of medication errors has been identified as a significant barrier to improving safety. Osborne et al. reported that nurses believed only 3.5% of medication error are ever reported[69]. Other studies indicate that fear of disciplinary action and job loss are the primary reasons for not reporting an error[69-73].

Some researchers use multiple methods to optimize the identification and collection of medication errors and adverse drug events. For example, Bates et al used incident reports, voluntary verbal reporting by staff to the researcher, and chart reviews to identify adverse drug events and potential adverse drug events. They identified 247 adverse drug events and 194 potential adverse drug events out of 4031 admissions to 11 hospital units over six months[74].

Studies of medication errors during the medication use process indicate variable results, finding errors are most frequent during prescribing or administering phases of the process. Bates et al. reported that the phase of medication use where the most adverse

drug events occur for hospitalized patients is during ordering (49%) and administering (26%)[74], whereas Santell reported 15% and 6% of medication errors occurred during prescribing, and 37% and 55% during administering in his 2003 and 2005 studies of hospitalized adults over the age of 65 respectively[30, 31]. Prescribing often occurs during transition as new orders are communicated to the transitioning care team[75]. Gurwitz in his study of two academic long-term care facilities found that 59% of the adverse drug events occurred during ordering (prescribing)[10]. In his study of 18 community based Massachusetts nursing homes 68% of the preventable errors occurred during ordering and only 3% during administering[33]. North Carolina nursing homes reported approximately 55% of the reported errors occurred during administering, 30% during documentation, and less than 5% during prescribing over a four year mandatory reporting period (2004-2007)[9].

Differences in reports of where an error is identified in the medication use process could be attributable to the medication error and adverse drug event detection method used in the study or the outcome being examined. Gurwitz et al. used chart reviews by pharmacists and nurses and prompted self reporting (via interviews with nursing staff), in both of his studies to identify adverse drug events. Incident reports were also used in his study of the two academic long-term care facilities, making the adverse drug event detection method similar to that used by Bates et al. Gurwitz et al. and Bates et al. reported more adverse drug events occurred during the prescribing phase of the medication use process. Studies examining medication errors versus adverse drug events may report different findings of the same data set. For example, Leape et al examined the number of errors that occurred in 4031 adult admissions in two medical and surgical units

using chart reviews and identified 334 errors of which 39% of the errors occurred during physician ordering and 38% of the errors occurred during nurse administration of the drug[66]. Bates et al examined the same data assessing the incidence of adverse drug events and reported 56% of the events occurred during ordering and 34% during administration of the drug. Differences in detection methods and outcomes being measured may contribute to variations in the findings. Santell reported medication errors of older adults using MEDMARX data, a national voluntary medication error program. This program allows participating hospitals to report medication errors to a national database using standard taxonomy. Standardization of reporting elements allows for evaluation of errors across multiple facilities. Studies using medication errors from self-reported errors versus studies using onsite chart reviews, observations and interaction with staff may account for the difference in the number of medication errors reported as originating in the administering versus prescribing phase [30, 31]. North Carolina mandates reporting of all medication errors and potential medication errors by nursing homes to the Medication Error Quality Initiative (MEQI) database[9]. MEQI is similar to the MEDMARX database in that medication errors are self-reported; different in that MEQI is mandatory reporting and MEDMARX is voluntary. These self-reported adverse drug event studies indicate administering the drug as the primary phase where the error was first identified.

Studies of the primary type of medication error indicate varying results. Dose omission is often reported as the most frequent type of error reported (23% to 53% of the errors reported)[9, 30, 68], with wrong dose following at a rate of (7% to 21%)[9, 30, 68]. Handler, in a 21 month study in one long term care facility, reported problems with documentation (interpreting and updating the medication administration record) as the

most prevalent among 98 medication errors with 27 occurrences, and delay in medication administration as a close second with 26 occurrences, wrong dose was reported 17 times[29]. Whereas Santell reported prescribing errors (10%), wrong administration technique (7%), wrong route (6%), and wrong dose (5%) as the primary error types in errors that caused harm in hospitalized older adults using a national voluntary error reporting database[31]. Differences in study populations contribute to the variation in findings.

Studies of perceptions and concerns with the medication process among nurses in nursing homes indicate underreporting of medication errors by nurses[29, 76, 77]. Several barriers exist deterring the reporting of errors including fear of disciplinary and punitive action[29], feelings of shame or inadequacy[75], and cumbersome reporting systems[78]. Nurses surveyed in a pediatric unit believed that the stage in the medication use process where the error occurred is associated with completing an error report. Errors later in the process (i.e. administering the drug) are more likely to be reported than prescribing errors[79]. Nursing home nurses reported 60 administration errors out of 88 medication error reports, and felt that the majority of medication errors occurred at this stage of the medication use process[29], findings similar to that of the pediatric nurses. One qualitative study of nurses' perceptions of the medication use process indicated common themes related to the complexity of the administration phase, concerns with the timeliness and accuracy of medication administration, and accuracy of the medication administration record[76]. The concerns identified by the nurses contribute to deeper understanding of how errors such as wrong time, wrong dose, and doses omitted became the prevalent medication errors noted.

Although identified as a time of high risk for medication errors, few studies have examined adverse drug events and medication errors for residents transferring to SNFs. Thus, it is useful to evaluate how resident, staff, and facility characteristics are associated with medication errors, and adverse events due to medication errors.

CHAPTER 3: DESIGN AND METHODS

3.1 Conceptual Framework

The literature is replete with research utilizing Donabedian's (1966) framework for analyzing quality in health care settings[80]. The interacting elements of structure, process and outcome have been systematically employed to describe and summarize the various dimensions of quality. In SNFs, structure refers to the characteristics of the institution and its infrastructure; process variables are the actions and procedures completed for and to the resident by staff; and health outcomes are the resultant changes in the resident physiologically, cognitively or functionally. Use of this framework in nursing homes often employs the structure variables of: location of nursing home (rural, urban), ownership (chain, independent), profit status (for-profit, not-for-profit), staffing (number and type), and size (number of beds). Examples of process variables studied include: use of restraints, catheters, medication use process, and use of medication reconciliation. Outcome indicators of quality previously studied include: development of pressure ulcers[81], frequency and harm of falls[25, 82-84], weight loss[85], adverse drug events[1, 10, 33, 86, 87], and mortality[1, 10, 88].

Donabedian's framework implies that when structural characteristics that support quality processes are in place, improved processes can be implemented producing better outcomes. The true interrelationship between structure and process is not simple nor

linear[89]. Atchely (1991) proposed that the model is a time-ordered process with outcomes and processes feeding back to structural components and process actions[90]. Having the appropriate structural components and providing the appropriate care influences outcomes. The outcomes observed provide feedback to the processes and structures influencing change or refinement of the system.

Other research discusses the causal linkages and relationship between structure, process and outcomes by dividing the structural factors into two components, those under management's control (mutable) and those characteristics not likely to be changed or altered by management (immutable)[91, 92]. Studies have evaluated the impact of the immutable characteristics on the amount and type of nursing staff[82, 93-95]. While others have evaluated immutable characteristics in relation to nursing processes such as restraint use[24, 25, 27]. Studies of structural characteristics such as ownership and number of beds and resident outcomes are numerous[18, 19, 27, 82, 84, 96]. Although Hillmer et al. (2005) in their systematic review of the literature state that the most common structure variable used in evaluating nursing home quality is staffing[97].

Studies assessing the impact of nurse staffing levels on quality outcomes indicate lower staff to resident ratios decreased quality and increased the prevalence of deficiencies[19, 97, 98]. Deficiencies are formally recognized departures in practice from state and federal guidelines by nursing homes in the provision of care (i.e. restraint use, development of pressure ulcers, and weight loss).

Process measures reflect the quality of care provided to residents in nursing homes and therefore are often used as indicators of nursing home quality[97]. Assessing organizational processes (such as restraint or urinary catheter use) determine which care

processes contribute to variation in an outcome such as development of a decubitus ulcer or urinary tract infection. Processes of care often are more able to identify smaller variations in quality than structure characteristics[89]. Additionally, processes can often be changed when needed, but structure cannot easily be changed. For example, it is much easier to change a policy or procedure for restraint or catheter use than it is to change the ownership or affiliation with a chain.

Studies have evaluated relationships between structural variables such as ownership[21, 83, 85, 99, 100], chain membership[21, 83, 85, 99], size[21, 83, 85], payer mix or payer type[21, 83, 101, 102], and staffing with outcomes such as quality indicators with varying results. For-profit long-term care facilities were found to hospitalize their residents suspected of pneumonia two times more often than not-for-profit facilities[102], increase restraint use by 20%[83], have 1.2 times more survey deficiencies, and have a higher total (25%) number of F-plus survey deficiencies [21] (defined as potential or actual harm occurred for at least one resident) than not-for-profit facilities. Chain-ownership was found to increase restraint use (31% increase)[83] and number of survey deficiencies[21, 103]. Facility size produced varying effects in differences in outcomes, for example, restraint use decreased by 5% for every ten bed increase in nursing home size[83], whereas number of beds was not determined to contribute to higher numbers of deficiencies or F-plus deficiences[21]. Amirkhanyan and associates reported that as number of beds increased, for-profit facilities had significantly more deficiencies [103]. Studies evaluating staffing as a structural variable and quality outcomes indicate facilities with more Registered Nurse (RN) full time equivalents (FTE) per 100 beds are less likely to increase restraint use, while facilities with more nurse aides per 100 beds are more likely to increase restraint

use[83]; facilities with an average increase of 1.17 Registered Nurses per 100 residents are likely to receive two less deficiencies[101]; and hospital based facilities with an increase in professional staffing were less likely to transfer a resident for pneumonia[102]. Calculations of nursing staff hours (nursing staff hours equals RN, licensed practical nurse (LPN) and certified nursing assistant (CNA) hours combined) per patient day in North Carolina nursing homes using the 2007 Nursing Home Compare - About Nursing Homes and About Nursing Home Staff data indicate for-profit nursing homes staff on average 3.63 nursing hours per resident day whereas not-for-profit homes staffed 4.86 nursing hours per resident day ($p < .0001$)[104].

Process variables of the Donabedian model have been studied less frequently than structure. Some researchers indicate that process is more difficult to measure[105] and that the elements used to measure structure and process contain aspects of both therefore blurring the lines of distinction between structure and process[17]. Process components studied include assessment of resident status, adequacy of the care plan, use of restraints[24, 25, 27, 82-84], urinary catheters[26, 27], and feeding tubes[28], use of psychoactive medications[26, 106-109], and the development and treatment of pressure ulcers[110].

Most studies of quality in nursing homes are based on survey deficiency data and quality indicators obtained from the On-line Survey, Certification and Reporting (OSCAR) system and the resident based assessment tool the Minimum Data Set (MDS), respectively. These federally mandated data sets contain assessment of residents function and health. The MDS requires a resident assessment be completed on a systematic basis depending upon resident changes and clinical needs as a requirement to receive Medicare or Medicaid payment for eligible residents. OSCAR data is a compilation of facility

characteristics, aggregate resident health status, and reported deficiencies. Various studies of resident outcomes such as pressure ulcers, incontinence, quality of life and resident behavior have been assessed using both OSCAR and MDS data. Medication errors and potential medication errors are not recorded in the MDS or OSCAR. Therefore studies of quality indicators using the MDS and OSCAR do not contain medication errors in their measures.

Studies of medication errors are fewer and have been dependent on chart reviews, interviews, observations, and voluntary reporting. Beginning January 2004, North Carolina Senate Bill 1016 mandated that all nursing homes licensed by North Carolina Department of Health and Human Services report all actual and potential medication errors. The database for collection of the errors is the nursing home Medication Error Quality Initiative (MEQI). Nursing homes reported medication errors and potential errors for the first three years of MEQI implementation using annual reporting. During year three individual error reporting was piloted in 23 facilities. Reporting year four (October 1, 2006 - September 30, 2007) provided the option to report errors using the individual error reporting system: 203 of the 393 SNFs opted to use the individual error system.

In the review of the literature no studies were identified that examined medication safety or medication errors using a modified Donabedian model during transition into the nursing home, suggesting an important gap in the literature. The conceptual model for this study is shown as Figure 1 (Appendix: A). The structure variable Profit status directly and indirectly impacts the outcome of harm from medication errors; directly as investigated with Hypothesis 1, and indirectly with Hypothesis 2 and Hypothesis 3. Profit status of a nursing home may determine the operational perspective relative to efficiency

and use of resources to provide care. The difference in nurse staff levels between for-profit and not-for-profit nursing homes in North Carolina supports this perspective. Previous research has linked profit status and chain affiliation and has shown that for-profit facilities are often members of a chain. In North Carolina 77% of for-profit nursing homes are chain affiliated whereas only 46% of not-for-profit nursing homes are chain affiliated[104].

The medication use process is a complex highly regulated nursing process. Considerable focus is placed on the administering phase as a means to optimize safety due to the multiple steps in the delivery of medication. Errors that occur during prescribing, dispensing, documenting and monitoring provide opportunities for error detection before reaching the patient due to reviews by pharmacists or other nurses. In contrast there is less opportunity to detect an error during administration as this typically is an independent task. Regulations abound for the delivery of medications from an array of agencies, including Centers for Medicare and Medicaid Services (CMS), Joint Commission on Accreditation of Healthcare Organizations (JCAHO), state agencies responsible for SNF inspections, and Boards of Nursing, to name a few. During the nursing home annual on-site visit by state agencies, a medication pass observation is required. From the observation of medications administered, an error rate is calculated, if greater than 5% a deficiency is issued. Previous research indicates that most medication errors in older adults occur during the administration phase. Leading to the question, do more harmful outcomes occur from medication errors during the administering phase of the medication use process than any other phase?

3.2 Data

The MEQI Data for North Carolina nursing homes for FY 2007 was the primary data source used. An observational case series design was used to evaluate the relationship between variables. The data set contains facility self-reported medication errors mandated by state legislation, described above. Facilities are expected to submit errors and potential errors according to regulation under the threat of legal penalty. Facilities enroll to use the individual error reporting system at the beginning of the reporting year. The number SNFs reporting errors as reported by the Cecil G.Sheps Center for Health Services Research at the University of North Carolina at Chapel Hill (Sheps Center) has remained constant for reporting years three, four and five (393 SNFs)[8, 9, 111]. A review of the OSCAR data to verify participation rates indicated no evidence of change in the number of facilities during the reporting year. Review of consistency of facility participation indicates that each facility in our dataset participated for the entire reporting year.

A comparison of the ownership status of the SNFs in the dataset to the SNFs in North Carolina is shown in Table 1. Of the number of SNFs licensed in North Carolina (423), 32% reported a medication error during the first seven days of a resident's admission into the facility. For-profit SNFs in the study (71.5%) were underrepresented when compared to the for-profit SNFs licensed in North Carolina. Yet, for-profit chain affiliated SNFs were overrepresented (79.6%), and not-for-profit chain affiliated SNFs (38.5%) were underrepresented when compared to facilities licensed in North Carolina.

Table 1. Comparison of North Carolina Nursing Home Ownership and MEQI-IE Ownership

	Chain Affiliated				Total	
	yes	**%**	**no**	**%**	**n**	**%**
NC 2007						
Non-Profit	43	46.2%	50	53.8%	93	22.0%
For Profit	246	77.1%	73	22.9%	319	75.4%
Government owned	4	36.4%	7	63.6%	11	2.6%
Total	293		130		423	100.0%
MEQI-IE Study						
Not For Profit	15	38.5%	24	61.5%	39	28.5%
For Profit	78	79.6%	20	20.4%	98	71.5%
Total	93		44		137	100.0%
Notes: Source Nursing Home Compare-About Nursing Homes: Center for Medicare and Medicaid Services; FY2007						

The data set contains structure variables of ownership (profit, not-for-profit), size (number of beds), location (urban, rural) and whether the facility is part of a chain of nursing homes. The data set does not contain information on government owned facilities. Process variables include: type of error, phase in medication process, personnel involved in error, effect of the error on resident, and causes of errors. The outcome variables are the number of medication errors reported and the adverse impact/effect on the resident. The following resident characteristics were used as potential covariates; age, gender, cognitive ability, and number of medications taken per day. Analysis of Hypothesis 1a was at the facility level using the number of reported medication errors for all facilities reporting at least one error, while analysis for Hypothesis 1b, Hypothesis 2, and Hypothesis 3 was the reported medication error. In 2007 there were 13,551 errors reported, of which 1,234 had a serious impact (harmful). 581 of the errors occurred during transition into the SNF, of which 73 were serious[9].

Errors were determined to be serious using the National Coordinating Council for Medication Reporting and Prevention Index for Categorizing medication errors (NCC MERP)[6] as modified by Sheps Center researchers in the MEQI report (see Appendix B: Figure 2). MEQI reports serious errors (harm) from Categories D-I, and non-serious errors (no-harm) from Categories A-C, whereas NCC MERP reports Category D as error, no harm[9].

Types of errors include: wrong resident, product, strength, form, route, time, technique, rate of administration, duration and documentation, expired product, dose omission, overdose, under dose, expired order, monitoring error, lab work error, and other. Types of errors were collapsed into five error categories due to small numbers of errors for each type of error, where each category contains both errors that cause harm and errors that do not cause harm. The category of wrong drug is comprised of wrong product, wrong product strength, wrong form of product and expired product. Wrong dosage errors were collapsed by combining over dose and under dose into wrong dose and leaving dose omission. Much of the literature presents dose errors in this manner, where dose omission is often the most frequent type of error reported[9, 31]. Wrong dose represents the process of administering the correct medication to the correct resident at the correct time but in the wrong dose. Wrong administration is comprised of wrong route, wrong time, wrong technique, wrong rate of administration, wrong duration, and expired order. Wrong follow up is made up of monitoring errors, labwork errors and wrong documentation. The collapsing methodology used follows the groupings noted on the individual error incident reporting form facilities used to report medication errors and potential medication errors.

Phases in the medication use process include: prescribing, dispensing, documenting, administering, and monitoring. Primary personnel involved in the error include: licensed practical nurse (LPN), registered nurse (RN), medication aide, physician, pharmacist, physician assistant, nurse practitioner, support personnel, resident or caregiver, student or trainee.

The health effects from errors in the data set include: falls, edema, excessive side effects, allergic reaction, constipation/diarrhea, cognitive change, change in blood sugar, somnolence, cardiac arrest, change in blood pressure, no injury or effect, and other.

Possible causes of errors were also collapsed into six categories of causes to increase the number in each category. The category of product issues includes medication name confusion, product label, and package design; record issues includes illegible handwriting, use of abbreviations, inadequate information, and transcription error; dispensing includes medication unavailable, pharmacy closed, pharmacy delivered to wrong facility, pharmacy delivered wrong medication, and other dispensing issues; facility issues include poor work conditions, shift change, following faulty policies, and frequent distractions on the floor; personnel issues include poor communication, basic human error, emergency on floor, exhaustion, too much workload, and improper training, and other causes remains in a category by itself. The grouping methodology used to create causes of error categories also follows the groupings noted on the individual error incident reporting form. The individual error incident reporting form allows for multiple selections for reporting the possible causes or reasons for the error or potential error, therefore the categories are not mutually exclusive and are not the sum of the individual cause variables.

3.3 Ethical Considerations

This study of an observational case series of medication errors and potential errors for residents at admission into North Carolina nursing homes followed the ethical, research, and operational guidelines of the researching institution including: Institutional Review Board approval (UNCC, Office of Research Protocol number 08-07-29), Institutional Review Board Training Tutorial, and those of the Data Use Agreement signed with the Sheps Center. The Sheps Center under contractual agreement with the State of North Carolina collects and maintains the MEQI data. Informed consent was not obtained as the data was de-identified through a nursing home identification encryption when received by the investigator from the Sheps Center. Efforts were made to ensure confidentiality of the study data including being stored on a computer with password protection and accessed only by the researcher. The data will be destroyed at the end of the study as prescribed in the data use agreement.

3.4 Data analysis

Analysis was conducted using SAS 9.1 (Cary, NC). Sample size and power analysis were conducted using Schesselman and associate's sample size equation for two proportions and found to be appropriate[112].

$$N = 2 \bullet \frac{\left[z_{crit}\sqrt{2\,\bar{p}(1-\bar{p})} + z_{pwr}\sqrt{p_1(1-p_1)+p_2(1-p_2)}\right]^2}{D^2}$$

MEQI reported 9% of the errors as serious or caused harm over the four year reporting period, using this as proportion one (p_1) and twice (18%) that as proportion two (p_2), a sample size of 450 was calculated with α as the type I error rate 0.05, and β the

type II error rate 0.20. The data set contains 581 errors reported during the seven days following admission.

With a small data set, such as this, missing data could bias the findings. Therefore the data was evaluated for missing variables. The Rural-Urban Commuting Area code (RUCA), a classification system used to aggregate geographic locations by population demographics, for one observation was zero (0); we believe this should have been coded as a ten (10); this is a 90 bed not-for-profit facility noted as not affiliated with a chain. Missing values for age, gender and cognitive ability were identified for seven observations that were reported as NA. The observations with these data missing did not appear to be systematically different from the observations without missing data. Therefore the values were assessed to be missing completely at random and dropped, resulting in 574 observations used in bivariate analysis and logistic regression analysis.

Number of medications the resident was taking at the time of the medication error was missing for 332 of the 581 reported medication errors. Therefore a sub-analysis of the data was completed and assessed using 249 reported medication errors to determine if the difference was statistically significant[113]. The number of medications appears to impact the models used to test Hypothesis 2: (Medication errors are more likely to be harmful when administering is reported as the medication use phase compared to any other phase in the medication use process during the seven days following admission) and Hypothesis 3: (Medication errors are more likely to be harmful when wrong dose is reported as the error type compared to any other type of error during the seven days following admission). This is likely to be due to the model being under-powered, with

only 249 observations, 12 variables and 236 degrees of freedom. Therefore, two models were used in the analysis; one with number of medications in the model and one without.

Variables were assessed for multicollinearity using multicollinearity diagnostic statistics produced by linear regression analysis. Variance inflation factor for each independent variable was examined and found to be less than 2.5. In a logistic regression model values above 2.5 are thought to cause concern for multicollinearity[114].

Descriptive statistics, including chi square analysis, were obtained for the structure, process and outcome variables of interest. Structure variables of profit status (for-profit, not-for-profit) and chain affiliation (chain, free-standing) are dichotomous, RUCA is a nominal polychotomous variable, frequencies for each category were obtained. The data set does not differentiate between the multiple types of for-profit ownership types (i.e. corporation, partnership, or limited liability corporation), or not-for-profit ownership types (i.e. church, community). RUCA codes were aggregated into four categories (Categorization A)[115], and renamed location. The new variable, location, contains the following categories; urban focused, large rural/town, small rural town, and isolated small rural town. For the multivariate analysis location was dichotomized as urban versus all other. Bed size (number of licensed beds in the SNF) is an interval variable that was categorized as follows: $\geq$ 50, 51-100, 101-150, and $\geq$151 beds. For the multivariate analysis bed size was categorized $\leq$ 100 (reference group), 101-150, and $\geq$151 beds.

Chi square analysis was conducted for each of the tables to assess homogeneity and measures of association between the variables present. For some independent variables chi square analysis was assessed for each category of the variable or for the

collapsed variable that includes several categories. For other variables such as (primary error type) assessment of homogeneity and measures of association were conducted both at the category level and the variable level. Details for chi square analysis are indicated in the footnote of each table.

Process variables include: type of error, phase in medication use process, personnel involved in error, effect of error on resident, and causes of errors. Type of error, effect of error on resident, and cause of error are presented as separate dichotomous variables, 0 if not indicated and 1 if indicated. Medication phase and personnel involved are nominal polychotomous variables. Frequencies of occurrence for each variable were obtained.

The facility-level outcome variable for Hypothesis 1a, number of medication errors, is an interval (count) variable. The outcome variable for Hypotheses 1b, 2, and 3 is a dichotomous variable indicating whether the resident was harmed by the medication error (1) or not (0). This variable is constructed using a nominal polychotomous variable from the data with 9 possible categories of which only 1-6 have occurrences in the data set. Categories of capacity to cause harm, did not reach resident, and did not cause harm were recoded to 0, indicating no harm. Categories of required monitoring/intervention, temporary harm to resident, and temporary harm to resident with trip to emergency room were recoded to 1, indicating that the resident endured harm. This follows the categorization utilized in MEQI report[9], in which categories 1-3 indicate minor errors and categories 4-9 indicate serious errors.

Age, gender, cognition, and number of medications taken by the resident were assessed for confounding and interaction in each error level model (Hypothesis 1b,

Hypothesis 2 and Hypothesis 3). Previous research on age, gender and cognition as potential confounders indicate conflicting results in their association with harm from the medication error. Therefore they were tested by comparing the estimated coefficient for the risk factors in the harm models with and without the covariates (age, gender, cognition and number of medications) in the model. The estimated coefficients for the risk factors did not change when age, gender or cognitive ability were removed from the model. The final logistic regression model includes age, gender and cognition to control for these characteristics.

Variables with known clinical significance (through *a priori* studies) and statistical significance through bivariate analysis were included in the regression models, taking into account power analysis. For example, prior research indicates age and number of medications as risk factors, therefore were included in the analysis of harm models (Hypothesis 1b, Hypothesis 2, & Hypothesis 3). Analysis of Hypothesis 1a was at the facility level and did not include resident characteristics. Since the error reports do not represent a random sample of residents from the facility there is no reason to believe that resident characteristics as constructed from the medication error data are representative of the facility population. Including resident characteristics in the analysis could bias the results with no ability to determine the direction of the bias. Average resident age for each facility will represent only ages of residents for a reported medication error not the average age of the residents in the facility. Therefore when evaluating facility characteristics average resident age obtained from the data could be considerably higher or lower than the average resident age for the facility and not be representative of the facility acuity level. The data use agreement prohibited matching of the error data to

external data sources that would contain facility level measures. Therefore resident characteristics were not included in facility level analysis.

Independent variables in each of the models were assessed for confounding and interactions. An interaction was identified with ownership status and chain membership, therefore a second model was used and analysis and interpretation were based on the significance of the interaction effect. Interactions were tested by creating strata of independent variables of interest (e.g. profit status and chain status) then using regression evaluated the increase in risk of medication error occurring by strata. The interaction term for chain membership and profit status was included in the final models for both negative binomial and logistic regression analysis.

Multivariable analysis was used to evaluate the relationships of specific SPO elements contributing to harmful medication errors. Negative binomial regression was used to test Hypothesis 1a: For-profit nursing homes will report a higher rate of medication errors during the seven days following admission than not-for-profit nursing homes. Negative binomial regression is a generalization of the Poisson model that allows for over dispersion (variance exceeds the mean) in count data, making it more useful with real-life data which are often characterized by over dispersion. Data characterized by over-dispersion can yield underestimates of standard errors which then lead to incorrect interpretation of statistical significance. Use of negative binomial regression corrects for the standard errors. Logistic regression was used to test the other three hypotheses (Hypothesis 1b, Hypothesis 2, & Hypothesis 3).

Negative binomial regression, used to determine the relationship between nursing home ownership and the number of medication errors that occurred during the seven days

following admission, is discussed below. It is important to note that the number of medication errors must be greater than zero for a facility to be included in the analysis. As such, the sample being considered is more error prone or reports more errors than the general population of nursing homes if some nursing homes report no errors. For a discrete random variable, Y (number of medication errors), with observed frequencies, y_i, for i=1,…,N, where y_i is non-negative, and x_i includes the regressors, the negative binomial regression model is as follows:

$$\text{Prob}(Y=y_i \mid \varepsilon) = e^{-\lambda_i \exp(\varepsilon)} \lambda_i^{y_i} / y_i!,$$

Where $\ln \lambda_i = \beta' x_i + \varepsilon$ and ε has a gamma distribution with a mean of one and a variance of α. The dependent variable Y, is the count of the number of medication errors reported by the nursing facility *i, i*=1,2,3,…, n, where n denotes the sample size. The distribution of the count data (medication errors) is dependent upon exogenous variables some observed (x_i) and others unobserved. Let (ε) represent the unobserved variables and measurement errors on the data. The estimated coefficients ($\hat{\beta}$) may be interpreted as the log of the incidence rate ratio[116, 117].

The link between the expectation of the dependent variable (medication error) and the linear predictor (ownership type) is a logarithmic function. The rate at which medication errors occur is the incidence rate. Chain affiliation, bed size and facility location are included in the model as control variables. For ease of interpretation, we reported the incidence rate ratio estimates for each explanatory variable. The expression (100*(exp[$\hat{\beta}$]-1) depicts the percentage change in the incidence or rate of medication error for each strata of the explanatory variable in the model.

Hypotheses 1b, 2, and 3 were tested using logistic regression, as the dependent variable in all three cases is whether a medication error was harmful or not. The structure variables include the interaction terms not-for-profit and part of a chain, for-profit and part of a chain, for-profit not part of a chain, with not-for-profit not part of a chain as the reference group. Also included are categorical variables location and bed size. Process variables include the phase in the medication use process where the error occurred (prescribing, dispensing, documenting, administering, and monitoring), type of medication error by category, primary personnel involved in error dichotomized to LPN versus all other personnel, and cause of error.

Two sets of models were developed for the analysis of Hypothesis 1b, Hypothesis 2, and Hypothesis 3. As noted above, there were 332 missing observations for the variable number of medications, reducing the observations used for analysis to 259 when number of medications is included in the model. Analysis of Hypothesis 1b, Hypothesis 2, and Hypothesis 3 without number of medications is shown as Model 1 and with number of medications Model 2. Resident characteristics in Model 1 include age, gender, and cognitive ability; Model 2 adds number of medications. Bivariate analysis of process variables did not indicate statistical significance for all variables. Previous studies indicate conflicting results for age, gender and cognitive ability as risk factors for medication errors; therefore even though bivariate analysis did not indicate statistical significance they were included in the expanded model. To evaluate the significance of structure and process variables other than the predictor variables on the impact of a reported medication error, reduced models were analyzed. The reduced models (Model 1 and Model 2) included the interaction variables for ownership and chain status, types of

medication errors and phases of the medication use process. The expanded models (Model 1 and Model 2) included the reduced model variables plus structure variables location and bed size; process variables personnel and reported causes of medication error; and resident characteristics age, gender, and cognitive ability.

The general version of both the reduced and expanded models for testing Hypotheses 1b, 2 and 3 is $\Pr(Y = 1|X1, X2, \dots, Xk) = \frac{1}{1+ e^{-(\beta 0+\beta 1X1+\beta 2X2+\cdots \beta kXk)}}$. For the reduced models, the set of explanatory variables used is a subset of the set of variables used in the expanded models. Odds ratios and 95% confidence intervals for covariates were obtained for all models.

Goodness of fit logistic regression diagnostics were used to examine the conceptual model. These tests were used to indicate satisfactory models for use in discriminating between factors contributing to harm occurring to the resident during admission into the nursing home. The Akaike Information Criterion (AIC) were evaluated for each of the four logistic regression models. These criteria present the association of predicted probability of the variables in the model while adjusting for the number of variables and number of observations used in the model; lower values indicate a better fitting model. Lower AIC values were obtained for both the reduced and expanded models with number of medications included in the model. The other test of model fit assessed is the area under the ROC (receiver operator curve) represented by the c-value obtained in the association of predicted probabilities and observed responses output section of the fit test analysis. The c-value ranged from 0.71 – 0.81 for the four models. Models with the number of medications included had higher values. The model fit tests support the models' ability to discriminate between the likelihood of profit status,

administration phase of the medication use process, or wrong dose as contributing to harm occurring when a medication error occurs during admission to the nursing home.

CHAPTER 4: RESULTS

The purpose of the study is to elucidate the relationships and inter-relatedness of specific SPO elements contributing to harmful medication errors for the vulnerable people who reside in SNFs. In this chapter the findings of the study are presented.

As noted above, the dataset contains 13,551 medication errors that were reported by 203 North Carolina SNFs from October 1, 2006 - September 30, 2007 using the MEQI-Individual Error (MEQI-IE) reporting method, 581 of those occurred in 138 (68%) SNFs during the first seven days of admission into the nursing home and were used for this analysis.

4.1 Analysis by Profit Status

4.1.1 Facility and Resident Characteristics

As shown in Table 2, 137 SNFs reported the 581 medication errors that occurred during the first seven days of admission into the nursing home (One facility was dropped due to incorrect location code). The average facility size was 120 (SD 40.9) beds, 62% of the facilities had 101 beds or more, 67% were part of a chain, and 88% were either urban focused or in a large town.

As shown in Table 3, residents experiencing medication errors were predominately female (65%), unable to direct their own care (58.5%), and 75 years of age or older (69.3%). Harm occurred in 73 (12.6%) of the reported errors. The average number of medications taken was 12.0 (SD 4.9). While only 259 of the reported

medication errors indicated the number of medications being taken at the time of the incident, 103 of the reports indicated residents received between 7-12 medications.

4.1.1.1 Bivariate analysis of profit status and facility characteristics

For-profit SNFs reported an average of 4.13 medication errors per facility and a rate of 3.4 per 100 beds, whereas not-for-profit facilities reported an average of 4.4 medication errors and a rate of 3.8 per 100 beds. For-profit facilities had on average 121 beds, with approximately one half (58.2%) located in urban focused locations. Not-for-profit SNFs are primarily in urban focused locations (71.8%), and had on average had 118 beds. A large number (80%) of for-profit SNFs are members of a chain; only 38% of the not-for-profit SNFs are affiliated with a chain. In summary, there are twice as many for-profit SNFs they tend to be larger, and affiliated with chains, whereas not-for-profit SNFs reported more errors on average and had more facilities in urban focused areas.

Table 2. Descriptive statistics for facility characteristics by facility profit status and chain affiliation

	Not-for Profit		For Profit		Not Chain Affilated		Chain Affiliated		Total	
	N	%	N	%	N	%	N	%	N	%
Total	39	28.5%	98	71.5%	44	32.1%	93	67.9%	137	100
Facility part of a Chain **										
no	24	61.5%	20	20.4%					44	32%
yes	15	38.5%	78	79.6%					93	67%
Facility size by number of beds										
μ (sd) *	118	(42.8)	121	(40.5)					121	(40.4)
<50	3	7.7%	2	2.0%	2	4.4%	3	3.2%	5	4%
51-100	12	30.8%	34	34.7%	14	31.1%	32	34.4%	47	34%
101-150	18	46.2%	42	42.9%	21	46.7%	39	41.9%	60	43%
>151	6	50.0%	20	20.4%	7	15.6%	19	20.4%	26	19%
Facility location by RUCA code										
Urban focused	28	71.8%	57	58.2%	27	60.0%	58	62.4%	85	62%
Large rural/town	8	20.5%	28	28.6%	14	31.1%	22	23.7%	36	26%
Small rural town	1	2.6%	8	8.2%	2	4.4%	7	7.5%	9	7%
Isolated small rural town	2	5.1%	5	5.1%	1	2.2%	6	6.5%	7	5%

Notes: RUCA code for one observation coded (0), dropping one facility from analysis from 138 to 137. Chi square tests of independence were conducted for facility characteristics. Statistically signficant differences in profit status for each characteristic are indicated using *<.05; **<.01; ***<.001.

4.1.1.2 Bivariate analysis of profit status and resident characteristics

Residents 85 or older experienced fewer (175) medication errors than those aged 75-84 years of age (228). For-profit facilities reported 63.5% of the residents who experienced a medication error could not direct their own care, two thirds were women, and 68.8% were over the age of 75, whereas 47.2% of the not-for-profit facilities' residents could not direct their own care and 73.4% were over the age of 75. Residents experiencing a medication error in for-profit facilities on average were prescribed 12.2 (SD 4.9) medications per day whereas those in not-for-profit facilities were prescribed on average 11.8 (SD 5.1). For-profit SNFs reported 11.9% of the medication errors caused harm whereas not-for-profit SNFs reported 14.2% of the errors caused harm. In

summarizing the errors, for-profit facilities have younger patients, but they are more likely to take more medications and are less likely to be able to direct their own care on average.

Table 3. Descriptive statistics for resident characterisitics of medication errors by facility profit status

	Not-for Profit		**For Profit**		**Total**	
	N	%	N	%	N	%
Total	173	100	401	100	574	100
Resident Age						
μ (sd)	78.5	(12.0)	77.4	(11.5)		
<64	20	11.6%	52	13.0%	72	12.5%
65-74	26	15.0%	73	18.2%	99	17.2%
75-84	70	40.5%	158	39.4%	228	39.7%
>85	57	32.9%	118	29.4%	175	30.5%
Resident Gender						
Male	57	32.4%	140	34.6%	197	33.9%
Female	116	65.9%	261	64.4%	377	64.9%
Patient able to direct own care * **						
Yes	68	38.6%	133	32.8%	201	34.6%
No	83	47.2%	257	63.5%	340	58.5%
Unknown	22	12.5%	11	2.7%	33	5.7%
Number of Medications (332 missing)	N=69		N=180		N=249	
μ (sd)	11.8	(5.10)	12.2	(4.9)		
1-7 meds	15	21.7%	30	16.7%	45	18.1%
7-12 meds	26	37.7%	77	42.8%	103	41.4%
13-18 meds	19	27.5%	45	25.0%	64	25.7%
18-30 meds	9	13.0%	28	15.6%	37	14.9%
Impact						
N=581 no missing observations						
No Harm	151	85.8%	357	88.1%	508	87.4%
Harm	25	14.2%	48	11.9%	73	12.6%

Notes: Chi square tests of independence were conducted for resident characteristics. Statistically signficant differences in profit status for each characteristic are indicated using *<.05; **<.01; ***<.001.

Resident age, gender and ability to direct own care are missing 7 observations reducing the number used for analysis to 574.

4.1.2 Medication Error Characteristics

Frequencies for probable and potential causes of errors, primary type of error, and personnel involved in medication errors by ownership type are presented in Table 4. Basic human error was reported as the primary cause of error for 58.2%, transcription error for 35.6%, and poor communication for 7.1% of the medication errors. Causes of error by category indicate that personnel issues accounted for 65.4% medication errors, and record issues were reported for 39.2%. Over one third of the primary errors were dose omissions (36.3%). Errors occurred most frequently in the documenting (46.6%) and administering (33.4%) phases of the medication use process. The primary personnel involved in the errors were LPNs (64.2%) and RNs (26.5%); this follows the staffing patterns used by SNFs where LPNs often outnumber RNs two to one. Overall, reported medication errors were primarily dose omissions identified by LPNs with basic human error as the primary error cause and the documenting phase as the most prevalent phase of the medication use process.

4.1.2.1 Bivariate analysis of profit status and medication error type

For-profit SNFs reported 63.5% of the errors were due to basic human error, 37.5% transcription error, and 8.1% due to poor communication. Not-for-profit SNFs reported 46% were due to basic human error, 31.3% transcription error and 4.5% to poor communication. For-profit SNFs reported 36.8% of the primary error types were dose omissions, 15.1% were overdoses, whereas not-for-profit SNFs reported 35.2% were dose omissions, with only 9.7% overdoses. Wrong dose (combination of overdose and under-dose) occurred in 22.5% of the for-profit SNF errors and 14.8% of the not-for-profit errors. Wrong drug was reported for 19.9% and wrong patient 8.0% of the errors

reported by not-for-profit facilities, while for-profit SNFs reported wrong drug and wrong patient errors for 10.6% and 1.7%, respectively. For-profit SNFs reported 10.1% of the errors were wrong administration, twice the frequency of not-for-profit SNFs. To summarize, 70% of the medication errors reported by for-profit SNFs were attributable to personnel issues with over one-third of the errors being dose omission errors, and for-profit SNFs had a higher proportion of wrong drug and wrong patient errors.

Medication errors occurred most often during the documenting phase of the medication use process. For-profit SNFs reported 49.1% of the medication errors occurred during documentation, whereas not-for-profits reported 40.9% occurred during documentation of the medication. In contrast, for-profit facilities reported fewer (32.3%) medication errors during the administering phase than not-for-profit facilities (35.8%).

For-profit facilities reported licensed practical nurses (LPN) as the primary personnel involved in 69.4% of the medication errors and registered nurses (RN) in 24.0%, whereas not-for-profit facilities reported LPNs were the primary personnel involved in 52.3% and RNs for 31.8% of the medication errors. Medication aides were reported as the primary personnel in 4 and pharmacists in 10 (2.5%) of the errors reported by for-profit facilities, whereas not-for profits reported no errors by medication aides and 13 (7.4%) errors by pharmacists.

For-profit SNFs had more beds and tended to be affiliated with a chain, residents were on average younger and were ordered more medications, but fewer could direct their own care than not-for-profit SNFs. For-profit SNFs reported fewer errors that caused harm. In both types of facilities more errors occurred during the documentation phase and more were dose omission errors.

Table 4. Descriptive statistics of error characterisitcs by facility profit status

	Not-for Profit		**For Profit**		**Total**	
	N	%	N	%	N	%
Total	176	100	405	100	581	100
Causes for reported errors						
Product Issues	**9**	**5.1%**	**20**	**4.9%**	**29**	**5.0%**
Medication name confusion	3	1.7%	13	3.2%	16	2.8%
Medication incorrectly labeled	5	2.8%	5	1.2%	10	1.7%
Package design	2	1.1%	2	0.5%	4	0.7%
Record Issues	**61**	**34.7%**	**167**	**41.2%**	**228**	**39.2%**
Illegible handwriting	0	0.0%	8	2.0%	8	1.4%
Prescription order unclear	5	2.8%	12	3.0%	17	2.9%
Use of abbreviations	1	0.6%	1	0.2%	2	0.3%
Transcription error *	55	31.3%	152	37.5%	207	35.6%
Dispensing	**24**	**13.6%**	**37**	**9.1%**	**61**	**10.5%**
Medication unavailable	3	1.7%	15	3.7%	18	3.1%
Pharmacy closed	0	0.0%	2	0.5%	2	0.3%
Pharmacy delivered wrong medication *	10	5.7%	0	0.0%	19	3.3%
Other dispensing issues *	13	7.4%	16	4.0%	29	5.0%
Facility Issues	**27**	**15.3%**	**47**	**11.6%**	**74**	**12.7%**
Poor working conditions	0	0.0%	1	0.2%	1	0.2%
Shift change	4	2.3%	6	1.5%	10	1.7%
Following faulty policies/systems *	13	7.4%	12	3.0%	25	4.3%
Distractions on floor	10	5.7%	31	7.7%	41	7.1%
Personnel Issues *	**98**	**55.7%**	**282**	**69.6%**	**380**	**65.4%**
Poor communication *	8	4.5%	33	8.1%	41	7.1%
Basic human error ***	81	46.0%	257	63.5%	338	58.2%
Emergency on floor	0	0.0%	1	0.2%	1	0.2%
Exhaustion	0	0.0%	1	0.2%	1	0.2%
Work overload	1	0.6%	4	1.0%	5	0.9%
Improper training ***	15	8.5%	1	0.2%	16	2.8%
Other causes *	**17**	**9.7%**	**17**	**4.2%**	**34**	**5.9%**
Total Causes for reported error	**236**		**570**		**806**	
Primary Error Type ***						
Wrong Patient ***	**14**	**8.0%**	**7**	**1.7%**	**21**	**3.6%**
Wrong Drug ***	**35**	**19.9%**	**43**	**10.6%**	**78**	**13.4%**
Wrong product	13	7.4%	24	5.9%	37	6.4%
Wrong strength	19	10.8%	15	3.7%	34	5.9%
Wrong form	3	1.7%	4	1.0%	7	1.2%
Dose Omission	**62**	**35.2%**	**149**	**36.8%**	**211**	**36.3%**

Table 4 (continued)

Wrong Dose *	**26**	**14.8%**	**91**	**22.5%**	**117**	**20.1%**
Overdose	17	9.7%	61	15.1%	78	13.4%
Underdose	9	5.1%	30	7.4%	39	6.7%
Wrong Administration *	**10**	**5.7%**	**41**	**10.1%**	**51**	**8.8%**
Wrong time	4	2.3%	11	2.7%	15	2.6%
Wrong technique	1	0.6%	2	0.5%	3	0.5%
Wrong rate of administration	0	0.0%	2	0.5%	2	0.3%
Wrong duration	0	0.0%	5	1.2%	5	0.9%
Expired order	5	2.8%	21	5.2%	26	4.5%
Wrong Followup	**12**	**6.8%**	**40**	**9.9%**	**52**	**9.0%**
Monitoring error	3	1.7%	3	0.7%	6	1.0%
Labwork error	1	0.6%	6	1.5%	7	1.2%
Wrong documentation	8	4.5%	31	7.7%	39	6.7%
Other	**17**	**9.7%**	**34**	**8.4%**	**51**	**8.8%**
Total Primary Error Type	176	100.0%	405	100.0%	581	100.0%
Medication Use Process						
Prescribing	13	7.4%	15	3.7%	28	4.8%
Dispensing	25	14.2%	53	13.1%	78	13.4%
Docmumenting	72	40.9%	199	49.1%	271	46.6%
Administering	63	35.8%	131	32.3%	194	33.4%
Monitoring	3	1.7%	7	1.7%	10	1.7%
Total Medication Use Process	176	100.0%	405	100.0%	581	100.0%
Primary personnel involved in error						
LPN	92	52.3%	281	69.4%	373	64.2%
RN	56	31.8%	98	24.2%	154	26.5%
Medication Aide	0	0.0%	4	1.0%	4	0.7%
Physician	6	3.4%	7	1.7%	13	2.2%
Pharmacist	13	7.4%	10	2.5%	23	4.0%
Nurse Practitioner	0	0.0%	1	0.2%	1	0.2%
Support Personnel	9	5.1%	4	1.0%	13	2.2%
Total Primary Personnel	176	100.0%	405	100.0%	581	100.0%

Notes: Chi square tests of independence were conducted for each of the error characteristics indicated in bold in the left-hand column. In addition chi square tests of independence for each of subcategories of cause and primary error type were conducted. Statistically significant differences in profit status for each characteristic are indicated using*<.05; **<.01;
Bold indicates categories. Causes of errors is not mutually exclusive as selection of multiple causes was allowed.

4.1.3 Multivariate analysis by ownership status

The findings from the negative binomial regression models are presented in Table 5. Model 1 indicates no difference in the incidence rate ratio for medication errors between for-profit SNFs and not-for-profit SNFs (IRR,1.16; 95% CI 0.79-1.69). Nursing homes that were members of a chain reported 42% (IRR, 0.58; 95% CI 0.41-0.83) fewer medication errors than those not affiliated with a chain. Model 2 suggests that being a member of a chain may interact with ownership status. According to Model 2, a not-for-profit SNF that is a member of a chain is expected to have a 51% (IRR, 0.49; 95% CI .25-.92) lower rate of medication errors than a for-profit SNF that is not part of a chain holding all other variables in the model constant. A for-profit SNF that is a member of a chain is expected to have a 27% (IRR, 0.63; 95% CI 0.40-0.99) lower rate of medication errors than a for-profit SNF that is not a member of a chain holding all other variables in the model constant. Both models indicate a SNF with greater than 151 beds is expected to have two times the rate (IRR, 2.02; 95% CI 1.33-3.08) of medication errors than a SNF 100 beds or less holding all other variables in the model constant (Table 5).

Table 5. Medication Error Incidence Rate Ratios by Facility Status

	Model 1		Model 2	
Variable/Category	**IRR**	**95% CI**	**IRR**	**95% CI**
Ownership				
Not For Profit				
For Profit	1.16	.79 - 1.70		
Affiliated with a chain				
No				
Yes	0.58	.41 - .83		
Interaction				
For-profit & not Chain member				
Not-for-profit & Chain member			0.49	.26 - .92
For-profit & Chain member			0.63	.40 - .99
Not-for-profit & not Chain member			0.96	.56 - 1.65
Location				
Non-urban				
Urban	0.88	.65 - 1.20	0.86	.63 - 1.19
Bed Size				
< 100				
101-150	1.49	1.04 - 2.14	1.49	1.04 - 2.13
≥ 151	2.05	1.35 - 3.11	2.02	1.33 - 3.08

Note: Model 1 no interaction between ownership and profit status, Model 2 shows interaction between ownership profit status.

4.2 Analysis by harm endured by resident

4.2.1 Bivariate analysis

4.2.1.1. Bivariate analysis of harm and primary type of error

Examination of the primary error types and categories of errors by whether the medication error caused harm is shown in Table 6. Harm occurred in 12.6% of the reported errors, where 32.9% were reported as wrong dose, 30.1% dose omission, and 12.3% as wrong drug. Of the errors where no harm was reported, 37.2% were dose

omissions, 18.3% wrong dose and 13.6% wrong drug. Statistical significance between harm and no harm was found only in wrong dose errors.

Table 6. Examination of primary errors and error categories by harm

	No Harm		**Harm**		**Total**	
	N	%	N	%	N	%
Total	508	100.0%	73	100.0%	581	100.0%
Wrong Patient	**17**	**3.3%**	**4**	**5.5%**	**21**	**3.6%**
Wrong Drug	**69**	**13.6%**	**9**	**12.3%**	**78**	**13.4%**
Wrong product	32	6.3%	5	6.8%	37	6.4%
Wrong strength	30	5.9%	4	5.5%	34	5.9%
Wrong form	7	1.4%	0	0.0%	7	1.2%
Dose Omission	**189**	**37.2%**	**22**	**30.1%**	**211**	**36.3%**
Wrong Dose *	**93**	**18.3%**	**24**	**32.9%**	**117**	**20.1%**
Overdose	59	11.6%	19	26.0%	78	13.4%
Underdose	34	6.7%	5	6.8%	39	6.7%
Wrong Administration	**48**	**9.4%**	**3**	**4.1%**	**51**	**8.8%**
Wrong time	15	3.0%	0	0.0%	15	2.6%
Wrong technique	2	0.4%	1	1.4%	3	0.5%
Wrong rate of administration	2	0.4%	0	0.0%	2	0.3%
Wrong duration	5	1.0%	0	0.0%	5	0.9%
Expired order	24	4.7%	2	2.7%	26	4.5%
Wrong Follow-up	**47**	**9.3%**	**5**	**6.8%**	**52**	**9.0%**
Monitoring error	4	0.8%	2	2.7%	6	1.0%
Labwork error	6	1.2%	1	1.4%	7	1.2%
Wrong documentation	37	7.3%	2	2.7%	39	6.7%
Other	**45**	**8.9%**	**6**	**8.2%**	**51**	**8.8%**
Category Totals	**508**	**87.4%**	**73**	**12.6%**	**581**	**100.0%**

Notes: Chi square tests for independence were conducted for each of the error characteristics indicated in bold in the left-hand column. Statistically signficant differences in harm for each characteristic are indicated using *<.05. Bold indicates categories. The category total is the sum of the bold categories and percent of the total errors (i.e 73/581)

4.2.1.2. Bivariate analysis of harm and probable and potential causes of errors

Descriptive statistics for probable and potential causes of reported errors by whether the medication error caused harm are shown in Table 7. The causes of errors do not sum to the categories of cause due to the opportunity to select more than one cause when submitting the incident report. Of the errors that caused harm 56.2% were reported as personnel issues which include basic human error and 38.4% reported as recording issues which includes transcription errors. Of the errors where no harm occurred 66.7% of the errors were reported as personnel issues and 39.4% were recording issues. Harm was reported for 10.4% of the errors caused by basic human error, whereas package design (25%), illegible handwriting (25%), and distractions on the floor (22%) were reported to cause harmful errors more frequently. In summary, personnel issues are often reported as the cause of errors but result in harm less frequently than other reported causes such as package design and illegible handwriting.

Table 7. Examination of causes of errors and categories of causes of errors by harm

	No Harm			**Harm**			**Total**	
	N			N			N	%
Total	508	Column%	Row %	73	Column%	Row %	581	100.0%
Product Issues	**24**	**4.7%**	**82.8%**	**5**	**6.8%**	**17.2%**	**29**	**5.0%**
Medication name confusion	14	2.8%	87.5%	2	2.7%	12.5%	16	2.8%
Medication incorrectly labeled	8	1.6%	80.0%	2	2.7%	20.0%	10	1.7%
Package design	3	0.6%	75.0%	1	1.4%	25.0%	4	0.7%
Record Issues	**200**	**39.4%**	**87.7%**	**28**	**38.4%**	**12.3%**	**228**	**39.2%**
Illegible handwriting	6	1.2%	75.0%	2	2.7%	25.0%	8	1.4%
Prescription order was unclear	14	2.8%	82.4%	3	4.1%	17.6%	17	2.9%
Use of abbreviations	2	0.4%	100.0%	0	0.0%	0.0%	2	0.3%
Transcription error	183	36.0%	88.4%	24	32.9%	**11.6%**	207	35.6%

Table 7 (continued)

Dispensing	**54**	**10.6%**	**88.5%**	**7**	**9.6%**	**11.5%**	**61**	**10.5%**
Medication unavailable	15	3.0%	83.3%	3	4.1%	16.7%	18	3.1%
Pharmacy closed	2	0.4%	100.0%	0	0.0%	0.0%	2	0.3%
Pharmacy delivered wrong	19	3.7%	100.0%	0	0.0%	0.0%	19	3.3%
Other dispensing issues	24	4.7%	82.8%	5	6.8%	17.2%	29	5.0%
Facility Issues	**61**	**12.0%**	**82.4%**	**13**	**17.8%**	**17.6%**	**74**	**12.7%**
Poor working conditions	1	0.2%	100.0%	0	0.0%	0.0%	1	0.2%
Shift Change	10	2.0%	100.0%	0	0.0%	0.0%	10	1.7%
Following faulty policies	21	4.1%	84.0%	4	5.5%	16.0%	25	4.3%
Distractions on floor	32	6.3%	78.0%	9	12.3%	22.0%	41	7.1%
Personnel Issues	**339**	**66.7%**	**89.2%**	**41**	**56.2%**	**10.8%**	**380**	**65.4%**
Poor communications	36	7.1%	87.8%	5	6.8%	12.2%	41	7.1%
Basic human error	303	59.6%	89.6%	35	47.9%	10.4%	338	58.2%
Emergency on floor	1	0.2%	100.0%	0	0.0%	0.0%	1	0.2%
Exhaustion	1	0.2%	100.0%	0	0.0%	0.0%	1	0.2%
Too much workload	5	1.0%	100.0%	0	0.0%	0.0%	5	0.9%
Improper training	13	2.6%	81.3%	3	4.1%	18.8%	16	2.8%
Other causes	**28**	**5.5%**	**82.4%**	**6**	**8.2%**	**17.6%**	**34**	**5.9%**
Total Reported Causes	**706**			**100**			**806**	

Notes: Individual causes do not equal category sums due to the ability to select more than one cause. Categories of causes of errors shown in bold. Column percent is equal to the n for the category divided by n for the column (i.e. 24/508=4.72%). Row percent is equal to the n for the category divided by the n for the row (i.e. 24/29=82.76%)

4.2.1.3 Bivariate analysis of the medication use process and facility and resident characteristics

Reported medication error frequencies by phases of the medication use process are shown in Tables 8 and 9 (Appendix C and Appendix D). Documenting and administrating were reported as the primary phase of the medication use process for 46.6% and 33.4% of the reported errors, respectively. For-profit SNFs reported 73.4% of the documenting errors, 67.5% of the administering errors, and only 53.5% of the prescribing errors. SNFs affiliated with chains reported 60.2% of the documenting errors and 59.3% of the administering errors, while those not affiliated with a chain reported

75% of the prescribing errors. Prescribing errors were reported more in larger SNFs (35.7%, >151 beds) and monitoring errors in smaller SNFs (60%,101-150 beds). Error frequencies for the medication use process by impact show that harm occurred in 46.4% of the prescribing errors, 35.6% of the documenting errors, and 11.3% of the administering errors. The average age of the residents experiencing a medication error during the administering phase is 76.8 (SD 11.7), whereas the average age for the residents experiencing a medication error during the prescribing or monitoring phases is 72.3 (SD 12.4) and 85.8 (SD 11) respectively. In summary, prescribing errors caused harm more often than errors in any other phase of the medication use process, but errors occur more often in the documenting phase.

4.2.1.4 Bivariate analysis of the medication use process and error characteristics

Descriptive statistics of the error characteristics by the medication use process are presented in Table 9. Personnel issues were reported as the primary cause of the error for 59.6% of the documenting errors, 77.8% of the administering errors, and 67.9% of the prescribing errors. One half of the dose omission errors occurred in the documenting phase; while only 36% occurred during administering. Wrong dose was reported for only 18.6% of the administering errors, yet 23.1% of the dispensing errors were wrong doses. Physicians were reported as the primary personnel involved in prescribing errors for only 39.3% of the errors, with LPNs for 32.1% and RNs for 25%. Pharmacists were reported as the primary personnel for only 29.5% of the dispensing errors, LPNs were responsible for 56.4%, RNs 11.5% and medication aides 2.6%. Of the four errors reported to be made by medication aides one was during the administering phase, one during documenting, and two during dispensing. These results could indicate the primary personnel who

identified the error, not necessarily the discipline responsible for where the error originated. To summarize, LPNs are the primary personnel involved in the medication use process, with almost 80% of the dose omissions occurring during the documenting and administering phases combined. Personnel issues (which include basic human error) were reported as the cause for 77% of the administering errors. Harm was reported in almost one-half of the errors that occurred during the prescribing phase with 39% of the prescribing errors being dose omissions.

4.2.1.5 Bivariate analysis of primary type of error and facility and resident characteristics

Characteristics of the medication errors by error type are shown in Tables 10 and 11(Appendix E and Appendix F). A disproportionate percent of errors were reported as wrong patient and wrong drug in not-for profit and chain affiliated SNFs when compared to the distribution of facilities in the data. Not-for-profit SNFs reported 66.7% of the wrong patient and 44.9% of the wrong drug errors, non-chain affiliated SNFs reported 66.7% of the wrong patient and 51.3% of the wrong drug errors. Younger residents and females (85.7%) experienced wrong patient errors more often than older patients and men (14.3%). The average age of residents who experienced a drug administered wrong was 81.5, with 88.2% of the residents being older than 75. Wrong drug (42.3%) and wrong dose (40.2%) were reported more often for residents able to direct their own care. Harm was reported more frequently from wrong dose (32.9%) and dose omission (30.1%) errors than any other type of error. Wrong dose was reported for 117 medication errors, of these 77.8% occurred in for-profit SNFs, 63.3% were affiliated with a chain, 66.7% were urban facilities. Although the distribution is similar to the facility characteristics of

the data, wrong dose was reported by a greater percent of for-profit SNFs with urban locations but fewer SNFs affiliated with a chain.

4.2.1.6 Bivariate analysis of primary type of error and error characteristics

Descriptive statistics for error characteristics by type of error are shown in Table 11. Administering was reported for 81% of the wrong patient errors, 42.3% of the wrong drug errors, and 30.8% of the wrong dose medication errors. RNs were reported as the primary personnel involved for 47.6% of the wrong patient errors, 19.6% of the wrong administration errors, and 26.5% of the wrong dose errors; whereas RNs were reported as the primary personnel involved in only 26.5% of the errors reported in the MEQI dataset. Three out of the four errors reported by Medication Aides as the primary personnel involved were wrong dose errors. Pharmacists were primarily involved in wrong drug errors, whereas 38% of the physician errors were reported as other type of error. In summary, not-for-profit SNFs had a disproportionate percentage of wrong person errors, for-profit SNFs had a disproportionate percentage of wrong administration errors, chain affiliated SNFs had a disproportionate percentage of all errors except wrong personnel. Although dose omission errors were the most frequently reported type of error, they caused harm in only 10.4% of the errors. Of the residents who experienced a dose omission, 63% were unable to direct their own care and took on average 12.5 medications. Whereas wrong dose errors were reported less often yet they caused harm in 20.5% of the reported errors, 40.2% of residents experiencing a wrong dose error were unable to direct their own care and took on average more medications (12.9).

4.2.2 Multivariate analysis of medication errors by harm

The findings from the logistic regression models are shown in Tables 12 and 13. Four models were used to evaluate harm caused by medication errors. Both Model 1, which does not include the number of medications as an explanatory variable, and Model 2, which includes the number of medications, are presented as reduced and expanded models. In Table 12, reduced Model 1, indicates the odds that a dose omission is associated with harm are 58% (OR 0.42; 95% CI 0.22 - 0.82) lower than the odds that a wrong dose error is associated with harm, and the odds that a wrong administration error is associated with harm are 73% (OR 0.27; 95% CI 0.07 - 0.98) lower than the odds that a wrong dose error is associated with harm as primary error types. Prescribing errors are more likely to be associated with harm than administering errors during the medication use process (OR 8.6; 95% CI 3.34 - 22.13). Reduced Model 2 in Table 12, indicates the odds that a dose omission error is associate with harm are 68% (OR 0.32; 95% CI 0.12 - 0.85) lower than the odds that a wrong dose error is associated with harm as the primary error type. Prescribing errors are more likely to be associated with harm than administering errors during the seven days following admission (OR 7.1; 95% CI 1.18 - 43.05) (Table 12).

Table 12. Multivariable analysis of the probablity that a medication error is harmful using the reduced model

	Model 1			Model 2		
Odds Ratio Estimates						
Effect	**Odds Ratio**	**95% CI**		**Odds Ratio**	**95% CI**	
Facility Ownership						
NFP[1] & not Chain affiliated (reference)						
NFP & Chain affiliated	0.43	0.11	1.60	0.14	0.02	1.23
FP[2] & not Chain affiliated	0.57	0.24	1.32	0.37	0.10	1.30
FP & Chain affiliated	0.90	0.48	1.71	0.49	0.19	1.25
Type of Medication Error						
Wrong Dose (reference)						
Wrong Patient	0.96	0.27	3.34	1.23	0.11	13.38
Wrong Drug	0.55	0.23	1.32	0.71	0.20	2.50
Dose Omission	0.42	0.22	0.82	0.32	0.12	0.85
Wrong Administration	0.27	0.07	0.98	0.18	0.02	1.54
Wrong Follow-up	0.39	0.12	1.22	0.18	0.03	1.20
Other Type of Error	0.35	0.12	1.02	0.12	0.01	1.16
Medication Use Phase						
Administering (reference)						
Dispensing	1.16	0.50	2.69	1.18	0.34	4.04
Documenting	0.95	0.50	1.80	1.13	0.43	3.00
Monitoring	2.49	0.41	15.22	9.92	0.49	200.01
Prescribing	8.59	3.34	22.13	7.14	1.18	43.05
Number of medications				1.00	0.92	1.08

Note: 1= Not-for-profit; 2= For-profit. Model 1 does not include number of medications, Model 2 includes number of medications.

Expanded Model 1 in Table 13 indicates prescribing errors are more likely to be associated with harm than administering errors during the medication use process (OR 8.6; 95% CI 2.98 - 24.79), and the odds that a dose omission error is associated with harm are 55% (OR 0.45; 95% CI 0.23 - 0.91) lower than the odds that a wrong dose error is associated with harm as the primary error type controlling for other variables in the model. The odds that a personnel issue is associated with harm are 50% (OR 0.50: 95%

CI 0.29 - 0.96) lower than the odds that a non-personnel issue is associated with harm. Factors associated with errors are not mutually exclusive therefore more than one factor could be reported and personnel issues could contribute to the other factors. Expanded Model 2 in Table 13 contains only 259 observations due to number of medications missing for 322 observations, this few observations and the number of variables in the expanded model could impact the results. No difference was found in the odds of a medication error associated with harm during the administering phase versus any other phase of the medication use process.

Table 13. Multivariable analysis of the probability that a medication error is harmful using the expanded model

	Model 1			Model 2		
Effect	**Odds Ratio**	**95% CI**		**Odds Ratio**	**95% CI**	
Facility Ownership						
NFP[1] & not Chain affiliated (reference)						
NFP & Chain affiliated	0.41	0.10	1.69	0.13	0.01	1.41
FP[2] & not Chain affiliated	0.76	0.29	2.02	0.67	0.13	3.39
FP & Chain affiliated	1.02	0.50	2.08	0.76	0.22	2.62
Medication Use Process						
Administering (reference)						
Dispensing	1.20	0.45	3.21	3.34	0.23	48.87
Documenting	0.97	0.45	2.10	1.72	0.34	8.59
Monitoring	4.17	0.61	28.54	0.34	0.11	1.04
Prescribing	8.59	2.98	24.79	0.13	0.01	1.23
Type of Medication Error						
Wrong Dose (reference)						
Wrong Patient	0.74	0.18	3.12	0.09	0.01	0.79
Wrong Drug	0.64	0.23	1.77	0.10	0.01	1.07
Dose Omission	0.45	0.23	0.91	1.63	0.37	7.15
Wrong Administration	0.30	0.08	1.17	0.88	0.26	3.00
Wrong Follow-up	0.43	0.14	1.37	32.40	1.16	909.20
Other Type of Error	0.40	0.13	1.26	13.96	1.46	133.13

Table 13 (continued)

Location						
Urban (reference)						
Non-Urban	1.86	0.98	3.55	2.27	0.75	6.85
Number of Beds						
<100 (reference)						
101-150	0.69	0.36	1.31	1.19	0.40	3.50
≥151	0.49	0.22	1.07	1.04	0.25	4.30
Gender						
Female	0.84	0.47	1.51	0.43	0.15	1.24
Age	0.98	0.96	1.00	1.06	1.00	1.12
Patient able to direct own care						
No	1.11	0.62	1.99	0.98	0.36	2.69
Personnel involved						
LPN						
all other non LPN	0.68	0.39	1.20	2.02	0.74	5.57
Causes of Errors						
Product issue	1.42	0.42	4.83	0.21	0.01	3.98
Recording issue	0.78	0.36	1.71	1.52	0.40	5.84
Dispensing	0.51	0.17	1.49	0.53	0.09	3.13
Facility issue	1.94	0.91	4.13	2.18	0.61	7.86
Personnel issue	0.50	0.26	0.96	0.41	0.14	1.20
Other causes	1.40	0.46	4.24	1.75	0.22	13.89
Number of medications				1.02	0.93	1.13

Note: 1= Not-for-profit; 2= For-profit. Model 1 does not include number of medications, Model 2 includes number of medications.

CHAPTER 5: DISCUSSION

5.1 Discussion

This study is the first to explore the relationships between and inter-relatedness of specific SPO elements contributing to harmful medication errors for those persons transitioning into SNFs. Understanding these elements and the inter-relationships between structure and process factors will contribute to improvements in systematic processes of the medication use process as residents transition into SNFs. Reducing medication errors and adverse drug events through process changes will contribute to improved resident safety. Bivariate, multivariable, and regression statistics were used to examine the relationships for 581 medication errors that were reported by North Carolina SNFs from October 1, 2006 - September 30, 2007, and occurred during the first seven days of admission into the nursing home.

This study contained medication errors from 138 SNFs which is approximately one third of the SNFs in North Carolina. The percent of for-profit SNFs in the data was less than the percent of for-profit SNFs in North Carolina (Table 1), yet there were more for-profit chain affiliated SNFs reporting errors during the first seven days of admission. This could be because more errors occurred during this time period in these facilities or for-profit non chain affiliated SNFs are less likely to report medication errors. In contrast, not-for-profit chain affiliated SNFs were underrepresented with the smallest number of facilities reporting errors during the first seven days of admission. A for-profit SNF that is a member of a chain is more likely to report an error than a not-for-profit SNF that is a

member of a chain, indicating profit status is associated with reporting medication errors when controlling for the interaction of chain membership.

Using a structure variable such as profit status or number of beds has been shown in previous studies to contribute to the study of quality in nursing homes. In this study profit status was shown to interact with chain affiliation, but was not associated with a harmful medication error. Further study of the interaction of profit status and chain affiliation could contribute to understanding the effect of ownership status and work processes that contribute to quality outcomes for long-term care residents. Location had no effect on the number of medication errors reported by the facility. Facility size was associated with reporting of medication errors, larger facilities reported more errors. This is consistent with previous findings related to quality and facility size. Although larger facilities have been reported to have more deficiencies this could be due to the increased number of residents and opportunities for errors, not necessarily a higher rate of errors per resident or per bed. In addition, other factors related to the reporting of errors such as reporting protocols, or increased awareness of near miss incidents have not been accounted for and could contribute to reporting more errors. As in this study, where a larger facility (>151 beds) is two times more likely to report a medication error than a smaller (<100 beds) facility, may not indicate a higher rate of errors per resident.

Errors reported during the seven day transition period into the SNF were more prevalent during the documentation phase of the medication use process than the administering phase. In contrast, when all MEQI errors are considered, administration errors were the most frequently reported. This indicates that error detection during the first seven days of admission may be related to admission documentation and the

transcribing of orders for new residents, rather than the process of medication administration. Prescribing errors although reported less frequently were the most harmful, similar to the entire MEQI year where 23% of the prescribing errors caused harm. These findings indicate an opportunity to improve resident safety, further study of the prescribing process to include disciplines involved in identification of a prescribing error will contribute to a safer medication use process.

The medication use process is comprised of five steps each contributing to the provision of safe, effective, and optimal pharmaceutical care. Documenting (transcribing) is the process of transferring the physician orders from document to document, or to document the completion of a task. During admission into the SNF documenting of orders is often a part of the admissions process, where the medication list is transferred from the discharging facility's forms onto the SNF medication administration record. Errors occurring or identified during the documentation phase of the medication use process may not reach the resident and therefore incur fewer harmful outcomes than other phases of the medication use process. In this study more of the administering errors caused harm than documenting errors. Reported potential and probable causes for errors indicate that recording errors (which includes transcription errors) occurred five times more often during documentation than the administration phase of the medication use process. This is possibly due to errors being identified earlier in the process (during transcription) preventing errors later (during administering) in the sequence.

This study did not support Hypothesis 1a. For-profit SNFs did not have significantly more medication errors during the seven days following admission than not-for-profit SNFs. However, not-for-profit SNFs were overrepresented and for-profit SNFs

were underrepresented in the study when compared to the SNFs in North Carolina. Yet when accounting for the interaction of being affiliated with a chain, this study indicates that for-profit SNFs affiliated with a chain reported close to four times more medication errors than for-profit SNFs not affiliated with a chain. And in the study, not-for-profit chain affiliated SNFs reported fewer medication errors than not-for-profit non chain affiliated SNFs. The interaction of being a member of a chain and profit status appears to impact the risk of medication errors during the seven days following admission into the SNF. Not-for-profit SNFs who were members of a chain are less likely to report medication errors than for-profit SNFs who were not members of chains. Chain membership appears to have a protective effect, as for-profit SNFs who were members of chains had fewer medication errors than for-profit SNFs who were not members of chains, possibly due to standardized procedures (Table 4).

Model 2 which controlled for bed size and location did not support previous findings on ownership status but did support previous findings on facility size and quality. Our study indicates that SNFs with greater than 151 beds are two times more likely to report a medication error during transition than a SNF with fewer than 100 beds. Previous findings indicate larger facilities provide lower quality care such as increased use of restraints and number of deficiencies. Although as indicated above this could be due more to increased opportunities by volume than actual error rates per resident.

The findings in this study did not support Hypothesis 1b: A harmful medication error is more likely to be reported by a for-profit nursing home than not-for-profit nursing home during the seven days following admission. This is inconsistent with previous studies of structure and quality that report for-profit nursing homes provide lower quality

of care than not-for-profit facilities. This difference could be due to the variables used in the analysis. Harrington et al. used deficiencies from state inspections obtained through the national OSCAR database[19]; O'Neill et al. used deficiencies from California nursing homes from the OSCAR and California licensing reports[21]; and Amirkhanyan et al. used the OSCAR database and Nursing Home Compare website[103]. A variety of quality indicators can be found in the OSCAR database (i.e. decubiti, restraint use, weight loss, abuse, staffing, etc.) medication errors and their causes are not a component of the OSCAR database. The medication errors in this study were self-reported whereas the OSCAR database is comprised of observed deficiencies and facility annual required reporting elements. Another difference could come from whether the facility actually had a medication error and did not report it. For example, if a nurse identified a wrong dose on a new admission's medication list she might obtain a correct order from the provider, make the change on the chart and not report this as a potential medication error. Nurses' perceptions of medication errors have been shown to impact reporting[76, 118].

The policy and processes for reporting of errors varies between facilities and organizations. A group of facilities under the same chain ownership could all follow one set of processes; a facility not affiliated with a chain could have a different set of processes. Thus all the facilities belonging to the chain will follow the same identifying and reporting processes in the reporting of errors. The ownership philosophy on resident safety and identification of actual and potential medication errors contributes to reporting methods and frequencies. The data in this study were facility reported potential or actual errors, the percent of for-profit-SNFs reporting errors during the first seven days of admission is similar to the percent of for-profit-SNFs in North Carolina. Further study of

the processes of reporting errors between ownership and chain affiliation will contribute to improved practices in resident safety.

These results could be due to the small sample size of 581 medication errors and 137 SNFs and a power analysis that proposed for-profit SNFs would have two times more medication errors than not-for-profit SNFs at an alpha level of .05.

The findings of the study did not support Hypothesis 2: Medication errors are more likely to be harmful when administering is reported as the medication use phase compared to any other phase in the medication use process during the seven days following admission. Although one-third of the errors reported were during the administration phase and 11.3% caused harm, a greater percentage of errors that caused harm occurred during the prescribing and dispensing phases of the medication use process. Regression analysis indicates errors that occur during prescribing are more likely to cause harm than errors during the administering phase. Santell and Hicks in their study of hospitalized older adults reported that out of 80,169 medication errors 6% were prescribing errors and 10% of the prescribing errors were harmful[31]. In Gurwitz et al. study of adverse drug events in two academic long term care facilities preventable adverse drug events (errors) occurred most often (59%) in the ordering (prescribing) phase and only 13% in the administering phase. Both studies indicate similar findings; although the volume of reported errors is lower, the harm occurring during prescribing is often greater than during administration. One study of medication error reporting indicates the likelihood of an error being reported increases during the administration phase and when the error was not prevented from reaching the patient. Most errors were prevented from reaching the patient and not reported indicating fewer reports of errors

during the prescribing phase because they were corrected[118]. Further research in this area would support identifying systems to prevent prescribing errors reaching the resident. A system which has received attention for the prevention of adverse drug events is computer physician order entry (CPOE). Evaluation of CPOE in relation to prescribing errors will contribute to the use of CPOE and potentially electronic medical record (EMR) systems. Use of mandatory CPOE and EMR has broad reaching policy implications for SNFs as their use is limited at this time.

Basic human error was reported as a cause of the error for over one half of the errors in the data set. This could be due to: the ability to select more than one cause, basic human error could contribute to other error causes, or it could be used as a 'catch all' category. Basic human error as defined by the MEQI-IE reporting form is: simple mistake, forgot, orders overlooked, carelessness or oversight. The individual completing the form could select basic human error to conceal the real cause or as a means to not assign blame. Errors could be the result of a simple mistake which occurred due to poor lighting, environmental distractions, workload, or not being aware of facility policies. Further analysis of the cause category will contribute to better understanding of the causes and perceptions of the causes of errors. Assessing the additional causes selected in coordination with basic human error will contribute to an understanding of the contributing factors and their relationships. Exploring the written comments and responses submitted under the 'other' category will also contribute to this knowledge.

The findings of the study support Hypothesis 3: Medication errors are more likely to be harmful when wrong dose is reported as the error type compared to any other type of error during the seven days following admission. Wrong dose errors were the most

likely error type to cause harm. Dose omissions were less likely to cause harm than wrong dose errors when controlling for ownership and the medication use process. Similar findings were reported by Santell with 5% of the improper dose/quantity type of errors and 2% of the dose omissions reported as harmful in his study of hospitalized older adults[31]. Leape et al. reported wrong dose and wrong choice (choice of drug or dose inappropriate) errors caused injury in 42% of the adverse drug events in their study of eleven medical and surgical units[66]. This same study reported that almost half of the wrong dose errors occurred at the physician ordering phase and 70% were intercepted, whereas only two wrong dose errors that occurred in the nurse administration phase were intercepted. Further research evaluating wrong dose errors will contribute to reducing harmful medication errors through changes in the ordering and administering processes. Research evaluating wrong dose errors and their origination in the medication use process (e.g. wrong dose ordered, wrong dose administered due to packaging, wrong dose calculated, wrong dose due to illegible handwriting) will provide opportunities to modify medication processes. Potential policy implications include designating packaging specifications for medications to prevent wrong dose dispensing.

Of the errors medication aides were involved in wrong dose was reported for three of the four. As the use of medication aides continues to grow further research into the types and causes of errors where medication aides are the primary personnel involved will contribute to understanding their benefit in staffing of SNFs. In this study the use of medication aides was relatively new for North Carolina SNFs. Future research will contribute to understanding whether only four errors being reported indicates a safer

medication administration by medication aides, or just fewer SNFs using medication aides at the time of this research.

5.2 Study Limitations

North Carolina requires a mandatory self reporting of medication errors for SNFs. The IOM in its 1999 report[34] presents the incongruous nature of reporting systems, where they are intended for both learning from the incident and addressing accountability. Mandatory reporting of errors has been implemented as an effort to address accountability and has raised strong objections due to fear of damaged reputations and increased legal liability[75]. Voluntary reporting systems are used to study medication errors (a learning activity) as a means to prevent and reduce errors and potentially harm. Mandatory reporting does not ensure that all actual and potential medication errors are reported. Reports indicate compliance with mandatory programs has been inconsistent and that practitioners perceive mandatory programs as assigning blame rather than identifying system-based causes that could lead to process correction. Of the 203 NC SNFs reporting medication errors in the MEQI-IE system during FY 2007 only 137 were used in the facility level analysis in this study, indicating the remaining facilities did not report medication errors within the first seven days or incomplete information was submitted.

One of the most significant limitations to the study was that the medication errors in the dataset were self reported medication errors. Medication errors can be detected by various methods including observation, incident reporting, and medical record review. Each presents strengths and weaknesses in identifying medication errors. Studies of error collection methods indicate observation is the most valid and cost effective[15].

Observation entails the observation of preparation and administration of medication to the patient. One study reported that of the 318 medication errors reported through observation only one was detected by an error report[67]. Underreporting of medication errors is a significant barrier to improving safety; studies indicate that nurses believe that only 3.5% of medication errors are ever reported due to fear of disciplinary action, shame and job loss[69].

The data used in this analysis was for only one reporting year and only the data collected through the MEQI-IE, individual error reporting system, which represents about one half of the errors reported to the Sheps center during the study year. The errors reported in the MEQI-AR, annual report system were not available for the study. The published summary results state there were 190 facilities that used the annual report system with an average of 41 errors per facility and 34 errors per 100 beds, whereas those using the individual error had an average of 28 errors and 23 errors per 100 beds. Harm occurred in 8.2% of the errors reported in the annual report system, whereas harm occurred in 10.5% of the errors reported by facilities using the individual error system. In general, residents in facilities using the annual report reporting system were older, more were women and could not direct their own care. SNFs reporting using annual report system reported 53% of the errors as dose omissions, facilities using individual error system reported that 41% were dose omissions[9]. Facilities that chose the annual report system may have different error incidences than facilities who submitted reports through the individual error system. These differences are not known. The number of errors occurring during the seven days following admission into the SNF is also unknown for those facilities using the annual report system. In year five, the number of SNFs using the

individual error reporting system increased to 73% and beginning October of 2008, all SNFs were required to report using the individual error system, eliminating these unknown differences[111].

Limited facility and resident characteristics were available for analysis. Resident acuity levels are not known. Only age, gender, and cognitive ability and impact according to the NCC-MERP index are known. Therefore two residents may experience the same medication error but have different outcomes due to their physiological status, where resident acuity is not accounted for when dichotomizing into harm or no harm.

Limitations of the models include potential omitted variable bias and unexplained error. The data was self reported from a mandatory reporting program. MEQI data is only from the state of North Carolina during 2007, and contains limited resident and facility characteristics. The data is limited to medication errors during the transition period into the SNF, and the dataset could not be merged with any other data under the data use agreement.

5.3 Conclusions

This study supports the need for improved processes as patients transition between providers, with 68% of the SNFs reporting a medication error during the first seven days of a resident's admission. Further research in error reporting methods and cultures of reporting will improve the data collected and opportunities for safer resident care. The punitive culture of the nursing home environment does not likely support a transparent environment or one of open communication. Fear of litigation, survey deficiencies, and civil monetary penalties could contribute to under-reporting of errors.

The interaction between SNF ownership and chain affiliation deserves further study. Does the membership in a chain provide an increase in effectiveness by access to performance improvement programs, standardized processes, and resources, or merely more efficiency and profit? Is the impact of a chain different for not-for-profit and for-profit SNFs? In this study the relationship between being of a chain, regardless of profit status, had a protective effect from a resident experiencing a medication error. Further research evaluating the systems and processes used by multi-facility operations will contribute to an understanding of the processes that improve resident safety. Examples of systems and processes include: evaluation of systems such as corporate oversight and their evaluation of individual SNF operations, policy development at the corporate level with mandatory implementation at the facility level, use of economies of scale, and the use of resources to investigate and review errors and potential errors.

The medication use process is complex with multiple opportunities for error occurrence. The method of error detection and the persons involved often determine when an error is identified and the response. Additional study of both the phases where large numbers of errors occur (documenting and administering) along with studies of phases where the most harm occurs (prescribing) will identify processes contributing to harmful outcomes. Previous research indicates that observation of medication administration identifies considerably more errors than chart review and incident reporting. Further study of the relationship between the primary personnel involved in the study and phases of the medication use process will contribute to understanding reporting processes and where the error originates. As this study shows physicians were only involved with 39.3% of the prescribing errors. If the error is truly a prescribing error then

it should originate with the physician not the nurse. The same could be said for a dispensing error which should originate with the pharmacist.

This study did not indicate a relationship between the processes of administering medications and a harmful medication error. The process of prescribing medications was found to contribute to harmful medication errors. Donabedian's model where process contributes to outcome was supported with the medication use process of prescribing medications contributing to harmful medication errors.

Wrong dose errors contributed to considerable harm in this study. Further research in the prevention of wrong dose errors (under dose and overdose) will contribute to improved medication therapies for SNF residents. Evaluation of wrong dose causes (packaging, communication between providers, distractions, etc) will contribute to a better understanding and improved medication administering process. We reported almost two-thirds of the wrong dose errors were due to personnel issues, with basic human error being the most prevalent cause. Further defining basic human error into specific human errors will contribute to reducing medication errors and a safer resident care environment. Almost half of the wrong dose errors occurred during the documenting phase with 42.7% a recording issue. Further evaluation, such as observation of when and how documenting and recording of medications at admission occurs will contribute to a better understanding of how these processes contribute to safer resident outcomes. Implementing practices that rely on systematic processes, such as preprinted forms and checklists, instead of human memory for specific processes such as admission documentation will contribute to improved resident outcomes.

Potential policy implications include improved communication between providers across the continuum of care. Our study indicated 68% of the SNFs reported an error within the first seven days of the resident's admission to the facility; supporting the need for medication reconciliation at admission into the SNF. At the time of this study North Carolina did not have a requirement for SNFs to complete medication reconciliation for new admissions. Although JCAHO does mandate medication reconciliation across the continuum it is difficult to mandate reconciliation when many SNFs are not JCAHO accredited.

At the time of this study few nursing facilities in North Carolina used electronic health records and related information technology in documenting resident care processes. As the uses of information technology continue to indicate reduction in medication errors and adverse drug events in acute care, potential policy implications for SNFs include use of automated processes for physician orders and the prescribing process, on-line decision support systems and alert and warning systems for allergies and drug interactions.

As information on the use of medication aides becomes more prevalent, further study of their impact on the safe administration of medications should be evaluated. Studies with larger sample sizes will contribute to understanding their contribution to a safe medication use process and potentially relieving the expected shortage of nurses as the demographics change. The outcomes of these studies will have policy implications for the future of the nursing workforce and processes used to staff SNFs.

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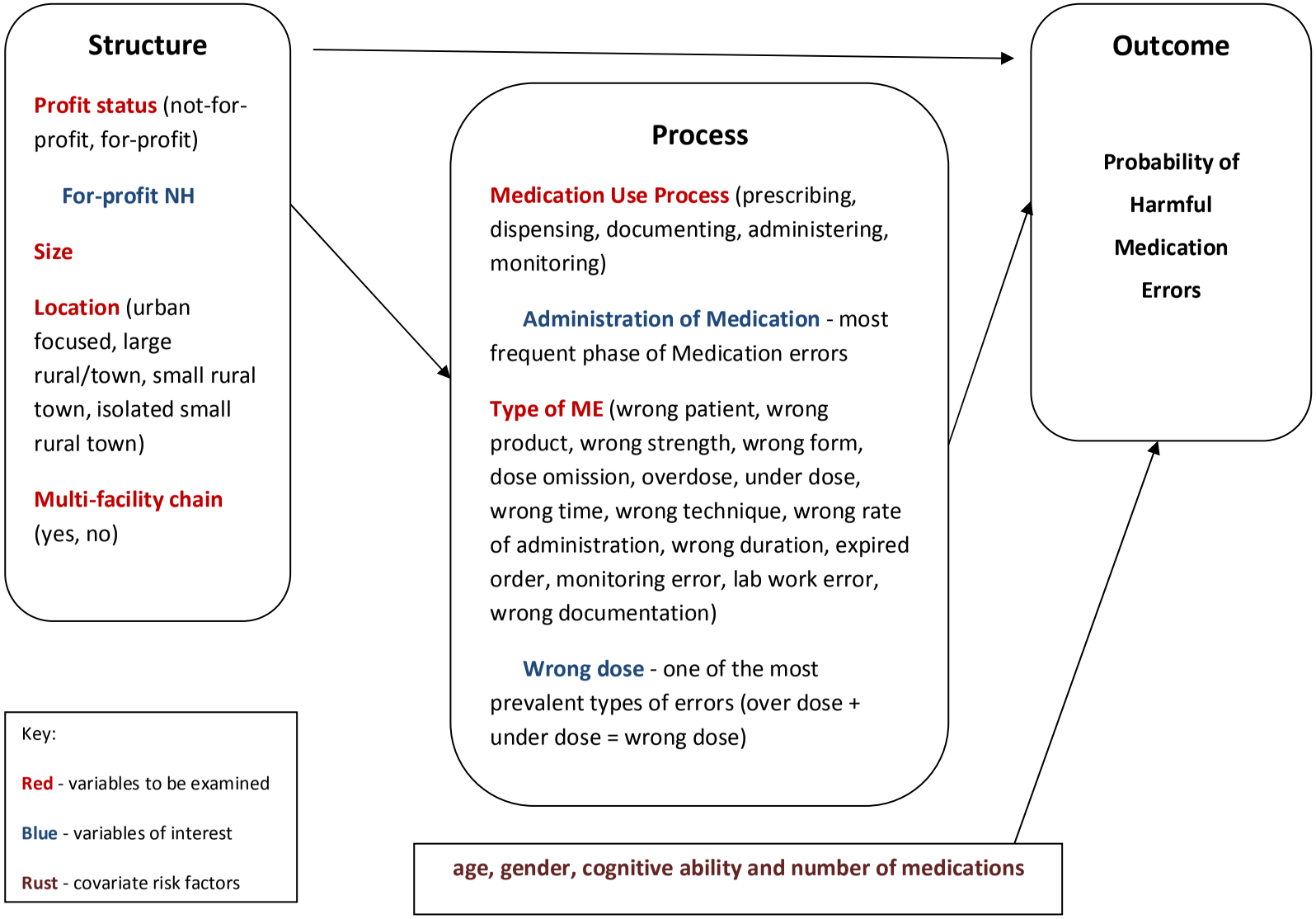
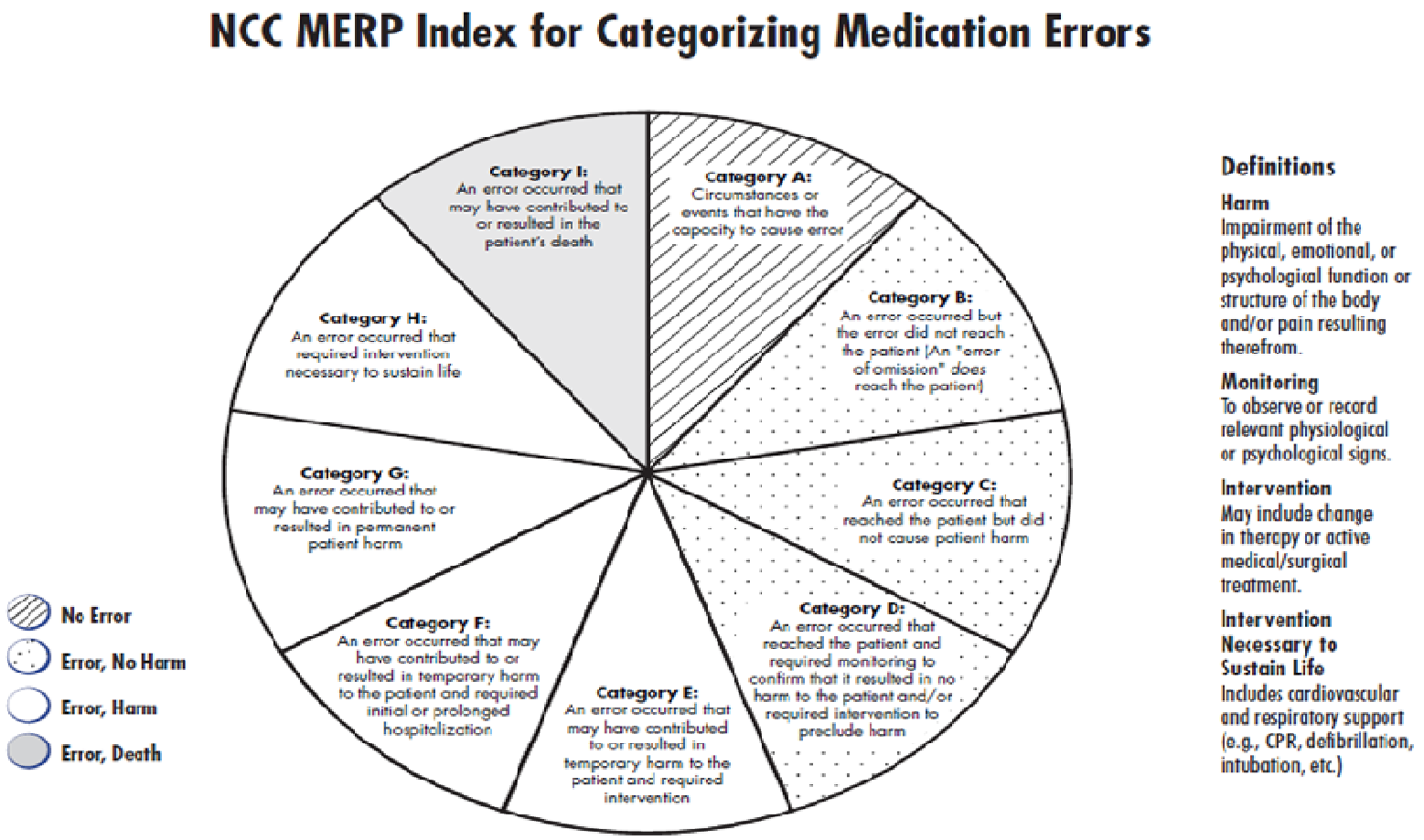
APPENDIX A: FIGURE 1. CONCEPTUAL MODEL



APPENDIX B: FIGURE 2. NATIONAL COORDINATING COUNCIL MEDICATION ERROR REPORTING INDEX



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APPENDIX C: TABLE 8

Table 8. Descriptive statistics for facility and resident characteristics per error by the medication use process

	Prescribing			Dispensing			Documenting			Administering			Monitoring			Total	
	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	%
Total	28	100%	4.8%	78	100%	13.4%	271	100%	46.6%	194	100%	33.4%	10	100%	1.7%	581	100%
Facility Characterisitcs																	
Ownership																	
For-Profit	15	53.6%	3.7%	53	67.9%	13.1%	199	73.4%	49.1%	131	67.5%	32.3%	7	70.0%	1.7%	405	69.7%
Not-for-Profit	13	46.4%	7.4%	25	32.1%	14.2%	72	26.6%	40.9%	63	32.5%	35.8%	3	30.0%	1.7%	176	30.3%
Affiliated with a Chain *																	
Yes	7	25.0%	2.1%	46	59.0%	13.6%	163	60.1%	48.1%	115	59.3%	33.9%	8	80.0%	2.4%	339	58.3%
No	21	75.0%	8.7%	32	41.0%	13.2%	108	39.9%	44.6%	79	40.7%	32.6%	2	20.0%	0.8%	242	41.7%
Number of Beds																	
μ (sd)		140(45)			127(43)			131(38)			131(34)			118(36)			
<50	1	3.6%	9.1%	2	2.6%	18.2%	5	1.8%	45.5%	2	1.0%	18.2%	1	10.0%	9.1%	11	1.9%
51-100	3	10.7%	2.3%	23	29.5%	17.6%	58	21.4%	44.3%	45	23.2%	34.4%	2	20.0%	1.5%	131	22.5%
101-150	14	50.0%	4.9%	38	48.7%	13.4%	143	52.8%	50.5%	82	42.3%	29.0%	6	60.0%	2.1%	283	48.7%
>151	10	35.7%	6.4%	15	19.2%	9.6%	65	24.0%	41.7%	65	33.5%	41.7%	1	10.0%	0.6%	156	26.9%
Facility Location by RUCA code																	
Urban focused	18	64.3%	5.1%	53	67.9%	15.0%	151	55.7%	42.7%	124	63.9%	35.0%	8	80.0%	2.3%	354	60.9%
Large rural/town	5	17.9%	3.1%	16	20.5%	10.0%	88	32.5%	55.0%	51	26.3%	31.9%	0	0.0%	0.0%	160	27.5%
Small rural town	5	17.9%	11.4%	7	9.0%	15.9%	20	7.4%	45.5%	12	6.2%	27.3%	0	0.0%	0.0%	44	7.6%
Isolated small rural town	0	0.0%	0.0%	2	2.6%	9.1%	11	4.1%	50.0%	7	3.6%	31.8%	2	20.0%	9.1%	22	3.8%
Resident Age *																	
μ (sd) **		72.3(12.4)			77.6(11.2)			78.7(11.5)			76.8(11.7)			85.8(11)			
<64	10	35.7%	12.7%	6	7.7%	7.6%	29	10.7%	36.7%	32	16.5%	40.5%	2	20.0%	2.5%	79	13.6%
65-74	5	17.9%	5.1%	17	21.8%	17.2%	43	15.9%	43.4%	33	17.0%	33.3%	1	10.0%	1.0%	99	17.0%
75-84	9	32.1%	3.9%	35	44.9%	15.4%	109	40.2%	47.8%	72	37.1%	31.6%	3	30.0%	1.3%	228	39.2%
>85	4	14.3%	2.3%	20	25.6%	11.4%	90	33.2%	51.4%	57	29.4%	32.6%	4	40.0%	2.3%	175	30.1%
Resident Gender																	
Male	8	28.6%	4.1%	28	35.9%	14.2%	93	34.3%	47.2%	67	34.5%	34.0%	1	10.0%	0.5%	197	33.9%
Female	20	71.4%	5.3%	50	64.1%	13.3%	175	64.6%	46.4%	125	64.4%	33.2%	7	70.0%	1.9%	377	64.9%

Table 8. (continued)

Patient able to direct own care																
Yes	10	35.7%	5.0%	34	43.6%	16.9%	80	29.5%	39.8%	71	36.6%	35.3%	6	60.0%	3.0%	201	34.6%
No	15	53.6%	4.4%	41	52.6%	12.1%	173	63.8%	50.9%	109	56.2%	32.1%	2	20.0%	0.6%	340	58.5%
Unknown	3	10.7%	9.1%	3	3.8%	9.1%	15	5.5%	45.5%	12	6.2%	36.4%	0	0.0%	0.0%	33	5.7%
Number of Medications																
μ (sd)		12.6(4.4)			11.9 (4.6)			12.6(4.9)			11.3(5.1)			800.0%			
1-7 meds	0	0.0%	0.0%	6	7.7%	13.3%	16	5.9%	35.6%	23	11.9%	51.1%	0	0.0%	0.0%	45	7.7%
7-13 meds	5	17.9%	4.9%	11	14.1%	10.7%	50	18.5%	48.5%	34	17.5%	33.0%	3	30.0%	2.9%	103	17.7%
13-18 meds	1	3.6%	1.6%	15	19.2%	23.4%	31	11.4%	48.4%	17	8.8%	26.6%	0	0.0%	0.0%	64	11.0%
19-30 meds	2	7.1%	5.4%	3	3.8%	8.1%	20	7.4%	54.1%	12	6.2%	32.4%	0	0.0%	0.0%	37	6.4%
Impact ***																
No Harm	15	53.6%	3.0%	68	87.2%	13.4%	245	90.4%	48.2%	172	88.7%	33.9%	8	80.0%	1.6%	508	87.4%
Harm	13	46.4%	17.8%	10	12.8%	13.7%	26	9.6%	35.6%	22	11.3%	30.1%	2	20.0%	2.7%	73	12.6%

Notes: Chi square tests of independence were conducted for each of the facility and resident characteristics indicated in bold in the left hand column. Statistically significant differences in the medication use process for characteristic are indicated using *<.05; **<.01; ***<.001.

Column percent is equal to the n for the category divided by n for the column (i.e. 15/28=53.57%)

Row percent is equal to the n for the category divided by the n for the row (i.e. 15/405=4%)

Age, Gender, Able to Direct own care missing seven observations, 574 observations used in the analysis

Number of Medications missing 322 observations

APPENDIX D: TABLE 9

Table 9. Descriptive statistics for error characteristics by the medication use process

	Prescribing			Dispensing			Documenting			Administering			Monitoring			Total	
	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	Column%	Row%	N	%
Total	28	100%	4.8%	78	100%	13.4%	271	100%	46.6%	194	100%	33.4%	10	100%	2%	581	100%
Causes for Reported Errors																	
Product Issues ***	1	3.6%	3.4%	16	20.5%	55.2%	0	0.0%	0.0%	12	6.2%	41.4%	0	0.0%	0%	29	5.0%
Recording Issues ***	14	50.0%	6.1%	7	9.0%	3.1%	181	66.8%	79.4%	26	13.4%	11.4%	0	0.0%	0%	228	39.2%
Dispensing Issues ***	3	10.7%	4.9%	44	56.4%	72.1%	3	1.1%	4.9%	11	5.7%	18.0%	0	0.0%	0%	61	10.5%
Facility Issues	3	10.7%	4.1%	5	6.4%	6.8%	36	13.3%	48.6%	29	14.9%	39.2%	1	10.0%	1%	74	12.7%
Personnel Issues ***	19	67.9%	5.0%	38	48.7%	10.0%	162	59.8%	42.6%	151	77.8%	39.7%	10	100.0%	3%	380	65.4%
Other Causes	4	14.3%	11.8%	4	5.1%	11.8%	14	5.2%	41.2%	12	6.2%	35.3%	0	0.0%	0%	34	5.9%
Primary Error Type * **																	
Wrong Patient ***	0	0.0%	0.0%	1	1.3%	4.8%	3	1.1%	14.3%	17	8.8%	81.0%	0	0.0%	0%	21	3.6%
Wrong Drug ***	1	3.6%	1.3%	30	38.5%	38.5%	14	5.2%	17.9%	33	17.0%	42.3%	0	0.0%	0%	78	13.4%
Dose Omission *	11	39.3%	5.2%	17	21.8%	8.1%	107	39.5%	50.7%	76	39.2%	36.0%	0	0.0%	0%	211	36.3%
Wrong Dose	6	21.4%	5.1%	18	23.1%	15.4%	56	20.7%	47.9%	36	18.6%	30.8%	1	10.0%	1%	117	20.1%
Wrong Administration	2	7.1%	3.9%	2	2.6%	3.9%	29	10.7%	56.9%	18	9.3%	35.3%	0	0.0%	0%	51	8.8%
Wrong Follow-up ***	2	7.1%	3.8%	3	3.8%	5.8%	38	14.0%	73.1%	2	1.0%	3.8%	7	70.0%	13%	52	9.0%
Other	6	21.4%	11.8%	7	9.0%	13.7%	24	8.9%	47.1%	12	6.2%	23.5%	2	20.0%	4%	51	8.8%
Primary Personnel Involved in Error * **																	
LPN	9	32.1%	2.4%	44	56.4%	11.8%	174	64.2%	46.6%	140	72.2%	37.5%	6	60.0%	2%	373	64.2%
RN	7	25.0%	4.5%	9	11.5%	5.8%	82	30.3%	53.2%	53	27.3%	34.4%	3	30.0%	2%	154	26.5%
Medication Aide	0	0.0%	0.0%	2	2.6%	50.0%	1	0.4%	25.0%	1	0.5%	25.0%	0	0.0%	0%	4	0.7%
Physician	11	39.3%	84.6%	0	0.0%	0.0%	1	0.4%	7.7%	0	0.0%	0.0%	1	10.0%	8%	13	2.2%
Pharmacist	0	0.0%	0.0%	23	29.5%	100.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0%	23	4.0%
Nurse Practitioner	1	3.6%	100.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0%	1	0.2%
Support Personnel	0	0.0%	0.0%	0	0.0%	0.0%	13	4.8%	100.0%	0	0.0%	0.0%	0	0.0%	0%	13	2.2%

Notes: Chi square tests of independence were conducted for primary error type and primary personnel involved in error. In addition chi square tests of independence were conducted for each of the subcategories of causes. Statistially significant differences in the medication use process for each characteristic are indicated using *<.05; **<.01; ***<.001. Column percent is equal to the n for the category divided by n for the column (i.e. 24/508=4.72%). Row percent is equal to the n for the category divided by the n for the row (i.e. 24/29=82.76%)

APPENDIX E: TABLE 10

Table 10. Descriptive Statistics for facility and resident characterisitics by type of error

	Wrong Patient			Wrong Drug			Dose Omission			Wrong Dose			Wrong Administration			Wrong Followup			Other type of Error			Total	
	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	%
Total	21	100%	3.6%	78	100%	13.4%	211	100%	36.3%	117	100%	20.1%	51	100%	8.8%	52	100%	9.0%	51	100%	8.8%	581	100.0%
Facility Characterisitcs																							
Ownership ***																							
For-Profit	7	33.3%	1.7%	43	55.1%	10.6%	149	70.6%	36.8%	91	77.8%	22.5%	41	80.4%	10.1%	40	76.9%	9.9%	34	66.7%	8.4%	405	69.7%
Not-for-Profit	14	66.7%	8.0%	35	44.9%	19.9%	62	29.4%	35.2%	26	22.2%	14.8%	10	19.6%	5.7%	12	23.1%	6.8%	17	33.3%	9.7%	176	30.3%
Affiliated with a Chain ***																							
Yes	7	33.3%	2.1%	38	48.7%	11.2%	137	64.9%	40.4%	74	63.2%	21.8%	26	51.0%	7.7%	35	67.3%	10.3%	22	43.1%	6.5%	339	58.3%
No	14	66.7%	5.8%	40	51.3%	16.5%	74	35.1%	30.6%	43	36.8%	17.8%	25	49.0%	10.3%	17	32.7%	7.0%	29	56.9%	12.0%	242	41.7%
Number of Beds ***																							
µ (sd)		148.50	(29.9)		132.8	(41.6)		133.9	(34.8)		123.2	(38.7)		130.5	(35.9)		132.8	(35.9)		127.1	(46.9)		
<50	0	0.0%	0.0%	3	3.8%	27.3%	0	0.0%	0.0%	2	1.7%	18.2%	1	2.0%	9.1%	1	1.9%	9.1%	4	7.8%	36.4%	11	1.9%
51-100	2	9.5%	1.5%	12	15.4%	9.2%	44	20.9%	33.6%	40	34.2%	30.5%	11	21.6%	8.4%	10	19.2%	7.6%	12	23.5%	9.2%	131	22.5%
101-150	7	33.3%	2.5%	35	44.9%	12.4%	109	51.7%	38.5%	51	43.6%	18.0%	30	58.8%	10.6%	30	57.7%	10.6%	21	41.2%	7.4%	283	48.7%
>151	12	57.1%	7.7%	28	35.9%	17.9%	58	27.5%	37.2%	24	20.5%	15.4%	9	17.6%	5.8%	11	21.2%	7.1%	14	27.5%	9.0%	156	26.9%
Facility Location by RUCA code *																							
Urban focused	15	71.4%	4.2%	36	46.2%	10.2%	135	64.0%	38.1%	78	66.7%	22.0%	29	56.9%	8.2%	31	59.6%	8.8%	30	58.8%	8.5%	354	60.9%
Large rural/town	6	28.6%	3.8%	27	34.6%	16.9%	55	26.1%	34.4%	35	29.9%	21.9%	13	25.5%	8.1%	7	13.5%	4.4%	17	33.3%	10.6%	160	27.5%
Small rural town	0	0.0%	0.0%	10	12.8%	22.7%	14	6.6%	31.8%	2	1.7%	4.5%	7	13.7%	15.9%	8	15.4%	18.2%	3	5.9%	6.8%	44	7.6%
Isolated small rural town	0	0.0%	0.0%	5	6.4%	22.7%	6	2.8%	27.3%	2	1.7%	9.1%	2	3.9%	9.1%	6	11.5%	27.3%	1	2.0%	4.5%	22	3.8%
Resident Age ***																							
µ (sd) *		69.9	(14.6)	*	77.6	(12.0)		77.2	(12.6)		77.2	(10.7)		81.5	(6.7)	*	78.9	(12.2)		79.6	(9.9)		
<64	8	38.1%	10.1%	7	9.0%	8.9%	29	13.7%	36.7%	13	11.1%	16.5%	2	3.9%	2.5%	12	23.1%	15.2%	8	15.7%	10.1%	79	13.6%
65-74	6	28.6%	6.1%	16	20.5%	16.2%	37	17.5%	37.4%	22	18.8%	22.2%	4	7.8%	4.0%	5	9.6%	5.1%	9	17.6%	9.1%	99	17.0%
75-84	4	19.0%	1.8%	32	41.0%	14.0%	71	33.6%	31.1%	52	44.4%	22.8%	33	64.7%	14.5%	17	32.7%	7.5%	19	37.3%	8.3%	228	39.2%
>85	3	14.3%	1.7%	23	29.5%	13.1%	74	35.1%	42.3%	30	25.6%	17.1%	12	23.5%	6.9%	18	34.6%	10.3%	15	29.4%	8.6%	175	30.1%

Table 10 (continued)

Resident Gender *																					
Male	3	14.3%	1.5%	28	35.9%	14.2%	79	37.4%	40.1%	36	30.8%	18.3%	25	49.0%	12.7%	10	19.2%	5.1%	16	31.4%	8.1%	197	33.9%
Female	18	85.7%	4.8%	50	64.1%	13.3%	132	62.6%	35.0%	81	69.2%	21.5%	26	51.0%	6.9%	40	76.9%	10.6%	30	58.8%	8.0%	377	64.9%
Patient able to direct own care																					
Yes	6	28.6%	3.0%	33	42.3%	16.4%	70	33.2%	34.8%	47	40.2%	23.4%	12	23.5%	6.0%	19	36.5%	9.5%	14	27.5%	7.0%	201	34.6%
No	13	61.9%	3.8%	39	50.0%	11.5%	134	63.5%	39.4%	65	55.6%	19.1%	35	68.6%	10.3%	28	53.8%	8.2%	26	51.0%	7.6%	340	58.5%
Unknown	2	9.5%	6.1%	6	7.7%	18.2%	7	3.3%	21.2%	5	4.3%	15.2%	4	7.8%	12.1%	3	5.8%	9.1%	6	11.8%	18.2%	33	5.7%
Number of Medications																					
μ (sd)		10.2	(6.7)		11.3	(4.0)		12.5	(5.3)		12.9	(4.9)		11.4	(5.0)		11.2	(4.7)		10.8	(4.2)		
1-7 meds	2	9.5%	4.4%	6	7.7%	13.3%	15	7.1%	33.3%	6	5.1%	13.3%	7	13.7%	15.6%	6	11.5%	13.3%	3	5.9%	6.7%	45	7.7%
7-13 meds	2	9.5%	1.9%	12	15.4%	11.7%	39	18.5%	37.9%	23	19.7%	22.3%	5	9.8%	4.9%	13	25.0%	12.6%	9	17.6%	8.7%	103	17.7%
13-18 meds	0	0.0%	0.0%	11	14.1%	17.2%	22	10.4%	34.4%	14	12.0%	21.9%	7	13.7%	10.9%	5	9.6%	7.8%	5	9.8%	7.8%	64	11.0%
19-30 meds	1	4.8%	2.7%	1	1.3%	2.7%	17	8.1%	45.9%	11	9.4%	29.7%	2	3.9%	5.4%	4	7.7%	10.8%	1	2.0%	2.7%	37	6.4%
Impact																					
No Harm	17	81.0%	3.3%	69	88.5%	13.6%	189	89.6%	37.2%	93	79.5%	18.3%	48	94.1%	9.4%	47	90.4%	9.3%	45	88.2%	8.9%	508	87.4%
Harm	4	19.0%	5.5%	9	11.5%	12.3%	22	10.4%	30.1%	24	20.5%	32.9%	3	5.9%	4.1%	5	9.6%	6.8%	6	11.8%	8.2%	73	12.6%

Notes: Chi square tests for independence were conducted for each of the facility and resident characteristics in bold in the left column. Statistically significant differences are indicated using *<.05; **<.01; ***<.001.

Column percent is equal to the n for the category divided by n for the column (i.e. 24/508=4.72%)

Row percent is equal to the n for the category divided by the n for the row (i.e. 24/29=82.76%)

APPENDIX F: TABLE 11

Table 11. Descriptive Statistics for error characterisitics by type of error

	Wrong Patient			Wrong Drug			Dose Omission			Wrong Dose			Wrong Administration			Wrong Followup			Other type of Error			Total	
	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	Col%	Row%	N	%
Total	21	100%	4%	78	100%	13%	211	100%	36%	117	100%	20%	51	100%	9%	52	100%	9%	51	100%	9%	581	100%
Medication Use Process ***																							
Prescribing	0	0.0%	0.0%	1	1.3%	3.6%	11	5.2%	39.3%	6	5.1%	21.4%	2	3.9%	7.1%	2	3.8%	7.1%	6	11.8%	21.4%	28	4.8%
Dispensing	1	4.8%	1.3%	30	38.5%	38.5%	17	8.1%	21.8%	18	15.4%	23.1%	2	3.9%	2.6%	3	5.8%	3.8%	7	13.7%	9.0%	78	13.4%
Documenting	3	14.3%	1.1%	14	17.9%	5.2%	107	50.7%	39.5%	56	47.9%	20.7%	29	56.9%	10.7%	38	73.1%	14.0%	24	47.1%	8.9%	271	46.6%
Administering	17	81.0%	8.8%	33	42.3%	17.0%	76	36.0%	39.2%	36	30.8%	18.6%	18	35.3%	9.3%	2	3.8%	1.0%	12	23.5%	6.2%	194	33.4%
Monitoring	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.9%	10.0%	0	0.0%	0.0%	7	13.5%	70.0%	2	3.9%	20.0%	10	1.7%
Causes for Reported Errors																							
Product Issues ***	1	4.8%	3.4%	22	28.2%	75.9%	0	0.0%	0.0%	4	3.4%	13.8%	0	0.0%	0.0%	0	0.0%	0.0%	2	3.9%	6.9%	29	5.0%
Recording Issues ***	3	14.3%	1.3%	17	21.8%	7.5%	89	42.2%	39.0%	50	42.7%	21.9%	20	39.2%	8.8%	31	59.6%	13.6%	18	35.3%	7.9%	228	39.2%
Dispensing Issues ***	1	4.8%	1.6%	24	30.8%	39.3%	17	8.1%	27.9%	9	7.7%	14.8%	1	2.0%	1.6%	2	3.8%	3.3%	7	13.7%	11.5%	61	10.5%
Facility Issues	6	28.6%	8.1%	7	9.0%	9.5%	31	14.7%	41.9%	14	12.0%	18.9%	6	11.8%	8.1%	6	11.5%	8.1%	4	7.8%	5.4%	74	12.7%
Personnel Issues	14	66.7%	3.7%	46	59.0%	12.1%	145	68.7%	38.2%	74	63.2%	19.5%	39	76.5%	10.3%	27	51.9%	7.1%	35	68.6%	9.2%	380	65.4%
Other Causes *	5	23.8%	14.7%	3	3.8%	8.8%	15	7.1%	44.1%	5	4.3%	14.7%	4	7.8%	11.8%	0	0.0%	0.0%	2	3.9%	5.9%	34	5.9%
Primary Personnel Involved in Error ***																							
LPN	11	52.4%	2.9%	41	52.6%	11.0%	146	69.2%	39.1%	76	65.0%	20.4%	39	76.5%	10.5%	28	53.8%	7.5%	32	62.7%	8.6%	373	64.2%
RN	10	47.6%	6.5%	18	23.1%	11.7%	53	25.1%	34.4%	31	26.5%	20.1%	10	19.6%	6.5%	20	38.5%	13.0%	12	23.5%	7.8%	154	26.5%
Medication Aide	0	0.0%	0.0%	0	0.0%	0.0%	1	0.5%	25.0%	3	2.6%	75.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	4	0.7%
Physician	0	0.0%	0.0%	1	1.3%	7.7%	3	1.4%	23.1%	0	0.0%	0.0%	1	2.0%	7.7%	3	5.8%	23.1%	5	9.8%	38.5%	13	2.2%
Pharmacist	0	0.0%	0.0%	16	20.5%	69.6%	3	1.4%	13.0%	2	1.7%	8.7%	0	0.0%	0.0%	0	0.0%	0.0%	2	3.9%	8.7%	23	4.0%
Nurse Practitioner	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	2.0%	100.0%	0	0.0%	0.0%	0	0.0%	0.0%	1	0.2%
Support Personnel	0	0.0%	0.0%	2	2.6%	15.4%	5	2.4%	38.5%	5	4.3%	38.5%	0	0.0%	0.0%	1	1.9%	7.7%	0	0.0%	0.0%	13	2.2%

Notes: Chi square tests for independence were conducted for the medication use process and primary personnel involved in error. In addition chi square tests of independence were conducted for each of the subcategories of cause for reported errors. Statistically significant differences in type of error for each characteristic are indicated using *=<.05; **=<.01; ***=<.001.
Column percent is equal to the n for the category divided by n for the column (i.e. 24/508=4.72%)Row percent is equal to the n for the category divided by the n for the row (i.e. 24/29=82.