The Effect Of Illumination On Medication Preparation Errors In A Long Term Care Facility

by

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Abstract

The main objectives of this study were to (1) measure the effect of increased illumination levels on the medication preparation error rate in a long term care facility, and (2) measure the effect of increased illumination levels on the medication preparation error types in the same facility.

The data collection process was divided into two phases:

1. Initial site visit to explore and operationally define the variables of interest and collect demographic information about the subjects in the study.

2. Explanatory phase to study the effect of the intervention variable (increased illumination level) on the dependant variable (medication preparation errors).

The sampling unit was the preparation of an oral prescription medication dose by the nurse-subject in the particular section of the study site and observed by the principal investigator, before administration to the resident, during the study period.

The data were collected by direct, undisguised observation method during the morning and evening medication pass shifts (8 am and 5 pm) at the study site, during a period of 45 days. The doses observed were randomly assigned for illumination at one of three levels of illumination (baseline, 100 and 145 foot-candles). Each nurse was observed for doses at all three illumination levels, thus each subject served as their own control. The illumination was controlled by a supplemental lighting apparatus (OttLite

508 Illumination™ rechargeable fluorescent task lamp), which was affixed to the study medication cart.

Seven nurse-subjects prepared a total of 6,758 doses during the observation period, of which 467 doses were in error (error rate 6.7%). The most frequently observed medication preparation error was Omission (N = 190, 40%), followed by Wrong time (N = 146, 31%), Wrong form (N = 72, 15%), Wrong Dose (23, 5%) and Unauthorized Dose (4, 1%). A repeated - measures Analysis of Variance (ANOVA) was performed on the observation data for the study period.

Significant treatment (illumination) effect ($F_{2,5} = 17.116,\ p < 0.05$) was found on the medication preparation error rate, with Illumination level 3 (145 foot-candles; error rate 4.3%) significantly associated with lower medication preparation error rate as compared to the baseline illumination level (30 foot-candles; error rate 8.5%).

Chi Square Analysis revealed Wrong dose form errors ($X^2 = 12.954,\ df = 2,\ p < 0.05$) and Omission errors ($X^2 = 180825,\ df = 2,\ p < 0.05$) to have significant relationship with the illumination level.

Linear regression analysis revealed no significant linear relationship between medication preparation workload of the nurse-subjects and their medication preparation error rate for all three illumination levels (Level 1: $F_{1,26} = 0.196$, $p > 0.05$, Level 2: $F_{1,26} = 0$, Level 2: $p > 0.05$, Level 3: $F_{1,26} = 0.122$, $p > 0.05$). There were no significant differences in the proportion of medication preparation errors for each nurse-subject for all three illumination levels.

It was concluded that adjustment of lighting from baseline level to 145 foot-candles achieved significant reduction in medication preparation errors. An important

implication of this study is that the elevation of illumination standards at long- term care facilities could reduce the rate of errors in the preparation of doses for administration on the order of 50%. The study directed attention to the need for setting higher illumination standards at long-term care facilities, in order to facilitate optimum visual performance by the healthcare staff.

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I. Introduction

General Problem Area

Patient safety is an important concern of current healthcare delivery systems. Medication errors are often used as an indicator of quality and patient safety in the healthcare environment. The Institute of Medicine published the Quality Chasm series (2007) wherein they estimated about 800,000 preventable medication errors to occur every year in long term care facilities, harming at least 1.5 million people. One of the factors reported as contributing to the errors in the healthcare delivery system, is lack of proper lighting conditions (Santell, 2003; (MEDMARX Data Report, 2008)

In the long-term care settings, the tasks performed during the medication delivery process (transcription, verification, drug dispensing, preparation and administration) are highly visual in nature. The problem of performing these tasks gets compounded with factors such as illegible prescriptions, look-alike/sound-alike drug names, high workload and visual fatigue. When such high visual demands must be met in unfavorable environmental conditions, the probability of making an error is higher. That the quantity and quality of light are of paramount importance for the medication distribution tasks that have a high visual component should not be surprising.

Poor lighting environment can contribute to visual discomfort and eye strain (Boyce, 1981). Visual performance is the only performance outcome that changing the lighting conditions can affect directly (Alvarado, 2007). While proper lighting cannot

produce work itself, it can make details easier to discriminate and colors easier to judge, without producing discomfort or distraction (Sanders & McCormick, 1993)

Although research in long term care settings for studying the effects of lighting conditions on medication errors has been minimal (non-existent), there has been evidence in other healthcare and human factors fields which has established that improved lighting conditions (such as increased illumination and reduced glare) help in improving the visual performance of the subjects, and thus help in decreasing errors.

Purpose Of The Study

The purpose of this study was to investigate the effect of increased illumination level on the medication preparation error rate in a nursing facility.

Significance

A survey of 53 nursing homes in four states found that the nursing home facilities were often dimly lit. The illumination was rated as inadequate or barely adequate in 45 percent of hallways, 17 percent of activity areas and 51 percent of the resident rooms (Sloane, Mitchell, Calkins, & Zimmerman, 2000). There are no federal standards or regulations requiring the quality and quantity of light to meet the visual needs of the older people in nursing homes. There is great variability among the nursing facilities in different states, regarding lighting regulations. Lack of lighting standards and specific minimum target illuminance values coupled with the aging nursing population catering to the nursing home residents likely aggravate the problem of medication errors in these facilities.

The consequences that medication errors can have in terms of mortality, morbidity and financial loss to both the patients and the nursing facility is well documented in literature (Bootman et.al, 1997). If environmental factors such as illumination can be shown to be related to the error rate, then greater emphasis can be placed upon the factors by governmental and professional grouups in the form of high standards in lighting regulations requiring adherence by architects and facility designers.

The significance of this study in particular is that the adjustment of lighting can be a relatively low cost measure requiring little or no change in nursing procedures.

Summary of Methods

This was an explanatory level research study, where the data were collected by direct observation. The principal investigator was trained in the scientific observation techniques (Barker, 1980) and observed the nurse-subjects, in the study nursing home site.

Data collection occupied 2 phases:

1) Exploratory phase – where the variables of interest were explored and operationally defined.

2) Explanatory phase – where the effect of the intervention variable (increased illumination level) was studied on the dependant variable (medication preparation error rate).

II. Literature Review

Overview

This review spans the literature from the general topic of human vision to the specific topic of studying the effect of illumination levels on work performance; in this case medication errors in the long term care setting.

The purpose of this literature review is:

1. To explain the need to conduct this study,
2. To explain the significance of this study with respect to the existing theory,
3. To explain the rationale for the study proposed.

Human Vision

The human eye, a very important receptor organ, senses the energy from the outside world in the form of light waves and converts these into a form of energy into nerve impulses.

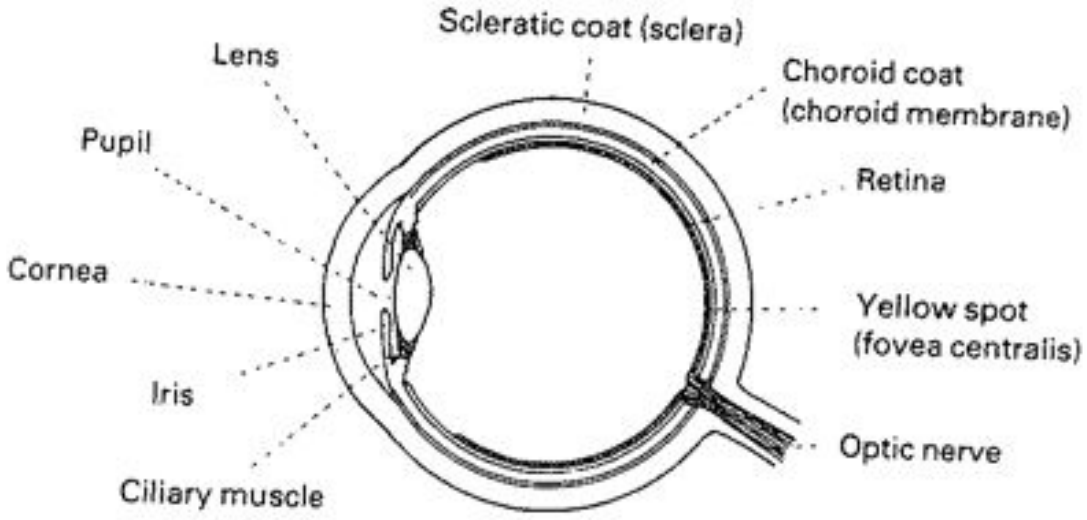


Figure 1: Diagrammatic horizontal section through the right eye (K. Kroemer & E. Grandjean, 1997)

The complete visual system controls about 90 percent of all our everyday activities (K. Kroemer & E. Grandjean, 1997)

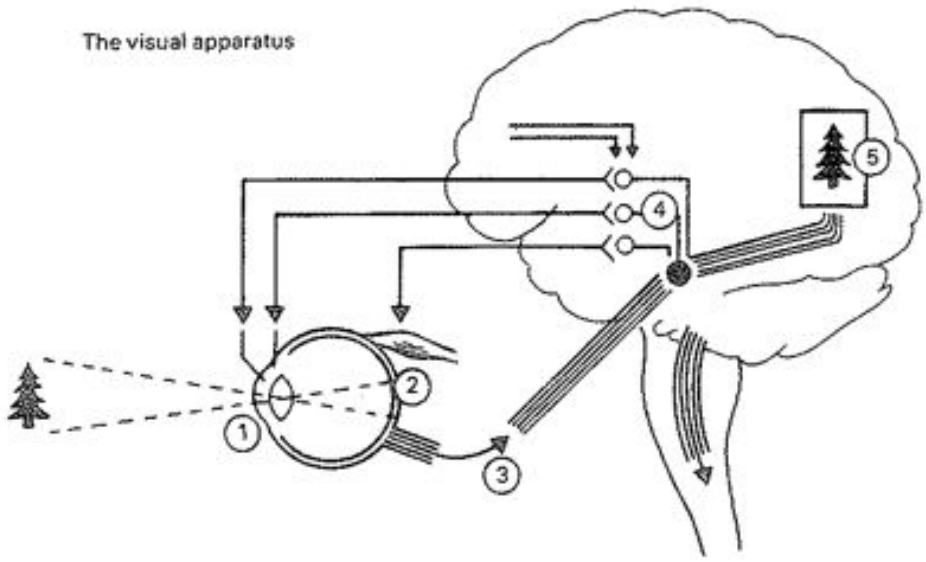


Figure 2: Diagram of the visual system (K. Kroemer & E. Grandjean, 1997)

1 = cornea and lens; 2 = light received on the retina; 3= transmission of optical information along the optic nerve to the brain; 4 = synapses and feedback to the eye; 5 = visual perception of the external world in the conscious sphere of the brain.

The human eye contains about 130 million rods and 7 million cones. Cones detect fine differences in either color or shape but need high illumination for this. Rods are more sensitive even in dim light, but conceive only shades of grey between black and white. They are the most important light-detecting organs in poor visibility and at night (K. Kroemer & E. Grandjean, 1997)

Illumination is also called as illuminance, and is the amount of light falling on to a surface (K. H. E. Kroemer & E. Grandjean, 1997; Niebel & Freivalds, 2003; Sanders & McCormick, 1993) It is measure in terms of luminous flux per unit area. The units of measurement are:

Lux (an SI unit) = 1 lumen per square meter, the lumen being the unit of luminous flux

Foot-candle (USCS unit) = 1 lumen per square foot

One foot-candle equals 10.76 lux, usually rounded off to 10 lux for practical purposes.(Sanders & McCormick, 1993)

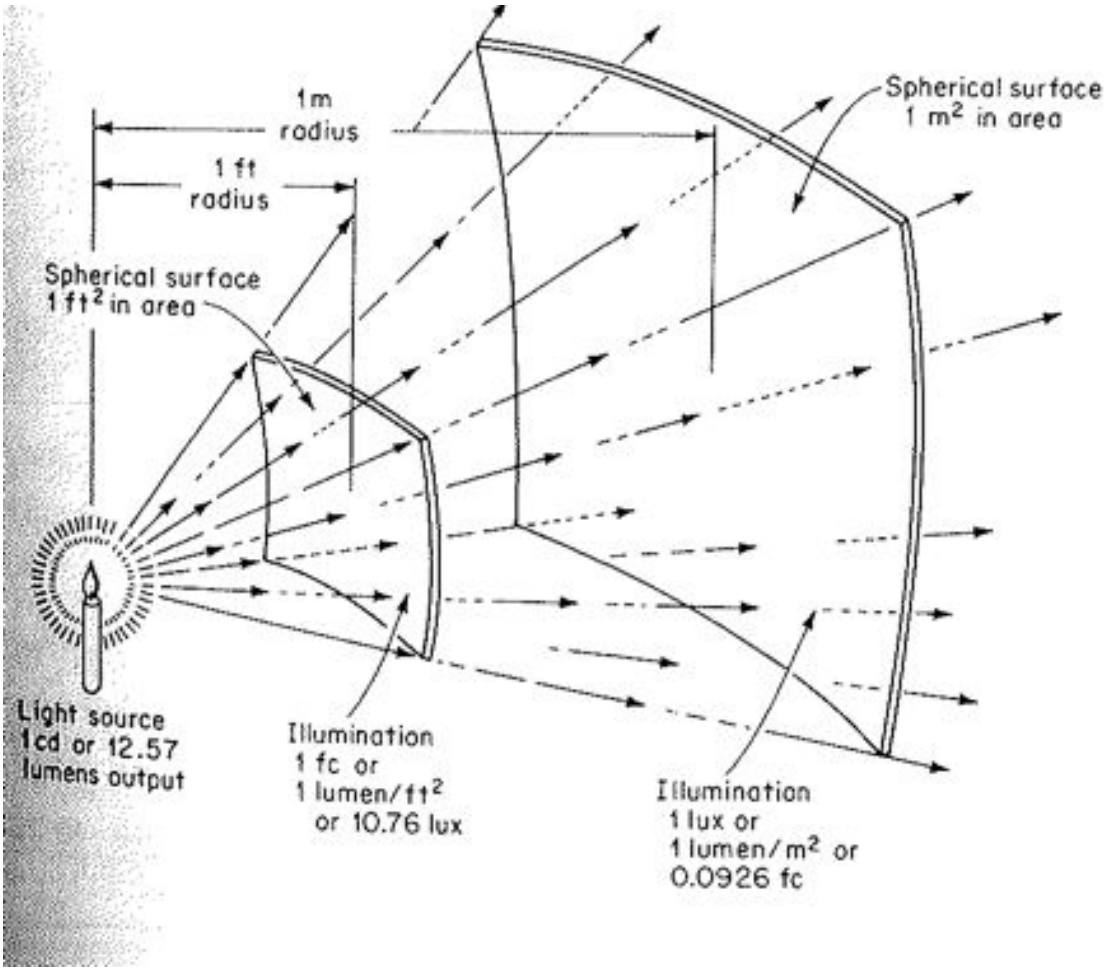


Figure 3: Relationship between candelas, foot-candles and lux (Sanders & McCormick, 1993)

The amount of illumination striking a surface drops off as the square of the distance ("White paper on Quality Pharmaceutical Care in Long Term Care,") in feet from the source of the surface (Niebel & Freivalds, 2003) : Illuminance = luminous intensity / d^2

Luminance - It is the amount of light reflected or emitted from a surface (K. H. E. Kroemer & E. Grandjean, 1997). Its unit of measurement is: Candela per m^2 (SI unit) or millilambert and footlambert (USCS unit). One millilambert is the amount of light emitted from a surface at the rate of 0.001 lm/cm^2. A footlambert is the amount of brightness of an ideally reflecting surface illuminated by one foot-candle (K. H. E. Kroemer & E. Grandjean, 1997). It is determined by the reflective properties of the surface, luminance = illuminance x reflectance (Niebel & Freivalds, 2003).

Reflectance is measured and compared by the ratio between reflected and incident amounts of light. It is expressed as the percentage of reflected to incident light (K. H. E. Kroemer & E. Grandjean, 1997).

Accommodation means the ability of the eye to bring into 'sharp focus' objects at varying distances from infinity down to the nearest point of vision, called the 'near point' (K. Kroemer & E. Grandjean, 1997). The level of illumination is a critical factor in accommodation. The better the luminance contrast of visual targets against the background, the faster, easier and more precise the accommodation (K. Kroemer & E. Grandjean, 1997). It has been shown that speed and precision of accommodation decrease with age, there is a marked decrease from about the age of 40 (K. Kroemer & E. Grandjean, 1997).

Glare is a gross overloading of the adaptation processes of the eye, brought about by overexposure of the retina to light (K. Kroemer & E. Grandjean, 1997).

There are 3 types of glare:

1) Reflective glare, caused by excessive brightness contrast between different parts of the visual field.

2) Absolute glare, when a source of light is so bright that the eye cannot possibly adapt to it (e.g. the sun)

3) Adaptive glare, a temporary effect during the period of light adaptation (e.g. coming out of a dark room into bright daylight). This phenomenon is also called 'transient adaptation'.

The most important visual capacities are:

Visual acuity_ - It is the ability to detect small details and to discriminate small objects (K. Kroemer & E. Grandjean, 1997). Measurement of visual acuity commonly uses standardized black stimuli (e.g. Landolt rings or Snellen letters) on a white background. The influences on visual acuity are: (K. Kroemer & E. Grandjean, 1997)

1) Visual acuity increases with the level of illumination, reaching a maximum at illumination levels about 100 foot-candles (1000 lux).

2) It increases with the contrast between the test symbol and its immediate background, and with the sharpness of signs or characters.

3) It is greater for dark symbols on a light background than for the reverse.

4) It decreases with age.

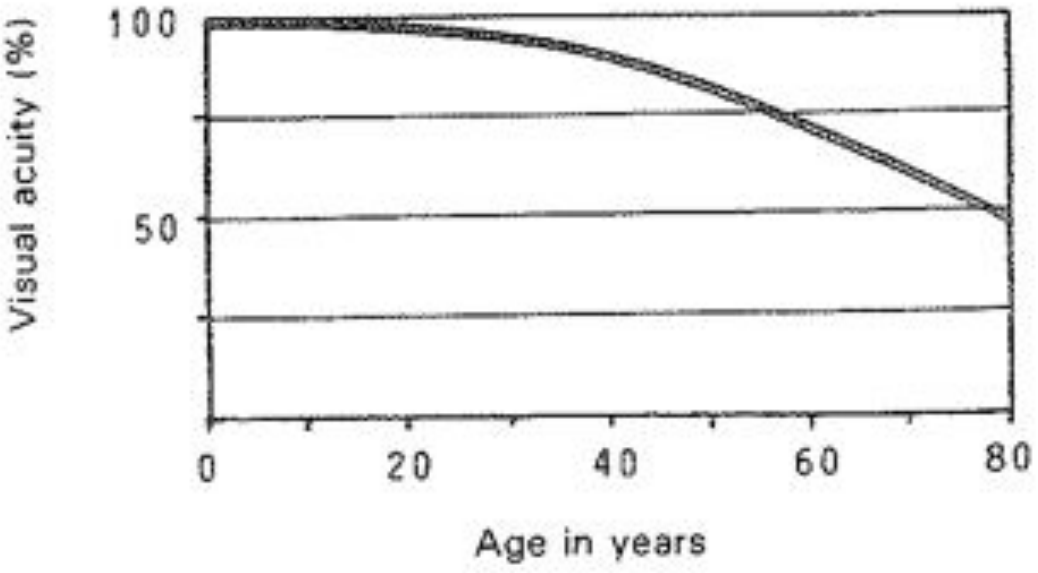


Figure 4: Decrease of visual acuity with age (K. Kroemer & E. Grandjean, 1997)

Contrast sensitivity_ - It is the ability of the eye to perceive a small difference in luminance.(K. Kroemer & E. Grandjean, 1997) It plays a very important role in jobs which involve visual inspection and product control. To measure contrast sensitivity, a procedure is used in which the luminance of a standardized target is compared with its surroundings.

The influences on contrast sensitivity are: (K. Kroemer & E. Grandjean, 1997)

1) It is greater in large areas than for small areas.

2) It is greater when boundaries are sharp and decreases when the change is gradual or indefinite.

3) It increases with the surrounding luminance and is greatest within the range of 70 cd/m^2 and 1000 cd/m^2

4) Within this luminance range, the background must be at least 2 per cent lighter or darker than the target.

5) It is greater when the outer parts of the visual field are darker than the center and weaker in the reverse contrast.

Luckiesh and Moss (1937) conducted a series of experiments and concluded that raising the illumination level from approximately 10 lux to 1000 lux (around 100 foot-candles) increases the visual acuity from 100 to 170 percent and contrast sensitivity up to 450 percent.(Luckiesh & Moss, 1937) They also recorded a decrease in muscular tension and rate of blinking the eyelids, which was interpreted as a reduction in nervous tension as a result of better lighting.

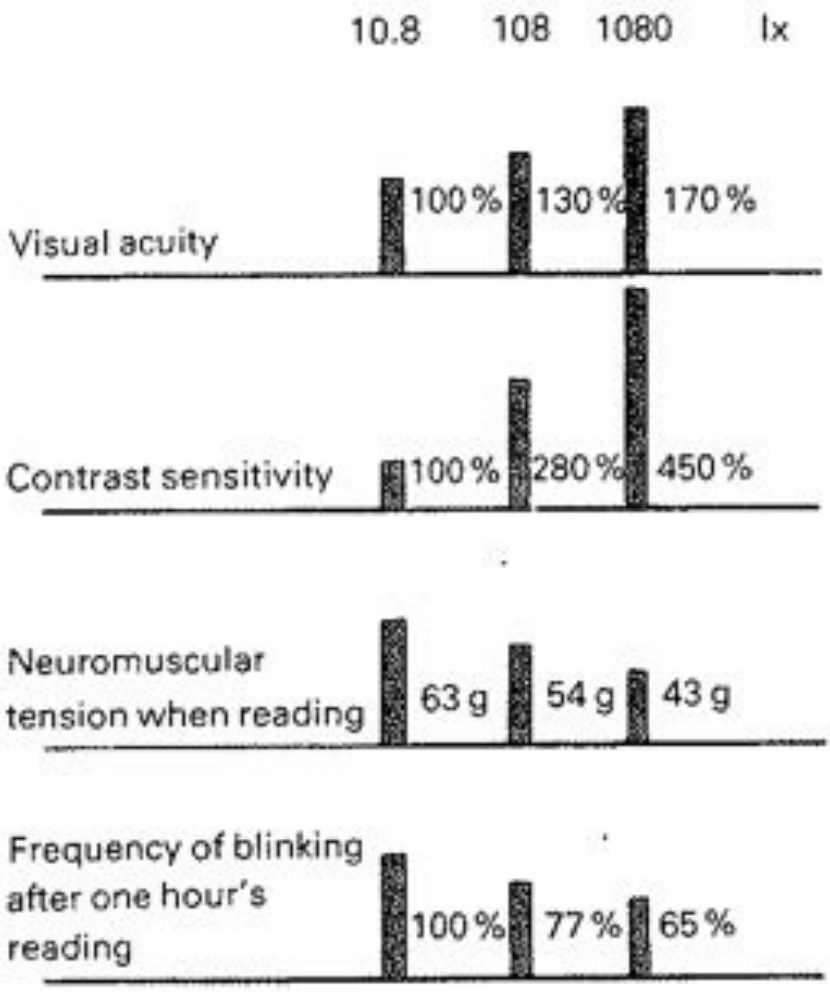


Figure 5: Effect of light intensity on visual acuity(Luckiesh & Moss, 1937)

Human Error

Reason defined human error as the failure of a planned sequence of mental or physical activities to achieve its intended outcome, when these failures cannot be attributed to chance (Reason, 2003).

Leape defined it as an unintended act (either of omission or commission) or one that does not achieve its intended outcome (Leape, 1994).

Errors have been classified as skill, rule and knowledge based models (Reason, 2003). Skill-based errors are errors of action. Reason (2003) defined them as unintended acts, which occur when there is a break in the routine while the attention is diverted. Rule-based errors usually occur during problem solving when a wrong decision is chosen- either because of a misperception of the situation and, thus, the application of a wrong rule or a misapplication of a right rule. Knowledge-based errors arise because of lack of knowledge or misinterpretation of the problem (Leape, 1994). Errors that occur during the prescribing, dispensing and administering stages are termed as Medication Errors (Bates, Boyle, Vliet, Schneider & Leape, 1995).

Visual Fatigue

Visual fatigue comprises all those symptoms that arise after excessive stress on any of the functions of the eye. One of the manifestations include reduced visual acuity, sensitivity to contrast and speed of perception (K. Kroemer & E. Grandjean, 1997). These symptoms are brought about in particular by strenuous fine work, poorly printed texts, inadequate lighting, and exposure to flickering light. Elderly people are more prone to visual fatigue (K. Kroemer & E. Grandjean, 1997).

The effects of visual fatigue on a person's occupation may include loss of productivity, lowering of quality, more mistakes and increased accident rate (K. Kroemer & E. Grandjean, 1997).

Grandjean (1988) referred to a report wherein experts concluded that bad lighting was the cause of 5 % of all industrial accidents and together with optical fatigue, it contributed to as much as 20 % (Grandjean, 1988).

They concluded that work that requires high visual acuity and contrast sensitivity needs high levels of illumination. Fine and delicate work need to be illuminated at 1000 (100 foot-candles) to 10,000 lux (1000 foot-candles) (Grandjean, 1988).

Lighting and Productivity

There are many studies that report increased productivity after the lighting was improved. These increases are partly a direct effect (through more rapid visual work assessment) and partly indirect (reduction in visual fatigue) (K. Kroemer & E. Grandjean, 1997).

McCormick and Sanders (1987) provided a table summarizing the results of 15 industrial studies, all of which showed increases in output, ranging from 4 to 35 %, after increasing the illumination level. But there were some reservations because of the existence of other uncontrollable factors that were present in such situations (Sanders & McCormick, 1993).

Table 1: Factors affecting visual inspection accuracy: different studies (Megaw, 1979)

Table 1: Factors that might influence inspector performance. (L) = laboratory based task, (R) = industrially based task

Subject factors	
Visual acuity	
Static	McCormick, 1950 (R)
Dynamic	Nelson and Barany, 1969 (L)
Peripheral	Johnston, 1965 (L)
Colour vision	Birch, 1975 (R)
Eye movement scanning strategies	Moraal, 1975 (R)
Age	Jamieson, 1966 (R)
Experience	Bevis and Towill, 1974 (R)
Personality	Wiener, 1975 (L)
Sex	Smith and Barany, 1970 (L)
Intelligence	Kappauf and Powe, 1959 (L)
Physical and environmental factors	
Lighting	
General	Faulkner and Murphy, 1973 (R)
Surround luminance	Lythgoe, 1932 (L)
Lighting for colour	Boyce and Simons, 1977 (L)
Aids	
Magnification	Harris and Chaney, 1969 (R)
Overlays	Harris and Chaney, 1969 (R)
Viewing screen	Schoonard *et al*, 1973 (R)
Closed-circuit TV	Kundel *et al*, 1969 (L)
Partitioning of display	Lovie and Lovie, 1968 (L)
Automatic scanner	Townsend and Fry, 1960 (L)
Background noise	Poulton, 1977 (L)
Music-while-you-work	Fox, 1971 (R)
Workplace design	Astley and Fox, 1975 (L)
Task factors	
Inspection time	
Stationary	Drury, 1973 (R)
Conveyor paced	Drury, 1973 (R)
Task factors (continued)	
Paced *vs* unpaced	MacFarling and Heimstra, 197
Direction of movement	Williams and Borow, 1963 (L)
Viewing area	Buck, 1975 (L)
Shape of viewing area	Reilly and Teichner, 1962 (L)
Density of items	Moder and Oswalt, 1959 (R)
Spatial distribution of items	Brown and Monk, 1975 (L)
Fault probability	Fox and Haslegrave, 1969 (R)
Fault mix	Megaw *et al*, 1978 (L)
Fault conspicuity	Drury, 1975 (R)
Product complexity	Harris, 1966 (R)
Organisational factors	
Number of inspectors	Harris and Chaney, 1969 (R)
Briefing/instructions	Teel *et al*, 1968 (L)
Feedback	Drury and Addison, 1973 (R)
Feedforward	Sheenan and Drury, 1971 (R)
Training	Chaney and Teel, 1967 (R)
Selection	Harris, 1964 (R)
Standards	Belbin, 1957 (R)
Time-on-task	Plummer *et al*, 1975 (R)
Rest pauses	Colquhoun, 1959 (L)
Shift	Toulouse, 1958 (R)
Sleep deprivation	Deaton *et al*, 1971 (L)
Social factors	
General	Thomas and Seaborne, 1961 (R
Isolation of inspectors	Jamieson, 1966 (R)
Working in pairs	Lion *et al*, 1975 (L)
Effects on sampling schemes	Toulouse, 1958 (R)
Motivation	Stok, 1965 (R)
Incentives	Mitten, 1957 (R)
Product price information	Valenzi and Andrews, 1971 (L)
Job rotation	Saito *et al*, 1972 (R)

Medication Errors

Medication error was defined in 1962, as the ‘’administration of the wrong medication or dose of medication, drug, diagnostic agent, chemical, or treatment requiring the use of such agents, to the wrong patient or at the wrong time, or the failure to administer such agents at the specified time or in the manner prescribed or normally considered as accepted practice’’. (Kenneth N. Barker & McConnell, 1962).

In hospitals, medication errors have been found to occur at the rate of about one per patient per day (Allan & Barker, 1990). This error rate includes the errors occurring in the dispensing and administration stages.

The American Society of Health-System Pharmacy (1998) defined medication errors as any preventable event that may lead to inappropriate medication use or patient harm while the medication is in control of healthcare professional, patient or consumer. Such events maybe related to professional practice, healthcare products, procedures and systems, including prescribing, order communication, product labeling, packaging and nomenclature, compounding, dispensing, distribution, administration, education, monitoring and use’.

The term ‘opportunity for error’ has been used as the basic unit of data for calculating the medication error rate. An opportunity for error includes any dose given plus any dose ordered but omitted. The ‘total opportunities for error’ is the sum of all the doses ordered plus all the unordered doses given. The medication error rate is calculated as the number of doses in errors (incorrect in one or more ways) divided by the total opportunities for error (Kenneth N. Barker, Kimbrough, & Heller, 1966).

$$\text{Medication error rate} = \frac{\text{Total number of actual errors}}{\text{Total opportunities for error}}$$

A medication error may or may not be labeled as an "Adverse event", depending upon whether the error caused the patient harm or discomfort. An Adverse drug event is defined as an injury resulting from medical interventions related to a drug. Adverse event reports are the 'tip of the iceberg' of the problem of errors (seen as system failures), since most errors do not result in reported injuries (Bates et al, 1995).

Medication errors have been categorized somewhat differently depending upon the healthcare settings, inpatient or outpatient.

Cohen (1999) defined the different types of medication errors as:

Prescribing/Ordering errors - Mistakes made by the physician (prescriber) when ordering a medication.

Transcription errors – Deviations from the prescriber's orders, made by the nursing staff or the pharmacist, when transcribing medication orders.

Dispensing errors - Deviation from the prescriber's order, made by pharmacy staff, when distributing medications to nursing units or to patient's in an ambulatory setting.

Administration errors – *The American society of hospital pharmacists & National League for Nursing liaison committee (1998)* defined them as 'the administration of the wrong medication or dose of medication, drug, diagnostic agent, chemical, or treatment requiring the use of such agents, to the wrong patient or at the wrong time, or the failure

to administer such agents at the specified time or in the manner prescribed or normally considered as acceptable practice.'

Near Errors – *The Joint Commission on Accreditation and Healthcare Organizations* (2001) defined near error as 'any process variation which did not affect the outcome, but for which a recurrence carries a significant chance of a serious adverse outcome.'

The Agency of Healthcare Research and Quality (2011) defined near errors as 'events in which the unwanted consequences were prevented because there was a recovery and correction of the failure.'

Such errors show that the quality assurance system in the pharmacy is working, but they also maybe taken to reflect a weakness exists in the dispensing system.

Davis stated that near errors should be constantly analyzed in an effort to develop methods to systematically reduce their occurrence (N. M. Davis, 1990).

Observation method

The disguised observation study was developed by Barker and McConnell (Barker K. N & McConnell, 1962) for the detection of medication errors. The observation is disguised in the sense that the subject is unaware of the goal of the study.

Some of the advantages of observation method are (Flynn, Barker, & Carnahan, 2003):

- Knowledge of error by the person involved is not required.
- Willingness to report the error is not a factor.
- Remembering to report or ability to communicate errors is not required
- Selective perception of the nurse or pharmacist is not involved.

- Unsolicited comments collected through the observation process can help identify or associations between errors and possible causes (K. N Barker, 1980).

The uses of observation data as suggested by Flynn et al (2002) are as follows:

- Indicate and signal major system breakdowns
- Evaluate expensive interventions
- Internally and externally benchmark for quality improvement
- Focus resource deployment for error correction and prevention
- Provide a source of examples for problem solving, continuing education programs
- Focus on root cause analysis.

Observation tends to be tiresome, if conducted over a long period of time. Special training is required for the data collectors, and some personality types may be unsuited for the role of observer (Flynn, Barker, Pepper, Bates, & Mikeal, 2002). Direct observation might be more expensive per examined dose due to the normal delays involved in medication administration sessions. The effect of the observer on the observed is also a concern.

Researchers have conducted various studies to detect any significant effect of the observer on the observed. The possible effect was studied by monitoring individual error rates for 5 consecutive days. The consistency of each subject's medication error rate was interpreted to indicate that the observer did not affect the rate.(Kenneth N. Barker, et al., 1966). It has been long known that when observation is unobtrusive and non judgmental,

the subject(s) adapts quickly to an observer's presence and act as they would usually act (F.N Kerlinger & Lee, 1999).

Dean and Barber studied the effect of observer intervention on nurses. They found that tactful intervention by the observer does not have significant effect on the observed, and that an observation period of less than seven days by one observer had high observer reliability. They concluded that concerns about the validity and reliability of observational methods for identifying medication administration errors may be unfounded (Dean & Barber, 2001).

Medication error problem in nursing homes

One of the earliest studies linking eyesight and medication errors in nursing students was conducted by Byrne (Byrne, 1953). Although the study did not specify environmental factors as causes of errors, it listed 'failure to accurately read the medicine card as one of the causes'.

The observation study of medication administration errors in a 300-500 bed, non-governmental, health care facility by Barker et. al (Kenneth N. Barker, et al., 1966) found that some of the nurses involved in the medication administration errors had poor eyesight; and the lighting in the area where they prepared medications was poor. The authors suggested the need to improve the lighting conditions in the facility.

A prospective cohort medication error study (Barker, Flynn et. al, 2002) of a stratified random sample of 36 healthcare institutions was conducted in Colorado and Georgia. Of the 36 institutions, 12 of them were skilled nursing facilities (6 facilities each

in Georgia and Colorado). The researchers found a medication error rate of 10.8% (Georgia) and 14.2 % (Colorado) at the skilled nursing facilities.

A prospective observational study (Barber et. al, 2009) of residents at 55 UK nursing care homes found that 69.5% of the residents living there had encountered one or more errors; with each resident experiencing a mean of 1.9 medication errors. Main contributing factors for the errors were found to be staff's high workload, interruptions during the drug rounds, insufficient nurse's knowledge and inadequate information about the residents in the facility.

Problems faced by the nursing facility

The nursing population in the long term care facilities is aging (Joint Commission on Accreditation of Healthcare Organizations, August 2002). The average age of a working registered nurse today is 43.3 years, and that average age is increasing at a rate more than twice that of all other workforces in this country. Only 12 percent of registered nurses in the workforce are under the age of 30 years. By 2010, it is projected that the average age of the working registered nurse will be 50.8 years.(Buerhaus, Staiger, & Auerbach, 2000; Joint Commission on Accreditation of Healthcare Organizations, August 2002) The performance of the human eye declines with age, with the effects beginning to be noticeable at 40 years of age. This leads to changes in the spectral light sensitivity that by 80 years of age causes loss of vision.(The IESNA Lighting for the Aged and Partially Sighted Committee, 2007) Research has established that aging eyes require more light as compared to younger eyes, for optimal visual performance.(M. O. Blackwell & Blackwell, 1980; Boyce, 1973; Crouch, 1965; Cullinan, 1986; R. G. Davis

& Garza, Winter 2002; Smith & Rea, 1978; The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007).

Thus special attention must be given to the good visual performance, (and hence improved lighting conditions) for the aging care provider.(Alvarado, 2007)

The following figures show that older eyes require increased lighting levels for better visual performance.

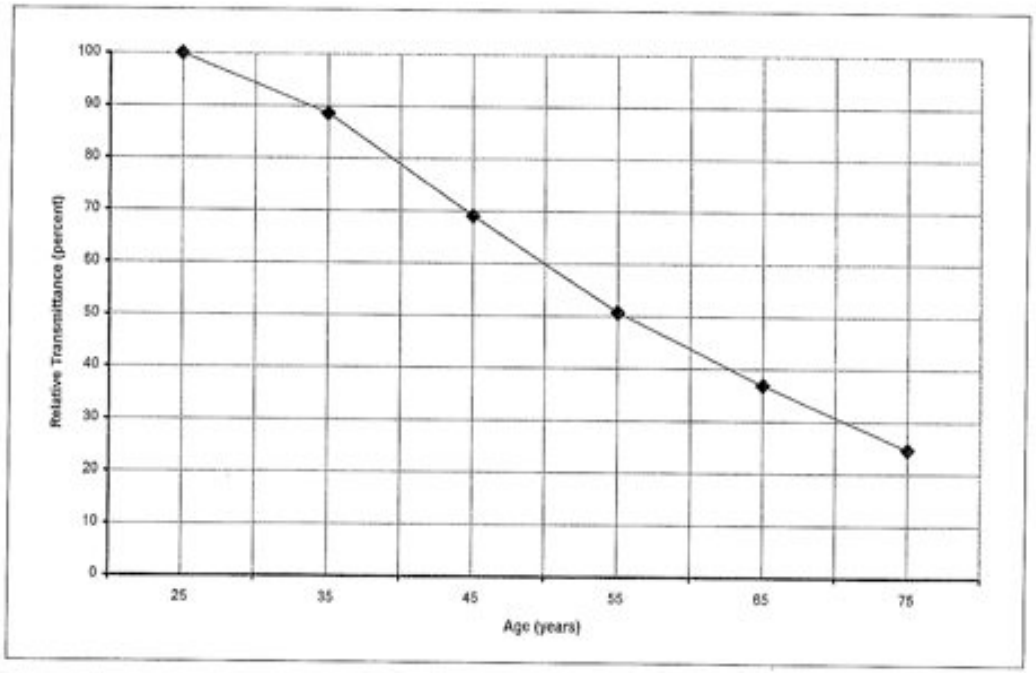


Figure 1. The transmittance of the human eye plotted as a function of age.[9] As people get older, they may require greater illuminance to offset the reduction in the amount of light reaching the retinas of their eyes.

Figure 6: Figure depicting a decrease in the transmittance of the human eye, with age.(The IESNA Lighting for the Aged and Partially Sighted Committee, 2007)

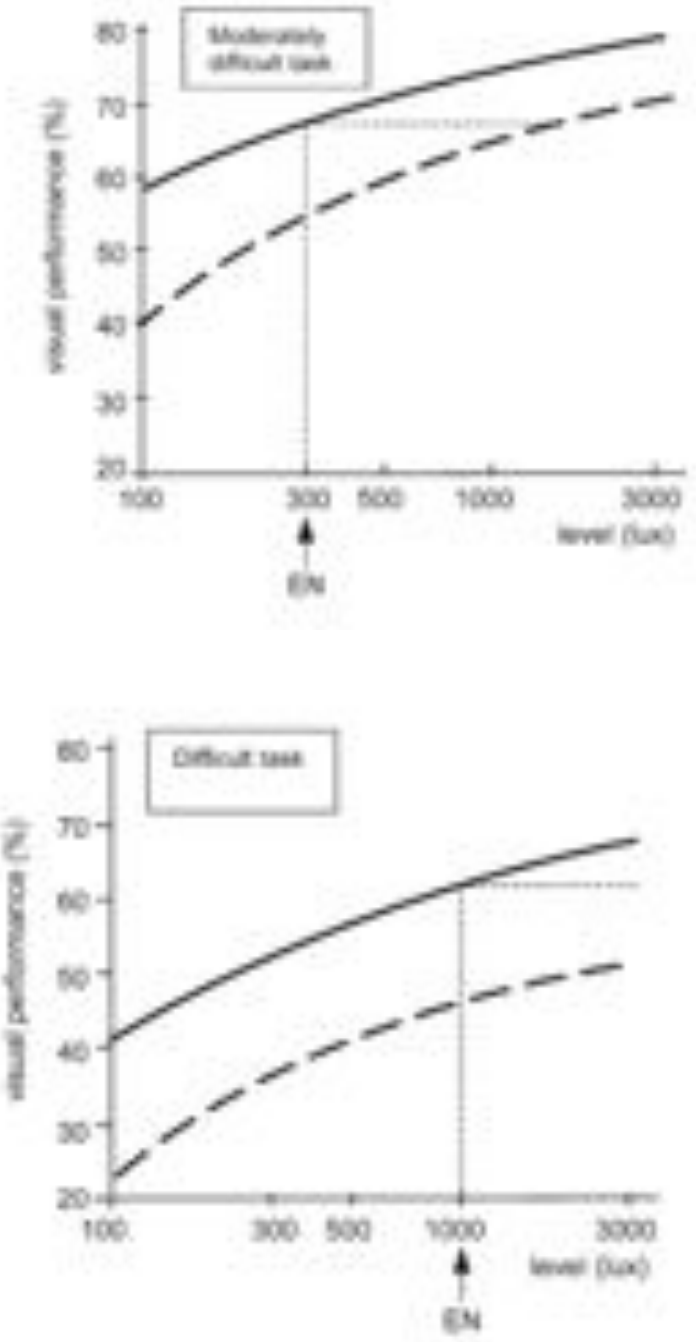


Figure 7: Figures showing the relative visual performance (%) and lighting levels (lux) for moderately difficult and difficult tasks.(Bommel & Beld, 2004)

Continuous line: young people, broken line: older people; EN – European Norm

The problem of insufficient lighting in nursing facilities

The problem of insufficient lighting in nursing homes was highlighted when a group of researchers (Lepeleire, Bouwen, Conninck, & Buntinx, 2007) measured lighting levels in different areas of a nursing home and found the lighting levels to be insufficient as per the lighting standards (The IESNA Lighting for the Aged and Partially Sighted Committee, 2007) for the nursing home residents. Although, this study was not conducted in a United States healthcare facility, it begs the question of whether this problem exists in American healthcare facilities.

Visual display terminals in the healthcare setting (such as computers, automated dispensing machine- monitors) need different lighting conditions. It is a well-known fact that too much lighting can cause reflected glare on the computer monitor (Henderson, Spring 1995; Sanders & McCormick, 1993; The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007).

In addition to recommending minimum illuminance levels, the IESNA committee also highlighted other lighting issues in the healthcare areas, like reducing reflected glare on the computer monitor in the automated delivery system, facility design changes to improve better light distribution, use of better quality luminaries (light installations) etc (The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007).

The Centers for Medicare and Medicaid (CMS) has included adequate lighting requirements in their surveyor guidelines for inspections in long term care facilities (The Centers for Medicare & Medicaid Services, December 2006 edition). Although this

guideline is meant to be for resident comfort, it does highlight the fact that lighting conditions can be an indicator of good quality of care provided in the long term care facilities.

One of the suggestions provided by Dr. Carolyn Clancy, the director for the Agency of Healthcare Research and Quality (AHRQ), to improve quality of care is to improve the lighting conditions in the American healthcare settings (Clancy, 2008). Special considerations should be given to the lighting conditions for health care staff that work during the night shifts. Lighting conditions have shown to have an effect on a person's circadian rhythm (biological clock) and the level of alertness, during work (Juslen, January 2005) A research study investigated the effects of light on alertness and mood, under night shift conditions. The results concluded that although there is a decline in arousal over the night, the group with the increased illumination level showed significantly increased arousal level, and thus better alertness and mood (Boulos Z, Campbell SS, Lewy JJ, & et.al., 1995).

The Illuminating Engineering Society (IESNA) provides recommendations and guidelines for lighting conditions in healthcare facilities (The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007). IESNA formulates lighting standards using illuminance categories and weighting factors based upon the subjects' age, speed and accuracy required to complete the task, and reflectance of the task background (The IESNA Committee for Healthcare Facilities, 2006).

The committee identified the areas requiring different illuminance categories, based on the complexity and demands on the healthcare visual performance. The

following table suggests minimum average illuminance for environments in a general hospital (Alvarado, 2007; Sanders & McCormick, 1993; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007).

Table 2: Minimum average illuminance recommended for different task areas (The IESNA Lighting for the Aged and Partially Sighted Committee, 2007)

Environment	**Ambient light** **Lux/Footcandles**	**Task Lighting** **Lux/Footcandles**
Patient rooms	300/30	750/75
Nursing station (day)	300/30	500/50
Nursing station (night)	100/10	500/50
Medication preparation	**300/30**	**1000/100**

Effect of illumination on work performance

The quantity and quality of light are of paramount importance for highly visual task components. Literature provides evidence demonstrating a positive relationship between illumination and task performance. In fact, its been suggested that illumination increases of up to 50 foot-candles results in the most dramatic increase in visual performance (Boyce, 1981).

Speed and accuracy are the two objective measures of visual performance of a task. There are a number of features of the visual system that are likely to affect the relationship between illumination and human performance:(Terry Lee Buchanan, 1989)

- Nature of the visual task; simple detection, recognition or color discrimination
- Task characteristics; size, contrast and color details
- Event predictability
- Time for which the information will be available
- Whether the stimuli is moving or stationary
- State of adaptation of the visual system

Lyons estimates that at least 80% of the sensory data required by an average worker in the performance of his task is obtained through visual modality (Lyons, 1981).

Two pioneers in the lighting field, H.C. Weston and H.R. Blackwell, developed visual performance models to better describe the relationship between lighting and its effects on work performance. Weston's model (Weston HC, 1945, 1949) concluded that performance increased with an increase in illumination, but not linearly. Also significant, larger improvements in visual performance can be achieved by increasing the contrast

and print size than by increasing the illuminance alone. Finally, one cannot reach the same level of performance for a visually difficult task (small print size and contrast) as compared to a visually easy task, by simply increasing the illumination level.

Blackwell's research on visibility threshold culminated in a model which characterized both threshold and suprathreshold visual performance.(H. R. Blackwell, 1961, 1964; R. H. Blackwell & Blackwell, 1968) He developed the Blackwell Visual Task Evaluator, which is a contrast-reducing meter. He used this meter to determine the visual task's equivalent contrast. The visual task evaluator can be used to determine the illumination levels required for a specific task. This system has been used for establishing recommendations of illumination levels by the CIE (International Commission on Illumination) and the IESNA (Illuminating Engineering Society of North America).

Faulkner (Faulkner & Murphy, 1973) suggested 2 basic approaches to improve task visibility:

1) Change the task;
2) Change the illumination falling upon the task. The most obvious way of varying the illumination level is by changing the intensity.

In 1978 Smith and Rea studied proofreading under different levels of illumination (Smith & Rea, 1978). They found that task performance improved as illumination increased to the highest level with rapid improvements at low levels and more gradual improvement at the higher levels. They also found that the subject's age and print quality of the visual task affected the results; with older subjects performed poorer as compared to younger subjects on the lower quality print tasks.

In 1982, Smith and Rea studied the performance of a reading test under different illumination levels (Smith & Rea, October 1982). Two forms of tests (one with good print quality and another with poor print quality) were performed under four different levels of illumination. The illumination level had no significant effect on task performance, but print quality did show significant effect; with the poor quality resulting in poor performance. They conducted a similar study with a check number verification task under different illumination levels, and found that handwriting quality and illumination level had a significant effect on visual performance (Smith & Rea, Winter 1987). Rea studied the effects of lighting conditions on reading, which indicated that for the same contrast level, visual performance of the subjects increased at higher illumination levels (Rea, Summer 1986).

Some of the factors affecting the visual inspection process include visual acuity, color-vision, age, lighting, noise, inspection time, complexity, paced versus unpaced, and number of inspectors (Megaw, 1979).

A study conducted by Lion (Lion, Richardson, & Browne, 1967, 1969) looked at the performance of industrial inspectors under two different lighting types (tungsten and fluorescent). The tasks involved inspecting links for surface flaws and buttons for off-center holes on a moving conveyor belt. They found that there were fewer errors in the link inspection task under fluorescent lighting as compared to tungsten (this task required greater visual acuity), but there was no difference in performance for the button inspection task.

The Effect of Illumination on Medication Errors

The study by Buchanan (T.L Buchanan, Barker, & et, 1991) was first of its kind where the relationship between illumination levels and the dispensing error rate in a high volume outpatient pharmacy was investigated. The study found a significantly lower error rate of 2.6% for an illumination level of 146 foot-candles as compared to the error rate of 3.8% for the baseline illumination level (45 foot-candles). Thus, this study provides a basis in fact for the belief that illumination level is definitely associated with the medication error rate in a healthcare facility.

Poor lighting condition has been one of the important contributing factors to hospital medication errors, as reported by USP's MEDMARX Program (MEDMARX Data Report, 2008). From the year 2002 -2006, hospitals have reported an average of 230 errors per year were contributed to poor lighting conditions.

There is considerable research done studying the effect of illumination on visual performance, in both laboratory and field settings. Illumination's positive relationship to visual performance is strongly established both analytically and empirically.(Terry Lee Buchanan, 1989) Illumination remains one of the most flexible and adjustable components of the visual performance model.

Thus, there is considerable theoretical basis to expect a positive relationship between illumination and a visually demanding task such as medication preparation in a nursing home setting.

Rationale For Study Proposed

The medication preparation process is highly visual in nature. The nurse must be able to read the contents of the medication administration record (MAR), read the label of the drug prescribed, compare the label to the MAR record and read any distinguishing numbers or letters on the medication in order to identify it.

Studies in human factors research have established that improving the quality and level of illumination greatly improves the visual performance. Weston's studies on the effect of light on visual tasks demonstrated that the visual performance increased with an increase in illumination and contrast size (Weston HC, 1945).

Blackwell developed the Blackwell Visual Task Evaluator (H. R. Blackwell, 1961), which is used by the Illuminating Engineering Society of North American (IESNA) to determine the levels of illumination for a specific task, for eg. Medication preparation, in different healthcare facilities (The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007). In subsequent studies, it was shown that the quality of the visual performance is highly dependant on the quantity and quality of illumination provided for the task (Bellchambers & Philipson, 1962; R. H. Blackwell & Blackwell, 1968; R. G. Davis & Garza, Winter 2002; Dockhorn, Scholz, Vandahl, & Gall, 2005; Faulkner & Murphy, 1973; Megaw, 1979; Smith & Rea, 1978; Wei & Konz, 16-19 October 1978).

The problem of insufficient lighting in nursing homes was highlighted when a group of researchers (Lepeleire, et al., 2007) measured lighting levels in different areas of a nursing home and found the lighting levels to be insufficient as per the IESNA (2007) guidelines for the nursing home residents and staff.

That increasing the illumination can reduce the error rate was the finding of the study of dispensing errors by Buchanan (T.L Buchanan, et al., 1991). A significantly lower error rate was achieved by increasing the illumination level from 45 to 146 foot-candles. This increase in illumination produced a reduction in error rate from 3.8% down to 2.6%. This study thus found that illumination level is definitely associated with the medication error rate in a healthcare facility.

A prospective cohort medication error study (Barker, Flynn et. al, 2002) of a random sample of 12 skilled nursing facilities in Colorado and Georgia found a medication error rate of 10.8% (Georgia) and 14.2 % (Colorado) respectively. It can be speculated that one of the contributing factors to the errors can be the improper preparation of medications during the preparation phase.

USP's MEDMARX Error Reporting Program also highlights Poor lighting conditions as one of the important factors contributing to hospital medication errors (MEDMARX Data Report, 2008). According to the MEDMARX reports, hospitals reported an average of 230 errors per year (for the years 2002-2006) which they attributed to poor lighting conditions.

All the above research studies support the need and value of focusing attention on the lighting system in the healthcare facilities. As the visual component in the healthcare medication distribution system becomes increasingly complex and possibly more prone to error, it is important that the positive impact that a good lighting system can have on the quality of care provided by long term care facilities receive further attention and study, thus ensuring patient as well as healthcare staff safety.

III. Statement Of The Problem

Problem Statement

The main objective of the study was to measure the effect of increased illumination levels on the medication preparation errors, by total error rate and error types, in a long-term care study site.

Main Research Questions

1) Will increased illumination level at the long-term care facility result in decrease of the medication-preparation error rate?

2) Will increased illumination level at the long-term care facility have an effect on the medication-preparation errors, by error types?

3) Is there an association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors detected for that nurse-subject in the long-term care facility?

4) Is there an association between the day of the illumination period and the number of medication preparation errors made during that day, at the long-term care facility?

5) Is the proportion of medication preparation errors constant over all the sections at the study facility?

6) Is there an association between the medication shift (work shift) and the medication preparation errors for all three illumination levels, at the study facility?

Research Hypotheses

Null (H_{0A}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation error rate.

Alternative (H_{1A}): An increased illumination level at the long-term care facility will result in decrease of the medication-preparation error rate.

Null (H_{0B1}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation errors, by wrong dose error type.

Alternative (H_{1B1}): An increased illumination level at the long-term care facility will have a significant effect on the medication-preparation errors, by wrong dose error type.

Null (H_{0B2}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation errors, by wrong form error type.

Alternative (H_{1B2}): An increased illumination level at the long-term care facility will have a significant effect on the medication-preparation errors, by wrong form error type.

Null (H_{0B3}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation errors, by wrong time error type.

Alternative (H_{1B3}): An increased illumination level at the long-term care facility will have a significant effect on the medication-preparation errors, by wrong time error type.

Null (H_{0B4}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation errors, by omission error type.

Alternative (H_{1B4}): An increased illumination level at the long-term care facility will have a significant effect on the medication-preparation errors, by omission error type.

Null (H_{0B5}): An increased illumination level at the long-term care facility will not have a significant effect on the medication-preparation errors, by unauthorized dose error type.

Alternative (H_{1B5}): An increased illumination level at the long-term care facility will have a significant effect on the medication-preparation errors, by unauthorized dose error type.

Null (H_{0C}): There is no association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors detected for that nurse-subject in the long-term care facility.

Alternative (H_{1C}): There is a significant association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors detected for that nurse-subject in the long-term care facility.

Null (H_{0D}): There is no association between the day of the illumination period and the number of medication preparation errors made during that day, at the long-term care facility.

Alternative (H_{1D}): There is a significant association between the day of the illumination period and the number of medication preparation errors made during that day, at the long-term care facility.

Null (H_{0E}): The medication preparation errors detected at the three sections of the study site are not significantly different.

Alternative (H_{1E}): The medication preparation errors detected at the three sections of the study site are significantly different.

Null (H_{0F}): There is no association between the medication shift and the medication preparation errors for all three illumination levels, at the study site.

Alternative (H_{1F}): There is significant association between the medication shift and the medication preparation errors for all three illumination levels, at the study site.

Hypothesis Testing

H_{0A1} : u1 = u2 = u3

H_{1A1}: one or more treatment means differ

H_{0A2} : u1 = u2

H_{1A2} : u1 ≠ u2

H_{0A3} : u1 = u3

H_{1A3} : u1 ≠ u3

H_{0A4} : u2 = u3

H_{1A4} : u2 ≠ u3

H_{0A5} : $T_{linear} = 0$

H_{1A5} : $T_{linear} \neq 0$

H_{0A6} : $T_{quadratic} = 0$

H_{1A6} : $T_{quadratic} \neq 0$

H_{0B1}: u1 = u2 = u3

H_{1B1}: one or more treatment means differ

H_{0B2}: u1 = u2 = u3

H_{1B2}: one or more treatment means differ

H_{0B3} : u1 = u2 = u3

H_{1B3} : one or more treatment means differ

H_{0B4} : u1 = u2 = u3

H_{1B4} : one or more treatment means differ

H_{0B5} : u1 = u2 = u3

H_{1B5} : one or more treatment means differ

Illumination level 1

H_{0C1} : M= 0

H_{1C1} : M ≠ 0

Illumination level 2

H_{0C2} : M= 0

H_{1C2} : M ≠ 0

Illumination level 3

H_{0C3} : M= 0

H_{1C3} : M ≠ 0

For each individual nurse-subjects

H_{0D} : u1= u2 =u3

H_{1D} : Error proportions differ for each nurse-subject for all 3 illumination levels

Illumination level 1

H_{0E1} : $U_X = U_{Y=} U_Z$

H_{1E1} : Error proportions differ for one or more study-sections

Illumination level 2

H_{0E2} : $U_X = U_{Y=} U_Z$

H_{1E2} : Error proportions differ for one or more study-sections

Illumination level 3

H_{0E3} : $U_X = U_{Y=} U_Z$

H_{1E3} : Error proportions differ for one or more study-sections

For all 3 Illumination levels

H_{0F} : $U_{9\ AM} = U_{5\ PM}$; H_{1F} : $U_{9\ AM} \neq U_{5\ PM}$

Concepts

The concepts addressed in this study are as follows:

Error - Failure of a planned sequence of mental or physical activities to achieve its intended outcome, when these failures cannot be attributed to chance (Reason, 2003)

It has also been defined as an unintended act (either of omission or commission) or the one that does not achieve its intended outcome (Reason, 2000, 2003).

Medication error – Errors occurring at any stage in the process of ordering or delivering a medication. Medication errors can occur at any stage in the drug ordering, dispensing and administration process (Leape, 1994).

Prescription – A medication order which designates a specific medication and dosage to be administered to a particular patient, at a specified time and issued by a physician or other properly licensed medical practitioner (Bates, Boyle, Vliet, Schneider, & Leape, 1995).

Illumination level – The illumination level is defined as the rate of light energy emission falling on the unit area of the task surface as measured in foot-candles by a portable, calibrated photometer with an illuminance sensor (Buchanan & Barker, 1991).

Nursing home – A nursing home is a generic term used to describe non-hospital institutions which provide nursing and other health and social related supportive services to the chronically ill and the elderly (Cheung & Vlasses, 1985).

The Congressional Discursive Dictionary of Health care (Cheung & Vlasses, 1985) defines nursing homes as 'generally, a wide range of institutions other than hospitals, which provide various levels of maintenance, and personal or nursing care to people who are unable to care for themselves and who may have health problems which range from minimal to very serious. The term includes freestanding institutions, or identifiable components of other health facilities, which provide nursing care and other related services, personal care and residential care. Nursing homes include skilled nursing facilities, intermediate care facilities and extended care facilities, but not boarding houses.'

Medication preparation - The preparation process is divided into 6 steps: (Barker & Heller, 1963)

- Obtaining the ordered drug in the form available
- Separation of the quantity of drug required for one unit dose
- Physical or chemical alteration of the drug form as required
- Maintenance of proper environment for dose-unit
- Maintenance of proper identification and other required information with dose-unit
- Macroscopic inspection of dose-unit for signs of unsuitability of use.

Ergonomics - Ergonomics the study of the relationship between the work system (the person, the job, and the work place) and human performance (Alexander, 1986).

Illumination - Also called illuminance, is the amount of light falling on to a surface (Sanders & McCormick, 1993). It is measured in terms of luminous flux per unit area. The units of measurement are:

Lux (an SI unit) = 1 lumen per square meter, the lumen being the unit of luminous flux.

Foot-candle (USCS unit) = 1 lumen per square foot.

One foot-candle equals 10.76 lux, usually rounded off to 10 lux for practical purposes (Sanders & McCormick, 1993).

Luminance - It is the amount of light reflected or emitted from a surface (Kroemer & Grandjean, 1997). Its unit of measurement is: Candela per m^2 (SI unit) or millilambert and footlambert (USCS unit).

Reflectance – It is measured and compared by the ratio between reflected and incident amounts of light. It is expressed as the percentage of reflected to incident light. (Kroemer & Grandjean, 1997)

Accommodation means the ability of the eye to bring into 'sharp focus' objects at varying distances from infinity down to the nearest point of vision, called the 'near point' (Sanders & McCormick, 1993)

Glare is a gross overloading of the adaptation processes of the eye, brought about by overexposure of the retina to light (Sanders & McCormick, 1993)

The most important visual capacities are (Sanders & McCormick, 1993):

Visual acuity - It is the ability to detect small details and to discriminate small objects.

Contrast sensitivity - It is the ability of the eye to perceive a small difference in luminance

Medication Preparation Error Categories

The medication preparation error categories addressed in this study are as follows (Cohen, 1999; Flynn, Barker, Pepper, Bates, & Mikeal, 2002):

Unauthorized drug error – Preparation of a dose of medication that was never ordered for that resident.

Extra dose error - Any dose prepared in excess of the total number of times ordered by the physician, as documented in the MAR, such as a dose given on the basis of an expired order, after a drug had been discontinued, or after a drug's administration had been put on hold.

Wrong dose error - Any dose of preformed dosage units (such as tablets) that contained the wrong strength or number.

Omission error - Failure to prepare an ordered dose. Omissions will be detected by comparing the medications prepared at the given observation period, with doses that should have been prepared at that time based on the physician's written order and protocols.

Wrong form error – The preparation of a dose in a different form than ordered by the physician when a form was specified. If enteric-coated aspirin is ordered, but plain aspirin is prepared, then a wrong form error will be counted.

Wrong time error - Preparation of a dose more than 60 minutes before or after the scheduled administration time. Routine administration times were obtained from study site, and times assigned on the MAR were used when no other policy was available.

Operational Definitions

The operational definitions addressed in this study are as follows:

Increased illumination level – The illumination level measured in foot-candles, by a portable, calibrated photometer with an illuminance sensor, when a supplemental task light fixture (of known and constant illuminance) is installed in the study medication cart. This value/increased level (experimental/treatment measure) was kept constant for the entire study period.

Medication preparation – It was defined as the process where the nurse-subject reads the resident medication administration record, retrieves the oral medication from the task area medication cart and measures the medication (counts the number of pills in case of

solids, measures the volume in case of liquids) and places it on a medication tray, before administering it to the particular resident.

Medication preparation error - A deviation from the resident's physician record filed in the study nursing home pharmacy, as made by the nurse when preparing medications to be administered to the nursing home residents.

Total opportunities for error - The total number of medication doses prepared (and omitted) by the nurse, as observed, during the study period.

$$\text{Medication preparation error rate} = \frac{\text{Number of medication preparation errors}}{\text{Total number of opportunities for error}} \times 100$$

IV. Methodology

Population

The target population for this study was all the oral prescription medication doses prepared by the nurses in the study facility.

Sample

This is a case study based on convenience sampling and based on the willingness of the nursing home staff to allow the study to be conducted. The study site must remain anonymous. Thus, any generalization to other nursing facilities must be made with caution.

The study inpatient care section was selected based on the highest volume of prescriptions administered on a given shift. The morning and the evening shifts were selected for observation because they were identified as the busiest shifts at the study site. The work areas where medications were prepared had no windows, and thus no natural lighting. The medication pass rounds observed are:

- Morning med pass (8AM – until end of the med-pass round, usually 10 AM)
- Evening med pass (4 PM – until end of the med-pass round, usually 6 PM)

The sampling unit was an oral prescription medication dose prepared by the nurse-subject in the particular section of the study site and observed by the principal investigator, before administration to the resident, during the study period.

The medications observed were retrieved from the nurse's medication cart, located at the study section. Any medications that were not retrieved from the medication cart, were excluded, as the illumination levels at the other storage/stock rooms were different than that of the study section area. But if the drug container (or blister card) was brought back to the medication cart for the appropriate dose to be prepared, then it was included in the study.

Only oral prescription medications was included in the observation study for 3 reasons:

- Most of the doses prepared and administered at the study nursing home (around 85%) are oral medications.
- They are prepackaged by the pharmacy in blister cards or bottles (liquids) and have standardized medication labels. This helps in standardizing the visual information throughout the observation study.
- Most of the oral prescription medications are stored in the medication cart.

Study Subjects

The study subjects were the nurses working in the selected nursing home unit, during the morning (8am-10 am) and evening (4 pm – 6 pm) medication pass shifts. All nurses (LPNs) who were involved in the medication preparation process and who had signed the informed consent letter were included in the study as subjects.

Independent Variable

Illumination Level

The baseline illumination level (control measure) of the study study medication cart was measured using a calibrated photometer with an illuminance sensor. (Sper Scientific light meter 840021)

The illumination levels selected for the observation study were:

Baseline illumination level – This was the current illumination level at the study medication cart at the selected study section where the observations take place.

Illumination level 2 – The Illuminating Engineering Society (IESNA) provides recommendations and guidelines for lighting conditions in healthcare facilities (The IESNA Committee for Healthcare Facilities, 2006;The IESNA Lighting for the Aged and Partially Sighted Committee, 2007)

The committee suggested an illumination level of 100fc for areas where medications are prepared (Refer Table: 2). Illumination level 2 (experimental measure) was set at 100 fc, which was obtained by fixing a supplemental lighting fixture (with constant illuminance) over the medication cart at the selected study section.

Illumination level 3 - This served as the experimental intervention measure. The increase in the illumination level (experimental measure) was obtained by fixing a supplemental lighting fixture (with constant illuminance) over the medication cart at the selected study section. A previous study by Buchanan et al (Buchanan, 1991) found that an illumination

level of 145 fc had a significant effect on the dispensing error rate of the study pharmacy. Therefore, illumination level 3 was set at 145 fc.

The three illumination levels were randomly assigned during the study period (each medication pass round), so as to obtain equal days of observation for all the levels. During the observation phase, care was taken to ensure proper control of the illumination level by periodic light measurements and controlling for any external sources of light near the study locations. Periodic light measurements were taken for the study area locations, during the observation phase, in order to ensure control of the illumination level.

Supplemental Lighting Apparatus

In order to increase the baseline illumination level to the higher levels of 100fc and 145fc, supplemental lighting fixture (OttLite 508 Illumination™ rechargeable fluorescent task lamp) was affixed to the study medication cart.

Research Design

This was an explanatory level research; with a repeated measures study design.

Independent variable: Increased Illumination levels

Dependent variable: Medication-preparation error rate

The study was a (within subjects) repeated measures design.

Design Structure

The study was (within subjects) repeated measures design.

$$\sim X \quad Y_{A1} \quad X \quad Y_{A2} \qquad R_a$$

X - Experimental condition; ~X - Control condition

Y_{A1} – Measurement after the control stimulus;

Y_{A2} – Measurements after the experimental stimulus

R_a - Random assignment of the experimental stimulus.

Controls

This design uses the subjects (in the experimental group) as their own control, thus minimizing the effects of individual differences.

The nurse-subjects were checked for vision prior to the study. Nurses who had completed the visual acuity test (may have corrective glasses/contact lenses) were included in the study.

The nurse-subjects were administered a distractibility questionnaire, in order to measure their susceptibility to distractions that may occur during the observation period and thus help control the differences between nurse-subjects' susceptibility to distractions from external variables during the study period.

The observation method used had been studied and found to be unobtrusive and objective with minimal effect of the observer on the subjects.

Standardization of the visual stimuli (medication labels) was achieved, as only oral prescription medications were included in the observation study.

The workload data of the nurses was examined prior and during the study. The random assignment of the illumination levels ensured control over workload or any other individual differences.

Additional sources of light (such as sunlight) that might influence the study were observed and controlled.

The study was designed to control for the threats to internal validity in the following ways:

1. Maturation - The study period was not long enough to cause maturation effects in the subject- nurses. The observer observed the nurse-subjects for the same shift- period (for eg. morning med pass rounds 8 am -10 am and evening med pass rounds 4 pm – 6 pm), which controlled for factors such as fatigue.

2. Testing – Testing in both the groups, involved observation during their regular med pass rounds. As the nurses are doing familiar activity, for both the groups, the effect of pre-testing were minimized.

3. Instrumentation – The observer was trained in the scientific observation method (Barker, 1980) Research has established that, if the observer is non-judgmental, objective and unobtrusive, then the effect of the observer on the observed nurse-subject were minimal. The observed subject adapts to the presence of an observer, if the subject is doing familiar activity and the observation conducted is unobtrusive, nonjudgmental and objective (Buchanan, 1991).

Data Collection

Data collection occupied 2 phases:

1. Initial site visit – where the variables of interest were explored and operationally defined.
2. Explanatory phase – where the effect of the intervention variable (increased illumination level) upon the dependant variable (medication preparation errors) was studied. The explanatory phase consisted of:

   Observation pilot study, conducted from May 25, 2010 to May 28, 2010;

   Explanatory level study, conducted from June 1, 2010 to August 10, 2010.

Phase I : Initial Visits For Orientation To Study Site

Initial visits for orientation to the study site were conducted from August 2009 to December 2009 to gather data about the study facility characteristics and workflow. A review was conducted to understand the dynamics of the nursing administration schedules, as well as help in operationally defining the variables of interest. The principal investigator also reviewed the staff job profiles and responsibilities. Lighting measurements of the facility and pictorial representations from early visits were noted.

Site Selection

The principal investigator and her academic advisor visited the State Nursing Home Association headquarters to interview top officials. They were asked to help identify nursing facilities which might be suitable for the research study and found one conveniently located in Auburn, Alabama. The principal investigator and her advisor

received assurance from the Alabama nursing home association officials that the proposed study site was not atypical when compared to the other nursing facilities around the area.

Background information about the facility

The principal investigator obtained the following basic background information about the facility on the Internet. A lot of nursing home review websites had information about their facility, such as the number of beds, types of services offered and number of deficiencies cited in the previous years. Although the accuracy of all of the information is questionable, it helped the investigator to get a general idea of the facility.

The nursing home study site is an average sized, non-profit facility with 85 beds. The facility has 73 residents indicating 97% of its beds are occupied, which is above average within this state. The provider participates in the Medicare & Medicaid programs and provides resident counseling services. A total of 49 Medicare patients were given 1,279 days of non-swing bed care and services in 2006 and this provider gave two Medicare patients outpatient care and services in 2006. (Anon, 2006)

Further background information needed for the preparation of the proposal were obtained in a series of trips to the study home site, as follows:

Trip 1

The first trip was to meet with the nursing home administrator. The principal investigator and her advisor met with him around 11 am. The purpose of the meeting was to explain the significance of the light- study research and to ask for permission to use the nursing facility as a study site.

The administrator agreed to let the principal investigator explore the lay out of the facility. In order to acquaint the staff, he suggested that the principal investigator prepare a one-page memo of the intent of the research, what she were doing at the site, the observation start date and an attached picture. He asked to submit the memo a week before the observation start date. The principal investigator drafted a memorandum citing some brief information about the purpose of the exploratory visits, which was to be stuck on the notice board, next to the clock-in machine for the nursing staff to see. Please refer Appendix A for a copy of the memorandum.

It was also learned that the study facility were surveyed every 9 months approximately; and the last time the state surveyors visited the site was in December 2008.

Trip 2

The investigator met with the pharmacist at the facility. The conversation provided the following information about the pharmacy and the study facility.

- The on-site pharmacy was not yet functional; and was still being set up.
- The nursing home orders all its medications on a monthly basis from a mail-order pharmacy, based in Alabama.

- The on-site pharmacy were fully functional by May 4th 2009.
- The medications are packaged in blister packs and stored in the medication carts.
- The study facility had 75 residents at that time
- The facility had 3 sections (section X, Y and Z) and 2 nursing stations. One nursing station took care of Section X and the other took care of sections Y and Z.
- Section X had the maximum number of residents and additional rooms being added to it.
- For the storage of over-the-counter drugs, the study facility had a stock closet.
- The prescription and medication records were all paper based.
- The pharmacy catered to the medication needs for the study facility, the assisted living facility and hospice care.
- She also mentioned that the nursing home was recently bought by the local hospital system (name confidential).
- A consultant pharmacist visits the nursing home once every month for inspections.
- The staff in the pharmacy comprised of:
    - A pharmacist
    - A fill-in pharmacist
    - A technician
    - A billing person
- The technician will manually blister pack a month's supply of medications for the nursing home residents.

- A sheet containing the study facility medication schedule was handed over to the principal investigator. Please refer Appendix C.

Trip 3

The main purpose of this meeting was to meet with the Director of Nursing. The principal investigator had an appointment with her in the afternoon; wherein they spoke about the nursing home in general and toured the facility. The information gathered:

- The study facility has 3 sections and 85 beds; all elderly patients.
- No specific services are provided in the sections; they are all general residents.
- The medication pass rounds occur at 6 am, 9 am, 1 pm, 5 pm and 9 pm
- The medication administration window is ± 60 minutes.
- There were around 650 medications administered at the study site during the busiest med pass rounds (9 am and 5 pm)
- There were 3 medication carts in total; and the main study station overlooked the medication needs of sections 2 and 3.
- Twelve new beds were being added to section 1 by the end of April; a new nursing station was also being built.
- The shifts are as follows
- 1^{st} shift - 7 am to 3 pm (3 nurses administer medications)
- 2^{nd} shift - 3 pm to 11 pm (3 nurses administer medications)
- 3^{rd} shift – 11 pm to 7 am (2 nurses administer medications)
- There were 5 registered nurses in the facility during the day shift
- A new MDS coordinator was going to be appointed by May 4^{th}
- They had no designated Quality Assurance personnel.

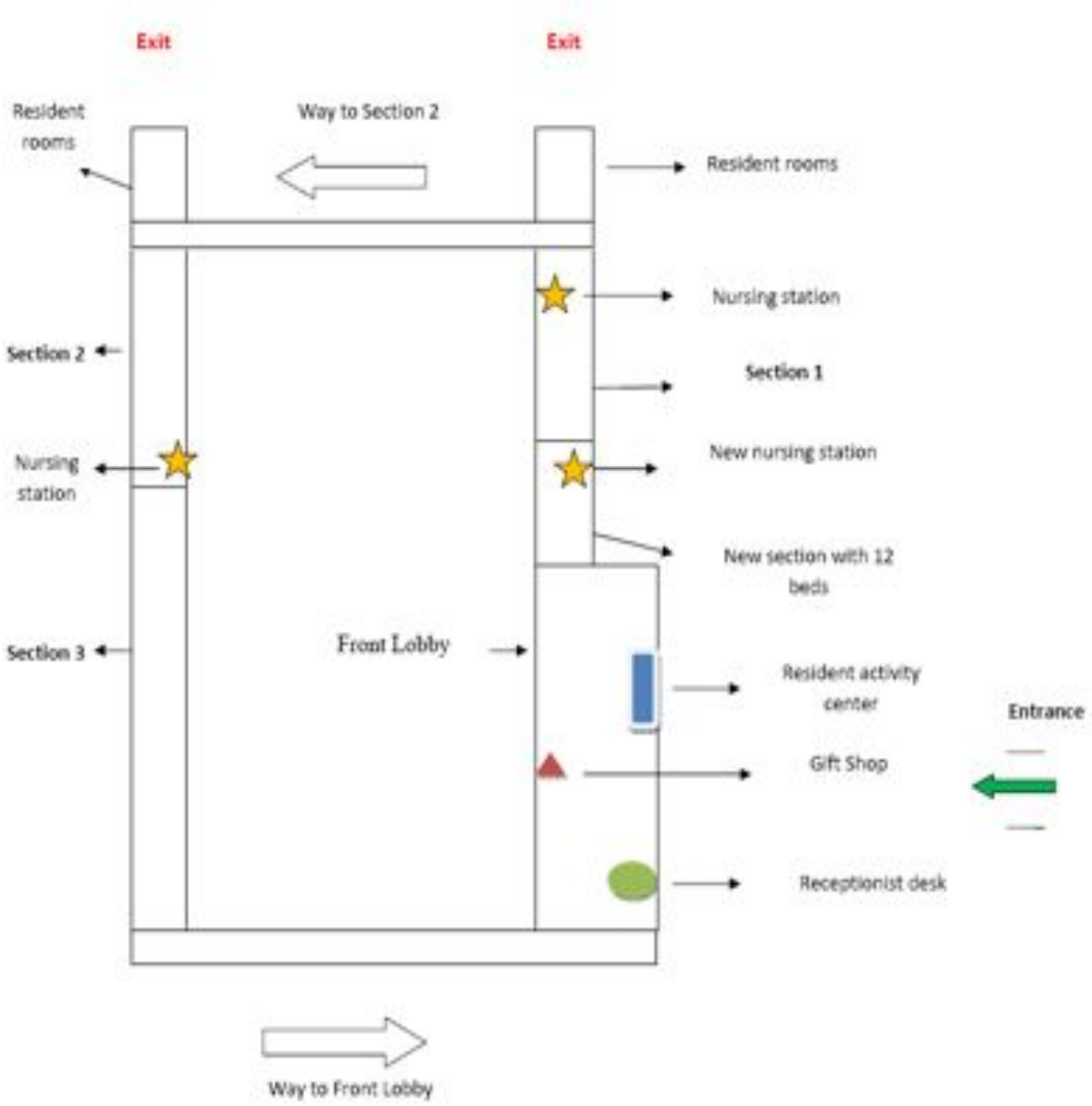


Figure 8 : The general layout of the room was as follows: (not to scale)

Trip 4

The fourth trip was to measure and take some pictures of the lighting fixtures in the facility.

Trip 5

The investigator took additional pictures and light measurements at different locations of the facility. She also visited the pharmacy, which was in the process of stocking up on their medications.

Section X

Floor level (middle of the lobby) – 41.8 fc

Mid- air level - 109 fc

Nursing station desk surface - 126 fc

Near the exit doors

Floor level - 114 fc

Mid-air level - 147.8 fc

Figure 9: Exit door

Figure 10: Section X Medication cart upper surface

Fluorescent Light

54 fc

24.4 fc

Section Y

Floor level (middle of the lobby) – 34.3 fc

Mid- air level - 106 fc

Nursing station desk surface - 124.3 fc

Figure 11: Section Y light measurements.

Figure 12: Dining /Activity room

A table in Dining / Activity room - 125 fc

Figure 13: Section Y Medication cart upper surface

Fluorescent Light

13.18 fc

12.8 fc

Section Z

Floor level (middle of the lobby) – 33.4 fc

Mid- air level - 125.6 fc

Reception desk in front lobby - 91.8 fc

Outside Gift shop in the front lobby - 37.5 fc (yellow light)

The principal investigator was informed that the new section was filled with residents, and that there were 85 residents in the facility at the time of the study.

Visit to the Pharmacy

The pharmacy caters to the medication needs for long-term care, hospice and assisted living facilities. Although the medications for the hospice care were already set up, the long-term care section (nursing facility and assisted living facility) was still under construction.

Here are some pictures and light measurements from the pharmacy site:

Figure 14: Security measure at the pharmacy site; all windows had bars on them.

Figure 15: Light fixtures used in the pharmacy

Figure 16: Blister packaging material for the medications

Figure 17: Medications stacked in the cabinet; bar-coded label

Figure 18: Hospice pharmacy cabinet

Hospice pharmacy medication cabinet floor - 10fc

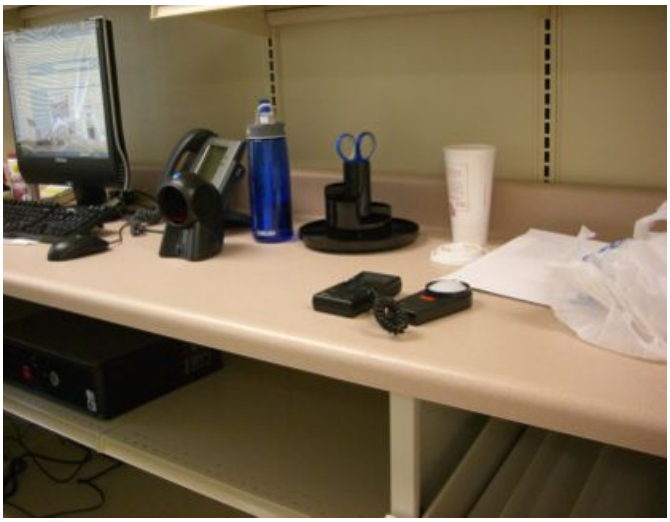
Figure 19: Hospice pharmacy window

Hospice pharmacy pharmacist station (near window) – 142.3 fc

Long term care section computer station

Computer station 1 - 88 fc

Figure 20: Computer station 1



Long term care section work stations

Workstation overlooking an open window (light fixture on top) - 127. 3 fc

Figure 21: Workstation overlooking an open window

Workstation overlooking a window with blinds (light fixture on top) - 120 fc

Figure 22: Workstation overlooking a window with blinds

Trip 6:

The investigator went to the study site around 10.10 pm to measure the light levels. It was learned that some residents are administered their 11 pm medications, which are prepared at 10 PM.

Figure 23: Section X: Medication cart light measurement

The nurse giving the medication pass was observed commenting on the light quality being dull. In her words she said, ‘’we need better lights here’’.

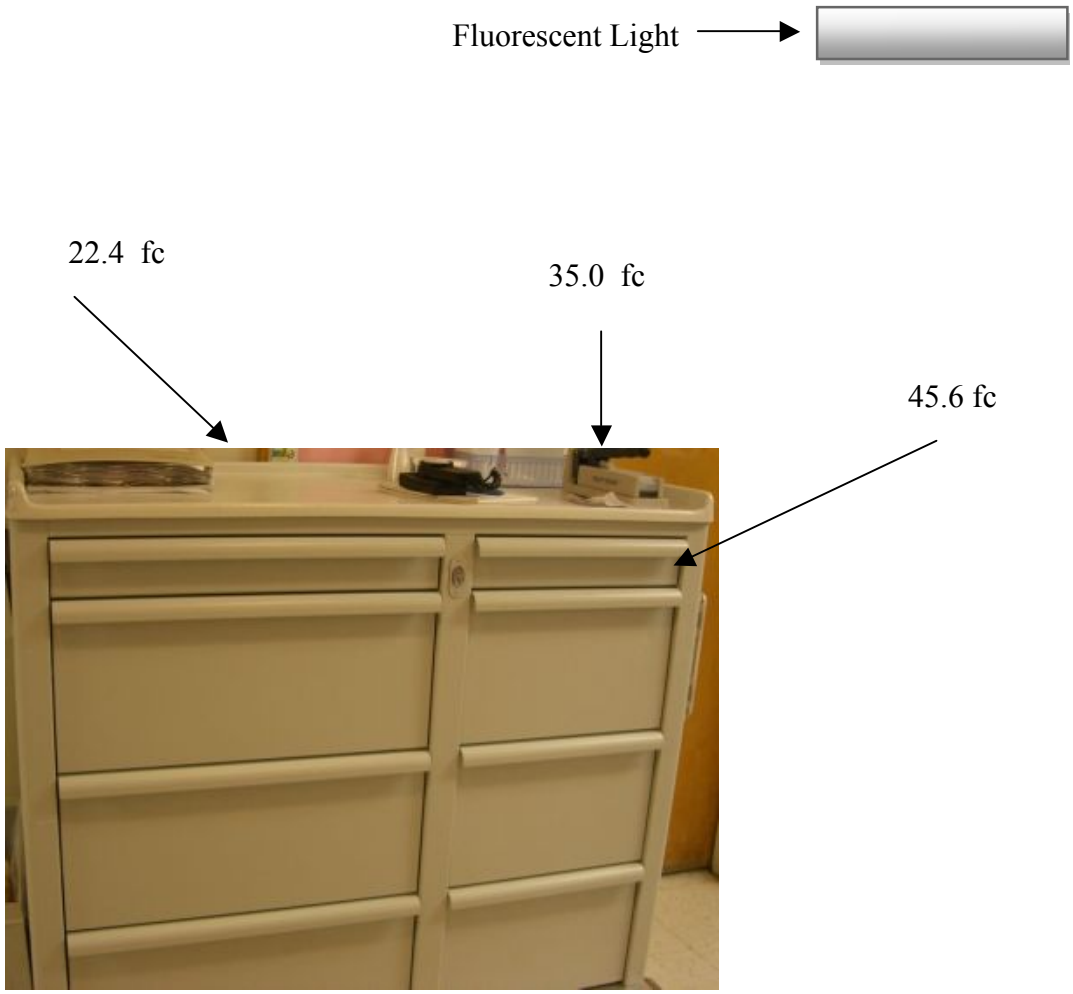


Figure 24: Section Y Medication cart

The lights in the resident rooms are turned off at night, when they sleep. So, in case the nurses have to administer medications, they turn on the light, after entering the resident room.

Trip 7:

The principal investigator visited the new pharmacy, now fully functional. The pharmacy caters to the medication needs of the hospice, nursing and assisted living facility. According to the chief pharmacist there, they fill on an average about 172 prescriptions per day, out of which 88 are for the study facility.

The estimated average number of prescriptions filled, per section per day are:

Section 1 ~ 15/day

Section2 ~ 13/day

Section 3 ~ 10/day

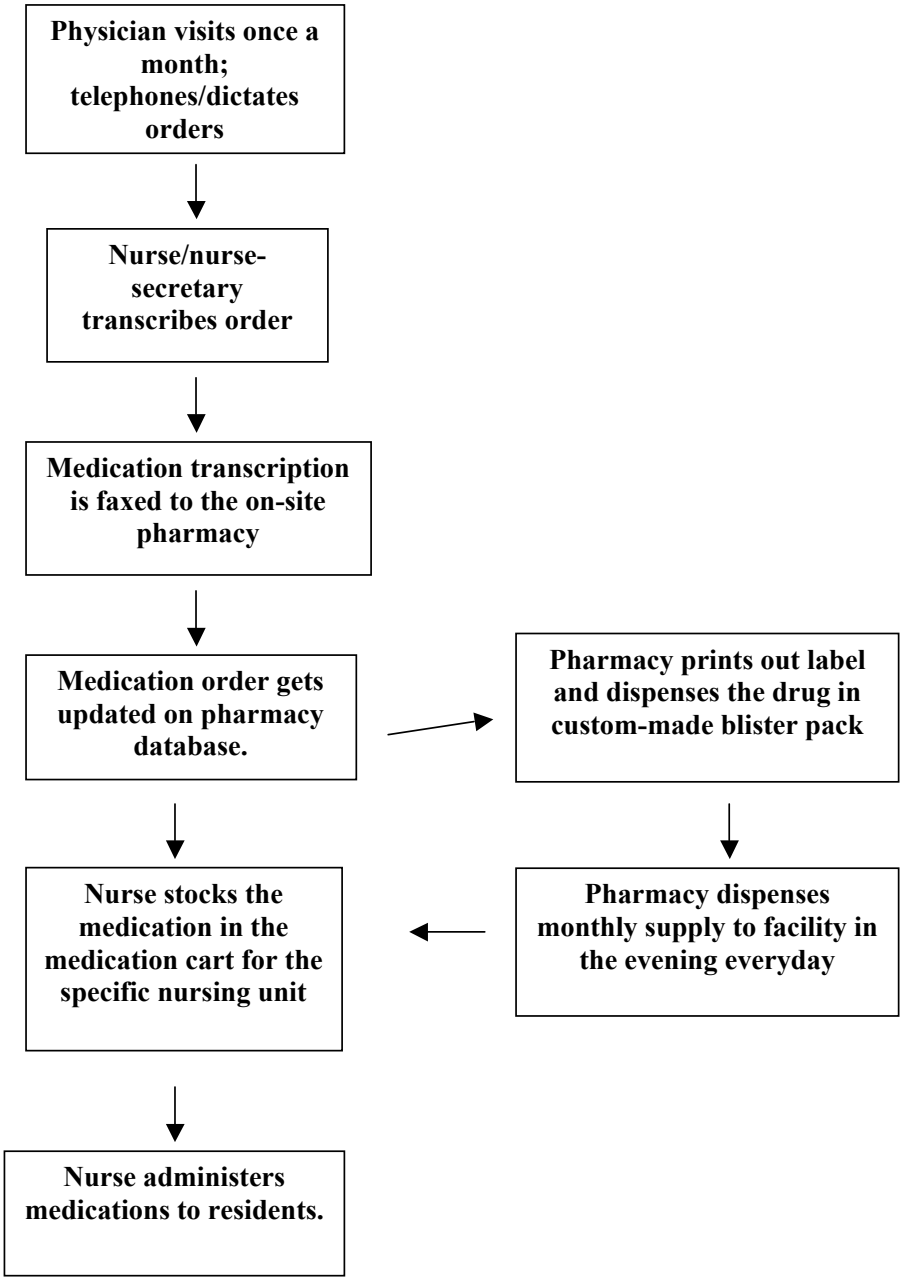


Figure 25: The detailed workflow diagram is as follows:

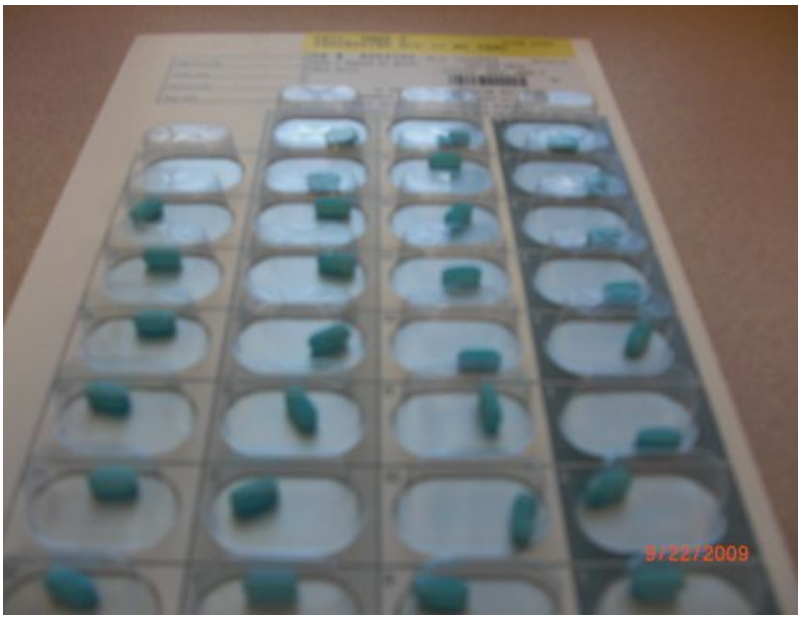


Figure 26: Blister packaging at the pharmacy

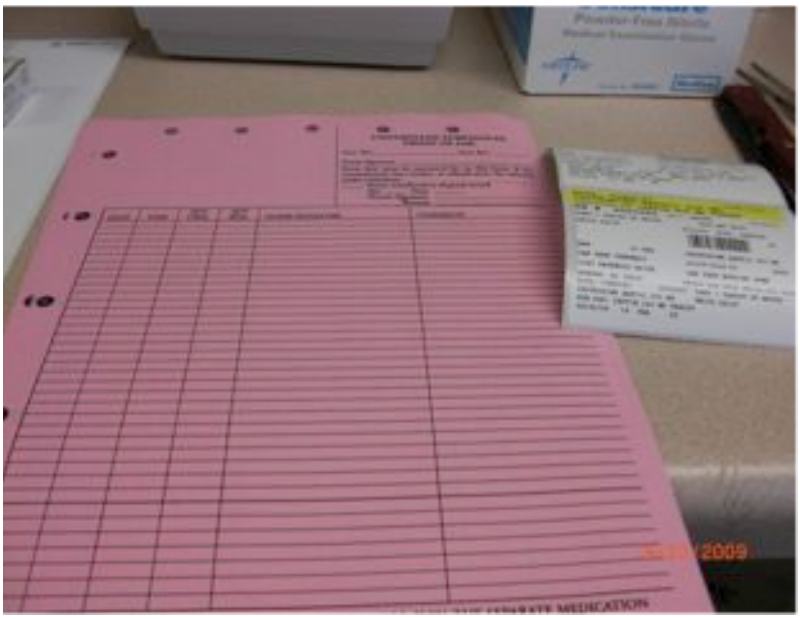


Figure 27: Controlled substance form and label beside it

Explanatory Study Phase

This phase consisted of:

Observation pilot study was conducted from May 25, 2010 to May 28, 2010;

Explanatory level study was conducted from June 1, 2010 to August 10, 2010.

IRB Approval

IRB approval (March 2010) was sought from Auburn University and the Study site, prior to data collection for the study. The IRB was renewed (February 2011) for the time-period of another year. (*Refer Appendices B and H*).

Informed Consent Letter

The principal investigator visited the study site on April 2, 2010 during the monthly nurse's meeting. At the meeting, the investigator was formally introduced to all the nurses by the study home administrator, and got a chance to brief them about the observation study. Each of the nurse-subject participating in the study was read an introduction memorandum explaining the research study and the role of the principal investigator.

The nurses who were interested in participating in the study were then asked to sign the consent letter. (Please refer Appendix G). They were also briefed about taking the visual tests and distractibility questionnaire, as part of the study protocol. Out of 10 nurses (LPN), 9 of them signed the informed consent letter. One of the nurses seemed a little resistant to the visual tests and was observed telling the investigator 'You cannot force me to wear glasses', for which the investigator simply smiled.

Demographic Information

Literature has suggested that demographic variables like person's age (Cullinan, 1986; Blackwell, 1980), visual acuity have a significant impact on their visual performance and their reaction to different lighting levels.

Prior to the start of the observation period, information about the demographic variables previously identified as possibly linked to medication errors like age, sex, nursing degree (education level), number of months employed in the study nursing home and employment status (RN, LPN, nurse intern) were collected from nurse-subjects who had signed the consent forms. The nursing home administrator provided the investigator with the demographic information for all the nurses. Workload information (number of residents and their medication regimen, number of doses prepared) for each nurse was also collected during the observation period by the principal investigator.

Visual tests

The nurses was administered a standardized visual acuity test by a licensed pharmacist – faculty at Auburn University, helped by the principal investigator. Snellen chart (Wendy Strauss Watt, 2003) was used to measure the visual acuity of the nurses. The test was administered during the monthly nurse's meeting (for the month of July). One of the nurses, who did not show up for the meeting was administered the test, the very next day.

Group Embedded Figures Test

Distractibility was defined by the score achieved by subjects on the Group Embedded Figures Test(GEFT). The nurses were administered a distractibility questionnaire (Flynn E.A, 1994), in order to measure their susceptibility to distractions that may occur during the observation period. This written test requires the subject to visually distinguish a simple geometric figure from within a complex figure. One point is awarded for each correctly identified figure. Higher the score, the more field independent (less distractible) the subject.

Each nurse was administered the test individually, as per their convenience. The testing location was kept standard for all the nurses and the principal investigator briefed the nurses about the rules of the test. Each nurse was given sufficient time to ask questions, before they could begin their tests. The investigator timed each section, and the time limit for the test was kept constant for all the nurses. The investigator referred to the GEFT Manual (Witkins et.al) for instructions on administration and scoring of the distractibility questionnaire.

Observation pilot study (May 25, 2010 - May 28, 2010)

The main objectives of the pilot study were:

1) To estimate the sample size for the main study;

2) To identify and operationally define the variables (error types) of the study;

3) To help design the med pass observation form for the main study;

4) To understand the med pass workload of nurses in all the three sections of the study site.

5) To help acquaint the observer/principal investigator with the pace of medication preparation by the nurses.

Explanatory level study (June 1, 2010 to August 10, 2010)

The main explanatory study began on June 1, 2010 and was concluded on August 10, 2010. The principal investigator observed each section for both the morning (9 am) and the evening (5 pm) med pass rounds.

The observer randomized the Illumination level for that particular day by the using of the random number generator on the Excel software.

The supplemental task light was placed on the study medication cart, irrespective of the illumination level, in order to control for participant sensitization.

The baseline level was achieved by measuring the light level on the medication cart, without switching on the supplemental task light apparatus. The experimental (intervention) levels were achieved by adjusting the arm of the apparatus, by moving it either up or down, until the desired level was met.

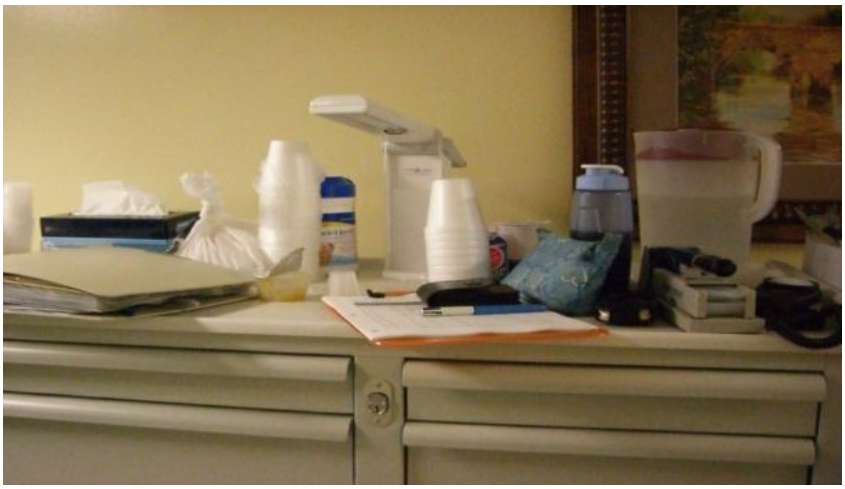


Figure 28: Baseline measurement

Figure 29: Experimental (Intervention) measurement

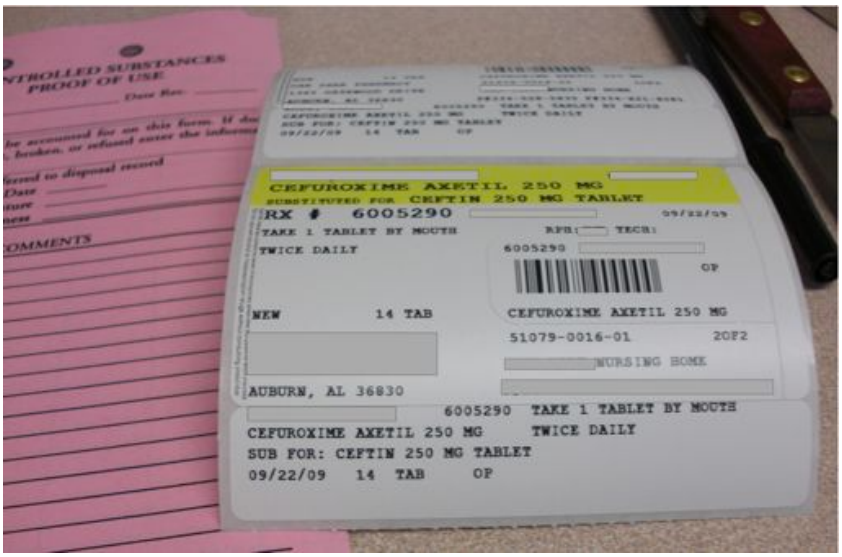


Figure 30: Sample of Visual Stimuli (medication label fixed on the oral doses)

Figure 31: Observation instruments used during the study

The observer recorded the medication preparation information as prepared by the nurse during the medication pass round and then noted the information from the original prescriber's orders for that particular section, after the end of the observation period. Reconciliation of the observed data to the original orders were done after the end of the observation study for that particular section/nurse, in order to control for any observer bias.

Statistical Analysis

Repeated measures analysis of variance was used to compare the total medication preparation error rate, as detected by observation, for the three lighting conditions.

Chi-square analysis was used to compare the medication preparation errors, by error types, as detected by observation, for the three lighting conditions.

Linear regression was used to examine the relationship between the daily medication pass workload and the medication preparation errors.

Chi-square analysis was used to study the relationship between the day of the illumination period and the number of medication preparation errors made on that day. This was to indicate the effect of the principal investigator/observer on the performance of the nurse-subjects.

Significance Level

The alpha level was preset at 0.05 for an estimated effect size of 0.2 and power of 0.8 (Cohen J, 1988).

V. Results

In this chapter, the results are presented as follows:

- Demographic information of the study subjects
- General description and observed results of the pilot study sample (May 2010)
- General description of the main observation study sample (June - August 2010)
- Comparison of errors for all three illumination levels
- Statistical tests and hypotheses

Study Subjects description

This study looks at the effect of illumination upon the performance of the nurses as they prepare the doses ordered by the physicians to be administered. The main focus of the study is the medication system, a 'non-machine system' in which the nurse-subject is the principal actor, though other environmental factors are present and may play a part in affecting the error rate.

Of the 9 nurses, only 7 nurses who worked the day shifts were included in the observation study. The 2 nurses who worked the night shifts were excluded, as the dynamics of illumination changes during the nighttime.

The nurse-subjects, their eyesight, Group Embedded Figures Test (GEFT) scores and other demographics for which there is evidence of possible involvement in producing errors are shown in Table 3.

Along with the nurse's eyesight, the observer too recorded her eyesight and GEFT scores, which is provided in Table 3.

None of the subjects in this study had significant visual impairment based on the results of the visual tests. The Group Embedded Figures Test (GEFT) scores ranged from 5 to 11 (out of possible zero to 18 range) with a mean of 8.14.

All the nurse-subjects were Licensed Practitioner Nurses (LPNs), and their duration of employment ranged from 9 months to 9 years.

Table 3: Demographic Information of the Study Subjects

Nurse	Age (yrs)	Gender	Employment status	Months employed at study site	Shift timings	Nursing unit	Corrective Measures	Left Eye Vision	Right Eye Vision	Both Eyes Vision	GEFT Score
1A	47	F	LPN	17	6:45AM -3:15PM	Z	Glasses	20/20	20/15	20/15	5 / 18
2B	24	F	LPN	10	2:45PM-11:15PM	X	Contacts	20/13	20/30	20/15	12 / 18
3C	38	F	LPN	16	2:45PM-11:15PM	Y	None	20/15	20/13	20/13	6 / 18
4D	23	F	LPN	9	2:45PM-11:15PM	varies	Glasses	20/40	20/30	20/40	10 / 18
5E	42	F	LPN	112 (9yr4 mo.)	6:45AM -3:15PM	X	Glasses	20/25	20/25	20/25	6 / 18
6F	25	F	LPN	14	6:45AM -3:15PM	Y	None	20/20	20/30	20/15	11 / 18
7G	37	F	LPN	12	6.45 AM – 3.15 PM	varies	Contacts	20/50	20/70	20/50	7 / 18
Observer		**F**					**Contacts**	**20/25**	**20/25**	**20/20**	**15 / 18**

Pilot Study: General description and results

The pilot observational study was conducted at the study site from May 25, 2010 to May 28, 2010, for the morning (9 am) and evening (5 pm) medication pass.

The main objectives of the pilot study were:

1) To estimate the sample size for the main study;

2) To help design the med pass observation form for the main study;

3) To understand the med pass workload of nurses in all the three sections of the nursing site.

4) To help acquaint the observer/principal investigator with the pace of medication preparation by the nurses.

A total of 653 medications were observed being prepared by the nurse subjects during the pilot study. A total of 34 medication preparation errors were confirmed; with an overall error rate of 5.2 %. The distribution of errors for each day of observation is shown in Table 4.

An error-rate, excluding wrong time errors was also computed, which was 4.3%. The reason for computing this error rate was due to the fact that the observer noticed that sometimes the nurses prepared the doses well in advance to the next medication pass rounds. For eg. Some of the nurses prepared the doses for the next medication pass round (9 pm) during their present med-pass (5 pm). Although, this may constitute a wrong time error, but the observer thought it would be useful to compute two error- rates, just to observe the effect of illumination with and without the wrong time errors.

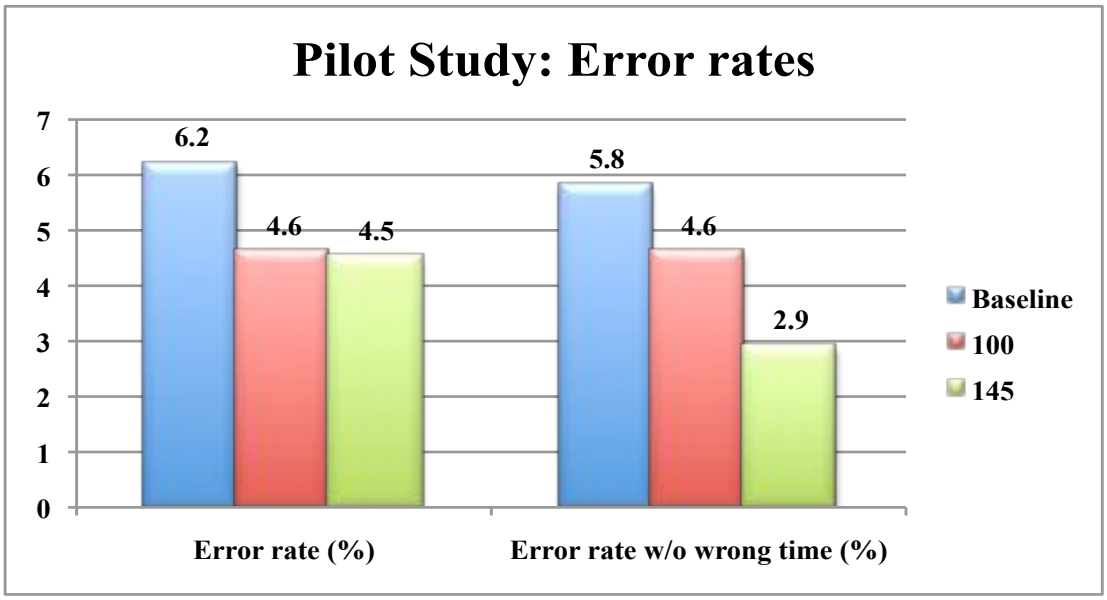
The total opportunity of errors (TOE) is the denominator of the measure of the workload demand upon the system, including the nurse-subjects (doses prepared and omitted) during the observation period.

Table 4: Pilot Study (May 25 – May 28, 2010)

Date	Section	Illumination Level (foot-candles)	Obs Time	Total Opp. for Errors	Errors	Error Rate	Error Rate w/o wrong time errors
May 25, 2010	Z	Baseline *	9:00 AM	82	5	6.1%	6.1%
	Y	Baseline *	4.00 PM	79	5	6.2%	5.1%
May 26, 2010	X	Baseline *	9.00 AM	95	6	6.3%	6.3%
	X	145	4.00 PM	91	4	4.4%	1.1%
May 27, 2010	Z	100	9:00 AM	80	3	3.7%	3.7%
	Z	145	4.00 PM	75	4	5.3%	5.3%
May 28, 2010	Y	145	9.00 AM	81	3	3.7%	2.5%
	Y	100	4:00 PM	72	4	5.5%	4.2%
Total				**655**	**34**	**5.2%**	**4.3%**

** Baseline level: Average illumination level of 30 foot-candles.*

Figure 32: Medication Preparation Errors for three illumination levels



The nature and frequency of each error type detected during the pilot study is described in Tables 5 and 6, to judge the clinical significance of the error detected, all of which share equal status as an incidence of system failure.

The distribution of error types for each illumination level is shown in Figure 26. The illumination levels 100 fc and 145 fc had fewer errors associated with them as compared to the baseline measurement (an average illumination level of 30 foot-candles)

Table 5: Frequency of error types during pilot study

Date	**Section**	**Ill. Level (foot-candles)**	**Obs Time**	**Errors**	**Wrong dose errors**	**Wrong form errors**	**Omission errors**	**Wrong time errors**
May 25, 2010	Z	Baseline*	9:00 AM	5	2	3		
	Y	Baseline*	5.00 PM	5	2	1		2
May 26, 2010	X	Baseline*	9.00 AM	6	3	3		
	X	145	5.00 PM	4	1			3
May 27, 2010	Z	100	9:00 AM	3		2	1	
	Z	145	5.00 PM	4	2	2		
May 28, 2010	Y	145	9.00 AM	3	1	1		1
	Y	100	5:00 PM	4		2	1	1
Total				**34**				

* Baseline level: Average illumination level of 30 foot-candles.

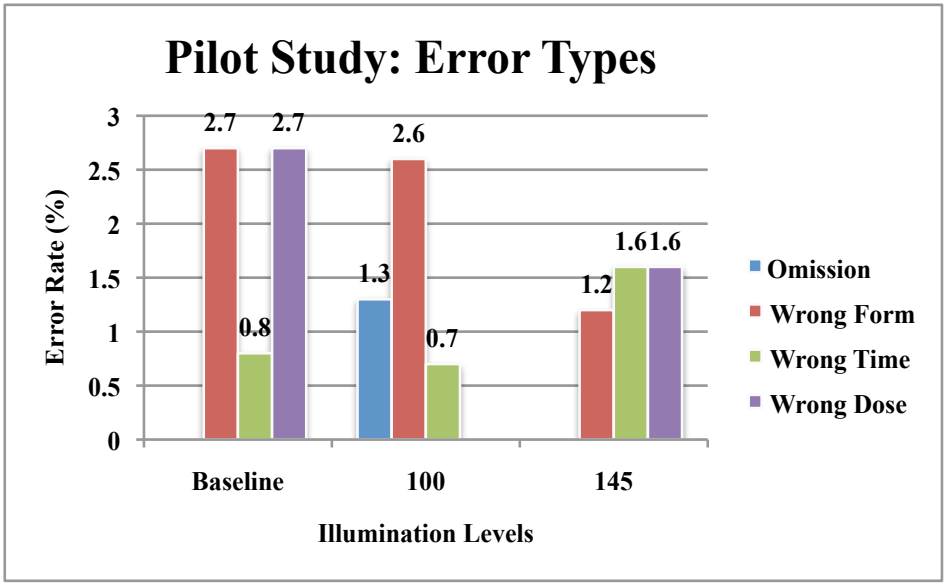


Figure 33: Frequency of error types for three illumination levels

The errors observed during the pilot study helped the observer in the preparation of the medication observation form.

The pilot study results revealed that Wrong time errors were frequently observed. It was observed that the nurse-subjects prepared some of the doses to be administered in the next med-pass round, during the previous round. But, this behavior was not observed uniformly across all nurse-subjects, so it was decided that the observation results be computed with and without wrong time errors.

Table 6: Description of Each Error during the Pilot Study

Date	Prescribed Drug	Prepared Drug	Error Type	Notes
May 25, 2010 9 AM	Aspirin 81 mg Enteric Coated (EC)	Aspirin 81 mg EC Crushed	Wrong Form	Nurse (LPN) said she was behind schedule and wanted to finish her med pass before 10 AM
	Colace Solution 5 ml	Colace solution 10 ml	Wrong Dose	
	Oxybutynin ER 10 mg	Oxybutynin ER 10 mg crushed	Wrong form	
	Nifedipine 30 mg ER	Nifedipine 30 mg ER Crushed	Wrong form	
	Therapeutic Vitamin # 1 tab	Therapeutic Vitamin # 2 tabs	Wrong dose	
May 25, 2010 5 PM	Senna S # 2 tabs	Senna S # 1 tab	Wrong dose	
	Therapeutic Vitamin # 1 tab	Therapeutic Vitamin # 2 tabs	Wrong dose	
	Simvastatin 40 mg; due at 9PM	Simvastatin 40 mg; given at 4.30PM	Wrong time	
	Detrol LA 4 mg	Detrol LA 4mg crushed	Wrong Form	
	Diazepam 5 mg; due at 9 PM	Diazepam 5m; given at 5.35 PM	Wrong time	
May 26, 2010 9 AM	Aspirin 325 mg EC	Aspirin 325 mg EC Crushed	Wrong Form	
	Bupropion HCL SR 100 mg	Bupropion HCL SR 100 mg Crushed	Wrong Form	
	Aspirin 81 mg EC	Aspirin 81 mg EC Crushed	Wrong Form	
	Loratadine 10 mg #1 tab po D	Loratadine 10 mg #2 tabs	Wrong dose	
	Senna Plus # 2 tabs	Senna Plus # 1 tab	Wrong dose	

Date	Prescribed Drug	Prepared Drug	Error Type	Notes
	Acetaminophen 325 mg #2 tabs	Acetaminophen 325 mg #1 tab	Wrong dose	
May 26, 2010 5 PM	Seroquel 100 mg @ 9PM	Seroquel 100 mg @ 4.35 PM	Wrong time	
	Aricept 10 mg @ 7 PM	Aricept 10 mg @ 5.17 PM	Wrong time	
	Simvastatin 20 mg @ 9 PM	Simvastatin 20 mg @ 5.30PM	Wrong time	
	Xanax 0.25 mg	Xanax 0.25 mg Spills crushed pill; some leftover on table	Wrong dose	
May 27, 2010 9 AM	Fish Oil 3000 mg	none	Omission	
	Aspirin 81 mg EC	Aspirin 81 mg EC Crushed	Wrong form	
	Oxybutynin ER 10 mg	Oxybutynin ER 10 mg Crushed	Wrong form	
May 27, 2010 5 PM	Klor Con M20 CR	Klor Con M20 CR Crushed	Wrong form	
	Senna S #2 tabs	Senna S # 1 tab	Wrong dose	
	Aspirin EC 81 mg ER	Aspirin EC 81 mg ER Crushed	Wrong form	
	Golden age Liquid (Vitamin) 10 ml	Golden Age Liquid 7 ml	Wrong dose	
May 28, 2010 9 AM	Calcium 600 + vitamin D; due at 7 am	Calcium 600 + vitamin D; given at 9.17 am	Wrong time	
	Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong Form	
	Colace solution 10 ml	Colace solution 7 ml	Wrong dose	
May 28, 2010 5 PM	Calcium 600 + vitamin D; due at 7 am	Calcium 600 + vitamin D; given at 10.07 am	Wrong time	

Date	Prescribed Drug	Prepared Drug	Error Type	Notes
May 28, 2010 5 PM	Klor Con M10	Klor Con M10 Crushed	Wrong form	
	Aspirin EC 81 mg	Aspirin EC 81 mg Crushed	Wrong Form	

Main Observation Study: Sample Description

A total of 6,808 medication doses were observed being prepared by the nurse-subjects during the 45-day study period from June 1, 2010 to August 10, 2010. An average of 151 doses were observed per day, with an average of 76 doses per shift.

The observation sample size of 6808 doses achieved a 95% confidence interval, with a relative accuracy of ± 5%, effect size of 0.2, power of 0.8 at an estimated medication error rate of 11%. (Flynn et.al, 2002)

However, 50 medication doses were excluded due to the following reasons:

Table 7: Reasons for excluded doses

Reason for Exclusion	**# Doses Excluded**
Incomplete Information recorded	25
Illumination level not met	12
Physician handwriting illegible	13
Total	50

So, a total of 6,758 prepared doses were included in the final study. The following table and figure summarize the characteristics of the observed sample with respect to the nurse-subjects who prepared them and the corresponding illumination levels.

Table 8: Total observed doses (after dose exclusion) for each nurse-subject for each Illumination level

Nurse code	**Illumination Level 1** **Baseline**	**Illumination Level 2** **100 fc**	**Illumination Level 3** **145 fc**	**Total doses observed**
1A	329	334	327	990
2B	389	399	406	1194
3C	218	230	223	671
4D	325	313	336	974
5E	325	332	341	998
6F	341	327	357	1025
7G	293	296	317	906
Total Doses Observed				6758

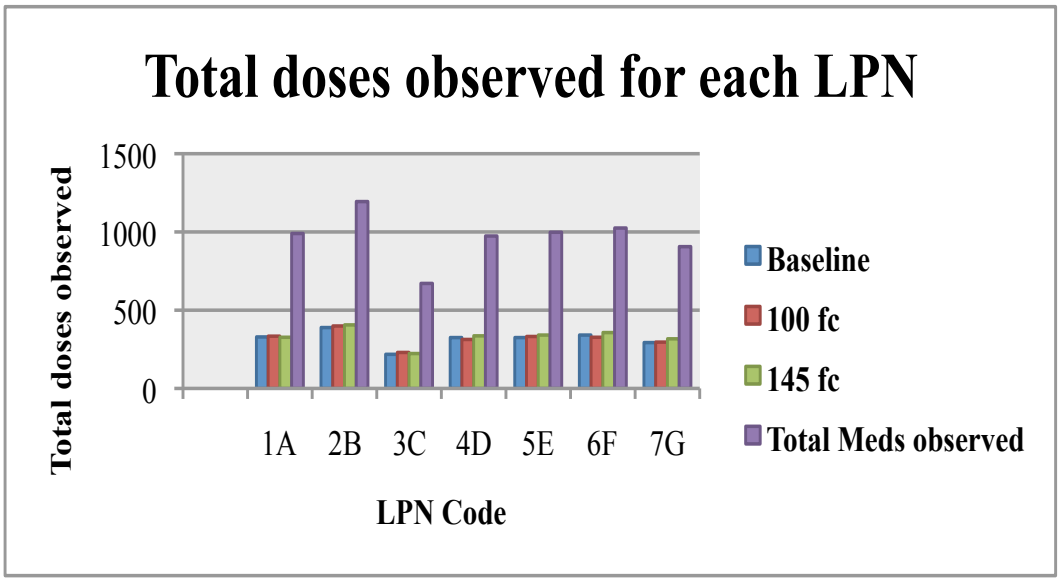


Figure 34: Doses prepared by each Nurse-subject (LPN) for three illumination levels

Medication Preparation Errors for the Study Sample (6,758 doses)

The total number of medication preparation errors observed for all the three sections of the study site under three illumination levels was 467, resulting in a total medication preparation error rate of 6.7%.

The total opportunities for error (doses observed being prepared plus the doses omitted by the nurses during the observation period) were 6,948 doses.

Medication Preparation Error Rate = 467 / 6948 x 100 = **6.7%**

Excluding Wrong time errors,

Medication Preparation Error Rate = 321 / 6948 x 100 = **4.6%**

Table 9: Medication Preparation Errors for the Study Site for three illumination levels

Illumination level	Average illumination level (fc)	Total meds observed	Errors	TOE	Error rate (%)	Error rate excluding wrong time errors (%)
Baseline	28.16	2220	196	2292	8.5	5.7
100	100.23	2231	173	2313	7.4	4.5
145	144.69	2307	98	2343	4.3	2.5
Total		**6758**	**467**	**6948**	**6.7**	**4.6**

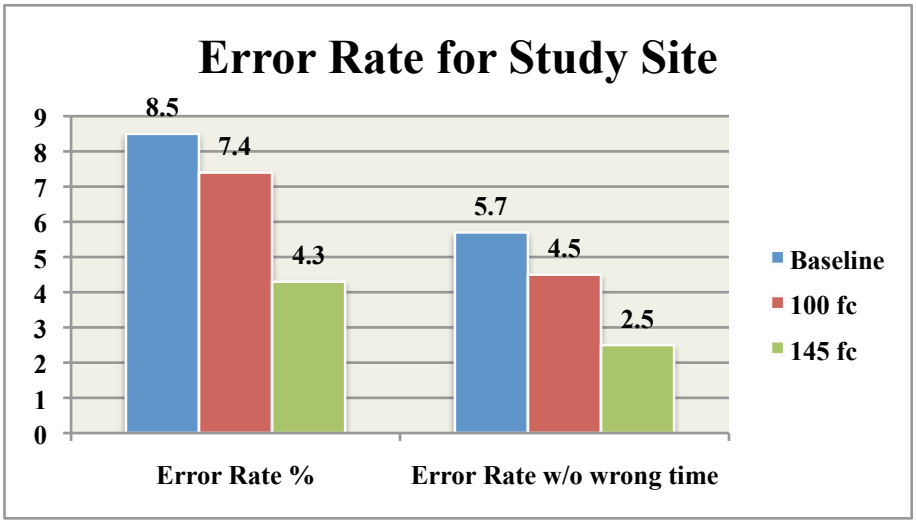


Figure 35: Error rate for the study site for three illumination levels

The most frequently observed medication preparation error was Omission (N = 190, 40%), followed by Wrong time (N = 146, 31%), Wrong form (N = 72, 15%), Wrong Dose (23, 5%) and Unauthorized Drug (4, 1%).

The observer observed that some of the nurse-subjects prepared few of the doses to be administered in the next med-pass round, during the previous round. But, this

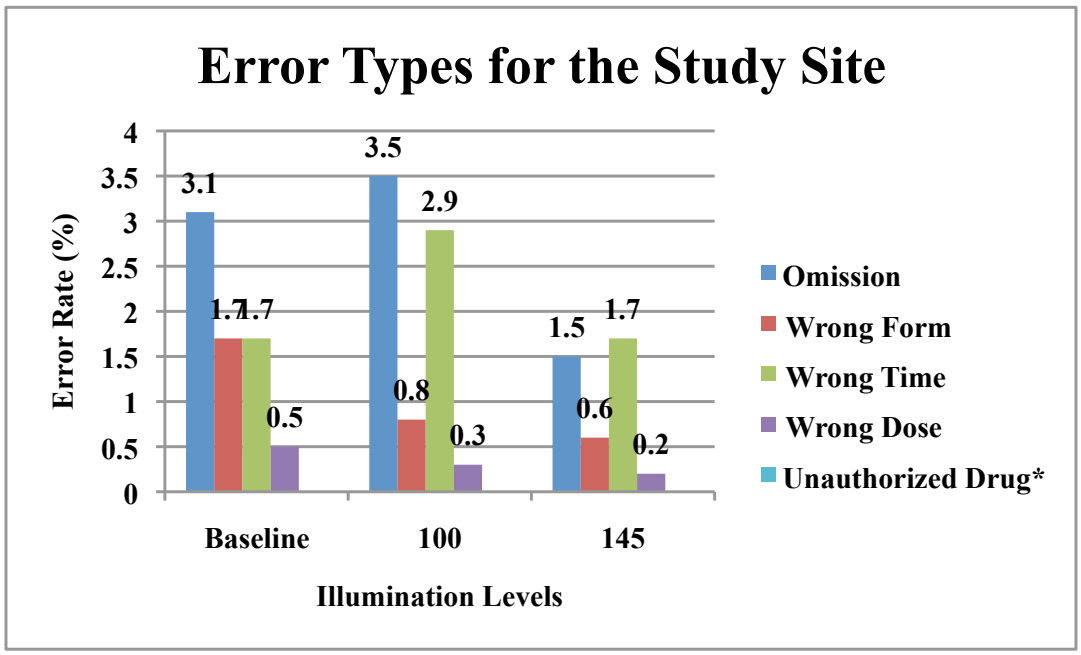
behavior was not observed uniformly across all nurse-subjects, so the results were computed with and without wrong time errors.

Wrong Form errors frequently observed were those where the dose was crushed during preparation, despite a specific order to the contrary written by the physician stating "do not crush". Such doses were sometimes for medications, which the manufacturer had enteric coated or otherwise intended for extended release. During the observation period, two nurses told the observer that the reason for crushing medications was to aid the resident in swallowing it. Although the observer understood the practical reason for crushing the doses, the operational definition of an error used in this study recognized the specific order by the physician as paramount for representing the best evidence of the outcome desired from the patient's point of view. Therefore, such doses were considered Wrong Form errors.

The description of errors by types is shown in Table 10, while Figure 36 describes the frequency of error types for each illumination level.

Table 10: Total Medication Preparation Errors, by Error Types

Illumination level	Total meds	Errors	TOE	Error rate	Unauth. Dose	Wrong dose	Omission	Wrong Form	Wrong Time
Baseline	2220	196	2292	8.5	3	12	72	38	39
100	2231	173	2313	7.4		6	82	19	66
145	2307	98	2343	4.3	1	5	36	15	41
Total	6758	467	6948	6.7	4	23	190	72	146



* *Error rates for Unauthorized Drugs were too low to report (Baseline : 0.0004%; 145fc : 0.002%)*

Figure 36: Frequency of Medication Preparation Error Types, by Illumination levels

Medication Preparation Errors, by Study Site Sections

Section X:

The study site has three sections, and the following tables show the distribution of errors and error types, across all the sections for all the three illumination levels.

The medication preparation error rate for Section X was 7.4%, with 235 detected errors for 3080 observed doses.

Table 11: Medication Preparation Errors for Section X

Illumn. level	Average ill level (fc)	Total meds observed	Errors	TOE	Error rate (%)	Error rate exclud wrong time errors (%)
Baseline	29.38	964	98	988	9.8	5.0
100	100.14	957	84	1003	8.2	5.9
145	144.75	1159	53	1179	4.5	2.4
Total		**3080**	**235**	**3170**	**7.4**	**4.2**

Figure 37: Medication Preparation Error rate for Section X, by Illumination levels

The most frequently observed medication preparation error for Section X was Wrong time (N = 101, 43%) followed by Omission (N = 90, 38%), Wrong form (N = 25, 11%), Wrong Dose (N = 15, 6%) and Unauthorized Drug (N = 4, 2%).

The description of errors by types is shown in Table 12, while Figure 38 describes the frequency of error types for each illumination level, for Section X. The description of each preparation error observed for Section X is provided in *Appendix I.*

Table 12: Medication Preparation Errors for Section X, by Error Types

Ill level	Total meds	Errors	TOE	Error rate	UnauthDose	Wrong dose	Omission	Wrong Form	Wrong Time
Baseline	964	98	988	9.8	3	8	24	13	50
100	957	84	1003	8.2	0	5	46	8	25
145	1159	53	1179	4.5	1	2	20	4	26
Total	3080	235	3170	7.413	4	15	90	25	101

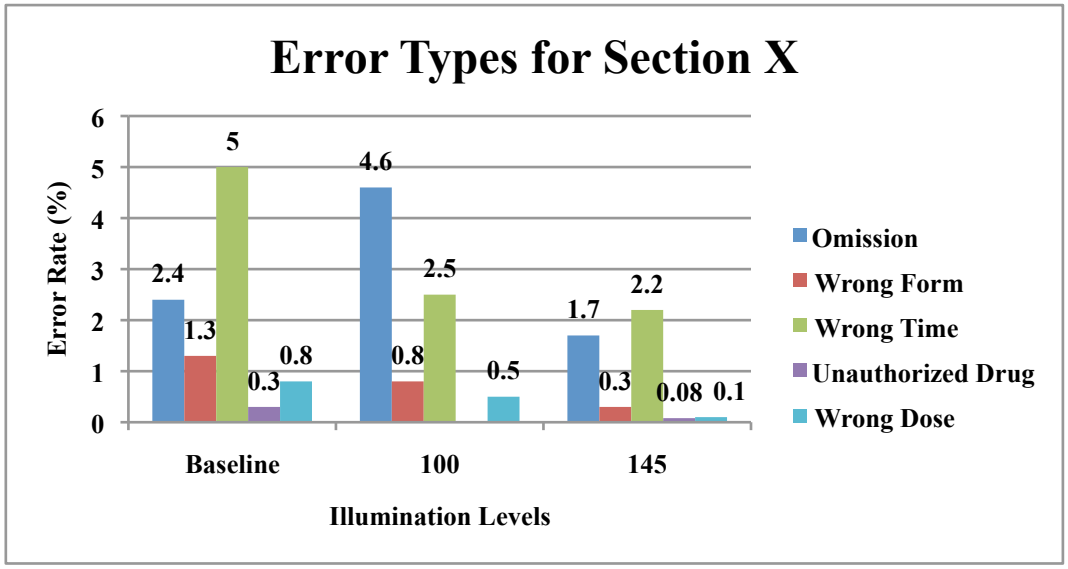


Figure 38: Medication Preparation Errors, by Error Types for Section X

Section Y:

The medication preparation error rate for Section Y was 6.7%, with 149 detected errors for 2,166 observed doses.

Table 13: Medication Preparation Errors for Section Y

Ill level	Average ill level (fc)	Total meds observed	Errors	TOE	Error rate (%)	Error rate exclud wrong time errors (%)
Baseline	27.74	788	68	818	8.4	6.3
100	100.175	635	45	659	6.8	4.3
145	144.7	743	36	756	4.8	3.4
Total		**2166**	**149**	**2233**	**6.7**	**4.6**

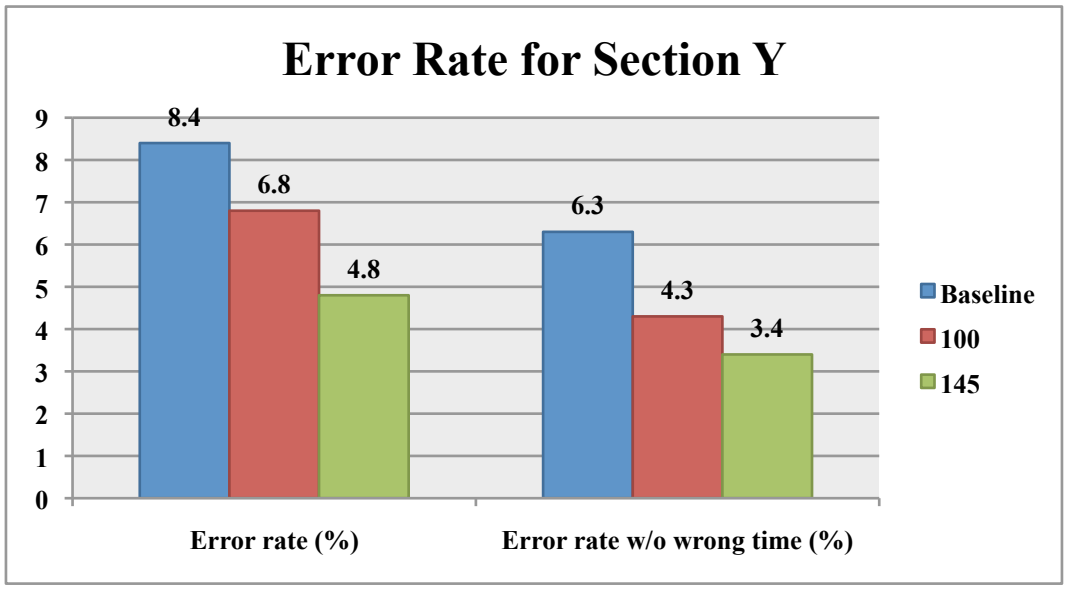


Figure 39: Medication Preparation Error rate for Section Y, by Illumination levels

The most frequently observed medication preparation error for Section Y was Omission (N = 67, 45%) followed by Wrong time (N = 47, 32%), Wrong form (N = 27, 18%) and Wrong Dose (N = 8, 5%).

The description of errors by types is shown in Table 14, while Figure 33 describes the frequency of error types for each illumination level, for Section Y. The description of each preparation error observed for Section Y is provided in *Appendix I*.

Table 14: Medication Preparation Errors for Section Y, by Error Types

Ill level	Total meds	Errors	TOE	Error rate	UnauthDose	Wrong dose	Omission	Wrong Form	Wrong Time
Baseline	788	68	818	8.4	0	4	30	13	21
100	635	45	659	6.8	0	1	24	4	16
145	743	36	756	4.8	0	3	12	10	10
Total	2166	149	2233	6.7	0	8	67	27	47

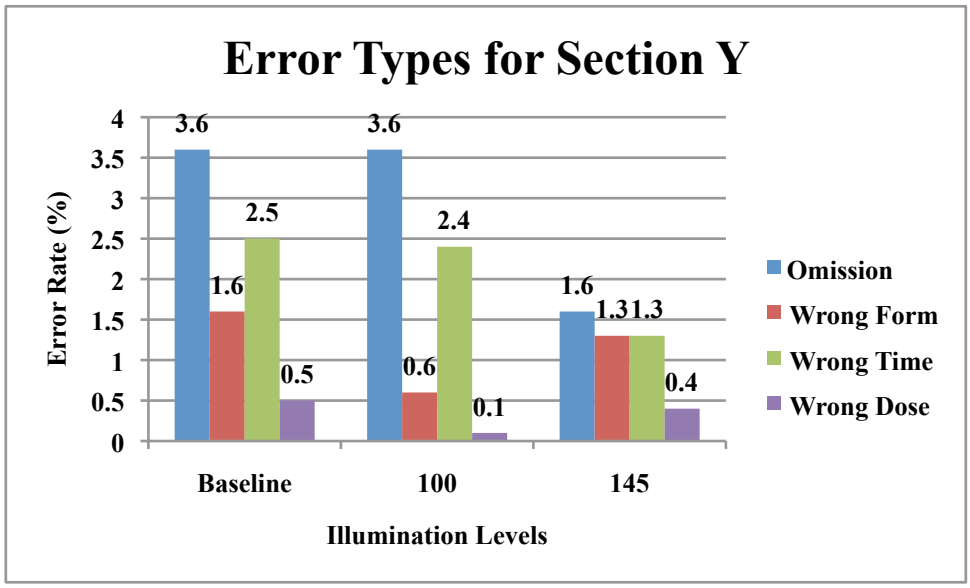


Figure 40: Medication Preparation Errors, by Error Types for Section Y

Section Z:

The medication preparation error rate for Section Z was 5.37%, with 83 detected errors for 1,512 observed doses.

Table 15: Medication Preparation Errors for Section Z

Ill level	Average ill level (fc)	Total meds observed	Errors	TOE	Error rate (%)	Error rate exclud wrong time errors (%)
Baseline	27.88	468	30	486	6.25	6.25
100	100.41	639	44	651	6.77	2.88
145	144.6	405	9	408	2.22	0.94
Total		**1512**	**83**	**1545**	**5.4**	**3.4**

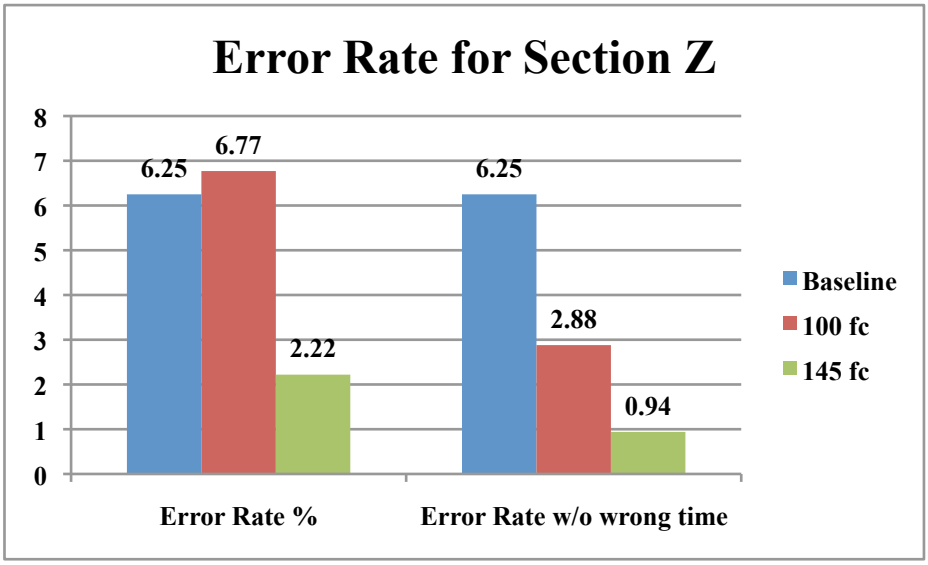


Figure 41: Medication Preparation Error rate for Section Z, by Illumination levels

The most frequently observed medication preparation error for Section Z was Omission (N = 33, 40%) followed by Wrong time (N = 30, 36%) and Wrong form (N = 20, 24%).

The description of errors by types is shown in Table 16, while Figure 35 describes the frequency of error types for each illumination level, for Section Z. The description of each preparation error observed for Section Z is provided in *Appendix I*.

Table 16: Medication Preparation Errors for Section Z, by Error Types

Ill level	Total meds	Errors	TOE	Error rate	UnauthDose	Wrong dose	Omission	Wrong Form	Wrong Time
Baseline	468	30	486	6.25	0	0	18	12	0
100	639	44	651	6.77	0	0	12	7	25
145	405	9	408	2.22	0	0	3	1	5
Total	1512	83	1545	5.37	0	0	33	20	30

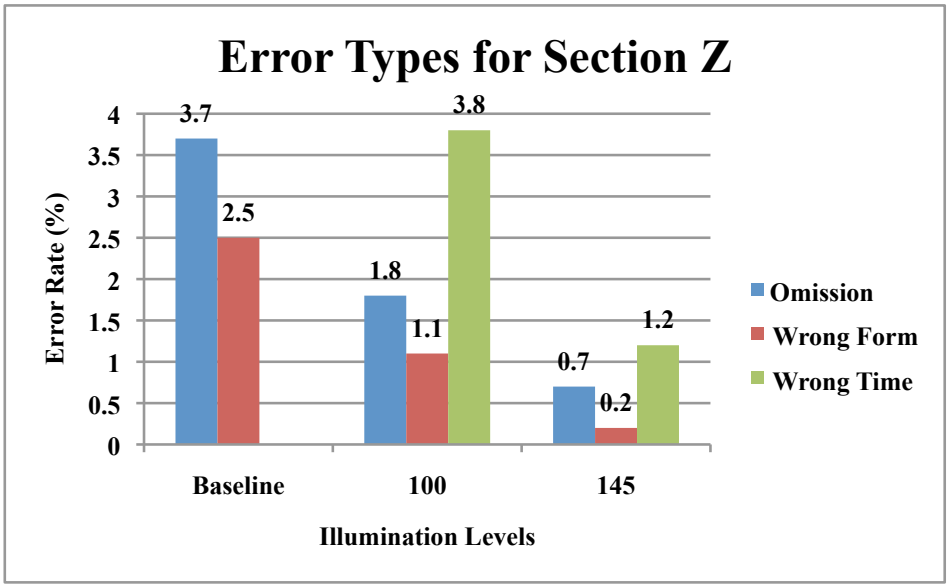


Figure 42: Medication Preparation Errors, by Error Types for Section Z

Medication Preparation Errors, by Nurse-Subjects

Seven nurse-subjects prepared the medication doses for the mornings and evening medication pass rounds (9 am and 5 pm respectively) at the study site, during the observation period.

The distribution of preparation errors by nurse-subjects and illumination levels is shown in Table 38. Pictorial representation is shown in Figure 43.

Nurse-subject 7G was associated with the highest medication preparation error rate of 10.4%, whereas Nurse-subject 1A was associated with an error rate of 2.8%.

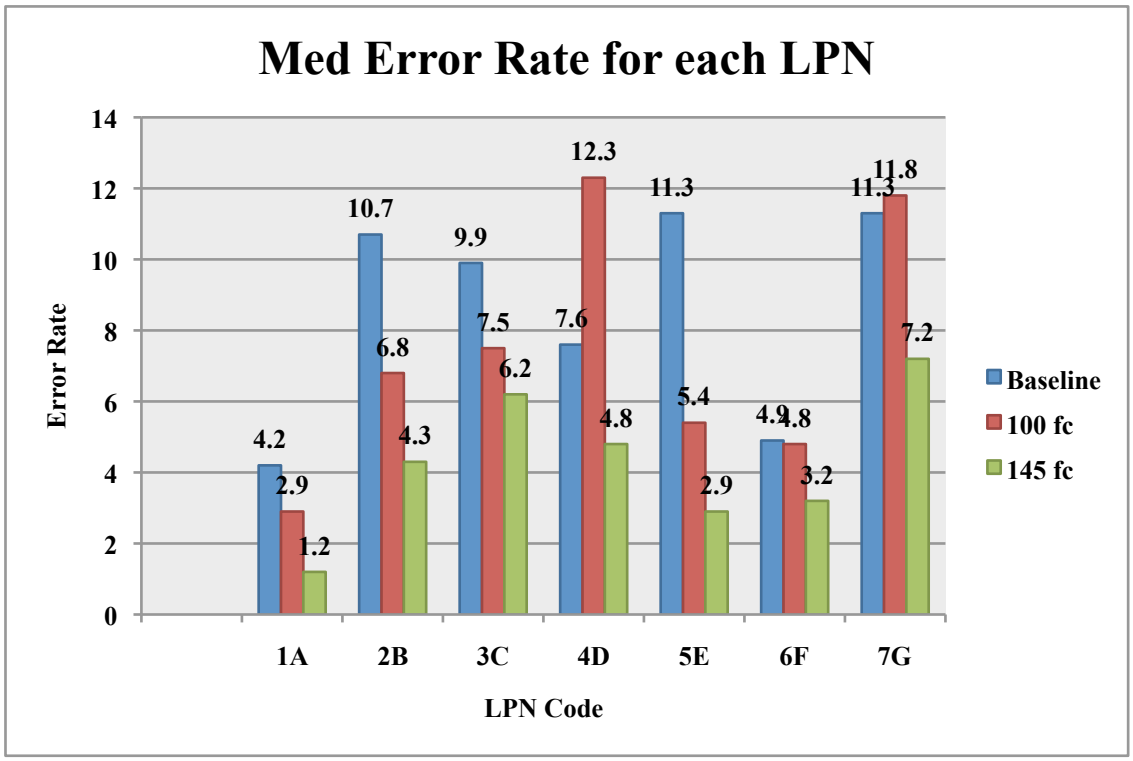


Figure 43: Medication Preparation Error rate for each nurse-subject, by illumination types

Table 17: Medication Preparation Errors by Nurse-subjects for 3 Illumination levels

Nurse subject	Illumination level	Average illumination level	Total meds	Errors	TOE	Error rate (%)	Error rate exclud wrong time errors
1A	B	35.25	329	14	333	4.2	4.2
	100	100.48	334	10	338	2.9	2.9
	145	144.68	327	4	330	1.2	1.2
Total			*990*	*28*	*1001*	*2.8*	*2.8*
2B	B	19	389	43	394	10.7	2.78
	100	99.9	399	28	407	6.8	1.88
	145	144.37	406	18	410	4.3	0.94
Total			*1194*	*89*	*1211*	*7.3*	*1.9*
3C	B	19.4	218	22	223	9.9	4.53
	100	100.53	230	18	238	7.5	4.58
	145	144.33	223	14	226	6.2	3.09
Total			*671*	*54*	*687*	*7.9*	*4.1*
4D	B	29.87	325	25	334	7.6	5.0
	100	100.16	313	40	321	12.3	2.425
	145	145.1	336	16	338	4.8	0.5625
Total			*974*	*81*	*993*	*8.2*	*2.7*
5E	B	26.02	325	38	338	11.3	8.58
	100	100.17	332	18	336	5.4	4.48
	145	144.92	341	10	346	2.9	2.88
Total			*998*	*66*	*1020*	*6.5*	*5.3*

Nurse subject	Illumination level	Average illumination level	Total meds	Errors	TOE	Error rate (%)	Error rate exclud wrong time errors
6F	B	17.87	341	17	348	4.9	4.60
	100	100.07	327	17	340	4.8	4.17
	145	144.82	357	12	362	3.3	2.73
Total			*1025*	*46*	*1050*	*4.4*	*3.9*
7G	B	15.36	293	37	322	11.3	10.3
	100	100.32	296	42	333	11.8	11.2
	145	144.65	317	24	331	7.2	6.0
Total			*906*	*103*	*986*	*10.4*	*9.2*

The following table describes the medication error types associated with each nurse-subject. Of the 467 errors, it was observed that Nurse-subject 7G was associated with the highest frequency of Omission errors (N = 80, 17%), whereas Nurse-subject 2B was associated with the highest frequency of Wrong time errors (N = 66, 14%).

Table 18: Medication Preparation Errors, by types for each nurse-subject

Nurse subject	Illumination level	Errors	Unauth. Dose	Wrong dose	Omission	Wrong Form	Wrong Time
1A	B	329			4	10	
	100	334			4	6	
	145	327			3	1	
Total					*11*	*17*	
2B	B	43		6	5		20
	100	28			8		14
	145	18			4		32
Total				*6*	*17*		*66*
3C	B	22		3	5	2	12
	100	18			8	3	7
	145	14		1	3	3	7
Total				*4*	*16*	*8*	*26*
4D	B	25		1	9	1	14
	100	40			8		32
	145	16			2	0	14
Total				*1*	*19*	*1*	*60*
5E	B	38	3	1	13	12	9
	100	18		4	4	7	3
	145	10	1		5	4	
Total			*4*	*5*	*22*	*23*	*12*
6F	B	17			7	9	1
	100	17		1	13	1	2
	145	12			5	5	2
Total				*1*	*25*	*15*	*5*
7G	B	293		1	29	4	3
	100	296		1	37	2	2
	145	317		4	14	2	4
Total				*6*	*80*	*8*	*9*

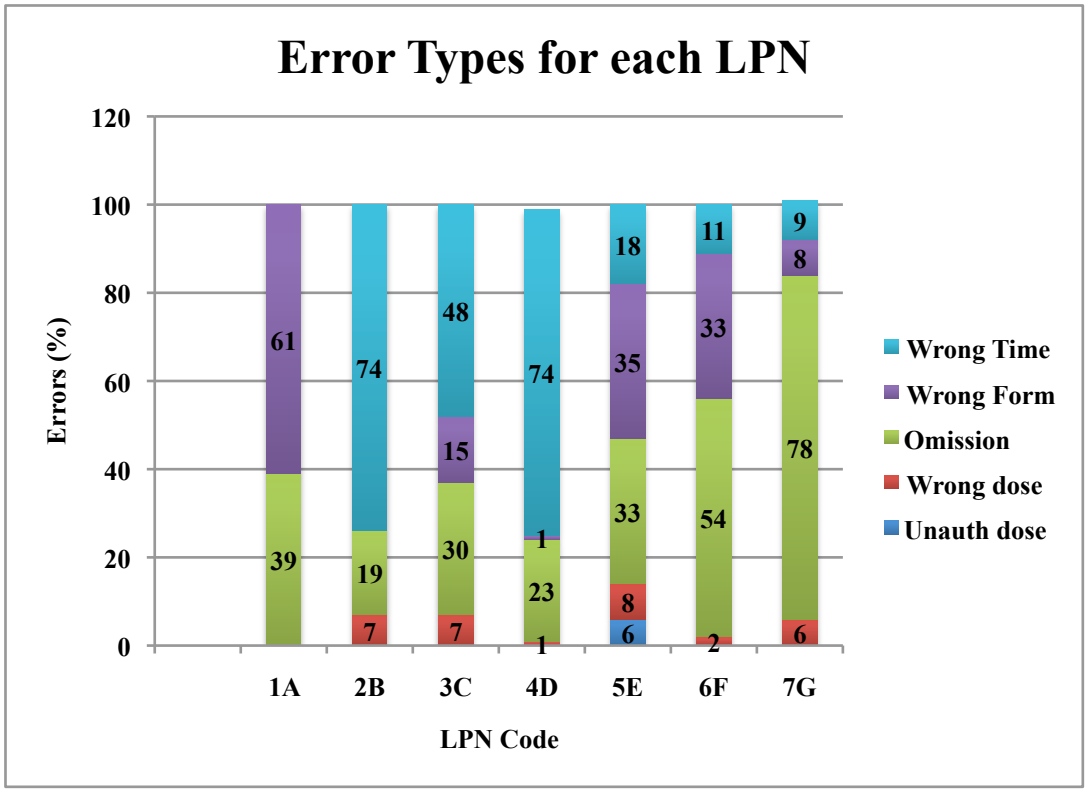


Figure 44: Medication Preparation Error types, by nurse-subjects

Statistical Hypotheses and Analysis

Research Question

Will increased illumination level at the nursing home study site result in decrease of the medication-preparation error rate?

Research Hypotheses

Null (H_{0A1}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation error rate.

Alternative (H_{1A1}): An increased illumination level at the nursing home study site will result in decrease of the medication-preparation error rate.

Analysis

Repeated measures analysis of variance (ANOVA) was used to compare the total medication preparation error rate, as detected by observation, for the three lighting conditions. The Statistical package used for the analysis was SPSS for Windows 18.0 version.

Table 19: Descriptive Statistics of the Total Medication Preparation Error rate, for each nurse-subject, by Illumination level

Illuminatn	Mean	Std. Deviation	N
Baseline	8.557	3.0199	7
100 fc	7.357	3.5293	7
145 fc	4.271	2.0345	7

* Baseline level: Average illumination level of 28 foot-candles.

Table 20: Repeated Measures Univariate ANOVA on the total medication preparation error rate, for nurse-subject by illumination level.

Effect	Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[b]
Pillai's Trace	.873	17.12[a]	2.000	5.000	.006	34.233	.906
Wilks' Lambda	.127	17.12[a]	2.000	5.000	.006	34.233	.906
Hotelling's Trace	6.847	17.12[a]	2.000	5.000	.006	34.233	.906
Roy's Largest Root	6.847	17.12[a]	2.000	5.000	.006	34.233	.906

a. Exact statistic, b. Computed using alpha = .05

The data was also analyzed for linear and quadratic trends using the Repeated Measures Univariate Analysis of Variance as shown in Table 21.

Table 21: Tests for Linear and Quadratic trends using Repeated Measures Univariate ANOVA on the total medication preparation error rate for each nurse-subject, by Illumination level

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Illumination	Linear	64.286	1	64.286	17.12	.003
	Quadratic	4.149	1	4.149	.90	.191
Error (Illumination)						
Error(illumination)	Linear	16.424	6	2.737		
	Quadratic	27.801	6	4.634		

Table 22: Pairwise Comparisons of the Medication Preparation Error rate for each nurse-subject, by Illumination levels.

Illumination	Paired Differences					t	df	Sig. (1-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
level1 - level2	1.2000	3.4093	1.2886	-1.9531	4.3531	.94	6	.194
level1 - level3	4.2857	2.3398	.8844	2.1217	6.4497	4.85	6	.001
level2 - level3	3.0857	2.2394	.8464	1.0146	5.1568	3.65	6	.005

**Level 1 : Baseline, Level 2 : 100 fc, Level 3 : 145 fc*

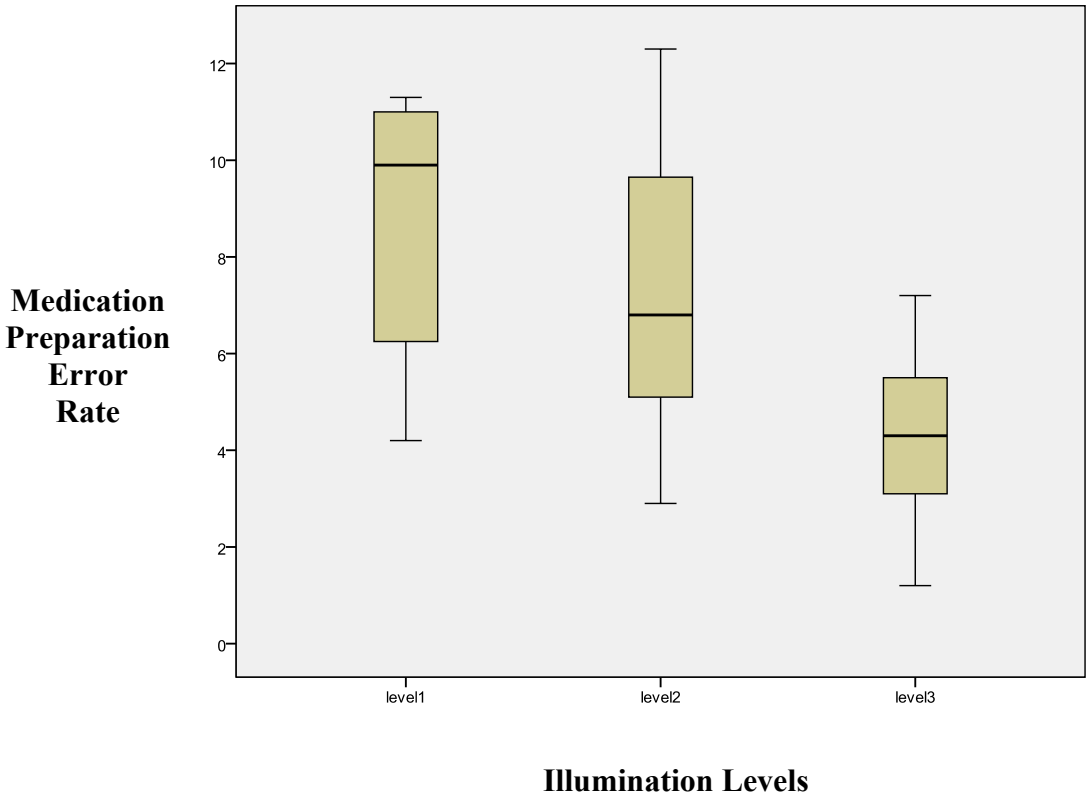


Figure 45: Box Plot of Medication Preparation Error rates for each nurse-subject across three Illumination Levels

Repeated measures Analysis of Variance was conducted with the factor being the three Illumination levels and the dependant variable being the Medication Preparation Error Rate. The mean and standard deviations for the Error Rates are presented in Table 40. The results for the ANOVA indicated a significant illumination effect, Wilks's λ = 0.127,

$F_{2,5} = 17.12, p < 0.05,$ multivariate $\eta^2 = 0.54$.

The results of the paired samples t-test (Table 22) indicated that the mean medication preparation error rates for Illumination level 3 (*M = 4.27, SD = 2.01*) are significantly different from that of Illumination level 1 (*M = 8.6, SD = 3.01*) and Illumination level 2 (*M = 7.4, SD = 3.5*). But, there was no significant difference found between the mean medication preparation error rates of Illumination levels 1 and 2.

Follow-up polynomial contrasts indicated a significant linear effect with mean error rates decreasing with increasing illumination levels, $F_{1,6} = 17.12$, $p < 0.05$. Higher order polynomial contrast (quadratic) was non-significant.

Research Question

Will increased illumination level at the nursing home study site have an effect on the medication-preparation error rate (after exclusion of wrong time errors)?

Research Hypotheses

Null (H_{0A1}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation error rate (after exclusion of wrong time errors).

Alternative (H_{1A1}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation error rate (after exclusion of wrong time errors).

Analysis

Repeated measures analysis of variance (ANOVA) was used to compare the total medication preparation error rate (excluding wrong time errors), as detected by observation, for the three lighting conditions. The Statistical package used for the analysis was SPSS for Windows 18.0 version.

Table 23: Descriptive Statistics of the Total Medication Preparation Error rate (excluding wrong time errors), for each observation day by Illumination level

Illumination	Mean	Std. Deviation	N
Baseline	5.750	3.5297	27
100 fc	4.522	4.3421	27
145 fc	2.467	2.0707	27

* Baseline level: Average illumination level of 28 foot-candles; N: Observations for each level.

Table 24: Repeated Measures Univariate ANOVA on the total medication preparation error rate (excluding wrong time errors), for each observation day by illumination level.

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter
Pillai's Trace	.632	21.433[a]	2.000	25.000	.000	.632	42.866
Wilks' Lambda	.368	21.433[a]	2.000	25.000	.000	.632	42.866
Hotelling's Trace	1.715	21.433[a]	2.000	25.000	.000	.632	42.866
Roy's Largest Root	1.715	21.433[a]	2.000	25.000	.000	.632	42.866

a. Exact statistic, b. Computed using alpha = .05

Table 25: Pairwise Comparisons of the Medication Preparation Error rate (excluding wrong time errors) for each observation day, by Illumination levels.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	level1 - level2	1.2281	4.8372	.9309	-.6854	3.1417	1.319	26	.199
Pair 2	level1 - level3	3.2833	3.3417	.6431	1.9614	4.6053	5.105	26	.000
Pair 3	level2 - level3	2.0552	3.0425	.5855	.8516	3.2587	3.510	26	.002

**Level 1 : Baseline, Level 2 : 100 fc, Level 3 : 145 fc*

A repeated measures univariate Analysis of Variance was conducted with the factor being the three Illumination levels and the dependant variable being the Medication Preparation Error Rate (without wrong time errors).

The mean and standard deviations for the Error Rates are presented in Table 23.

The results for the ANOVA indicated a significant illumination effect, Wilks's $\lambda = 0.37$, $F_{2,25} = 21.4$, $p < 0.05$, multivariate $\eta^2 = 0.63$.

The results of the paired samples t-test (Table 25) indicated that the mean medication preparation error rates for Illumination level 3 (*M =2.5, SD =2.1)* are significantly different from that of Illumination level 1 (*M = 5.7, SD = 3.5*) and Illumination level 2 (*M =4.5, SD =4.3*). But, there was no significant difference found between the mean medication preparation error rates of Illumination levels 1 and 2.

Medication Preparation Error Types

Research Question

Will increased illumination level at the nursing home study site have an effect on the medication-preparation errors, by error types?

Research Hypotheses

Null (H_{0B1}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by error types.

Alternative (H_{1B1}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by error types.

Analysis

Chi-square (*Independent samples Chi square test*) analysis was used to compare the medication preparation errors by error types for the three lighting conditions. The analysis was conducted using electronic software tool for Chi Square Analysis (Preacher, 2003)

Research Hypotheses

Null (H_{0B1}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by wrong dose error type.

Alternative (H_{1B1}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by wrong dose error type.

The analysis output table is as follows:

Table 26: Chi Square Analysis for Wrong Dose Preparation Errors

Analysis	Value	Degrees of Freedom	Significance
Pearson's Chi Square	3.888	2	0.143
Yates' Chi Square	2.833	2	0.242

Table 27: Wrong Dose Preparation error rate

	Baseline	100 fc	145 fc
Error rate	12/2292 x100 = 0.5 %	6/2313 x100 = 0.3 %	5/2343 x 100 = 0.2 %

The Chi Square analysis for Wrong Dose Preparation Errors, for all three illumination levels did not demonstrate significant difference ($X^2 = 3.88$, $df = 2$, $p > 0.05$). Thus, the error rates detected for Wrong Dose Preparation Errors across all three illumination levels were not significantly different. So, the null hypothesis was not rejected.

However it is important to note that the overall error rate for wrong dose errors for all three illumination levels was found to be low, which may effect the power to test for significance.

Research Hypotheses

Null (H_{0B2}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by wrong form error type.

Alternative (H_{1B2}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by wrong form error type.

The analysis output table is as follows:

Table 28: Chi Square Analysis for Wrong Form Preparation Errors

Analysis	Value	Degrees of Freedom	Significance
Pearson's Chi Square	12.954	2	0.0015
Yates' Chi Square	11.798	2	0.0027

Table 29: Wrong Form Preparation error rate

	Baseline	100 fc	145 fc
Error rate	38/2292 x 100 = 1.7 %	19/2313 x 100 = 0.8 %	15/2343 x 100 = 0.6 %

The Chi Square analysis for Wrong Form Preparation Errors, for all three illumination levels demonstrated significant difference. ($X^2 = 12.954$, $df = 2$, $p < 0.05$). Thus, the error rates detected for Wrong Form Preparation Errors across all three illumination levels were significantly different. So, the null hypothesis was rejected.

Research Hypotheses

Null (H_{0B3}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by wrong time error type.

Alternative (H_{1B3}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by wrong time error type.

The analysis output table is as follows:

Table 30: Chi Square Analysis for Wrong Time Preparation Errors

Analysis	Value	Degrees of Freedom	Significance
Pearson's Chi Square	9.121	2	0.05
Yates' Chi Square	8.423	2	0.05

Table 31: Wrong Time Preparation error rate

	Baseline	100 fc	145 fc
Error rate	39/2292 X 100 = 1.7 %	66/2313 X 100 = 2.8 %	41/2343 X 100 = 1.7 %

The Chi Square analysis for Wrong Time Preparation Errors, for all three illumination levels did not demonstrate significant difference ($X^2 = 9.121$, $df = 2$, $p = 0.05$). Thus, the error rates detected for Wrong Time Preparation Errors across all three illumination levels were not significantly different. So, the null hypothesis was not rejected.

It must be noted that during the study period, it observed that some of the nurse-subjects prepared few of the doses to be administered in the next med-pass round, during the previous round. But, this behavior was not observed uniformly across all nurse-subjects.

Research Hypotheses

Null (H_{0B4}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by omission error type.

Alternative (H_{1B4}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by omission error type.

The analysis output table is as follows:

Table 32: Chi Square Analysis for Omission Errors

Analysis	Value	Degrees of Freedom	Significance
Pearson's Chi Square	18.825	2	0
Yates' Chi Square	17.951	2	0

Table 33: Omission error rate

	Baseline	100 fc	145 fc
Error rate	72/2292 X 100 = 3.1 %	82/2313 X 100 = 3.5 %	36/2343 X 100 = 1.5 %

The Chi Square analysis for Omission Errors, for all three illumination levels demonstrated significant difference ($X^2 = 18.825$, $df = 2$, $p < 0.05$).

Thus, the error rates detected for Omission Errors across all three illumination levels were significantly different. So, the null hypothesis was rejected.

Research Hypotheses

Null (H_{0B5}): An increased illumination level at the nursing home study site will not have a significant effect on the medication-preparation errors, by Unauthorized Drug error type.

Alternative (H_{1B5}): An increased illumination level at the nursing home study site will have a significant effect on the medication-preparation errors, by Unauthorized Drug error type.

The analysis output table is as follows:

Table 34: Chi Square Analysis for Unauthorized Drug Preparation Errors

Analysis	Value	Degrees of Freedom	Significance
Pearson's Chi Square	3.559	2	0.168
Yates' Chi Square	1.59	2	0.451

Table 35: Unauthorized Drug Preparation error rate

	Baseline	100 fc	145 fc
Error rate	3/2292 X 100 = 0.13 %	0/2313 X 100 = 0	1/ 2343 X 100 =0.04 %

The Chi Square analysis for Unauthorized Drug Preparation Errors, for all three illumination levels did not demonstrate any significant difference ($X^2 = 3.559$, $df = 2$, $p > 0.05$). Thus, the error rates detected for Unauthorized Drug Preparation Errors for all three illumination levels were not significantly different. So, the null hypothesis was not rejected. However it is important to note that the overall error rate for Unauthorized Drug errors for all three illumination levels was found to be very low, which may effect the power to test for significance.

Medication Preparation Workload

Research Question

Is there an association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject at the study site?

Research Hypotheses

Null (H_{0C}): There is no association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject at the study site.

Alternative (H_{1C}): There is a significant association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject at the study site.

Analysis

Simple linear regression was used to investigate the relationship between daily medication pass workload and medication preparation errors for each individual nurse subject, across all three illumination levels.

An Analysis of Variance (ANOVA) procedure was used to test for Regression.

Table 36: Analysis of Variance for Linear Regression of Medication Preparation Errors with respect to the daily Medication doses prepared for Illumination level 1 (Baseline)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.447	1	3.447	.196	.662[a]
	Residual	439.738	25	17.590		
	Total	443.185	26			

a. Computed using alpha = .05

The Regression analysis for the daily medication pass workload and medication preparation errors for each individual nurse subject, for illumination level 1 was not found to be significant. ($F_{1,26} = 0.196, p > 0.05$).

No association was found between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject in the nursing home study site. The null hypothesis was not rejected.

Table 37: Analysis of Variance for Linear Regression of Medication Preparation Errors with respect to the daily Medication doses prepared for Illumination level 2 (100 fc)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.004	1	.004	.000	.989[a]
	Residual	518.515	25	20.741		
	Total	518.519	26			

a. Computed using alpha = .05

The Regression analysis for the daily medication pass workload and medication preparation errors for each individual nurse subject, for illumination level 2 was not found to be significant. ($F_{1,26} = 0, p > 0.05$).

Thus, there is no association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject in the nursing home study site. The null hypothesis was not rejected.

Table 38: Analysis of Variance for Linear Regression of Medication Preparation Errors with respect to the daily Medication doses prepared for Illumination level 3 (145fc)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.527	1	.527	.122	.730[a]
	Residual	107.769	25	4.311		
	Total	108.296	26			

a. Computed using alpha = .05

The Regression analysis for the daily medication pass workload and medication preparation errors for each individual nurse subject, for illumination level 3 was not found to be significant. ($F_{1,26} = 0.122, p > 0.05$).

Thus, there is no association between the total number of medications prepared by an individual nurse-subject each day and the medication preparation errors committed by that nurse-subject at the study site. The null hypothesis was not rejected.

Observer Effect

Research Question

Is there an association between the day of the illumination period and the number of medication preparation errors made during that day, at the nursing home study site?

Research Hypotheses

Null (H_0): There is no association between the day of the illumination period and the number of medication preparation errors made during that day, at the nursing home study site.

Alternative (H_1): There is a significant association between the day of the illumination period and the number of medication preparation errors made during that day, at the nursing home study site.

Analysis

A Chi-Square Analysis was performed on the medication preparation error data for each nurse-subject to determine the relationship between the day of the illumination period and the number of preparation errors made by the nurse-subjects during that day.

Table 39: Chi-Square Analysis of the Medication Preparation errors for each nurse-subject by illumination levels

Nurse - subjects	Baseline	100 fc	145 fc
1A	$X^2 = 0.74$ $df = 3$ $p > 0.01$	$X^2 = 1.907$ $df = 3$ $p > 0.01$	$X^2 = 1.896$ $df = 3$ $p > 0.01$
2B	$X^2 = 6.048$ $df = 3$ $p > 0.01$	$X^2 = 2.387$ $df = 3$ $p > 0.01$	$X^2 = 2.883$ $df = 3$ $p > 0.01$
3C	$X^2 = 0.738$ $df = 2$ $p > 0.01$	$X^2 = 0.123$ $df = 2$ $p > 0.01$	$X^2 = 0.128$ $df = 2$ $p > 0.01$
4D	$X^2 = 1.75$ $df = 3$ $p > 0.01$	$X^2 = 1.979$ $df = 3$ $p > 0.01$	$X^2 = 0.733$ $df = 3$ $p > 0.01$
5E	$X^2 = 11.31$ $df = 3$ $p \geq 0.01$	$X^2 = 8.388$ $df = 3$ $p > 0.01$	$X^2 = 1.833$ $df = 3$ $p > 0.01$
6F	$X^2 = 0.052$ $df = 3$ $p > 0.01$	$X^2 = 8.319$ $df = 3$ $p > 0.01$	$X^2 = 1.619$ $df = 3$ $p > 0.01$
7G	$X^2 = 1.448$ $df = 3$ $p > 0.01$	$X^2 = 8.223$ $df = 3$ $p > 0.01$	$X^2 = 1.649$ $df = 3$ $p > 0.01$

The results of the analysis for the three illumination levels indicated that the proportion of medication preparation errors remained constant.

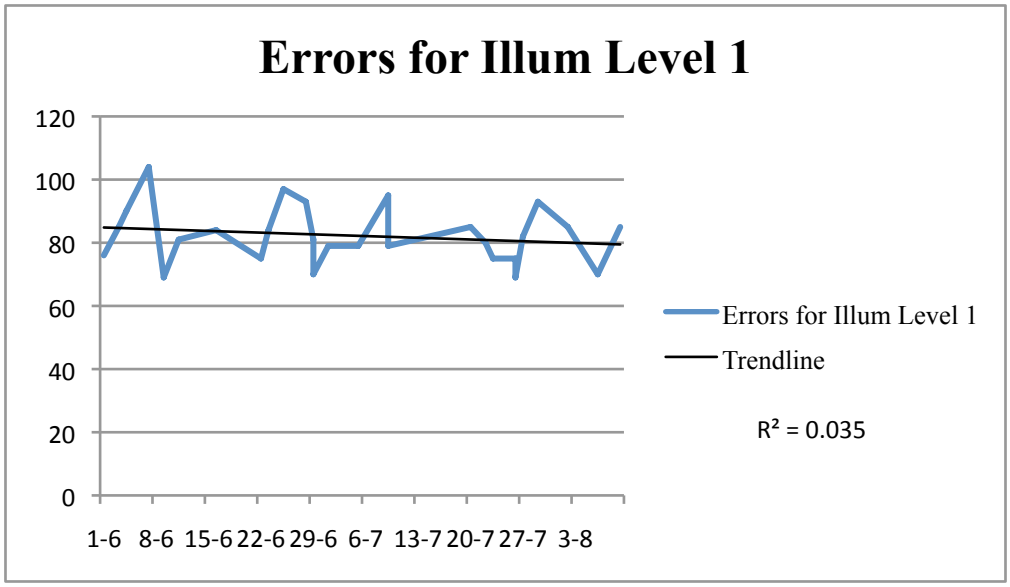


Figure 46: Trend-line of Medication Preparation Errors for Illumination Level 1 (Baseline)

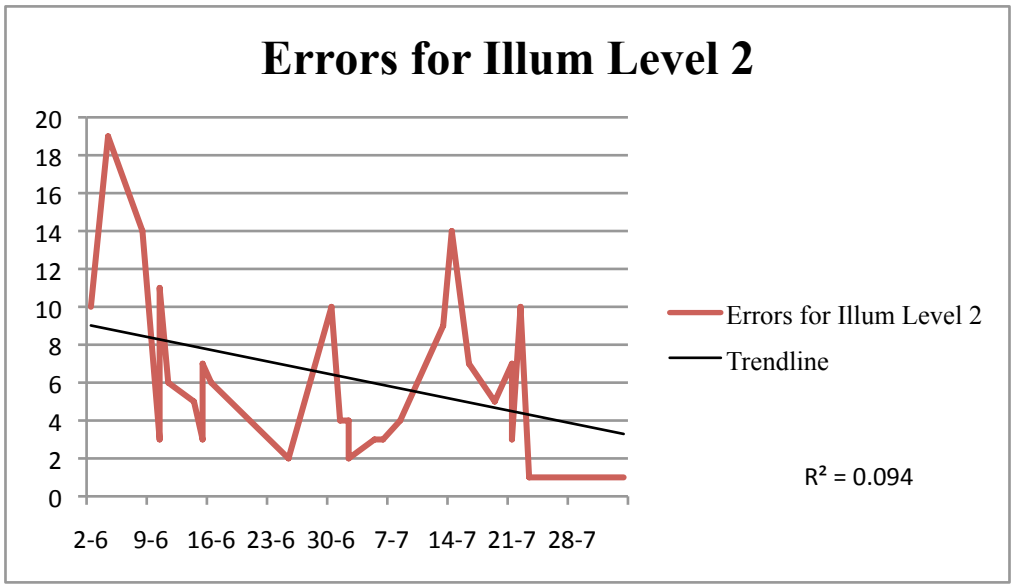


Figure 47: Trend-line of Medication Preparation Errors for Illumination Level 2 (100 fc)

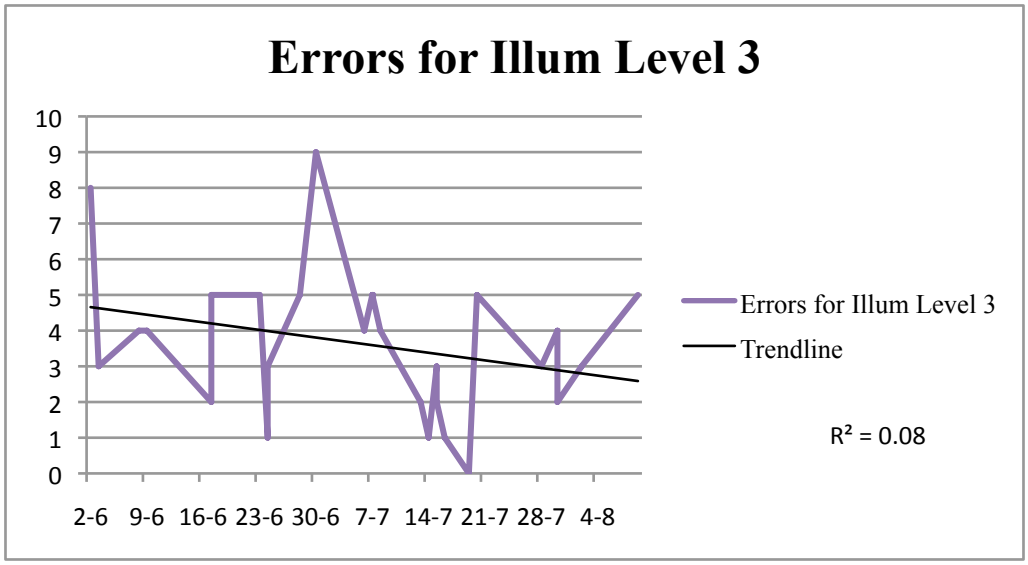


Figure 48: Trend-line of Medication Preparation Errors for Illumination Level 3 (145 fc)

The Regression Analyses for the observer effect on medication preparation error rates for illumination level 1 ($F_{1,26} = 3.665, p > 0.05$); illumination level 2 ($F_{1,26} = 2.60 , p > 0.05$) and illumination level 3 ($F_{1,26} = 2.163 , p > 0.05$) demonstrated no significant difference.

Medication Preparation Errors for Sections

Research Question

Is the proportion of medication preparation errors constant over all the three sections at the study site?

Research Hypotheses

Null (H_{0E}): The medication preparation errors detected at the three sections of the study site are not significantly different.

Alternative (H_{1E}): The medication preparation errors detected at the three sections of the study site are significantly different.

Analysis

A Chi-Square Analysis was performed on the medication preparation error data of each section for all three illumination levels.

Table 40: Medication Preparation Errors for all three illumination levels, by Sections

Section	Illumination level	Total meds	Errors	TOE
X	1	964	98	988
	2	957	84	1003
	3	1159	53	1179
Y	1	788	68	818
	2	635	45	659
	3	743	36	756
Z	1	468	30	486
	2	639	44	651
	3	405	9	328

The Chi-Square Analysis results were as follows:

For Illumination level 1: $X^2 = 4.719$, $df = 2$, $p > 0.01$

For Illumination level 2: $X^2 = 2.11$, $df = 2$, $p > 0.01$

For Illumination level 3: $X^2 = 4.698$, $df = 2$, $p > 0.01$

The results of the analysis for the three illumination levels indicated that the proportion of medication preparation errors remained constant for all the sections at the study site. So, the null hypothesis was not rejected.

Medication Preparation Errors for Medication Pass Shifts

Research Question

Is there an association between the medication shift and the medication preparation errors for all three illumination levels, at the study site?

Research Hypotheses

Null (H_{0F}): There is no association between the medication shift and the medication preparation errors for all three illumination levels, at the study site.

Alternative (H_{1F}): There is significant association between the medication shift and the medication preparation errors for all three illumination levels, at the study site.

Analysis

An Analysis of Variance test was performed on the medication preparation error data to test for association between the preparation errors and the medication shifts for all three illumination levels at the study site.

Table 41: Medication Preparation Errors for all three illumination levels, by medication shifts

Med Pass Shifts	Illumination level	Errors	TOE
9 AM	1	99	1264
	2	78	1206
	3	31	1117
5 PM	1	97	1028
	2	95	1107
	3	67	1226

Table 42: Analysis of Variance of Medication Preparation Errors with respect to med-pass shifts for all three illumination levels

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	57.664	1	57.664	3.775	.060
Within Groups	1206.879	79	15.277		
Total	1264.543	80			

The results indicate that there was no significant difference ($F_{1,80} = 3.775$, $p > 0.05$) between the medication preparation error rates, for both the medication pass shifts (9 am and 5 pm) for all three illumination levels.

Observation of Medication related incidents, which were not an error.

The observation of some of the medication-related incidents, as witnessed by the observers are presented in the following table. The observer recorded the prescribed dose the dose prepared by the nurse-subject and nurse-subject comments and actions.

Table 43: Observation of Medication-Related Incidents

Prescribed Drug	**Prepared Drug**	**(Near) Error type**	**Notes**
Digoxin 125 mcg	None	Omission	Resident refused meds
Lisinopril 2.5 mg	None	Omission	Resident refused meds
Klor Con M10	None	Omission	Resident refused meds
Glyburide Metformin 2.5mg/ 5mg	None	Omission	Resident refused meds
Furosemide 40 mg	None	Omission	Resident refused meds
Paroxetine 20 mg	None	Omission	Resident refused meds
Megestrol Acetate 10 ml	None	Omission	Resident refused meds
Lorazepam 0.5 mg	None	Omission	Resident refused meds
Senna S # 2 pills	Senna S # 1 pill	Wrong Dose Near Error	Nurse re-checks the MAR twice; and then puts in one more Senna-S pill
Coumadin 5 mg	Coumadin 2.5 mg	Wrong Dose Near Error	Nurse puts the pill in trash and gets the right strength.
		Wrong resident Near Error	Nurse does not recognize the resident, had to get help from the Certified Nursing Assistant to get to the right resident.

The observer also noted down the comments/feedback that nurse-subjects made during or after the observation period, regarding the illumination (supplemental lighting apparatus and/or the increased illumination levels) and the observer presence. The comments are listed in Table 44.

Table 44: Nurse-subjects' comments regarding the illumination and the observer

	LPN/Nurse Comments	**Observer Actions**
1	'I like the light, can see much better'	
2	'I love this light, I like being able to see.'	
3	'Are you going to tell them to give us the light? I really like the light. We move a lot so I like this extra light!'	
4	'Its Bright!'	
5	'I love this light.'	
6	' I forgot you were here'	
7	Nurse-subject to observer 'What are you writing in your note-pad?'	The observer promptly shows the Nurse-subject the data collection form and observation notes.

VI. Conclusion, Discussion, Limitations and Implications

The purpose of this chapter is to present and discuss the conclusions and general findings, their implications, the limitations of the study and to suggest topics for future research.

Main Conclusions

The main conclusions from the Statistical Analyses are as follows:

Table 45: Results and Conclusions of Hypothesis testing

Hypothesis	**Values**	**Conclusion based on Results**
H_{0A1} : u1 = u2 = u3 H_{1A1}: one or more treatment means differ	F =17.12 p < 0.05	Reject the null. Increase in illumination levels resulted in reduction of medication preparation error rate.
H_{0A2} : u1 = u2 H_{1A2} : u1 ≠ u2	t = 0.94 p > 0.05	Do not reject null. Increase in illumination level from Baseline to 100 fc did not result in reduction of medication preparation error rate.

Hypothesis	Values	Conclusion based on Results
H_{0A3} : u1 = u3 H_{1A3} : u1 ≠ u3	t = 4.85 p < 0.05	Reject the null. Increase in Illumination level from Baseline to 145 fc resulted in reduction of medication preparation error rate.
H_{0A4} : u2 = u3 H_{1A4} : u2 ≠ u3	t = 3.65 p < 0.05	Reject the null. Increase in Illumination level from 100 fc to 145 fc resulted in reduction of medication preparation error rate.
H_{0A5} : T_{linear} = 0 H_{1A5} : T_{linear} ≠ 0	F = 17.12 p < 0.05	Reject the null. There was a linear decrease in medication preparation error rates for increasing Illumination levels.
H_{0A6} : $T_{quadratic}$ = 0 H_{1A6} : $T_{quadratic}$ ≠ 0	F = 0.895 p > 0.05	Do not reject null. The mean medication preparation error rates did not decrease at a quadratic trend for increasing illumination levels.
H_{0B1}: u1 = u2 = u3 H_{1B1} : one or more treatment means differ	X^2 = 3.89 p > 0.05	Do not reject null. Increase in illumination levels did not result in reduction of Wrong dose preparation errors.

Hypothesis	Values	Conclusion based on Results
H_{0B2} : u1 = u2 = u3 H_{1B2} : one or more treatment means differ	X^2 =12.95 $p < 0.05$	Reject the null. Increased illumination levels resulted in reduction of Wrong form preparation errors.
H_{0B3}: u1 = u2 = u3 H_{1B3} : one or more treatment means differ	$X^2 = 9.12$ $p = 0.05$	Do not reject null. Increase in illumination levels did not result in reduction of Wrong time preparation errors
H_{0B4} : u1 = u2 = u3 H_{1B4} : one or more treatment means differ	$X^2 = 18.8$ $p < 0.05$	Reject the null. Increased illumination levels resulted in reduction of Omission errors.
H_{0B5} : u1 = u2 = u3 H_{1B5} : one or more treatment means differ	$X^2 = 3.56$ $p > 0.05$	Do not reject null. Increase in illumination levels did not result in reduction of Unauthorized drug preparation errors
Illumination level 1 H_{0C1} : M= 0 H_{1C1} : M ≠ 0	F = 0.196 $p > 0.05$	Do not reject null. Total number of medications prepared, did not affect the mean medication preparation error rate.
Illumination level 2 H_{0C2} : M= 0 H_{1C2} : M ≠ 0	F = 0 $p > 0.05$	Do not reject null. Total number of medications prepared, did not affect the mean medication preparation error rate.

Hypothesis	Values	Conclusion based on Results
Illumination level 3 H_{0C3} : M= 0 H_{1C3} : M ≠ 0	F = 0.122 p > 0.05	Do not reject null. Total number of medications prepared, did not affect the mean medication preparation error rate.
For each individual nurse-subjects H_{0D} : u1= u2 =u3 H_{1D} : Error proportions differ for all 3 illumination levels	Chi square Analysis results on Table 60 p > 0.01	Do not reject null. The presence of an observer did not affect the proportions of errors, detected for each nurse-subject.
Illumination level 1 H_{0E1} : $U_X = U_Y = U_Z$ H_{1E1} : Error proportions differ for one or more study-sections	X^2 =4.719 p > 0.01	Do not reject null. The proportions of medication preparation errors remained constant for all the three sections
Illumination level 2 H_{0E2} : $U_X = U_Y = U_Z$ H_{1E2} : Error proportions differ for one or more study-sections	X^2 =2.11 p > 0.01	Do not reject null. The proportions of medication preparation errors remained constant for all the three sections

Hypothesis	Values	Conclusion based on Results
Illumination level 3 H_{0E3} : $U_X = U_Y = U_Z$ H_{1E3} : Error proportions differ for one or more study-sections.	X^2 =4.698 $p > 0.01$	Do not reject null. The proportions of medication preparation errors remained constant for all the three sections.
For all 3 Illumination levels H_{0F} : $U_{9\ AM} = U_{5\ PM}$ H_{1F} : $U_{9\ AM} \neq U_{5\ PM}$	F = 3.78 $p > 0.05$	Do not reject null. The time of the medication shift (morning or evening) does not affect the medication preparation errors.

Discussion

Exploratory Findings Related To Demographic Variables Of Nurse-Subjects

Age

The performance of the human eye declines with age, with the effects beginning to be noticeable at 40 years of age. This leads to changes in the spectral light sensitivity that by 80 years of age causes loss of vision. Research has established that aging eyes require more light as compared to younger eyes, for optimal visual performance.(M. O. Blackwell & Blackwell, 1980; Boyce, 1973; Crouch, 1965; Cullinan, 1986; R. G. Davis & Garza, Winter 2002; Smith & Rea, 1978; The IESNA Committee for Healthcare Facilities, 2006; The IESNA Lighting for the Aged and Partially Sighted Committee, 2007). Figures 6 and 7 provide additional proof older eyes require increased lighting levels for better visual performance.

The average age of the nurse-subjects in the study was 34 years; with the oldest subject being 47 years and the youngest being 23 years old. The average age for this study is far less as compared to the national average of 51 years, as stated by the Joint Commission. (Joint Commission on Accreditation of Healthcare Organizations, August 2002).

The study results revealed no pattern linking the age of the nurse-subject and the medication preparation errors associated with them.

Employment Status

All the nurse-subjects were employed by the study facility for at least a period of 9 months, with the employment period ranging from 9 months to 112 months. It was the investigator's speculation that the longer the subject was employed by the facility, the better the subject's familiarity with the residents and the facility surroundings. This experience might provide the subject some improvement in his/her medication preparation and administration performance. But, there has been no research in the healthcare field investigating this association.

Exploratory observation of the study data suggested no direct relationship between employment status and the medication preparation error rate of the nurse-subjects. Future studies need to be conducted to further explore the association between medication errors and employment status (including overall nursing experience).

Educational Level

The results from literature investigating the association between level of healthcare staff credentials and the frequency of medication errors has been mixed.
While some studies reported significant differences in error rates for different levels of staff credentials (Registered Nurses (RN) and Licensed Practitioner Nurses (LPN)) and medication error frequency (Barker KN, Flynn EA et. al., 2002; Pape et. al., 2005; Pelletier, 2001), the study by Scott-Cawiezell, Pepper GA et.al, 2007 found no significant differences among the error rates for RNs, LPNs and CMTs (Certified Medication Technicians).

All the nurse-subjects in this study were Licensed Practitioner Nurses (LPNs), as only LPNs were assigned to prepare and administer medications in the study facility.

Gender

The task of medication preparation and administration often involves dosage calculations, which requires significant mathematical skills. Studies have shown that as many as 33% of the medication errors are the result of administering the wrong dosage (Bates et. al, 1995); which calls into question the dosage calculation skills of the nursing staff involved. The vast majority of nursing personnel are women; therefore, examining gender-associated factors in mathematics (dose calculations) achievement seems relevant. Research investigating the role of gender, personal attributes and self- efficacy in nursing students found no significant relationship between the gender of the nursing students and medication errors (Hodge M.B., 1999).

All the nurse-subjects who participated in this study were females, and thus the association of gender with medication preparation error rates was excluded from examination in this study.

Distractibility (GEFT) Scores

Research has shown that distractions negatively effect medication errors, wherein the higher the frequency of distractions, the higher the error rate of the particular subject. (Flynn E.A,1994). GEFT scores were used as an indicator of distractibility, where higher GEFT scores were associated with lower susceptibility to distractions, hence fewer error

rates; and lower GEFT scores were associated with higher susceptibility to distractions, hence higher error rates by the study subject. (Flynn E.A, 1994).

The GEFT scores of the nurse-subjects in the study ranged from 5 (low score) to 11 (medium score). But, comparison of the GEFT scores with the frequency of medication preparation errors for individual nurse-subjects did not reveal in any trend/pattern. The nurse-subject associated with the lowest GEFT score (high susceptibility to distractions) happened to have the lowest medication preparation error rate in the study (2.8%).

Visual test scores for nurse-subjects

Visual performance of the nurse-subjects was tested using Snellen charts (Wendy Strauss Watt, 2003). As a study measuring visual performance of nurses under varying illumination levels, measurement control for visual acuity of the nurses prior to the study was of paramount importance.

None of the subjects in this study had significant visual impairment based on the results of the Snellen tests. Most of the subjects wore corrective visual aids, such as glasses or contacts to help with their visual performance. One of the nurses with the lowest overall visual acuity score (20/50) was associated with the highest medication preparation error rate (10.4%) in the study. But, as the study design was repeated measures within-subjects design, it offered control for such personal characteristics of the study-subjects.

Medication Preparation Workload

The effect of medication preparation workload of each nurse-subject on the number of incorrect medications prepared by that nurse was investigated by simple linear regression analysis. The analysis results did not show any significant linear relationship between medication preparation workload of the nurse-subjects and their medication preparation error rate for all three illumination levels.

These findings are contrary to the results reported by other studies (Guernsey et al., 1983; Buchanan, 1989) wherein the authors found significant linear relationship between dispensing errors and prescription workload. One reason for this deviation might be that the nurse-subjects in this study prepared an average of 85 doses (with a range between 65 to 108 doses) per medication pass round, which was much less compared to the prescription workload of some of the pharmacists in the Buchanan study. None of the nurse-subjects in the study were new to the facility and they prepared many of the same medications (the physician reviews the medication order every month) for a particular medication pass round, so they were familiar with the daily medications to be prepared and administered to the residents. Also, the workload for the medication pass rounds was relatively constant, which might help speculate the deviation of the study findings from previous literature.

Explanatory (Observation) Study Findings

Effect Of Illumination On Medication Preparation Error Rate

The first main finding of the study was that there was a significant treatment (illumination) effect ($F_{2,5} = 17.116, p < 0.05$) on the medication preparation error rate. There was sufficient theoretical basis in the Human Factors and Ergonomics literature to expect a strong linear relationship between increased illumination levels and error rate (Blackwell, 1964-1968; Buchanan TL, 1989), and the present study results support the theory. The study found that Illumination level 2 (100 foot-candles) had no significant effect on medication preparation error rate, whereas illumination level 3 (145 foot-candles) had a significant effect. This result was suggested by the results of previous studies of dispensing errors, (Buchanan TL, 1989; Buchanan & Barker, 1991), where the authors detected similar results.

The overall medication preparation error rate for the baseline illumination level (30 foot-candles) was 8.5%, and it decreased to 4.3% for illumination level 3 (145 foot-candles). The study's results support the theoretical basis that since the task of medication preparation has a high visual component, the visual performance is positively affected by increasing the illumination level.

The observation data were also analyzed for polynomial contrasts, to see if there was a strong linear/quadratic trend to the data. The analysis revealed that the data had a strong linear trend, but no significant quadratic trend. That is, the relationship between illumination level and medication preparation rate is linear ($F_{1,6} = 23.48$, $p < 0.05$), but not quadratic (curvilinear). By inspecting the mean error rates in Table 19, it is evident that the linear effect is due to decrease in medication preparation error rates with

increasing illumination levels; therefore the significant linear trend was due to the increase in illumination levels. The strong linear trend supports the theoretical basis in illumination sciences literature (Blackwell HR, 1961; Blackwell HR, 1964) that suggest that the positive effect of increasing illumination levels on visual performance has a strong linear relationship initially, followed by a quadratic trend at higher illumination levels, as the effect levels off or even declines.

This finding was slightly different from the previous study (Buchanan 1989, Buchanan & Barker, 1991) investigating the effect of illumination levels on dispensing error rate, wherein the dispensing error rate showed significant linear and quadratic trend. The quadratic trend was due to the slight increase in dispensing error rate for illumination level of 102 foot-candles, as compared to the baseline measurement (46 foot-candles).

The observation error data were also analyzed after excluding the Wrong time errors, in order to check for any significant differences between the error rate and the illumination levels. The observer calculated the error rate with and without Wrong time errors, when it was observed that the nurse-subjects prepared some of the doses to be administered in the next med-pass round, during the previous round. But, this behavior was not observed uniformly across all nurse-subjects, so the results were computed with and without wrong time errors. The analysis found a significant relationship between the medication preparation error rate, excluding Wrong time errors and illumination levels ($F_{2,25} = 21.4, p < 0.05$).

The analysis also found that Illumination level 2 (100 foot-candles) had no significant effect on medication preparation error rate, whereas illumination level 3 (145

foot-candles) had a significant effect. The results were consistent with the previous findings.

Effect Of Illumination On Medication Preparation Error Types

The second finding of the study was that there were mixed results of significant associations between increased illumination levels and the medication preparation error types. Of the five types of error analyzed (wrong dose errors, wrong time errors, omission errors, wrong form errors and Unauthorized Drug errors), only wrong form errors ($X^2 = 12.954,\ df = 2,\ p < 0.05$) and omission errors ($X^2 = 18.825,\ df = 2,\ p < 0.05$) had a significant relationship with the illumination levels. Only wrong form error was found to have a linear relationship with increasing linear relationship, with the mean error rate decreasing from 1.7% at baseline illumination level to 0.8 % at 100 foot-candles and finally to 0.6% at 145 foot-candles. (Refer Table 29).

A reduction in the error rates of Wrong Dose (n=23) and Unauthorized Drug (n=4) errors occurred also, from baseline to 145 foot-candles, though the power was too low for statistical significance.

It must also be noted that during the observation period, two of the nurses mentioned that the reason behind them crushing the medications was to aid the resident in swallowing the medications. Although the observer understood the practical reason for crushing the medications, but for the purposes of the study, for the medications on the 'do not crush' list or when it was contra-indicated in the prescriber's orders, such instances were counted as an error of wrong form.

The observer noted the practice of preparing few of the doses to be administered in the next med-pass round, during the previous round, by some of the nurses. This behavior was not observed uniformly across all nurse-subjects, so medication preparation error rates were computed with and without the wrong time errors. Wrong time errors did not demonstrate a significant association with increased illumination levels (Table 30).

Although there may be reason to speculate that some of the wrong form errors and wrong time errors may not have been affected by illumination, it should be done with caution, as no follow up study (or interview) was conducted to explore the subject behavior or intention.

The primary focus of this study was to explore the association between increased illumination levels and medication preparation errors. It is important to note that no causal conclusion can be made about the effect of illumination on medication preparation error types. This association must be further explored in future studies, with specific focus on the effect of illumination on vision-related medication errors.

Reason (2003) defined human error as the failure of a planned sequence of mental or physical activities to achieve its intended outcome, when these failures cannot be attributed to chance. Whereas he defined mistakes as deficiencies/failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan. (Reason, 2003). So, interventions such as illumination can directly affect errors, whereas actions that are classified as mistake might need additional intervention tools like educational training or change in policies to address them. It may be speculated that certain behavior like preparing medications for the next

med-pass round during the present med-pass round, as well as crushing of medications that are contra-indicated for crushing might be examples of a mistake (or intended action), as per Reason's definitions. But such speculations must be carried out with extreme caution, as this study did not explore the intentions of the subjects for their behavior.

The observer recognizes the fact that changing/increasing the illumination levels is a part of the strategy (along with providing training tools, altering other environmental variables that impact errors) to reduce medication preparation errors.

Effect Of The Observer On The Observed

The effect of the presence of an observer on the nurse-subject being observed was analyzed using Chi-Square Analysis (Table 39) and found to be minimal. Specifically, the proportion of errors for each nurse-subject, for the entire observation period was examined for all three illumination levels. The analysis revealed that the proportions remained constant over each illumination period for each nurse-subject. This finding supports the literature (Barker, 1980) which suggests that the observed adapt quickly to the observer after an initial acclimation period. If the observer is trained to be non judgmental and unobtrusive, and his/her behavior convinces the study subjects that he/she is no longer a threat, then the effect of the observer on the observed can be minimized. (Barker,1980).

Qualitative feedback/comments from the nurse-subjects (Table 44) also helped reinforce the analysis findings that the nurses were not threatened by the presence of the observer. A graph of Medication preparation error rates was plotted for all

observation days, by illumination level (Figures 46 - 48). The error trend-line remained fairly constant for all three illumination levels, emphasizing that the proportion of errors by nurse-subjects were not associated with the presence of an observer, during the study period.

Significance Of Nursing Sections

Statistical control measures were implemented by analyzing the proportion of medication preparation errors for all the three sections of the long-term care study site, by illumination levels. The results of the analysis for the three illumination levels indicated that the proportion of medication preparation errors remained constant for all the sections at the study site (for baseline illumination level: $X^2 = 4.719, p > 0.01$; for 100 foot-candles Illumination level: $X^2 = 2.11, p > 0.01$; for 145 foot-candles Illumination level: $X^2 = 4.698, p > 0.01$).

Significance of Medication Shifts

Analysis of Variance was used to test for any association between the medications prepared during the medication pass shift (morning med-pass at 9 am and evening med-pass at 5 pm) and the medication preparation error rates. The results indicate that there was no significant difference ($F_{1,80} = 3.775, p > 0.05$) between the medication preparation error rates, for both the medication pass shifts (9 am and 5 pm) for all three illumination levels.

Limitations

Sampling Inadequacies

Sampling inadequacies may pose a limitation to the generalization of this study.

A. Only oral prescription medications (with pharmacy packaged medication labels) were included in the observation study, which limits the generalizability of the study. However, the study facility administered about 85% of its medications in oral form.

B. The study setting was in a long-term care facility with some unique characteristics (for eg. Onsite pharmacy, medication pass timings, baseline illumination levels etc.) that would be expected to differ from other facilities. Therefore, any generalization must be carried out with extreme caution.

Effect of the Observer on the observed

The observation method has advantages for certain kinds of studies, but there are some limitations that should be considered. Foremost is the danger of the effect of the observer on the observed. It is well known that the observer can affect the subjects of the observation simply by mere presence. However this effect varies greatly with the subject matter. Measures to counter this effect include the observer being trained to be non judgmental and unobtrusive and hence been shown to be effective, in short, subjects seem to get used to an observer if his behavior convinces the group members that he is no threat.[7]

Observer (Investigator) Accuracy

Also of concern is the possibility of errors by the observer, who was subject to some of the same environmental factors as the nurse-subjects during the observation period. Scientific training by the observer in the observation method as well as experience in observing medication pass rounds was important as a source of control. In addition, prior to the observation period, the observer had her vision checked (vision results: 20/20) and took the GEFT distractibility questionnaire with a medium score of 15/18.

In case of omission errors, the observer was not permitted to look at the MAR at the medication cart to confirm the reason for omission of certain doses. The basis of deciding on an omission error was by reconciling the observed information with that of the original physician's orders.

Blinding of the Observer

Since the observer was not blinded to the particular illumination level for a given medication shift, there might be potential bias introduced during the medication observation phase. In order to control for this bias, the observer masked the illumination level from the observation notes, during the medication review phase.

Subject Participation

The study subjects were selected by voluntary participation. The nurse-subjects were briefed about the main objectives of the observation study and the data collection process. The nurses who signed the Informed Consent Form (Appendix G) and met the

study criteria were included as subjects to be observed in the study. All the nurses, excluding one male nurse, signed the consent form.

Potential Extraneous variables

The investigator collected information on demographics such as age, level of experience, GEFT (distractibility) scores, educational levels and vision, as a measure of control for these potential extraneous variables.

Medication preparation workload was analyzed for its effect on the preparation error rate, and was found to be non-significant.

The investigator exercised caution during data collection, by keeping the illumination level constant, taking multiple measurement of the illumination levels during the observation period and not observing near any window or other external light sources.

Recommendations

Based on the study findings, the following recommendations are proposed:

1. It is recommended that the study be repeated in other long-term care facilities. Also, the study should investigate illumination level above 145 foot candles. This range of illumination will perhaps help us understand the presumed linear relationship between illumination and medication errors; and if there is a level where the effect reaches a plateau or even results in a decrement.
2. It is recommended that in addition to medication preparation errors, medication administration errors also be studied. This will help in better understanding the illumination level required in patient rooms, for the visual performance of healthcare staff to function optimally.
3. It is recommended that the explanatory study be repeated for the night shift (11 PM). Many long-term care facilities switch off some of the lights for the night shift, in order to facilitate rest for the residents. This decrease in the illumination level throughout the facility in addition to the resident rooms, might act as a barrier for the healthcare staff who are administering medications during the night shift. . Also there will be a higher level of contrast between the task and ambient lighting. It will also be interesting to look at the effect of increased illumination levels and the visual performance of the healthcare staff during the night shift.
4. It is recommended that this experimental study be expanded by simulation in a laboratory setting, in order to study the effects of lower illumination levels (lower than 100 foot-candles) on visual performances of the nurses. A more complicated

study would be to study the effects of illumination and varying workload levels on the visual performances of the nurses.

5. It is recommended that the effect of variables such as label contrast and font size on the medication preparation and administration error rate be investigated. Research studies in Illumination Sciences have suggested that variables such as font size and contrast impact visual performance; hence affect the medication preparation and administration error rate.
6. It is recommended that in addition to controlling for the subject's demographic variables and medication workload, an explanatory study be designed to control for environmental variables such as noise, interruptions and distractions. Medication error research studies have demonstrated that increase in the incidences of interruptions, distractions and high noise levels led to an increase in medication errors, hence the need to control these variables.
7. Based on the study findings, an illumination level of 145 foot candles led to the lowest medication preparation error rate of 4.3%, which is lower than the 5% medication error standard set by the Centers for Medicare and Medicaid (CMS) for long-term care facilities (Centers for Medicare and Medicaid Services, 2006). The federal government needs to place greater emphasis in the form of high standards in lighting regulations requiring adherence by architects and facility designers. In the light of the error rate improvement, CMS should consider setting standards for illumination levels at the long-term care facilities, in order to facilitate optimum visual performance by the healthcare staff.

8. It is important to note that this study found no significant improvement in the medication preparation error rate when the illumination was increased from baseline (average of 30 foot-candles) to 100 foot-candles. The Illumination Engineering Society of North America (IESNA), which serves as an expert for illumination standards and guidelines across facilities, should reconsider its general illumination recommendation for the medication preparation area. (Ambient lighting recommendation is 30 foot-candles; Task lighting recommendation is 100 foot-candles).

Implications for Future Research

There is great variability among the nursing facilities in different states regarding lighting regulations. Lack of lighting standards and specific minimum target illuminance values coupled with the aging nursing population catering to the increase in long term-care residents may aggravate the problem of medication errors in these facilities. The consequences, that medication errors can have in terms of mortality, morbidity and financial loss to both the patients and the nursing facility is well documented in literature (Bootman et.al, 1997).

This study demonstrated that it was possible to achieve a medication preparation error rate of no more than 4.3% by increasing the illumination level from 30 foot-candles to 145 foot-candles. The significance of this study in particular is to show that the adjustment of lighting from baseline level to 145 foot-candles, a relatively low cost measure requiring little or no change in nursing procedures, can achieve a reduction in

the medication preparation error rate of more than 50%, and thus surpass the CMS maximum medications error rate standard of 5% for long-term care facilities.(Centers for Medicare and Medicaid Services, 2006).

The findings of this study have implications for research in the area of the effect of varying illumination levels on medication errors in different healthcare settings. Future studies investigating the effect of illumination levels (maybe greater than 145 foot-candles) on the medication preparation error rate in different healthcare settings might help in understanding vision related medication preparation errors and likely reduce them to near zero.

The findings of this research study suggest the need to investigate the effect of illumination on target errors. A target error is defined as an error for which there is evidence or theoretical basis for hypothesizing that a particular intervention, in this case illumination, will change their occurrence or frequency.

Future research can also address the relation between label contrast and font size and its effect on the visual performance of the healthcare staff, under varying levels of illumination. It will be interesting to study the effects of workload, interruptions, distractions and environmental variables such as noise, temperature and humidity on the medication preparation error rate under different illumination conditions.

Research has demonstrated that the nursing homes with more deficiencies and those with more serious deficiencies are at higher odds of being sued as compared to the ones with fewer deficiencies cited by the CMS (Studdert, Spittal et. al., 2011). This simple intervention (increasing light levels) has the ability to significantly decrease preparation errors and perhaps liability exposure.

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APPENDICES

APPENDIX A

MEMORANDUM OF THE PROJECT

APPENDIX A

I. Copy of the memorandum

To: **All nursing staff**
From: **Investigator (Harrison School of Pharmacy, Auburn University)**
Re: **Student-researcher observing nursing staff regarding their work.**
Date: **March 31, 2009**

……

The investigator is a student - researcher from Auburn University. She is interested in studying the lighting levels at a nursing facility and its impact on work there. As part of this research, she will be observing the nurses during their medication pass rounds and asking them questions, if necessary.

The researcher will not interrupt the daily work schedule of the staff, and will shadow them without disturbing them.

The researcher will measure lighting levels at different places in the nursing facility, and that includes the medication carts and the nursing stations. She may also take pictures of certain areas to show the fixtures and equipment, while measuring the light levels. The data collected during the observation period will be used for research purposes, and will be kept strictly confidential.

The researcher will start her observation from April 7, 2009 and will continue until she collects enough data for her research.

If you have any questions, please contact: (Name with-held for confidentiality reasons).

Approved by: _____

APPENDIX B

IRB APPROVAL FORMS

AUBURN
UNIVERSITY

Office of Research Compliance
307 Sanford Hall
Auburn University, AL 36849

Telephone: 334-844-5966
Fax: 334-844-4391
hsubjec@auburn.edu

March 11, 2010

MEMORANDUM TO: Ms. Ranjani Varadarajan
School of Pharmacy

PROTOCOL TITLE: "The Effect of Illumination on Medication Preparation Errors in a Long Term Care Facility"

IRB AUTHORIZATION NO: 10-004 EP 1002

APPROVAL DATE: February 22, 2010
EXPIRATION DATE: February 21, 2011

The above referenced protocol was approved by IRB Expedited procedure under 45 CFR 46.110 (Category #7):

> "Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies."

You should report to the IRB any proposed changes in the protocol or procedures and any unanticipated problems involving risk to subjects or others. Please reference the above authorization number in any future correspondence regarding this project.

If you will be unable to file a Final Report on your project before February 21, 2011, you must submit a request for an extension of approval to the IRB no later than January 15, 2011. If your IRB authorization expires and/or you have not received written notice that a request for an extension has been approved prior to February 21, 2011, you must suspend the project immediately and contact the Office of Research Compliance for assistance.

A Final Report will be required to close your IRB project file. You are reminded that you must use the IRB-approved consent documents when you consent your participants.

If you have any questions concerning this Board action, please contact the Office of Research Compliance.

Sincerely,

Kathy Jo Ellison, RN, DSN, CIP
Chair of the Institutional Review Board
for the Use of Human Subjects in Research

cc: Dr. Salissa Westrick
Dr. Kenneth Barker

LETTER OF APPROVAL
Institutional Review Board

TO: Ranjani Varadarajan
Principal Investigator

FROM: [redacted]

DATE: February 4, 2010

The research project submitted for Expedited Review and approval entitled, "The Effect of Illumination on Medication preparation Errors in a Long-Term Care Facility", was reviewed and approved with the following stipulations:

A. Investigators acknowledge and accept their responsibility for protecting the rights and welfare of human research subjects and for complying with all applicable thereof.

B. Investigators must report promptly to the IRB:

(1) Any proposed changes in IRB approved research and acknowledge such research may not be initiated without IRB review and approval except where necessary to eliminate apparent immediate hazards to the human subjects.
(2) Any unanticipated problems involving risks to human subjects or others.
(3) Any instance of serious or unexpected adverse events arising during the research.

C. The above titled project is approved February 4, 2010 through February 2, 2011. If the project is to continue beyond the ending date of approval, application for renewal must be made as of November 2010 to be further approved by the IRB.

D. Approval is contingent upon modifications, if any, of the protocol or consent form and approved documentation of such modifications.

[redacted]

2 4 2010
Date

Please acknowledge your agreement to abide by these stipulations by your signature, keep a copy and return the original to the IRB office.

Principal Investigator

2-5-2010
Date

APPENDIX C

MEDICATION SCHEDULE

APPENDIX C

I. Medication schedule

Frequency:	Medication/Treatment Times:			
One/Day	09:00 AM			
Two/Day	09:00 AM	05:00 PM		
Three/Day	09:00 AM	01:00 PM	05:00 PM	
Four/Day	09:00 AM	01:00 PM	05:00 PM	09:00 PM
Five/Day	06:00 AM 10:00 PM	10:00 AM	02:00 PM	06:00PM
Six/Day	06:00 AM 06:00 PM	09:00 AM 09:00 PM	12:00 PM	03:00 PM
Morning	09:00 AM			
Bedtime	09:00 PM			
Before Meals	07:00 AM	12:00 PM	05:00 PM	
After Meals	08:00 AM	01:00 PM	06:00 PM	
PRN	As Needed			
None	As Directed			

APPENDIX D

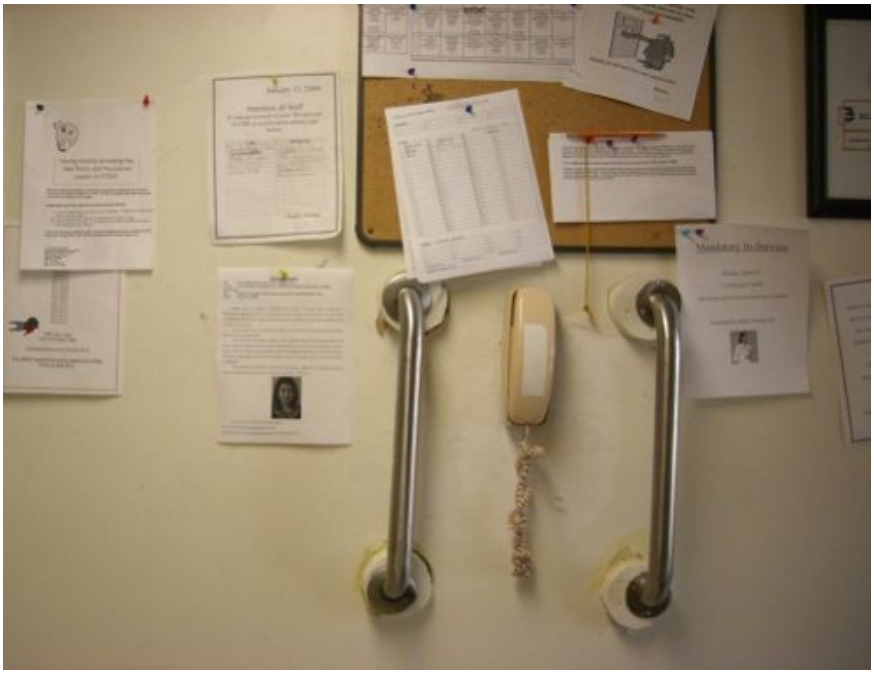
ADDITIONAL PICTURES FROM THE NURSING FACILITY

APPENDIX D

Pictures of the nursing facility

Typical medication cart in all sections

Blister card from Pharmacy



Memo stuck on the notice board

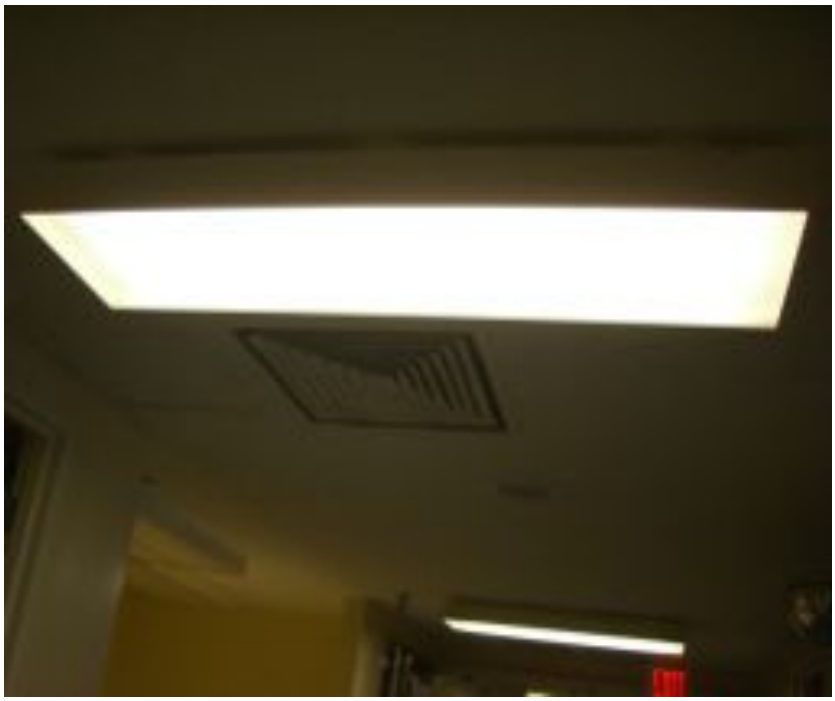
Resident Medication administration records stacked according to room numbers at the nursing stations

MAR folder for controlled substances

A typical resident room

Resident activity room

Light fixtures used in the facility



APPENDIX E

COPY OF INCIDENT REPORT FORM

APPENDIX E

Incident report form

Name of Resident: _____ Safety Registry number: _____

When the incident occurred (date & time): _____

Where the incident occurred (ex. Bathroom, bedroom, lawn, etc…): _____

Circumstances under which the incident occurred: _____

Incident was witnessed: Yes _____ No _____ if yes, please complete the following table:

Name of Witness:	Telephone Number:	Address:

Immediate treatment rendered: _____

Emergency treatment or any other out-of-facility treatment necessary: Yes ____ No ____ if yes, please describe in detail ER treatment (of-of-facility treatment) required and given by whom: _____

Extent of injury, if any, to the affected resident(s): _____

Actions taken to prevent reoccurrence: _____

Follow-up care and outcome resolution: _____

Physician notified Name: _____ Date & time: _____

Symptoms of pain and injury discussed with the physician (*if applicable*): _____

Family/Sponsor notified Name: _____ Date & time: _____

Staff signature: _____ Date: _____

Staff signature: _____ Date: _____

Administrator/designee signature: _____ Date: _____

If applicable, notify state hotline. See guidelines.
Alabama Department of Public Health (ADPH) notified via hotline (1-866-855-1913) or fax (1-334-206-8219): Yes ___ No ___
If yes, please list date & time of notification and details surrounding contact: _____

APPENDIX F

DATA COLLECTION FORMS

Form1 : Drug pass worksheet (Observation phase)

Page # _____ ; Date and Day: _____ ; Obs time : _____; Illumination Level: ___; Nursing unit: _____

OE #	LPN code	Prep time	Resident Initials and room #	Medicine, strength, amount, Form, Route Source	Other comments

Form 2: Drug Orders (Reconciliation phase)

Date: _____; Resident initial/room number: _____; Nursing unit:_____

OE #	Date and time of order	Medicine, strength, amount, Form, instructions	Time dose due

Form 3: Medication error summary sheet

Nursing unit: _____ ; Illumination level: _____

Day/Date: _____; Time/shift : _____

OE #	Resident initial, room #, med record #	Med error description (Prepared vs ordered)	Med error category					
			Extra dose	Unauthor. drug	Wrong dose	Omission	wrong form	Wrong time
		Subtotals :						

Total Errors = _____ ;
Total Opportunities for errors = _____ (# of doses given ____ + doses omitted _____)
Error rate = _____ % ; [(Total errors / T.O.E.) X 100]
Excluding wrong time errors; Error rate = _____ % ; [{(Total errors - wrong time errors) / T.O.E.} X 100]

APPENDIX G

INFORMED CONSENT LETTER

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT).

INFORMED CONSENT
for a Research Study entitled
"The Effect of Illumination of Medication Preparation Errors in a Long-Term Care Facility"

You are invited to participate in a research study to measure the effect of lighting on the medication preparation process. The study is being conducted by Ms. Ranjani Varadarajan MS, under the direction of Dr. Kenneth N. Barker in the Auburn University Department of Pharmacy Care Systems. You were selected as a possible participant because you are part of the nursing staff of Oak Park Nursing Facility and are age 19 or older.

What will be involved if you participate?
If you decide to participate in this research study, you will be asked to perform your daily duties, just like you did before. Before participating in the study, you will have your vision checked by the researcher (visual acuity and colorblindness tests) and fill out a distractibility questionnaire (also called the GEFT questionnaire). The researcher will collect basic demographic information such as education level, years of experience in the current position, gender, age, etc.

Are there any risks or discomforts?
The risks associated with participating in this study are minimal. There is a possibility of social risk, as the information gathered will be obtained by directly observing the nurses on their jobs. But to minimize this risk, no information identifying the nursing staff (for example: name) will be collected during observation. All the observed information about the nursing staff will be coded; and deleted after 30 days. You will be observed for approximately two weeks. The demographic information will not be associated with error information on an individual basis.

Are there any benefits to yourself or others?
Although there are no personal benefits, if you participate in this study you can expect to gain protection against the negative consequences in the medication preparation process which can result from insufficient lighting. We/I cannot promise you that you will receive any or all of the benefits described.

Participant's initials _____

207 Prestwick Hall, Auburn, AL 36849-5501; Telephone: 334-844-5852; Fax: 334-844-8307
www.auburn.edu

AUBURN UNIVERSITY

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Pharmacy Care Systems or Oak Park nursing facility.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be used to fulfill an educational requirement, published in a professional journal, presented at a professional meeting.

If you have questions about this study, please ask them now or contact Ms. Ranjani Varadarajan at 334-559-0538 or Dr. Kenneth N. Barker at barkekn@auburn.edu or Mr. Jason Banks at jason.banks@eamc.org. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjects@auburn.edu or IRBChair@auburn.edu; or Dr. Michael Lisenby at East Alabama Medical Center Institutional Review Board by phone (334)-528-1326.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

Participant's signature Date

Printed Name

Investigator obtaining consent Date

Printed Name

The Auburn University Institutional Review Board has approved this document for use from 2/22/10 to 2/21/11 Protocol # 10-004 EP 1002

Co-Investigator Date

Printed Name

207 Drucker Hall, Auburn, AL 36849-5506; Telephone: 334-844-5512; Fax: 334-844-8307

www.auburn.edu

APPENDIX H

RENEWED IRB APPROVAL FORMS

AUBURN UNIVERSITY INSTITUTIONAL REVIEW BOARD for RESEARCH INVOLVING HUMAN SUBJECTS

REQUEST for PROTOCOL RENEWAL

For information or help completing this form, contact: THE OFFICE OF HUMAN SUBJECTS RESEARCH, 307 Samford Hall
Phone: 334-844-5966 e-mail: hsubjec@auburn.edu Web Address: http://www.auburn.edu/research/vpr/ohs/index.htm

Complete this form using Adobe Acrobat Writer (versions 5.0 and greater). Hand written forms will not be accepted.

1. Protocol Number: 10-004 EP 1002
2. Original IRB Approval Dates: From: 2/22/2010 To: 2/21/2011
3. Requested ONE YEAR MAXIMUM Renewal Period: From: 2/21/2011 To: 12/31/2011
4. PROJECT TITLE: The Effect of Illumination on Medication Preparation Errors in a Long Term Care Facility

5.

Ranjani Vanadarajan	Student	Pharmacy Ca	334-559-0538	vanadra@auburn.edu
PRINCIPAL INVESTIGATOR	TITLE	DEPT	PHONE	AU E-MAIL
PI SIGNATURE	310 Gerelda Avenue, Apt # 6, Auburn AL 36832 MAILING ADDRESS			ranjaniyer@gmail.com ALTERNATE E-MAIL
Dr. Kenneth N Barker	[signature]	Pharmacy Care I	334-821-8050	barkekn@auburn.edu
FACULTY ADVISOR	SIGNATURE	DEPT	PHONE	AU E-MAIL

Name of Current Department Head: Dr. Richard A Hanson AU E-MAIL: rah0019@auburn

6. Current External Funding Agency: None

7. List any contractors, sub-contractors, or other entities or IRBs associated with this project:
EAMC IRB

8. Briefly list (numbered or bulleted) the activities that occurred over the past year, particularly those that involved participants.
1) Informed consent letters were signed by the nurse-participants.
2) Nurse participants filled out the Group Embedded Figures Test (GEFT).
3) Visual acuity tests were administered to all the nurse-participants.
4) Demographic information such as age, gender,education level, experience level were collected.
4) PI observed the nurse-participants, during their regular administration hours (medication pass hours), under three different lighting conditions.
5) PI reconciled the observed data with that of orginial prescriber's orders, stored in the nursing facility.

9. Explain why you are requesting additional time to complete this research project.
The Principal Investigator (PI) encountered personal problems outside this study, that stalled the progress of this research during the Fall. Hence, additional time required to conduct data reconciliation and analyses. But as of now, the PI has sorted out all the problems, and will focus on the reconciliation and data analyses part of the research. Hence, IRB extension is requested.

RECEIVED
JAN 27 2011

The Auburn University Institutional Review Board has approved this document for use from 2/2/11 to 2/24/12
Protocol # 10-004 EP 1002

LETTER OF APPROVAL
Institutional Review Board

TO: Ranjani Varadarajan
Principal Investigator

FROM: [redacted]

DATE: February 2, 2011

The research project submitted for Expedited Review and approval entitled, "The Effect of Illumination on Medication preparation Errors in a Long-Term Care Facility", was reviewed and approved with the following stipulations:

A. Investigators acknowledge and accept their responsibility for protecting the rights and welfare of human research subjects and for complying with all applicable thereof.

B. Investigators must report promptly to the IRB:

(1) Any proposed changes in IRB approved research and acknowledge such research may not be initiated without IRB review and approval except where necessary to eliminate apparent immediate hazards to the human subjects.
(2) Any unanticipated problems involving risks to human subjects or others.
(3) Any instance of serious or unexpected adverse events arising during the research.

C. The above titled project is approved February 2, 2011 through February 1, 2012. If the project is to continue beyond the ending date of approval, application for renewal must be made as of December 1, 2011 to be further approved by the IRB.

D. Approval is contingent upon modifications, if any, of the protocol or consent form and approved documentation of such modifications.

[redacted] 2-2-2011
Date

Please acknowledge your agreement to abide by these stipulations by your signature, keep a copy and return the original to the IRB office.

Principal Investigator Date

APPENDIX I

MEDICATION PREPARATION ERROR DESCRIPTION

Appendix I: Table 1I: Medication Preparation Error Types and Frequencies for Section X

Date	Nurse code	Ill. Level	Errors	Unauth. Dose	Wrong dose	Omission	Wrong Form	Wrong Time
6/1/10	5E	B	19		1	8	1	9
6/2/10	5E	100	10		2	4	1	3
6/3/10	5E	145	3			3		
6/9/10	5E	145	4			2	2	
6/10/10	5E	100	3		1		2	
6/11/10	5E	B	6			2	4	
6/15/10	5E	100	3		1		2	
6/16/10	5E	B	5	1		1	3	
6/17/10	5E	145	2	1			1	
6/23/10	5E	B	8	2		2	4	
6/24/10	5E	145	1				1	
6/25/10	5E	100	2				2	
6/3/10	4D	B	5			2		3
6/4/10	4D	B	5			2		3
6/8/10	4D	145	4			1		3
7/30/10	4D	145	4			1		3
8/2/10	4D	145	3					3
6/2/10	2B	145	8			1		7
6/7/10	2B	B	18		1	3		14
6/10/10	2B	100	11			4		7
6/11/10	2B	100	6			1		5
6/24/10	2B	145	3			2		1
6/25/10	2B	B	6					6
6/28/10	2B	B	12		5	2		5
7/1/10	2B	100	4					4

Date	Nurse code	Ill. Level	Errors	Unauth. Dose	Wrong dose	Omission	Wrong Form	Wrong Time
7/16/10	2B	145	4			1		3
7/9/10	2B	B	7					7
7/15/10	2B	145	3					3
7/16/10	2B	100	7			3		4
6/4/10	7G	100	19			18		1
6/8/10	7G	100	14		1	13		
6/22/10	7G	B	7		1	2	1	3
6/30/10	7G	145	9		1	6		2
7/7/10	7G	145	5		1	3		1
7/19/10	7G	100	5			3	1	1
TOTAL			**235**	**4**	**15**	**90**	**25**	**101**

Note: It might be possible that some doses categorized as omission errors were prepared and administered while the observer was not present at the study site. For the purposes of this study, if the observer did not observe the prescribed dose being prepared during the medication pass round (with a window of ± 60 minutes), it was termed an omission error.

Table 2I : Description of Medication Preparation Errors for Section X

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
6/1/10	Baseline	Metronidazole 250 mg	None	Omission	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
		Senna Plus	None	Omission	
		Cetirizine 10 mg	None	Omission	
		Namenda 10 mg	None	Omission	
		Acetaminophen 325 mg	None	Omission	
		Calcium 600 + Vit D	None	Omission	
		Aspirin 325 mg	None	Omission	
		Glimepiride 2 mg	None	Omission	
		Furosemide			
6/2/10	100 fc	Bupropion HCL SR 100 mg	Bupropion HCL SR 100 mg; crushed	Wrong form	LPN comments 'Its bright'
9 AM		Meclizine 25 mg	None	Omission	
		Glimepiride 2 mg	None	Omission	
		Loratadine 10 mg # 1	Loratadine 10 mg#2	Wrong dose	
		Furosemide 20 mg # ½ tab	Furosemide 20 mg # 1	Wrong dose	
		Ibuprofen 400 mg	none	Omission	
6/2/10	145 fc	Famotidine 20 mg	None	Omission	
5 PM		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.28 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
6/2/10	145 fc	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.20 PM	Wrong time	
5 PM		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.35 PM	Wrong time	
		Carbi-Levo 25/100; due at 6 PM after food	Carbi-Levo 25/100; given at 4.40 PM	Wrong time	
		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 5 PM	Wrong time	
		Metformin 25 mg; due at 7 PM	Metformin 25 mg; given at 5.10 PM	Wrong time	
		Vytorin 10-20 mg; due at 7 PM	Vytorin 10-20 mg; given at 5.35 PM	Wrong time	
6/3/10	145 fc	Glimepiride 2 mg	None	Omission	
9 AM		Ibuprofen 400 mg	None	Omission	
		Therapeutic Vitamin	None	Omission	
6/3/10	B	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.35 PM	Wrong time	
5 PM		Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 4.40 PM	Wrong time	
		Metoprolol 50 mg	None	Omission	
		Ferrous Sulphate 325 mg; due at 9 PM	Ferrous Sulphate; given at 4.50 PM	Wrong time	
		Colace 100 mg	None	Omission	
6/4/10	100 fc	Omeprazole 25 mg	None	Omission	
9 AM		Atenolol 25 mg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Famotidine 40 mg	None	Omission	
		Senna Plus	None	Omission	
		Cetirizine 10 mg	None	Omission	
		Citalopram 20 mg	None	Omission	
		Aspirin 81 mg	None	Omission	
6/4/10	100 fc	Namenda 10 mg	None	Omission	LPN says ‘ Light is good; can see much better’.
9 AM		Calcium + Vit D	None	Omission	
		Tylenol 325 mg	None	Omission	
		Metoprolol 25 mg; due at 7 AM	Metoprolol 25 mg; given at 9.30 AM	Wrong time	
		Therapeutic Vitamin	None	Omission	
		Metronidazole 250 mg	None	Omission	
		KCL 10 MEQ	None	Omission	
		Claritin 5 mg	None	Omission	
		Azithromycin 250 mg	None	Omission	
		Colace 100 mg	None	Omission	
		Therapeutic Vitamin	None	Omission	
		Sodium citrate-citric acid solution 10 ml	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
6/4/10	B	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.15 PM	Wrong time	
5 PM		Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 4.25 PM	Wrong time	
		Metoprolol 50 mg	None	Omission	
		Ferrous Sulphate 325 mg; due at 9 PM	Ferrous Sulphate; given at 5.10 PM	Wrong time	
		Colace 100 mg	None	Omission	
6/7/10	B	Singulair 10 mg	None	Omission	
5 PM		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.30 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.45 PM	Wrong time	
6/7/10	B	Megestrol Acetate 40mg/ml (10ml); due at 9 PM	Megestrol Acetate 40mg/ml (10ml); given at 4.45 PM	Wrong time	
5 PM		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.55 PM	Wrong time	
		Benzonatate 100 mg; due at 9 PM	Benzonatate 100 mg; given at 5.10 PM	Wrong time	
		Doxepin 10 mg; due at 9 PM	Doxepin 10 mg; given at 5.20 PM	Wrong time	
		Ibuprofen 400 mg	None	Omission	
		Vytorin 10-40 mg; due at 9 PM	Vytorin 10-40 mg; given at 5.35 PM	Wrong time	
		Aricept 10 mg; due at 9 pm	Aricept 10 mg; given at 5.25 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.53 PM	Wrong time	
		Metronidazole 250 mg	None	Omission	
		Metoprolol 25 mg; due at 7 PM	Metoprolol 25 mg; given at 5.18 PM	Wrong time	
		Vytorin 10-20 mg; due at 7 PM	Vytorin 10-20 mg; given at 5.33 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.20 PM	Wrong time	
		Aricept 5 mg	Aricept 10 mg	Wrong dose	
		Mirtazapine 25 mg; due at 9 PM	Mirtazaping 25 mg; given at 5.11 PM	Wrong time	
		Alprazolam 0.25mg; due at 9 PM	Alprazolam 0.25 mg; given at 5.31 PM	Wrong time	
6/8/10	100 fc	Cal-carb 600+ Vit D	None	Omission	
9 AM		Therapeutic tablet	None	Omission	
		Cefuroxine 250 mg	None	Omission	
		Aspiring 325 mg	None	Omission	
		Cal-carb 600+ Vit D	None	Omission	
		Namenda 10 mg	None	Omission	
6/8/10	100 fc	Ibuprofen 400 mg	None	Omission	
9 AM		Colace 100 mg	None	Omission	
		Alprazolam 0.25 mg	None	Omission	
		Doxycycline 100 mg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Warfarin Sodium 1 mg	None	Omission	
		Atenolol 25 mg	Atenolol 20 mg	Wrong dose	
		Omeprazole 20 mg	None	Omission	
		Metronidazole 250 mg	None	Omission	
6/8/10	145 fc	Metoprolol 50 mg	None	Omission	
5 PM		Ferrous Sulphate 325 mg; due at 9 PM	Ferrous Sulphate 325 mg; given at 5 PM	Wrong time	
		Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 5.10 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.35 PM	Wrong time	
6/9/10	145 fc	Glimepiride 2 mg	None	Omission	
9 AM		Thiamine HCL 100 mg	None	Omission	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong Form	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong Form	
6/10/10	100 fc	Bupropion SR 100 mg	Bupropion SR 100 mg; crushed	Wrong form	
9 AM		Aspirin EC 81 mg; # 1	Aspirin EC 81 mg; #2	Wrong dose	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
6/10/10	100 fc	Ibuprofen 400 mg	None	Omission	
5 PM		Citalopram 40 mg	None	Omission	
		Colace 100 mg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Metformin HCl 500 mg	None	Omission	
		Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 5.20 PM	Wrong time	
6/10/10	100 fc	Vytorin 10-20 mg; due at 7 PM	Vytorin 10-20 mg; given at 4.20 PM	Wrong time	
5 PM		Metoprolol 25 mg; due at 7 PM	Metoprolol 25 mg; given at 4.38 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.45 PM	Wrong time	
		Vytorin 10-40 mg; due at 9 PM	Vytorin 10-40 mg; given at 5 PM	Wrong time	
		Senna Plus; due at 9 PM	Senna Plus; given at 5.15 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 5.20 PM	Wrong time	
6/11/10	B	Haldol 1 mg	Haldol 1 mg; crushed	Wrong form	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
		Bupropion SR 100 mg	Bupropion SR 100 mg; crushed	Wrong form	
		Senna Plus	None	Omission	
		Tylenol 325 mg	None	Omission	
6/11/10	100 fc	Atenolol 0.25 mg; due at 9 PM	Atenolol 0.25 mg; given at 4.18 PM	Wrong time	
5 PM		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.35 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.47 PM	Wrong time	
		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 5.10 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.13 PM	Wrong time	
		Klor Con	None	Omission	
6/15/10	100 fc	Aspirin EC 81 mg	Aspirin EC 81 mg; crushed and removed outer coating	Wrong form	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
		Hydroxyzine 25 mg	Hydroxyzine 20 mg	Wrong dose	
6/16/10	B	Bupropion SR 100 mg	Bupropion SR 100 mg; crushed	Wrong form	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
		Aspirin EC 325 mg	Aspirin EC 325 mg; crushed	Wrong form	
			Pyridium 200 mg	Unauthorized drug	
		Senna S	None	Omission	
6/17/10	145 fc		Pyridium 200 mg	Unauthorized drug	Big lunch today, so med pass early
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
6/22/10	B	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.17 PM	Wrong time	
5 PM		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.11 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Ceftin 250 mg; due at 9 PM	Ceftin 250 mg; given at 4.21 PM	Wrong time	
		Omeprazole 20 mg	None	Omission	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
		KCL 10 MEQ		Wrong dose	Spills the crushed contents
		Ibuprofen 400 mg	None	Omission	
6/23/10	B	Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
6/23/10	B		Senna S	Unauthorized drug	
9 AM			Senna S	Unauthorized drug	
		Doxycycline 100 mg	None	Omission	
		Lansoprazole SR 30 mg	Lansoprazole SR 30 mg; crushed	Wrong form	
		Metoprolol ER 50 mg	Metoprolol ER 50 mg; crushed	Wrong form	
6/23/10	B	Ibuprofen 400 mg	None	Omission	
9 AM					
6/24/10	145 fc	Metoprolol ER 50 mg	Metoprolol ER 50 mg; crushed	Wrong form	
9 AM					
6/24/10	145 fc	Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.15 PM	Wrong time	
5 PM		Metronidazole 250 mg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Klor Con M10	None	Omission	
6/25/10	100 fc	Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
6/25/10	B	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.45 PM	Wrong time	
5 PM		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.55 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 4.59 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.11 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 5.17 PM	Wrong time	
		Meclizine 12.5 mg; due at 7PM	Meclizine 12.5 mg; given at 5.20 PM	Wrong time	
6/28/10	B	Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.01 PM	Wrong time	
5PM		Doxepin 10 mg	None	Omission	
		Hydroxyzine 25 mg	None	Omission	
		Senna S; due at 9 PM	Senna S; given at 4.57 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 5.17 PM	Wrong time	
		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 5.21 PM	Wrong time	
6/28/10	B	Mirtazapine 15 mg		Wrong dose	LPN crushes the pills and drops the med-cup. More than half of the contents spill on the cart

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
5PM		Senna S		Wrong dose	
		Xanax 2.5 mg		Wrong dose	
		Aricept 5 mg		Wrong dose	
		Carbi-Levo 25/100		Wrong dose	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.50 PM	Wrong time	
6/30/10	145 fc	Senna Plus	None	Omission	
5 PM		Tylenol 325 mg	None	Omission	Resident asks for it; LPN ignores.
		Colace 100 mg	None	Omission	
		Mirtazapine 30 mg	None	Omission	
		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.15 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 5.30 PM	Wrong time	
7/1/10	100 fc	Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.27 PM	Wrong time	
5 PM		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.31 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.45 PM	Wrong time	
		Xanax 0.5 mg; due at 9 PM	Xanax 0.5 mg; at 4.51 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/6/10	145 fc	Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.17 PM	Wrong time	
5 PM		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.31 PM	Wrong time	
		Starlix 120 mg	None	Omission	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.47 PM	Wrong time	LPN comments ' I forgot you were here'
7/7/10	145 fc	Sensipar 30 mg	None	Omission	
5 PM		Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.27 PM	Wrong time	
		Sod- citrate + Citric acid solution 30 ml	Sod- citrate + Citric acid solution 25 ml	Wrong dose	
		Colace 100 mg	None	Omission	
		Carbi-Levo 25/100	None	Omission	
7/9/10	B	Meclizine 12.5 mg; due at 7 PM	Meclizine 12.5 mg; given at 4.11 PM	Wrong time	
5 PM		Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.25 PM	Wrong time	
		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.47 PM	Wrong time	
		Xanax 0.5 mg; due at 9 PM	Xanax 0.5 mg; given at 4.50 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 4.55 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 5.10 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Vytorin 10-40 mg; due at 9 PM	Vytorin 10-40 mg; given at 5.15 PM	Wrong time	
7/15/10	145 fc	Seroquel 100 mg; due at 9 PM	Seroquel 100 mg; given at 4.10 PM	Wrong time	LPN moves med cart to new spots, as CNAs kept distracting.
5 PM		Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.27 PM	Wrong time	
		Xanax 0.5 mg; due at 9 PM	Xanax 0.5 mg; given at 4.30 PM	Wrong time	
7/16/10	100 fc	Aricept 10 mg; due at 9 PM	Aricept 10 mg; given at 4.17 PM	Wrong time	
5 PM		Xanax 0.5 mg; due at 9 PM	Xanax 0.5 mg; given at 4.24 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.27 PM	Wrong time	
		Senna S; due at 9 PM	Senna S; given at 4.54 PM	Wrong time	
		Ibuprofen 400 mg	None	Omission	
		Metformin HCl 500 mg	None	Omission	
		Colace 100 mg	None	Omission	
7/19/10	100 fc	Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 4.45 PM	Wrong time	
5 PM		Famotidine 40 mg	None	Omission	
		Senna Plus	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Senna Plus	None	Omission	
		Aspirin EC 81 mg	Aspirin EC 81 mg; crushed	Wrong form	
7/30/10	145 fc	Ferrous Sulphate 325 mg; due at 9 PM	Ferrous Sulphate 325 mg; given at 5.10 PM	Wrong time	
5 PM		Metoprolol 50 mg	None	Omission	
		Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 5.15 PM	Wrong time	
		Aricept 10 mg;due at 9 PM	Aricept 10 mg; given at 5.20 PM	Wrong time	
8/2/10	145 fc	Xanax 0.25 mg; due at 9 PM	Xanax 0.25 mg; given at 4.17 PM	Wrong time	
5 PM		Aricept 10 mg;due at 9 PM	Aricept 10 mg; given at 4.23 PM	Wrong time	
		Ferrous Sulphate 325 mg; due at 9 PM	Ferrous Sulphate 325 mg; given at 5.10 PM	Wrong time	

Table 3I: Medication Preparation Error Types and Frequencies for Section Y

Date	Nurse code	Ill. Level	Med pass time	Total meds	Errors	TOE	Error rate	Error rate exclud wrong time errors
7/22/10	4D	100	5:00 PM	78	10	81	12.3	3.7
7/23/10	4D	B	5:00 PM	75	7	75	9.33	8
7/26/10	4D	B	5:00 PM	75	8	80	10	7.5
6/28/10	7G	145	9:00 AM	76	5	79	6.33	6.33
7/9/10	7G	B	9:00 AM	79	14	92	15.2	15.2
8/9/10	7G	145	5:00 PM	87	5	89	5.61	4.49
6/29/10	6F	B	9:00 AM	81	4	83	4.81	4.81
6/30/10	6F	100	9:00 AM	84	10	94	10.64	10.64
7/6/10	6F	100	9:00 AM	87	3	89	3.37	3.37
7/7/10	6F	145	9:00 AM	92	5	95	5.26	4.21
7/13/10	6F	145	9:00 AM	90	2	92	2.17	2.17
7/20/10	6F	B	9:00 AM	85	4	87	4.59	4.59
7/21/10	6F	100	9:00 AM	74	3	75	4	2.66
7/23/10	6F	100	9:00 AM	82	1	82	1.22	0
7/27/10	6F	B	9:00 AM	82	4	84	4.76	4.76
7/28/10	6F	145	9:00 AM	90	3	90	3.33	2.22
7/29/10	6F	B	9:00 AM	93	5	94	5.32	4.25
7/30/10	6F	145	9:00 AM	85	2	85	2.35	2.35
6/9/10	3C	B	5:00 PM	69	7	70	10	4.29
6/14/10	3C	100	5:00 PM	73	5	75	6.66	4

Date	Nurse code	Ill. Level	Med pass time	Total meds	Errors	TOE	Error rate	Error rate exclud wrong time errors
6/15/10	3C	100	5:00 PM	81	7	85	8.23	5.88
6/16/10	3C	100	5:00 PM	76	6	78	7.69	3.85
6/17/10	3C	145	5:00 PM	75	5	75	6.66	1.33
6/23/10	3C	145	5:00 PM	75	5	76	6.58	3.95
6/29/10	3C	B	5:00 PM	70	9	74	12.16	6.76
7/5/10	3C	B	5:00 PM	79	6	79	7.59	2.53
7/8/10	3C	145	5:00 PM	73	4	75	5.33	4
TOTAL				**2166**	**149**	**2233**	**6.672**	**4.57**

Table 4I : Description of Medication Preparation Errors for Section Y

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
6/9/10	Baseline	Sertraline 50 mg; due at 9 PM	Sertraline 50 mg; given at 4.15 PM	Wrong time	
5 PM		Renagel 800 mg; # 4 pills	Renagel 800 mg; #2 pills	Wrong dose	
		Furosemide 40 mg	None	Omission	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.45 PM	Wrong time	
		Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 4.47 PM	Wrong time	
		Simvastatin 10 mg; due at 9 PM	Simvastatin 10 mg; given at 5.02 PM	Wrong time	
		Detrol LA 4 mg	Detrol LA 4 mg; crushed	Wrong form	
6/14/10	100 fc	Hydralazine 25 mg	None	Omission	
5 PM		Xanax 0.25 mg	None	Omission	
		Detrol LA 4 mg	Detrol LA 4mg crushed	Wrong form	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 5.30 PM	Wrong time	
		Ferrous Gluconate 324 mg; due at 9 PM	Ferrous Gluconate 324 mg; given at 5.47 PM	Wrong time	
6/15/10	100 fc	Senna Plus	None	Omission	
5 PM		Senna Plus	None	Omission	
		Megestrol Acetate 40 mg/ml	None	Omission	
		Ferrous Gluconate 324 mg; due at 7PM	Ferrous Gluconate 324 mg; given at 4.50 PM	Wrong time	
		Klor Con M10	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
6/15/10	100 fc	Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 5.40 PM	Wrong time	
5 PM					
6/16/10	100 fc	Senna Plus	None	Omission	
5 PM		Detrol LA 4 mg	Detrol LA 4mg curshes	Wrong form	
		Aspirin 325 mg	None	Omission	
		Ferrous Gluconate 324 mg; due at 7PM	Ferrous Gluconate 324 mg; given at 4.30 PM	Wrong time	
		Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 5.10 PM	Wrong time	
		Simvastatin 20 mg; due at 9PM	Simvastatin 20 mg; gien at 5.35 PM	Wrong time	
6/17/10	145 fc	Ferrous Gluconate 324 mg; due at 7PM	Ferrous Gluconate 324 mg; given at 4.10 PM	Wrong time	
5 PM		Simvastatin 20 mg; due at 9PM	Simvastatin 20 mg; gien at 4.25 PM	Wrong time	
		Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 5.17 PM	Wrong time	
		Detrol LA 4 mg	Detrol LA 4mg curshes	Wrong form	
		Simvastatin 10 mg; due at 9PM	Simvastatin 10 mg; gien at 5.48 PM	Wrong time	
6/23/10	145 fc	Miralax Powder	None	Omission	
5 PM		Colace solution 10 ML	Colace solution 5 ML	Wrong dose	
		Simvastatin 20 mg; due at 9PM	Simvastatin 20 mg; at 5.11	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 5.21 PM	Wrong time	
		Detrol LA 4 mg	Detrol LA 4mg curshes	Wrong form	
6/28/10	145 fc	Aspirin 81 mg, EC	Aspirin 81 mg EC, crushes	Wrong form	
9 AM		Senna solution 15 ML	Senna solution around 5 ML	Wrong dose	LPN does not accurately measure the solution.
		Carvedilol 6.25 MG	None	Omission	LPN takes pill; but puts it in trash
		Calcitrol 25 MG	None	Omission	
		Miralax Powder	None	Omission	
6/29/10	B	Omeprazole DR 20 mg	Omeprazole DR 20 mg; crushes	Wrong form	
9AM		Metoprolol Succinate ER 50 mg	Metoprolol Succinate ER 50 mg; crushes	Wrong form	
		Megestrol Acetate solution 10 ml	None	Omission	LPN says not on cart; will give it later. Did not given until observer present at site.
		Lorazepam 0.5 mg	None	Omission	
6/29/10	B	Klor Con M10	None	Omission	2 residents hospitalized; 1 resident passed away; LPN expressed concern.
5PM		Sertraline 50 mg; due at 9PM	Sertraline 50 mg; given at 4.37 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Renagel 800 mg; # 4	Renagel 800 mg; # 3 given	Wrong dose	LPN commented 'I could use a light here!'
		Furosemide 40 mg	None	Omission	
		Amoxycillin 500 mg	None	Omission	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 5.15 PM	Wrong time	
6/29/10	B	Calcium 600 mg+ Vit D; due at 7 PM	Calcium 600 mg+ Vit D; given at 5.27 PM	Wrong time	
5 PM		Megestrol Acetate 10 ml	None	Omission	
		Simvastatin 10 mg; due at 9 PM	Simvastatin 10 mg; given at 5.30 PM	Wrong time	Stopped med-pass at 5.30 PM to feed residents. Asked observer to leave.
6/30/10	100 fc	Carvedilol 6.25 mg	None	Omission	Interruptions by family members of a resident. LPN commented 'I like that light'. One LPN to another 'Do you like to keep that light?' Study LPN 'I don't know; but I like that light.' Fire alarm drill from 9.03 am to 9.06 am; LPN works throughalarm.

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
9 AM		Senna S	None	Omission	Resident refused the following 9 medications; so LPN trashes all the meds.
		Digoxin 125 mcg	None	Omission	
		Lisinopril 2.5 mg	None	Omission	
		Klor Con M10	None	Omission	
6/30/10		Glyburide Metformin 2.5mg/ 5mg	None	Omission	
9 AM		Furosemide 40 mg	None	Omission	
		Paroxetine 20 mg	None	Omission	
		Megestrol Acetate 10 ml	None	Omission	
		Lorazepam 0.5 mg	None	Omission	
7/5/10	B	Detrol LA 4mg	Detrol LA 4mg; crushes	Wrong form	
5 PM		Ferrous Gluconate 324 mg; due at 7 PM	Ferrous Gluconate 324 mg; given at 4.15 PM	Wrong time	
		Calcium 600 mg + Vit D; due at 7 PM	Calcium 600 mg + Vit D; given at 4.23 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 4.47 PM	Wrong time	
		Sertraline 50 mg; due at 9 PM	Sertraline 50 mg; given at 5.25 PM	Wrong time	
		Senna solution 10 ml	Senna solution; measured around 5 ml	Wrong dose	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/6/10	100 fc	Aspirin 325 mg	None	Omission	
9 AM		Miralax Powder	None	Omission	
		Colace solution 10 ml	Colace solution; around 5 ml	Wrong dose	
7/7/10	145 fc	Carvedilol 6.25 mg	None	Omission	LPN commented that she did not sleep the whole night.
9AM		Torsemide 20 mg	None	Omission	
		Colace 100 mg	None	Omission	
		Aspirin EC 81 mg	Aspirin EC 81 mg crushes	Wrong form	
		Calcium 600 mg + Vit D; due at 7 AM	Calcium 600 mg + Vit D; given at 9.25 AM	Wrong time	
7/8/10	145 fc	Namenda 10 mg	None	Omission	
5 PM		Detrol LA 4 mg	Detrol LA 4mg; crushes	Wrong form	
		Ferrous Gluconate 324 mg; due at 7 PM	Ferrous Gluconate 324 mg; given at 5.10 PM	Wrong time	
		Klor Con M10	None	Omission	LPN got distracted watching TV
7/9/10	B	Metformin 1000 mg	None	Omission	
9 AM		Senna solution 15 ml	None	Omission	LPN on seeing observer enter site ‘ oh, she is again on my face!’ But did not stop observer from observation.

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Colace solution 10 ml	None	Omission	
		KCL 10 MEQ	None	Omission	
		Colace 100 mg	None	Omission	
		Zyrtec 10 mg	None	Omission	
		Protonix 40 mg; due at 7 AM	Protonix 40 mg; given at 9.45 AM	Omission	
		Torsemide 20 mg	None	Omission	
		Ranitidine 150 mg	None	Omission	
		Senna S	none	Omission	
		Senna S	None	Omission	
		Carvedilol 6.25 mg	None	Omission	
		Calcitrol 0.25 mg	None	Omission	
7/13/10	145 fc	Torsemide 20 mg	None	Omission	
9AM		Amitiza 24 mcg	None	Omission	
7/20/10	B	Omeprazole DR 20 mg	Omeprazole DR 20 mg; crushes	Wrong form	
9AM		Metoprolol Succinate ER 50 mg	Metoprolol Succinate ER 50 mg; crushes	Wrong form	
		Aspirin 325 mg	None	Omission	
		Torsemide 20 mg	None	Omission	
7/21/10	100 fc	Aspirin EC 81 mg	Aspirin EC 81 mg; crushes	Wrong form	
9AM		Calcium 600 mg + Vit D; due at 7 AM	Calcium 600 mg + Vit D; given at 9.23	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Namenda 10 mg	None	Omission	
7/22/10	100 fc	Colace 100 mg	None	Omission	
5PM		Warfarin sodium 2 mg	None	Omission	
		Ferrous Gluconate 324 mg; due at 7 PM	Ferrous Gluconate 324 mg; given at 5.07 PM	Wrong time	
		Klor Con M10	None	Omission	
		Diazepam 5 mg; due at 7 PM	Diazepam 5mg; given at 5.19 PM	Wrong time	
		Simvastatin 40 mg; due at 9 PM	Simvastatin 40 mg; given at 5.23 PM	Wrong time	
		Haldol 2 mg; due at 9PM	Haldol 2 mg; given at 5.26 PM	Wrong time	
		Simvastatin 20 mg; due at 9 PM	Simvastatin 20 mg; given at 5.31 PM	Wrong time	
		Calcium 600 mg+Vit D; due at 7 PM	Calcium 600 mg +Vit D; given at 5.33PM	Wrong time	
		Clonazepam 0.5 mg; due at 9 PM	Clonazepam 0.5 mg; given at 5.35 PM	Wrong time	
7/23/10 9AM	100 fc	Calcium 600 mg+ Vit D; due at 7 AM	Calcium 600 mg+ Vit D; given at 10.25 Am	Wrong time	LPN stopped med-pass at 9.30 am, as one of the resident's blood sugar level elevated. Resumed med-pass , but remained concerned and distracted for rest of med-pass

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/23/10	B	Renagel 800 mg # 4	Renagel 800 mg #2	Wrong dose	
5 PM		Simvastatin 10 mg; due at 9 PM	Simvastatin 10 mg; given at 4.30 PM	Wrong time	
		Simvastatin 40 mg; due at 9 PM	Simvastatin 40 mg; given at 4.47 PM	Wrong time	
		Ferrous Gluconate 324 mg; due at 7 PM	Ferrous Gluconate 324 mg; given at 5.11 PM	Wrong time	
		Haldol 2 mg; due at 9PM	Haldol 2mg; given at 5.17 PM	Wrong time	
		Diazepam 5 mg; due at 9PM	Diazepam 5 mg; given at 5.27 PM	Wrong time	
7/26/10	B	Simvastatin 40 mg; due at 9 PM	Simvastatin 40 mg; given at 4.30 PM	Wrong time	
5 PM		Colace 100 mg	None	Omission	
		Senna Plus	None	Omission	
		Senna Plus	None	Omission	
		Diazepam 5 mg; due at 9 PM	Diazepam 5 mg; given at 4.47 PM	Wrong time	
		Carvedilol 6.25 mg	None	Omission	
		Warfarin Sodium 2.5mg	None	Omission	
		Detrol LA 4 mg	Detrol LA 4mg; crushes	Wrong form	
7/27/10	B	Omeprazole DR 20 mg	Omeprazole DR 20 mg; crushes	Wrong form	
9 AM		Detrol LA 4 mg	Detrol LA 4 mg; crushes	Wrong form	
		Amitiza 24 mcg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Calcium 600 mg + Vit D	None	Omission	
7/28/10	145 fc	Calcium 600 mg +Vit D; due at 7 AM	Calcium 600 mg+ Vit D; given at 9.10 AM	Wrong time	
9 AM		Detrol LA 4 mg	Detrol LA 4 mg; crushes	Wrong form	
		Aspirin EC 81 mg	Aspirin EC 81 mg crushes	Wrong form	
7/29/10	B	Calcium 600 mg+Vit D; due at 7 AM	Calcium 600 mg +Vit D; given at 9.17 AM	Wrong time	
9 AM		Lortab 7.5/500 mg	None	Omission	LPN drops pill, but does not replace it.
		Detrol LA 4 mg	Detrol LA 4 mg crushes	Wrong form	
		KCL 10 MEQ	KCL 10 MEQ crushes	Wrong form	LPN observed dropping pills at 3 different instances.
		KCL 10 MEQ	KCL 10 MEQ crushes	Wrong form	
7/30/10	145 fc	Detrol LA 4 mg	Detrol LA 4 mg crushes	Wrong form	
9 AM		Klor Con M10	Klor Con M10 crushes	Wrong form	Rx stated 'do not crush'
8/9/10	145 fc	Detrol LA 4mg	Detrol LA 4mg crushes	Wrong form	
5 PM		Colace solution 10 ml	Colace solution; around 5 ml	Wrong dose	
		Miralax powder	None	Omission	
		Verapamil 80 mg	None	Omission	
		Trazodone 50 mg; due at 9 PM	Trazodone 50 mg; given at 5.10 PM	Wrong time	

Table 5I : Medication Preparation Error Types and Frequencies for Section Z

Date	Nurse code	Ill. Level	Errors	Unauth. Dose	Wrong dose	Omission	Wrong Form	Wrong Time
7/13/10	4D	100	9			1		8
7/14/10	4D	100	14			4		10
7/20/10	4D	145	5					5
7/21/10	4D	100	7					7
7/2/10	7G	100	4			3	1	
7/26/10	7G	B	8			8		
8/6/10	7G	B	8			6	2	
7/1/10	1A	B	4			1	3	
7/2/10	1A	100	2				2	
7/5/10	1A	100	3				3	
7/8/10	1A	100	4			3	1	
7/14/10	1A	145	1			1		
7/15/10	1A	145	2			2		
7/16/10	1A	145	1				1	
7/19/10	1A	145	0					
7/22/10	1A	B	2				2	
8/2/10	1A	B	4			2	2	
8/3/10	1A	100	1			1		
8/9/10	1A	B	4			1	3	
TOTAL			**83**	**0**	**0**	**33**	**20**	**30**

Table 6I: Description of Medication Preparation Errors for Section Z

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/1/2010	B	Colace 100 mg	None	Omission	LPN said she was behind schedule; so was rushing her med-pass. Wanted to finish before 10 AM
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg crushes	Wrong form	LPN said for some reason I keep losing the Aspirin tablet.
		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	
		KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
7/2/10	100 fc	Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
9 AM		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	Order states' do not crush'
7/2/10	100 fc	Erythromycin ER 250 mg	None	Omission	
5PM		Colace 100 mg	None	Omission	
		Senna Plus	None	Omission	
		KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
7/5/10	100 fc	KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
9 AM		Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	do not crush'

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/8/10	100 fc	KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
9 AM		Colace 100 mg	None	Omission	
		Vitamin D	None	Omission	
		Therapeutic Tablet	None	Omission	
7/13/10	100 fc	Senna tablet; due at 9 PM	Senna tablet; given at 4.08 PM	Wrong time	LPN: Are you going to tell them to give us this light? I really like the light. We move a lot, so I like this extra light.
5 PM		Senna tablet; due at 9 PM	Senna tablet; given at 4.09 PM	Wrong time	
		Hydralazine 50 mg; due at 9 PM	Hydralazine 50 mg; given at 4.20 PM	Wrong time	
		Mirtazapine 30 mg; due at 9 PM	Mirtazapine 30 mg; given at 5.11 PM	Wrong time	
		Seroquel 25 mg; due at 9 PM	Seroquel 25 mg; given at 5.15 PM	Wrong time	
		Niacin SR 250 mg; due at 9 PM	Niacin SR 250 mg; given at 5.30 PM	Wrong time	
		Vytorin 10/20; due at 9 PM	Vytorin 10/20; given at 5.47 PM	Wrong time	
		Erythromycin film coated 250 mg	None	Omission	
		Simvastatin 40 mg; due at 7 PM	Simvastatin 40 mg; given at 5.53 PM	Wrong time	
7/14/10	145 fc	Erythromycin film coated 250 mg	None	Omission	
9 AM					

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
7/14/10	100 fc	Hydralazine 50 mg; due at 9 PM	Hydralazine 50 mg; given at 4.25 PM	Wrong time	
5 PM		Senna tablet; due at 9 PM	Senna tablet; given at 4.39 PM	Wrong time	
		Colace; due at 9 PM	Colace; given at 5.09 PM	Wrong time	
		Simvastatin 40 mg; due at 7 PM	Simvastatin 40 mg; given at 5.20 PM	Wrong time	
		Diltiazem 240 mg	None	Omission	
		Lisinopril 20 mg	None	Omission	
		Lisinopril 20 mg	None	Omission	
		Therapeutic tablet	None	Omission	
		Simvastatin 40 mg; due at 9 PM	Simvastatin 40 mg; given at 5.27 PM	Wrong time	
		Vytorin 10/20; due at 9 PM	Vytorin 10/20; given at 5.31 PM	Wrong time	
		Niacin SR 250 mg; due at 9 PM	Niacin SR 250 mg; given at 5.37 PM	Wrong time	
		Aspirin EC 81 mg due 30 mins before Niacin (8.30 PM)	Aspirin EC 81 mg ; given at 5.40 PM	Wrong time	
		KCL 10 MEQ; due at 9 PM	KCL 10 MEQ; given at 5.41 PM	Wrong time	
		Mirtazapine 30 mg; due at 9 PM	Mirtazapine 30 mg; given at 5.45 PM	Wrong time	
7/15/10	145 fc	Erythromycin film coated 250 mg	None	Omission	
9AM		KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
7/16/10	145 fc	Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
9 AM					
7/20/10	145 fc	Aspirin EC 81 mg due 30 mins before Niacin (8.30 PM)	Aspirin EC 81 mg ; given at 4.10 PM	Wrong time	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
5 PM		Colace; due at 9 PM	Colace; given at 4.19 PM	Wrong time	
		Lipitor 80 mg; due at 9 PM	Lipitor 80 mg; given at 4.21 PM		
		Seroquel 25 mg; due at 9 PM	Seroquel 25 mg; given at 4.35 PM	Wrong time	
		Mirtazapine 30 mg; due at 9 PM	Mirtazapine 30 mg; given at 4.45 PM	Wrong time	
7/21/10	100 fc	Colace; due at 9 PM	Colace; given at 4.09 PM	Wrong time	
5 PM		Aspirin EC 81 mg due 30 mins before Niacin (8.30 PM)	Aspirin EC 81 mg ; given at 4.13 PM	Wrong time	
		Niacin SR 250 mg; due at 9 PM	Niacin SR 250 mg; given at 4.27 PM	Wrong time	LPN: This light is really good. You should patent it. I will ask the administrator to get a light like this for me. I cant see otherwise.
		Seroquel 25 mg; due at 9 PM	Seroquel 25 mg; given at 4.35 PM	Wrong time	
		Hydralazine 50 mg; due at 9 PM	Hydralazine 50 mg; given at 4.39 PM	Wrong time	
		Simvastatin 40 mg; due at 9 PM	Simvastatin 40 mg; given at 5.07 PM	Wrong time	
		KCL 10 MEQ; due at 9 PM	KCL 10 MEQ; given at 5.11 PM	Wrong time	
7/22/10	B	Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
9 AM		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	Order states' do not crush'
7/26/10	B	Vitamins	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
9 AM		Dulcolax 5 mg	None	Omission	
		Miralax Powder; 1 capful	None	Omission	
		Loratadine 10 mg	None	Omission	
		Nexium 40 mg	None	Omission	
		Zyrtec 10 mg	None	Omission	
		Colace 100 mg	None	Omission	
		Saltropine 0.4 mg	None	Omission	
8/2/10	B	Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
9 AM		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	Order states' do not crush'
		Dulcolax 5 mg	None	Omission	
		Erythromycin film coated 250 mg	None	Omission	
8/3/10	100 fc	Erythromycin film coated 250 mg	None	Omission	
9 AM					
8/6/10	B	KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
9 AM		Erythromycin film coated 250 mg	None	Omission	
		Nifedipine ER 30 mg	None	Omission	
		Ferrous Sulphate 325 mg	None	Omission	
		Paroxetine HCL 10 mg	None	Omission	
		Metorpolol Succinate ER 50 mg	None	Omission	

Date	Illumination level	Prescribed Drug	Prepared Drug	Error Type	Notes
		Aspirin EC 81 mg	None	Omission	
		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	Order states' do not crush'
8/9/10	B	KCL 10 MEQ	KCL 10 MEQ; crushed	Wrong form	Order states' do not crush'
9 AM		Erythromycin film coated 250 mg	None	Omission	
		Aspirin EC 81 mg	Aspirin EC 81 mg crushed	Wrong form	
		Oxybutynin ER 10mg	Oxybutynin ER 10mg crushed	Wrong form	Order states' do not crush'