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Measuring the effectiveness of terminal cleaning by housekeepers at the Foothills Medical Center

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Measuring the effectiveness of terminal cleaning by housekeepers at the Foothills Medical Center

by

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Abstract

The primary objective of this study was to quantify and map the biological contamination within private hospital rooms at Foothills Medical Center in Calgary Alberta. Secondary objectives were to assess the ability of two common cleaning products to remove biological contamination from surfaces as well as compare two methods of measuring housekeeping efficacy (UV gel and microbiological sampling techniques).

Researchers covertly observed 9 housekeepers terminally clean 31 private rooms. Assessment took place using microbial swabbing and UV gel technology to evaluate cleanliness. Results suggest that the type of cleaning product does not make an impact, and that cleaning technique may be of higher importance. Lastly, the use of UV gel is may not be a suitable substitute for measuring a reduction of microbial contamination.

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Chapter One: Introduction

1.1 Introduction

Infections acquired while admitted to a hospital, commonly referred to as hospital acquired infections (HAIs) result in the death of approximately 8 000 Canadians each year (89). In the United States, the estimated number deaths per year due to HAIs is 98 987 (52). Although both of these figures are considered the most up to date and are frequently cited, they both rely on data that is at least a decade old. In particular, the Zoutman estimate of 8 000 HAI deaths per year used figures from a paper published in the American Journal of Epidemiology in 1985 (41) – which at the time was 18 years old. This paper by Haley *et al.,* (41) found a rate of 5.7 HAIs per 100 admissions. The rate of 5.7 HAIs per 100 admissions used by Zoutman may be a significant underestimate of the true burden of HAIs in Canada. A 2002 point prevalence study by the Canadian Nosocomial Infection Surveillance Program (CNISP) found that 10.5% of patients were currently suffering from at least one type of HAI (39). Therefore one could infer that the 8 000 deaths per year provided by Zoutman (89) may be an underestimate. It is clear that HAIs are a significant problem for Canadians.

Administrators for hospitals and other health care sites adopt various measures to help eliminate hospital acquired infections including hand hygiene promotion, environmental cleaning using disinfectants, sterilization of equipment, antimicrobial stewardship, to name a few. This study focuses on how environmental cleaning of hospital rooms affects the microbial burden on surfaces in rooms after a patient has been discharged or transferred.

1.2 Purpose and Objectives

The primary purpose of this study was to examine environmental cleaning and ways to improve terminal cleaning of patient rooms at Foothills Medical Centre (FMC), a large teaching hospital in Calgary, Alberta. The primary objective was to determine if short, one on one educational sessions, including visual aids documenting personal cleaning results, with housekeepers could improve their efficacy at removing microorganisms from the environment. The second primary objective was to evaluate whether two techniques often used to measure cleanliness of hospital surfaces are interchangeable. These two techniques are UV light analysis and microbial swabbing. Secondary objectives were to;

- determine the pre-cleaning burden and spatial pattern of microorganisms within a patients room,
- evaluate the effectiveness of two hospital approved disinfectants,
- investigate the ability of housekeepers to clean surfaces measured by the two techniques, microbial swabbing and UV light analysis,

Chapter Two: Background

2.1 Introduction

Various types of HAIs will be covered including a discussion on the rates found here in Canada and also specifically with the province of Alberta. The section will cover specific microorganisms that cause HAIs as well as general types of infections affecting patients.

This chapter will then focus on the background knowledge of housekeeping within the healthcare system. Housekeeping is a broad topic and various methodologies will be covered. This will include a discussion of the various technologies that have emerged, or in some cases re-emerged in light of increasing rates of HAIs. It is important to discuss the various cleaning products that are used by hospitals and health care systems and evaluate the advantages and disadvantages of the most common products.

Of particular concern is the contamination of the hospital environment with some microorganisms that can also cause HAIs in susceptible patients. Data will be presented on past findings by researchers examining the presence of bacteria, viruses and other various microorganisms on the surfaces of items with in the hospital.

Lastly, past attempts at improving the efficacy of housekeepers within hospitals will be discussed.

2.2 Hospital Acquired Infections

Many different types of bacteria, viruses and fungi can cause infections in patients. There are common causes such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE) and *Clostridium difficile*. There are also many uncommon sources of infection as well. The following is a list of some of the more common causes of HAIs.

2.2.1 Vancomycin-Resistant Entercocci

The Canadian Nosocomial Infection Surveillance Program (CNISP) began in 1994, with the objective of determining Canada wide rates of hospital-acquired infections. The program relies on the work by sentinel hospitals across Canada. These sentinel hospitals provide the data CNISP uses to produce baseline rates of hospital acquired infections.

An early publication by the CNISP group reported rates of VRE in Canadian hospitals. In high risk patients, mainly patients in intensive care units, they found a 0.1% colonization rate. However, this number was based on 2 positive cultures from 26 hospitals across Canada. The authors separately reported the rate of VRE colonization in an endemic hospital, which they defined as a hospital experiencing a VRE outbreak within the previous year. Endemic VRE hospitals contributed 23 of the 26 total positive VRE isolates. The CNISP authors reported an endemic hospital VRE colonization rate of 3.7% (68). The CNISP group next reported on the status of VRE in Canada in 2001.

Using a passive reporting network from 650 health care facilities in Canada, the authors found that 53% of these facilities reported the presence of VRE. Between 1994 and 1998, the authors received reports of 1315 cases of VRE, with an infection rate of 4.6 per 100 admissions. They did not collect the appropriate data to enable a calculation of a rate of colonization/infection and therefore cannot be compared to the previous study. The authors reported that 43.6% of participating facilities cultured the environmental or equipment in search of a VRE reservoir. Of these facilities, 28% reported finding a positive culture of VRE within the environment (21). The final paper by the CNISP group that examines VRE rates in Canada was published in 2008. This paper summarized the data collected from the sentinel hospitals between 1999 and 2005. The colonization rate of VRE increased from 0.37 per 1000 patients admitted in 1999 to 1.32 in 2005. Over the same time period, the infection rate per 1000 patients admitted increased from 0.02 to 0.05. The authors concluded that the VRE carriage rate was still low in Canadian hospitals as compared to our American counterparts (66). In a non-CNISP report published in 1999, the authors concluded that high risk patients were rarely colonized with VRE at a rate of 0.75%, however this data is now greater than 10 years old. The authors did stress the importance of VRE's ability to survive in the environment and how this can enable easier transmission (50). The most up to date information on VRE rates in Canadian hospitals comes from an online CNISP report. This report generally echo's what is seen in the previous papers that is that VRE infection rates remain low. However, the VRE colonization rates have seen an increase from 1999 to

2005, with a slight dip in rates in 2006 (15). The Canadian Nosocomial Infection Surveillance Program must continue to track VRE rates to ensure the recent rise in colonization does not translate into increased VRE infections. Hospitals should continue to put in place precautions that will help to minimize the threat VRE places on the health care system.

2.2.2 Methicillin-Resistant Staphylococcus aureus (MRSA)

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been on the CNISP surveillance list for over 15 years. The latest report, which summarizes the data from 1995 to 2003, was published in 2005 in the Canada Communicable Disease Report (80). The report puts the MRSA rate at 5.1 infections per 1000 patient admissions in 2003. This has increased from 0.46 infections per 1000 admissions when the program first started collecting data in 1995. Seventy-two percent of infections are believed to be hospital acquired, and the rate of nosocomially acquired MRSA has raised from 0.91 to 3.83 per 1000 patient admissions. The authors note that much of the rise in MRSA detection rate may be due to increased screening in hospitals. The proportion of *S. aureus* isolates that are considered methicillin-resistant has also risen. In 1995, 1.2% of the *S. aureus* were considered methicillin-resistant (78), which increased to 5.97% in 1999 (79).

The Canadian Nosocomial Infection Surveillance Program has published two papers on MRSA in subsets of the Canadian population; the elderly and aboriginals. Elderly patients represent a large proportion of MRSA cases in Canadian hospitals. Between 1995 and 2002, CNISP identified 6613 patients with MRSA over the age of 65, which represented 66% of all MRSA cases (81). Elderly patients represent a particularly vulnerable population at risk for MRSA infection.

Aboriginal or native patients represent a population with a unique epidemiology in respect to MRSA colonization and infection. Unlike the large CNISP dataset where 66% of MRSA cases were over 65, aboriginal MRSA cases were more likely to be under the age of 18. Compared to non aboriginal patients, aboriginal patients were more likely to be infected with MRSA. Aboriginal or native patients represented 2.2% of the MRSA cases identified by CNISP between 1995 and 2002 (67).

2.2.3 Clostridium difficile

An early attempt to determine a baseline rate of *Clostridium difficile* infections in Canada was done by 3 researchers in Manitoba. They sent out a survey to 380 hospitals in Canada and received a response rate of approximately 63%. They calculated a *C. difficile* incidence rate of between 23.5 and 40.3 cases per 100 000 patient days, depending on the size of the hospital (3).

The first study by CNISP on *Clostridium difficile* associated-diarrhea (CDAD) occurred over a period of six weeks in 1997. Diarrheal stools from inpatients of 19 Canadian hospitals were tested for the presence of CDAD toxin production. The authors found an overall prevalence of 13.0% and an incidence rate of 66.3 CDAD cases per 100 000 patient days or 5.9 CDAD cases per 1000 patient admissions (49). Using the same data, the authors concluded that 1.5% of the participants died either directly or indirectly as a result of their nosocomially acquired CDAD infection. The cost of CDAD readmission alone was estimated to be $128 000 per facility per year (62).

More recently, CNISP has completed surveillance on *C. difficile* from November 2004 to April 2005. A 2007 report on the general rate of CDAD (both nosocomial and community acquired) revealed a prevalence of 4.5 CDAD cases per 1000 patient admissions. The province of Quebec is somewhat of a CDAD "hotspot" in that their prevalence rate is 11.1 vs. 3.9 per 1000 patient admission for the rest of Canada (36). In 2009, a health care-associated specific report was published using the data from the 2004-2005 CNISP data. A similar prevalence rate was reported, and an incidence rate of 65 health care associated *C. difficile* infections (HA-CDI) per 100 000 patient days was found. The mortality rate attributable to HA-CDIs was 5.7% (38).

2.2.4 Bloodstream Infections (Bacteremia)

In 1997, the SENTRY Antimicrobial Surveillance Program was developed and implemented in Canada, the United States, Latin America and Europe. One of their first reports focused on bloodstream infections due to Gram-negative bacilli. However, the objective of this research was not to determine rates of bloodstream infections (BSI), rather it was to determine the particular pathogen pattern responsible for infections in patients. This data can be used to gain a sense of how many BSI's were occurring in Canadian hospitals during 1997. Participating hospitals submitted 1727 isolates that caused a BSI in a patient. However, it is important to note that this is not the total number of BSI's in those Canadian hospitals, as each hospital was only required to submit their first 20 isolates obtained from a patient suffering from a BSI. This relates back to the papers objectives where the authors were only interested in determining which pathogens were causing BSI's, not the rate of BSI's in participating hospitals. The authors did indicate that 24.1% of their total number of isolates from United States, Canada and Latin America were nosocomial in origin, and 35.9% were unknown (29).

A report by the Canadian Neonatal Network focused on bacteremia infections in infants in neonatal intensive care units (NICU) across Canada. From January 1996 to October 1997 the authors collected data from 17 NICU's. Of the neonates that visited 1 of the 17 participating NICU's, HAI's were identified in 765 (23.5%) of the 3253 NICU infants weighing less than 1500 grams, and 328 (2.5%) of the 13228 infants weighing more than 1500 grams. Greater than 95% of the infections were due to nosocomial

bacteremia (5). The Canadian Neonatal Network also published data regarding nosocomial bloodstream infections related to central venous catheter use in infants. Based on 19 507 infants in Canadian NICUs, they found that these patients experienced a baseline BSI rate of 2.9 per 1000 non-catheter days. This rate increased to between 7.2 and 12.1 per 1000 catheter days depending on which type of catheter was used (19). The general finding that patients with an indwelling catheter experienced higher BSI rates was supported by the work of Holton *et al.* (46) and Taylor *et al.*, (85).

2.2.5 Ventilator-Associated Pneumonia

In 1998, researchers investigated the rate of ventilator-associated pneumonia(VAP) in 1014 mechanically ventilated patients in 16 ICUs across Canada. Of the 1014 patients, approximately 17.5% developed VAP (22). Almost 10 years later, another set of researchers determined the Canada wide rates of VAP. These authors found the incidence of VAP to be 10.6 cases per 1000 ventilator days. Ventilator-associated pneumonia increased length of stay in the intensive care unit, and is predicted to cost the health care system in Canada approximately $46 million per year (64). Patients experiencing VAP are quite ill to begin with, and therefore are at an elevated risk for developing infection.

2.2.6 Other Nosocomial Infections

Within the literature review, a few papers surfaced researching lesser known nosocomial infections. Between 1992 and 1994, a prospective cohort study was conducted in 9 Canadian paediatric university-affiliated hospitals. The authors looked for cases of nosocomially acquired respiratory syncytial virus (RSV) in 1516 pediatric patients. Ninety-one, or 6% had acquired a RSV infection while admitted to hospital. The authors found that nosocomially acquired, as compared to community acquired RSV infections increased length of stay and death in children (53).

Recently, CNISP investigated healthcare-acquired febrile respiratory infections (HA-FRI) in pediatric patients. For four months in early 2005, the researchers looked for cases of HA-FRI in 8 Canadian hospitals. The authors found 96 cases of HA-FRI for an incidence rate of 0.97 infections per 1000 patient days (86).

In 2004, researchers undertook a one-day point prevalence study of *Candida* fungal colonizations in ICU patients from 35 Canadian hospitals. *Candida* fungal colonizations have been found to lead to invasive infections in ICU patients, and are therefore a risk that should be addressed. The authors collected samples from 357 ICU patients and found that almost 50% of the patients had positive respiratory or rectal swabs. Although *Candida* is normally a naturally occurring flora fungus, increased sites of colonization can lead to invasive infections (58).

2.2.7 General Healthcare-associated Infection Rates

The Canadian Nosocomial Infection Surveillance Program has conducted two, large one-day point prevalence surveys of hospital acquired infections in particular patient populations (37, 39). Both occurred in early February of 2002 in sentinel hospitals across Canada. The pediatric arm of the survey took place in 18 sentinel hospitals, while the adult survey took place in 25 centres. In the adult investigation, 5750 patients were surveyed regarding there healthcare-associated infection status. In this group, 601 patients had 667 hospital-acquired infections for a prevalence of 10.5% of patients infected. The authors report that this prevalence is similar to what is seen in other industrialized countries (39). The other CNISP prevalence study focused on the Canadian pediatric population admitted to hospital. Nine hundred ninety-seven children were surveyed for the presence of a healthcare-associated infection. Eighty patients were found to have 91 healthcare-associated infections, for a prevalence of 9.1%. Once again, the others found the rate to be similar to other industrialized nations (37).

In 1999, CNISP members mailed or faxed surveys to 145 Canadian hospitals regarding nosocomial infections of MRSA, *Clostridium difficile*-associated diarrhea (CDAD) and VRE. One hundred twenty (82.8%) hospitals responded and using the information provided, the authors were able to calculate rates of various nosocomial infections. The mean MRSA rate was 2.0 per 1000 admissions, while the CDAD rate was higher at 3.8 per 1000 admissions. The mean VRE was 0.4 per 1000 admission which corresponds with previously discussed data (88).

2.3 Hospital Acquired Infections in Alberta

A search of the literature did not reveal any papers that have estimated the general number of HAIs in Alberta specifically. However, some researchers have focused on specific HAIs such as bloodstream infections (BSI) or urinary tract infections (UTI) that have occurred in certain cities, hospitals, or populations within Alberta.

Four articles have discussed either the rate or economic burden of BSI's in adults in the Calgary region. In 2 of the papers, researchers found that there was approximately 4 episodes of BSI's for every 100 adult intensive care unit (ICU) admission in Calgary area hospitals (55, 56). Researchers also studied adult trauma patients (injury severity score >= 12) that were admitted to the Foothills Medical Centre in Calgary from 1999-2002 and found that approximately 1 in 25 cases were complicated by a hospital acquired BSI (54). The burden from these BSI's put on the Alberta healthcare system is three-fold. First, in a matched case-control study (adult ICU patients with BSI (case) vs. adult ICU patients without BSI (control)), patients with a BSI were found to have a longer length of stay (15.5 vs. 12 days, p=0.003). The longer length of stay values created by these HAIs will take away potential hospital beds for other patients. Secondly, an important factor resulting from BSI's is the added economic cost. The same study found that the median cost to treat an adult ICU patient with a BSI was $85 137, compared to $67 879 in the non BSI patient (p=0.02). Finally, BSI's in adult ICU patients also

increases the mortality rate (42% cases vs. 26% controls, p=0.002), adding to the already huge burden BSI's place on the healthcare system (57).

In January 2003, an outbreak of norovirus occurred at the Glenrose Rehabilitation Hospital (GRH) in Edmonton. Thirty-two of the 73 patients exposed to the virus became ill during the 14 day outbreak, and 42 staff members became symptomatic. Among other actions, the staff at GRH increased environmental cleaning in an attempt to control the outbreak. To further control the outbreak, complete discharge cleaning was completed on the closed units and the importance of this action was recognized and believed to *"...have averted a resurgence of the outbreak."*(1). Other Edmonton researchers studied HAIs in burn patients caused by gentamicin resistant *Pseudomonas aeruginosa.* Between 1979 and 2001, 3651 patients were admitted to the University of Alberta Teaching Hospitals burn unit. Forty-eight of these patients (1.3%) became ill with this antibiotic resistant pathogen. The authors identified a strong relation between burn infections and contaminated environments. During the 22 years, two major outbreaks occurred on the burn unit. One was controlled by redesigning the sinks where the pathogen was found to prevent infection. The second outbreak was controlled by discontinuing the use of hydrotherapy tanks where the pathogen was also found (4). In both insistences, the environment played a pivotal role in the outbreak and modifications to the physical environment or healthcare practice were successful in reducing infections.

One article by Embil *et al.*, (31) found that 17 of 22 (77%) MRSA cases at Calgary General Hospital between 1990 and 1992 were hospital acquired. However, the

authors did state that their figures of hospital acquired infections could have been underestimated since some of their community acquired cases had previous hospital visits and could have been acquired there.

Another study in the city of Calgary reported that there was 111 ICU acquired urinary tract infections (UTI) in 1158 patient admissions of 48 hours or more between May 1999 and April 2000. These figures translate into 11.3 ICU acquired urinary tract infections for every 1000 ICU patient days. Fortunately, the authors did not find an increased mortality associated with ICU acquired UTI's (55).

2.4 Economic Impact of Hospital Acquired Infections

An article published in 2001 used costing information gathered from a Toronto, Ontario hospital and applied this data to all hospital admissions across Canada. The researchers' goal was to determine the economic burden of methicillin-resistant *Staphylococcus aureus* (MRSA) on the Canadian healthcare system; MRSA is a significant and common HAI. The authors assumed an incidence of MRSA infection at 4.12 per 1000 admissions which was taken from a CNISP report (79). Using these figures, the authors estimated that MRSA infections alone cost the Canadian healthcare system between $42 and $59 million annually (51). In general, Zoutman *et al.,* (89) estimated that 220 000 cases of HAI's are seen in Canada each year, and of those cases, approximately 8000 will die. These numbers are old and based upon American figures and therefore updating these values would be beneficial to health care planning.

There is no question that HAI's are an important concern to the Canadian healthcare system and warrant further research. The link between cleanliness of patient rooms and HAI's has begun to emerge, and therefore more research must be done to further understand the importance that terminal cleaning plays in the transmission of pathogens throughout a hospital.

2.5 Introduction to Housekeeping

Hospital housekeeping is experiencing a major shift in opinion in both the academic community and with the public. People are again starting to recognize that a clean hospital is a safe hospital. This theory is far from new, it began in the 1800's when Florence Nightingale advocated for cleaner conditions for the British troops in the Crimean War. When the majority of the troops were dying of infections, Nightingale demanded clean sheets, fresh air and removal of raw sewage from the field hospitals. With cleaner conditions, Nightingale and colleagues witnessed a dramatic drop in deaths from infectious diseases; her opinion and actions were revolutionary considering this all took place before Pasteur had developed the germ theory (35).

Despite the basic theory pioneered by Nightingale long ago, housekeeping in Canada over the past few decades have seen dramatic cuts to their budget. In 1976, support services (which include housekeeping) in Canadian hospitals accounted for 26% of total hospital expenditures. Due to budget cuts, this figure dropped to 16% in 2002, which was the largest percentage decline in any category of hospital spending (12).

Between 1995 and 1999, housekeeping budgets experienced an average annual 1.8% decrease in spending (13). It was not until the last decade that housekeeping budgets started to receive more funding. This increase in spending saw housekeeping budgets increase at an annual rate of 1.3% until 2002. In 2002-2003, housekeeping alone accounted for 2.8% of the nearly $35 billion spent by Canadian hospitals that year.

2.5.1 Environmental Contamination

Environmental contamination is a controversial area in the hospital housekeeping research community (47). Many in the research community are divided on whether surfaces and objects contaminated with microorganisms can lead to newly acquired infections in patients. Nightingales experience, previously described, would not act as a sufficient argument for increased cleaning today as policy makers and hospital administrators require peer reviewed evidence. The problem with this prerequisite is that it is often difficult to link contamination in the hospital with infections in the patient.

As summarized by Fraise (32), the question that plagues researchers in this area is whether the contaminated hospital infected the patient or if the infected patient contaminated the hospital? However, with techniques such as pulsed-field gel electrophoresis (PFGE) which allows for a “fingerprinting” of bacteria for comparison, researchers are increasingly able to connect contamination with HAIs. The PFGE technique allows researchers to easily identify identical strains of bacteria after a process which provide a visual “fingerprint” type of identity. With this type of information

emerging continuously, the role of the housekeeping staff is becoming increasingly important and entering an era in which they are seen as significant contributors in the control of HAIs. However, before housekeeping staff assumes an increased responsibility a large problem needs to be addressed.

Many studies, discussed further in this paper, have indicated that housekeepers are failing to clean patient rooms properly. Housekeepers are not cleaning all the proper surfaces within a patient room. Failure to clean a surface and potentially leaving behind pathogenic organisms can lead to HAIs. The number of HAIs in Canada caused by contamination of the environment remains unknown. Some researchers have suggested links between a contaminated environment and patient safety (7, 11, 25, 30, 42, 61, 72, 76). Some researchers have even shown an increased risk of becoming colonized with the same bacteria that the patient that occupied your bed prior to you had (48). The magnitude of the burden HAIs place on the Canadian healthcare system is relatively unknown.

2.5.2 Housekeeping Methods

Health care facility administrators have many options available to them to clean both the patients care areas as well as public areas. Each hospital needs to decide what will work best for them given their physical layout and the resources available to them. Due to the rise of infections that may be related to environmental contamination, new

technologies have been developed as well some older technologies have been re-developed to help stop the spread of infectious organisms throughout a hospital.

In general, proper housekeeping has been found to help control outbreaks or reduce infections (27, 45).

2.5.2.1 'Rag and Bucket' Cleaning Method

The "rag and bucket" method is a simple way of cleaning the environment. It is the use of a rag or some type of cloth and a bucket filled with a disinfectant solution that when wiped over a surface or object will hopefully result in a cleaner surface. Disinfecting solutions often comes with recommended contact times measured in minutes.

Disinfectant cleaners will kill the microorganisms found in the environment, however, they require a pre-determined contact time to meet their disinfectant label claims. Contact time is typically measured in minutes. This means that the surface such as a counter or bed side table needs to be kept wet with the disinfectant for the entire contact time duration. Typically this is achieved quite easily with the application of disinfectant to the object; it is still a protocol that needs to be taught to the housekeepers as this may be a new concept to someone who has not worked with disinfectants before.

The rag and bucket method, although easily recognized and adopted by housekeeping staff introduces some barriers to overcome. Most housekeepers will come to the job with a built in behaviour and knowledge of this type of cleaning. It therefore

becomes more difficult to overcome their habits that have been with them for many years. It could be argued that a new technique, completely foreign to incoming workers could be beneficial as they can be taught without preconceived ideas of how it is done.

2.5.2.2 Ultraviolet Light

One of the newer technologies emerging in housekeeping research is the use of UV light units to clean the entire patient's room. Although UV light has long been known to kill microorganisms, it is not until recently that companies started to develop machines capable of decontaminating an entire room. Of note, this UV light disinfection is not the same as the UV light analysis used in this study to measure mechanical cleaning ability of housekeepers.

A study in the rooms of patients colonized with vancomycin resistant Enterococcus (VRE) found that a pulsing xenon UV light was able to significantly reduce the amount of VRE microbial contamination on surfaces following occupation (83). The UV unit, manufactured by Xenex Healthcare Services was placed in 3 various positions in the room and operated for 4 minutes in each location. This, like all other UV technologies require the room to be properly terminally cleaned prior to UV decontamination to remove the biological soiling, which UV light cannot penetrate. The authors of this study found an average increase in cleaning time of approximately 18 minutes.

Other products on the market have shown similar results, but do so at an increased amount of time. One unit, described by a group lead by John Boyce showed that longer exposure resulted in a decreased level of both general aerobic colonies and *C. difficile* spores (9). The authors found that the best results were accomplished in a two stage procedure (UV unit placed in two separate positions sequentially) which took an average of 83 minutes on top of the terminal cleaning which is generally considered to take about 30 minutes. The consequence of this is a considerable amount of increased down time each room experiences between patients. With FMC typically operating at or near 100% capacity, this down time results in longer emergency wait times, which is an important measure of health care delivery success.

One group from the United Kingdom has developed a UV unit that does not require the room to be unoccupied and therefore eliminates the problem of increased down time (59). The technology utilizes high-intensity narrow spectrum (HINS) light which is harmless to humans but exhibits antimicrobial activity. The light is installed in the patient's room in the existing ceiling. It is operated during the day when the main lighting system is on. The authors tested their system by examining the amount of microorganisms on the surface surrounding the patients. They found a significant reduction in microbial contamination while the HINS unit was used. The benefits of this system are that it can be operated while the patient is present, all day and every day. It does not require any additional work by housekeeping staff members and therefore could

prove to be a valuable investment for hospitals trying to tackle the problem of transmission of potential pathogens through room contamination.

All of the above units have characteristics that need to be considered by the hospital before full scale implementation. In addition, relatively few studies exist that support the claims that this type of technology will reduce contamination of the patient rooms.

2.5.2.3 Vapourized Hydrogen Peroxide

Another housekeeping technique that has been reviewed in a few small studies is hydrogen peroxide vapour (HPV) technology. This technology works by filling the room with a hydrogen peroxide vapour that is capable of killing many different types of microorganisms. The use of a vapour rather than a disinfect liquid requires the room to be completely sealed off to the outside environment and therefore introduces some additional obstacles.

A study in the United Kingdom found that 90 minutes of HPV exposure was able to kill all organisms tested (Acinetobacter, MRSA, VRE and *C. difficile*). However, this testing all occurred in a laboratory setting (70). Within a hospital Boyce *et al.*, (10) investigated HPV's ability to remove *C. difficile* from the environment. Prior to HPV treatment, 11 of 43 (25.6%) samples from the environment yielded *C. difficile*. After HPV treatment, 0 of 37 (0%) of samples contained *C. difficile*. French and colleagues similarly looked at HPV's ability to remove MRSA from the environment (33). They

found that traditional cleaning often failed to remove MRSA from the environment, 66% of 124 environmental swabs contained MRSA after cleaning. Once treated with HPV, only 1.2% of 85 environmental swabs contained MRSA. Havill *et al.,* (44) looked at general aerobic colony counts (ACC) as well as *C. difficile* growth on surfaces within 15 patient rooms. They found that 93% of surfaces that had general ACC growth before HPV treatment had no growth following treatment. The authors also found a greater than 6 log reduction in the amount of *C. difficile*. In another study by Otter *et al.,* (69), HPV, in addition to terminal cleaning was able to reduce the amount of environmental contamination of MRSA from 60% to 3.3%, Gram negative rod contamination from 30% to 0% and VRE from 6.7% to 0%. Continued testing found that after about 1 week of room occupation by a patient with MRSA, VRE and Gram negative rods the environmental contamination approached pre HPV levels.

As with any cleaning method, it has to be effective in not only reducing environmental contamination, but also transmission of microorganisms. This is a difficult thing to measure and can only ever be speculated. In one study by Ray *et al.,* (73), application of HPV room decontamination during an Acinetobacter outbreak resulted in the commencement of the outbreak.

For new and novel technologies to be successful, they must not greatly affect the turnover time of a patients rooms (the time it takes for housekeeping to prepare the room for the next patient). A study by Otter *et al.*, (71) investigated the required time of HPV decontamination in a hospital setting. They implemented the technology on patient's

rooms that had one or more of the following (C. difficile, norovirus, MRSA, VRE, Acinetobacter or any multidrug resistant organism). They found that the whole HPV process took on average 270 minutes as compared to 67 minutes for regular bleach cleaning. The authors did mention that part of the 270 minutes was waiting for housekeeping to arrive and set up the room for the next patient so with careful planning, the HPV time could be reduced but would still be greater than regular terminal cleaning. The study by Havill *et al.*, (44) found that the HPV room decontamination process took on average 153 minutes. The difference between these two studies indicates that more research is needed in the field of HPV technology and its effect on patient room turnover times.

Hydrogen peroxide vapour technology has shown positive outcomes in the field of room decontamination, however the increased cleaning time has to be balanced against the need for a clean environment.

2.5.2.4 Microfiber Cloths

A new technology has emerged that improves the efficiency of the basic rag and bucket method. Instead of using simple cotton rags, a microfiber cloth has been developed and is sold by many companies. The threads of microfiber are much thinner than the those used in cotton cloths and this facilitates greater capacity to pick up dirt and microorganisms. The fibres in microfiber cloths weigh less than one decitex (1 decitex = 1g/10 000m) (87). There have been a few studies that examine the effectiveness of

microfiber cloths and their ability to remove bacteria from common hospital surfaces. An early paper by Moore and Griffith (63) found that not all microfiber cloths worked the same. The term "microfiber" did not automatically mean enhanced ability to pick up bacteria from surfaces. The authors did find that some microfiber cloths picked up bacteria better than regular cloths and paper towels. In addition they found that when used dry, microfiber cloths had no significant advantage over other commonly used cloths. Microfiber cloths are also used to clean floors within hospitals. A study published in 2007 examined the difference between microfiber mops and regular cotton string mops. The authors found that when used with a detergent only, the microfiber mop was able to remove 95% of the bacterial challenge while the standard cotton string mop removed only 68%. When a disinfectant was used with both mops, they found no difference (75).

The previous two studies examined new, unlaundered microfiber material. Researchers have questioned the continued effect of microfiber cloths after they have been put through the wash and dry cycle in a hospital or health care facility. A study by Smith *et al.,* (82) found that the effectiveness of microfiber cloths varied through a 150 wash cycle. They found the performance improved around 75 washes and had reduced cleaning ability around 150. The authors also concluded that the price of the cloth had no bearing on the ability to remove bacteria from a surface and also that there was no difference between the 10 microfiber cloths tested; which opposes the result found by Moore and Griffith (63). A study published in 2010 found that cotton cloths actually

outperformed microfiber cloths after multiple wash and dry cycles. Microfiber was better able to remove *Staphylococcus aureus* and *Escherichia coli* when new, but the performance degraded over time while the cotton remained more consistent (28).

An advanced product, called ultramicrofiber cloths was developed in which the threads were even thinner; less than 0.3 decitex. The authors used MRSA, Acinetobacter, Klebsiella and *C. difficile* to test the effectiveness of the ultramicrofiber. They found that compared to regular cloths, the ultramicrofiber cloths were better able to remove the bacterial contamination from surfaces although no statistical results were provided. However, when testing the relative light unit (RLU) difference, as measured by levels of adenosine triphosphate there was a statistically significant difference in favour of ultramicrofiber cloths ($p<0.001$) (87).

Microfiber (and ultramicrofiber) cloths both show promise in the few studies that have been published, however the data has not been overwhelmingly conclusive. The technology needs to be improved to allow for multiple washes and more consistent results.

2.5.3 Housekeeping Evaluation Techniques

Housekeeping administrators need a way of evaluating their staff. A few techniques, described below, are commonly implemented by hospitals. They each have their own advantages and disadvantages which need to be taken into consideration by the

hospital. At FMC, housekeepers currently utilize two of the techniques below, visible inspections and the use of UV light analysis.

2.5.3.1 Ultraviolet Light Analysis

Carling (16) described a novel method of detecting the cleaning ability of housekeepers within a hospital. An invisible gel that glows under ultraviolet (UV) light is placed on objects or surfaces within the hospital before cleaning. After cleaning, researchers re-enter the room and using a UV light source are able to detect whether the invisible gel was removed through the mechanical action of cleaning. This technique is used to assess the efficacy of hospital housekeepers, and can be used in educational interventions to try to improve cleaning (6). Carling and his team have used this technique to identify areas of infrequent cleaning (17, 18). However, the effectiveness of this method for assessing the efficacy of the cleaning staff has been questioned. An article by Alfa et al., (2) found that the pathogen *C. difficile* could be found on objects even when all of the invisible gel was removed. This is contrary to the belief that removal of the gel equals a clean surface, and importantly removal of potential pathogens. This technique also identifies poor cleaning habits once they have taken place, and does not prevent them from happening. Use of invisible UV gel to identify areas that are often improperly cleaned must be used in partnership with educational interventional to prevent the poor cleaning habits from continuing.

2.5.3.2 Adenosine Triphosphate Bioluminescence

A technique known as adenosine triphosphate (ATP) bioluminescence often used in the food industry has recently been adopted by healthcare administrators and researchers (84). This technique measures the amount of ATP, an energy molecule used by all life forms, as a general indicator for cleanliness. This technique provides the advantages of real time, quantitative results that can be compared to other surfaces or to a set standard (8, 26, 65). One of the major disadvantages of this technique is that the tool is not specific to potentially harmful pathogens; any cell, living or dead whether plant, animal or bacterial in origin will contain ATP, and therefore may result in higher readings. A surface within a hospital theoretically could be covered in only harmless plant cells from the patients last meal, yet result in a reading that is above a set standard of cleanliness. As well, like the invisible UV gel, ATP bioluminescence identifies poor cleaning once it has already taken place and therefore is only a tool to be used in conjunction with educational interventions to improve cleaning.

2.5.3.3 Visible Cleanliness Inspections

One of the most common techniques used by hospital administrators to asses the efficacy of housekeepers is simple visual inspections. This technique does not accurately predict microbial cleanliness. Researchers have found that surfaces that appear clean, often fail to meet microbial benchmarks for cleanliness (23, 40, 60, 77). This method of

inspection is still commonly used as it is a very quick way of determining if a room is clean or not. It has value as the public expects a visually clean environment, however, it should be the only measure of cleanliness.

2.5.3.4 Microbial Swabbing

The idea of swabbing hospital surfaces to determine cleanliness goes back many years as seen by the paper published by Hall and Hartnett (43). The authors identified the need to go beyond visible inspections and evaluate the cleanliness of various surfaces and equipment within a hospital. As is true today, the authors noted that microbial swabbing is difficult due to the time it takes a laboratory to return results. Microorganisms take time to grow, and therefore results are not available immediately.

Microbial swabbing involves the actual enumeration or identification of microorganisms on surfaces within a hospital. Microbial swabbing involves the use of a swab (a tool to pick up microorganisms, often made of cotton) and various media used to promote the growth of microorganisms. Majority of the testing occurs within a microbial laboratory, and therefore hospital administrators using this method must have access to the right equipment and space.

Often this technique is performed in pairs, one swab collected prior to cleaning and the second swab after cleaning. The pre-cleaning swab reveals a baseline level of contamination. The second swab is then compared to the first swab to see if the level of contamination increased, decreased or stayed the same.

Chapter Three: Methodology

3.1 Introduction

Chapter 3 will summarize the process in which housekeepers were recruited into the study and also how hospital rooms were identified and subsequently sampled. Exclusion and inclusion criteria will be discussed for both housekeepers and also hospital rooms. Methods of assessing cleanliness used in this study will be discussed in detail. The two methods were microbial swabbing of the surfaces and detection of mechanical cleaning by UV light analysis.

3.2 Study Design

This project employed a non-randomized, pretest-posttest cross sectional study design to examine terminal cleanings in private patient hospital rooms at Foothills Medical Centre. Midway through the study, each housekeeper was to be given personalized, hands on educational intervention that aimed to improve their efficiency of removing microbial contamination during terminal cleanings. This study was conducted over a period of 6 months from November 2010 to April 2011. Cleaning efficacy was measured using two different methods that are commonly used by hospital administrators. The first is microbial swabbing of surfaces to detect the change in contamination levels before and after cleaning. The second was UV light analysis which uses a invisible dye that that marks a surface and allows for investigators to determine if the employee cleaned the surface or not.

3.3 Study Definitions

Alberta Health Services (AHS): Alberta's fully integrated health system that is responsible for delivering health care to all Albertans.

Housekeeper: an employee of AHS who is responsible for cleaning health care facilities. These employees are part of support services within a hospital. In this study, we focus on a subset of housekeepers that are responsible for cleaning hospital rooms after the patient has left, also known as a terminal clean.

Private room: a hospital room in which the patient has their own non-shared bathroom and non-shared bed space.

Process Cleaning Solution (PCS): a sodium hypochlorite disinfecting solution used by some nursing units at Foothills Medical Centre.

Quaternary Ammonium Chloride (Quats): a common disinfectant used by housekeepers at Foothills Medical Centre. The chemical structure carries a permanent positive charge and acts on microorganisms by disrupting their cell membrane.

Terminal Cleaning: sometimes referred to as discharge cleaning, terminal cleaning is the process in which hospital rooms are given a more thorough cleaning once a patient has been discharge, transferred to another room/unit/facility or has passed away.

Ultraviolet (UV) Gel Spots: UV spots are a simple and quick method of determining if a housekeeper has physically cleaned a surface. A small amount of the UV gel like solution is placed on the surface of interest before the housekeeper has cleaned. Without

a special UV light, the solution is nearly invisible to the naked eye. Once the housekeeper has cleaned the room, the investigator can return with a UV light and determine if the housekeeper removed the gel, and therefore can be consider to have cleaned the surface. If UV gel remains, the housekeeper most likely did not wipe down that surface, and therefore that surface can be considered missed by the housekeeper.

3.4 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were needed for both housekeepers and the hospital rooms included in the study.

3.4.1 Inclusion Criteria for Housekeepers

Three separate inclusion criteria were set up for housekeepers. The first is that the housekeeper had to be assigned to completing terminal cleanings. At Foothills Medical Centre, some housekeepers are tasked to only complete daily, routine cleaning of nursing units and hospital rooms. This type of cleaning is not considered terminal cleaning and these housekeepers were not included in this study. The second inclusion criterion was that Foothills Medical Centre was the primary place of work for each housekeeper. This was used to prevent loss to follow up once a housekeeper returned to their regular place of work. The final inclusion criterion was that each housekeeper had completed all their required training. This criterion was included to ensure that each

housekeeper has received an equal amount of training and was qualified to independently clean a hospital room.

3.4.2 Exclusion Criteria for Housekeepers

Few terminal cleanings are completed during the night shift and therefore data was not collected during this period. Housekeepers assigned to these shifts were excluded from entry into this study.

3.4.3 Inclusion Criteria for Hospital Rooms

Two separate criteria were used to determine whether a hospital room terminal cleaning could be included in this study. The first is that all included rooms were private rooms. Only private rooms were included due to the potential of contamination by room mates, or visitors between the time the cleaning is complete and the time when the investigator arrived to collect the data after cleaning. The second inclusion criteria was the patient had occupied the room for at least 24 hours. This allowed the patient sufficient amount of time to interact with the room and potentially leave behind microorganisms that could be detected.

3.4.4 Exclusion Criteria for Hospital Rooms

Rooms were excluded from this study if they were located in a particular nursing area. These units were intensive care unit, neonatal intensive care unit, cardiovascular

intensive care unit, labour and delivery and any mental health unit. The first four areas were excluded as the acuity of the patients often required a very quick turn around time for reoccupation of the beds. Mental health units were not included as these patients are not as acutely ill like patients in the rest of the hospital.

3.5 Housekeeper Recruitment

With assistance from housekeeping supervisors, the investigators were able to recruit housekeeping staff members into the study. One investigator would be present at the start or end of a shift and would approach any housekeepers that are responsible for terminal cleanings. The investigator would explain the research study, including the purpose and objectives, and also discuss what would be required by the housekeepers themselves. After explaining the study, and answering any questions they had, the investigator would ask if they would like to participate. Housekeepers that agreed to participate were asked to sign a consent form (Appendix A) which included information regarding the scope of the project in addition to expectations of participants. Two copies were signed, one remained with the investigator, the second copy was given to the housekeeper. Some housekeepers asked for some time to review the consent form and make a decision. When this occurred the housekeeper was given the consent form to take home and review. An investigator followed up with them once they came back to work to inquire about their decision.

Housekeeping supervisors were aware of the individuals who were participating in the study. The supervisors were never informed of the participant's results including how well or how poorly they cleaned the room. This was an important aspect of the study as our intention was not to relay job performance on to those staff directly in charge of subject participants. If participants felt their job may be in jeopardy, they would have been less likely to participate.

3.6 Hospital Room Recruitment

Housekeeping supervisors use the bed tracking software *BedTracking* (TeleTracking V3.06, Pittsburgh, PA) to assign and follow the progress of their various housekeepers. It is a computer based system that allows housekeepers to log cleaning jobs by dialling any phone and entering various number combinations. The investigators did not have access to this software and therefore were not able to view when research participants were scheduled to clean a room that met the criteria. The housekeeping supervisors were aware of the research and asked to help by contacting the research staff when a room was to be cleaned by a particular housekeeper. On any given day, the research staff would receive an electronic text page by the supervisor. The research staff would call the housekeeping supervisor and collect information about the room, such as the location, the type of clean and the housekeeper that was assigned to clean it. Patient information was obtained using *Clinibase*, (Logibec, Montreal, PQ) software that is used to track patients. This software allowed research staff could determine exactly how long

the patient had been admitted to the room. If the patient had occupied the room longer than 24 hours, the pre-clean was immediately collected as data as outlined below (Section 3.7). The housekeeping supervisor would delay assigning the terminal clean to the housekeeper until the investigator had collected all the necessary data. Every effort was made to ensure the research participants were not aware that data was being collected.

3.7 Pre-Clean Data Collection

When a hospital room was vacated by the patient, the terminal clean was ordered by the nursing unit. Normally the housekeeping staff would come up to the room and begin the cleaning. However, if this room met the study the inclusion criteria then the cleaning was delayed and the pre-clean data was collected. The housekeeping supervisor was responsible for delaying the terminal cleaning assignment. When present on the nursing unit, the investigator informed the nursing desk the reason for their visit. After this, the investigator would collect the data. The following steps were completed in every room that was included:

1. Record general information about the room on the Data Collection Form (Appendix B), including date and time of the terminal clean, the housekeeper responsible for the clean, the room and unit number, which cleaning product the nursing unit uses, presence or absence of an isolation sign on the door, and the general cleanliness of the room prior to cleaning.

2. All swabs were prepared by placing pre-printed labels on each of the 10 swabs. Swabs used in this study were Copan Venturi Transystem ® (Brescia, Italy). Before use, the swab was pre-moistened to enhance the ability to pick up microorganisms on various surfaces. This was accomplished by placing the swab into the transport container. The bottom of the container had a small sponge with liquid medium in it. By inserting the swab into the sponge and squeezing the transport tube, the swab became moistened.
3. The investigator would aseptically remove the moistened swab from the transport tube and swab the tip back and forth over the surface. As much surface as possible, up to approximately 10 square centimetres, was swabbed. In each room, the following 10 objects/surfaces were swabbed: main door handle (facing hallway), bed rails (near head of bed), nurse call button, overbed table (top side only), bathroom door handle (bathroom side), toilet seat (top and bottom), bathroom grab bar, sink taps, light switch (switch plate and switch) and drawer pull handles.
4. Once the swabbing was finished, the UV gel (Glo Germ™, Brockville, ON) was placed on the 10 surfaces mentioned in step 3. This was done by placing a small amount on the UV gel on the end of their finger and dabbing it on each of the 10 surfaces. Each surface was checked using

a small handheld UV light to ensure enough gel was placed that would allow for identification after cleaning. The gel was placed in an area that was not readily visible to the housekeeper, but also was kept in an area that was to be cleaned. The same general spot was used in each terminal cleaning to help with post-cleaning identification.

5. After collecting the swabs and placing the UV gel, the housekeeping supervisor was called and the housekeeper was assigned to terminally clean the room.

3.8 Post-Clean Data Collection

Once the housekeeper had completed the terminal clean, they would log out of the job using the nearest telephone. This would alert the housekeeping supervisor through the bed tracking software that the room was complete. The housekeeping supervisor contacted the investigator to inform them the terminal cleaning was complete, and the post-clean data collection was done. The following steps were carried out in each room to collect the post-clean data:

1. The lights were turned off and the blinds were closed to darken the room for reading of the UV gel spots. The UV light source was used to look for the presence or absence of the gel on each of the 10 surfaces. Each was ranked as either; (1) fully removed (no gel remaining); (2)

partially removed (some gel remaining); (3) not removed (all gel remaining).

2. Once all the UV gel information was collected the 10 surfaces were swabbed again just as they had in the pre-clean data collection steps.
3. Once the swabbing was completed, the 20 swabs (10 pre-clean and 10 post-clean) were delivered to the laboratory at the University of Calgary for testing. Methods for testing the swabs are outlined in the following section.

3.9 Laboratory Testing

The packages of 20 swabs were delivered to the laboratory immediately after they were collected. They were plated onto differential media within 24 hours to determine the presence or absence of bacteria on the surface. The swabs were stored at 4°C until plating. Plating was done as follows:

1. Each swab was removed from the transport tube and streaked onto a small portion of a Petri plate of sheep's blood agar.
2. A sterile wooden stick was dragged through the small portion of media covered in step 1 and continued across one quarter of the plate. The action of dragging a stick through the bacteria will draw a decreasing

amount of bacteria across the plate and allow single colonies to grow and be more easily identified.

3. The process from step 2 was repeated twice more until there were 4 separate quadrants on the plate were covered each with decreasing numbers of bacteria.
4. Once all the swabs have been streaked onto the blood agar media, the plates were labelled and placed into a 36°C, aerobic incubator overnight. The incubator used regular room air.
5. The plates were examined for growth at 24 and 48 hours.
6. Results were recorded based on the amount of growth on the plate. Growth in the area swabbed in step 1 was counted on a per colony basis (for example, 3 colonies of mix skin organisms). Growth in any of the 4 quadrants was given a corresponding result of + (for first quadrant), ++ (for second quadrant), +++ (for third quadrant), and ++++ (for fourth quadrant). The rating of '+/- growth' occurred when more than a few colonies grew in the initial swab phase (outlined in Step 1).
7. Results were recorded on tables specific to each housekeeper.

3.10 Educational Intervention

The goal of the research was to collect data on 10 terminal cleanings from each of the participating housekeepers. After 5 terminal cleanings, the housekeepers would

receive a personalized educational intervention aimed at increasing their awareness of commonly non-cleaned surfaces. An example of the intervention handout is in Appendix C. The data presented on the sheets in Appendix C was based on the UV light analysis results and the strict analysis technique. One investigator shared the housekeepers their results in a patient room as part of the educational intervention. Areas of concern were pointed out to them. Due to time constraints, no data was collected on housekeepers past the mid way point of the research (5 terminal cleans).

3.11 Data Handling

Raw data results were compiled at the end of the data collection period. All data was handled and stored using Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA) spreadsheet software. Statistical analysis was performed used Stata version 11 for Apple OS X (StataCorp LP, College Station, TX).

3.12 Data Categorization

Both measures of cleanliness used in this study could be categorized in many ways. The results from the microbial sampling have no readily apparent cut off between “clean” and “dirty”. The UV light analysis is a bit more objective in that only 3 categories exist (not removed, partially removed and fully removed). Due to the subjective nature of result categorization, it was decided to present and analyze the data using the two techniques described below.

3.12.1 Practical Analysis Technique

The categories in the first technique represent what may be a more practical or achievable way of breaking down the data. The microbial swabs results are considered "clean" if they have less than +/- level of growth seen on the sheep blood agar plate. Surfaces with greater than +/- growth are considered "dirty". The inclusion of +/- and below as "clean" allows for a low background level of microorganisms to exist on the surface either before or after cleaning. Three cleaning outcomes from 4 possible combinations of pre/post cleaning exist. These are reviewed in **Table 3.1** below.

Table 3.1 Two states of cleanliness exist for both the pre and post cleaning surfaces. From these 4 combinations, 3 possible outcomes can be applied to the surface. The rating of clean or dirty depends on the type of analysis technique applied to the results (strict or practical analysis techniques).

Pre-Cleaning State	Post-Cleaning State	Outcome
Clean	Dirty	Not Cleaned
Clean	Clean	No Cleaning Required
Dirty	Dirty	Not Cleaned
Dirty	Clean	Cleaned
Dirty or Clean	Missing	Missing
Missing	Clean or Dirty	Missing

For the practical analysis technique, UV light results are considered “clean” if the gel was either partially removed or fully removed after cleaning. Including the partially removed UV gel gives credit to housekeepers who attempted to clean the surface manually but did not remove the entire gel spot.

This technique, which is easier to achieve success with, may be better suited for hospitals or health care facilities that are just beginning an audit system.

3.12.2 Strict Analysis Technique

The strict analysis technique has a high benchmark for what it considers ‘clean’ surfaces. For a surface to be considered clean by microbial sampling, the post clean results must show no growth, as opposed to some growth allowed in the practical analysis technique. Once again, any surface that switches from clean (no growth) to dirty (some growth) is labelled as “not cleaned”.

In the strict analysis technique, the partially removed UV gel result is moved from “clean” to “dirty” category. A UV gel spot that is partially removed may indicate inadequate cleaning and therefore seen as suboptimal level of housekeeping. This technique although strict and harder to accomplish, is possible to achieve in real life settings and could possibly be adopted by areas experiencing higher than average contamination or infectious disease transmission.

3.13 Ethics Approval

The research proposal and protocol were submitted to the University Of Calgary Conjoint Health Research Ethics Board (CHREB). Submission was made in early 2010 and approval was confirmed on June 11, 2010. This study was given the ethics ID of 23026 (Appendix D). An additional 3 amendments were made to the study protocol, and each of these amendments received approval by CHREB.

The first amendment was submitted on June 17, 2010 which added two consent forms to the study (Appendix E). One consent form was for collection of patient information (Appendix F), however, this was subsequently removed from the study. The second form was used to collect data on the housekeeping events (Appendix B). The amendment on June 17, 2010 also added the UV light analysis portion to the study protocol and updated the co-investigator list to include Ms. Nancy Alfieri. This amendment was approved on July 16, 2010 (Appendix G).

A second amendment (Appendix H) was submitted to CHREB on November 24, 2010 which updated the sample size and also the housekeeper consent form. Approval from CHREB was received on December 16, 2010 (Appendix J).

A third and final amendment was submitted on January 12, 2011 to CHREB (Appendix K). This was a major amendment as it removed the collection of patient information. This section of the protocol was difficult to organize and resulted in inefficient use of time. Approval from CHREB to remove this portion of the study protocol was received on January 28, 2011 (Appendix L).

3.14 Statistical Analyses

Various types of analyses were used within this study to evaluate potential relationships between variables. Majority of statistical tests were too performed to evaluate if the means of two were the same or different. The null hypothesis was always that the means were the same, and the alternative hypothesis was that the means were statistically different from each other. These various statistical tests used are described below.

3.14.1 Student's t-test

Student's t-test was used to test hypotheses involving the comparison of two means. Student's t-test determines whether the means of two samples are significantly different from each other given the mean and sample size. A two-tailed version of Student's t-test was selected as it allows for bi-directional evaluation of the means; simply put, the test considers the possibility that one mean could be either smaller or larger than the second mean. In each test, an alpha of 0.05 was used. This allows for only a 5% chance of committing a type 1 error (rejecting the null hypothesis when null hypothesis is true).

3.14.2 Confidence Intervals

Computing confidence intervals about a mean provides researchers a possible quantitative range of where the true population mean may exist. Comparing the confidence intervals of various means allows for a hypothesis testing similar to Student's

t-test. If the confidence intervals overlap, the null hypothesis cannot be rejected as the true population means may be the same. If the confidence intervals do not overlap, researchers have evidence to suggest that the true population means are not the same, and therefore the null hypothesis can be rejected in favour of the alternative hypothesis. In each case, a 95% confidence interval was used. This allows for only a 5% chance of committing a type 1 error in which researchers reject the null hypothesis when the null hypothesis is in fact true.

3.14.3 Positive Predictive Value / Negative Predictive Value

Positive predictive value (PPV) and its counterpart, negative predictive value (NPV) were used to compare the two types of testing (microbial swabbing and UV light analysis). Positive predictive value is the proportion of positive test results, that when compared to a gold standard of testing, are actually true. The negative predictive value is the opposite of this, the proportion of negative test results that are actually negative when tested using the gold standard. In this paper, microbial swabbing is used as the gold standard, and therefore the results of the UV light analysis are compared to the results of the microbial swabbing.

3.15 Cohen's Kappa Coefficient

Cohen's unweighted kappa coefficient (20) was used to measure the ability of two tests (microbial swabbing and UV light analysis) to come to the same conclusion about

whether a surface was cleaned or not. Kappa is a measurement involving the analysis of concordant pairs (when both tests agree with each other) and disconcordant pairs (when the tests disagree with each other). A small kappa coefficient indicates poor agreement between the tests and a large kappa coefficient indicates good agreement. The kappa coefficient has potential values of 0 – 1.

Chapter Four: Results for Housekeeper Recruitment and General Data Collection

4.1 Introduction

This section will discuss the results of the housekeeper recruitment including how many were recruited and of those housekeepers, how many contributed to the overall data collection. The number of hospital rooms, and also the number of surfaces sampled will also be presented. Results from each of the two data analysis techniques (practical and strict) will be presented separately in the following two chapters.

4.2 Housekeeper Recruitment

Recruitment of the housekeepers began on November 24, 2010. It continued until January 27, 2011 when the last and final housekeeper was recruited into the study. In total 12 housekeepers were recruited. In total, data was collected from 9 of the 12 (75%) housekeepers. No opportunities presented themselves to collect from the remaining 3 housekeepers. One of the 3 housekeepers moved to night shift, which is a period when no data collection took place. The other 2 housekeepers were not assigned any terminal cleaning during the data collection period. No housekeepers chose to withdraw from the study.

4.3 Data Collection

Data collection began on January 19, 2011. Data was collected when possible until April 28, 2011 (4 months) when the decision was made by the committee to cease

collecting data and begin work on analysing the data that researchers had collected. Data were collected on both weekdays and weekends. Data were collected for a total 31 terminal cleans. These 31 terminal cleans were captured from 16 different nursing units with at least one terminal clean done for each building at the Foothills Medical Center (main building, Special Services Building, McCaig tower). Each building, although physically connected was built at different times and features different layouts and designs. Both medical units and surgical units are represented in the data collection.

Within each of the 31 patient rooms, 10 surfaces were to be tested for a total of 310 surfaces potentially included in the analysis. In reality, some of the surfaces were not present in all patients rooms or removed during cleaning (eg. patient bed was not present), and therefore the number of surfaces included in the analysis is a bit lower that the maximum of 310 possible surfaces. In total, 295 surfaces were swabbed for microbial cleanliness before terminal cleaning took place. Once the terminal cleaning was complete, microbial swabs were collected on a total of 289 surfaces. In some rooms, furniture or items were removed during cleaning and that accounted for the lower number of surfaces swabbed between the pre and post cleaning microbial swabbing totals. In total 584 swabs were collected and analysed for cleanliness.

The UV gel was applied to 288 surfaces; however results from only 286 surfaces were collected. The 2 items not followed included an overbed table and a bedside table with the drawer handles. These were removed from the room between when UV gel was

first applied and when the room was visited to collect the post cleaning data. These items could not be assessed to whether the UV gel spot was removed.

4.4 Educational Intervention

Each housekeeper was responsible for terminally cleaning 5 patient rooms before they entered the second phase of the research. At this point, a research team member would visit the housekeeper on site in a patient room and review their results. This was to be followed by analysis of 5 additional terminal cleans.

A one page sheet was given to 5 of the 9 housekeepers that participated in the study and reached the beginning of the second phase. Each of these 5 housekeepers had completed terminal cleans on 5 patient rooms. A copy of the educational sheet can be seen in Appendix C. The sheet was designed to be simple with no quantitative values. Percentage values may not be understood by every housekeeper and therefore they were not included. The sheet included a pictorial diagram of a common patient room that would be recognizable by housekeepers.

The goal of this sheet was to educate housekeepers on surfaces they frequently missed while cleaning. If the research went as planned, once the sheet had been handed out, data from 5 additional terminal cleanings was to be collected from each housekeeper. This would allow for a quantitative comparison of a pre and post educational intervention analysis. This would allow researchers to determine if a simple visual tool could help improve terminal cleaning. Although the second phase of the study never occurred, data from the 5 sheets that were handed out is not all lost. When speaking with the

housekeepers and showing them exactly the types of places they were missing, they all seemed genuinely interested in how to improve. The housekeepers seemed to understand what was being communicated in the diagrams. The use of such a tool should be examined in future research.

4.5 Level of Microbial Contamination

Microbial data was collected and evaluated using a semi-quantitative system to evaluate the various levels of contamination. This system can be seen in Section 3.9.

Table 4.1 Levels of growth seen on blood agar plates pre-cleaning and post-cleaning. Level of growth is categorized using the system discussed in Section 3.9.

Level of Growth	# Swabs Pre-Cleaning	# Swabs Post-Cleaning	Difference
No growth	86	174	+88
Less than +/-	79	88	+9
+/-	36	15	-21
+	34	6	-28
++	43	5	-38
+++	12	1	-11
++++	2	0	-2

Seen in **Table 4.1** are the levels of contamination found on the surfaces as a result of microbial swabbing. The highest number of swabs in both categories came back with 'no growth', meaning no organisms appeared on the blood agar plates. Only two surfaces

had ++++ growth and they were both on pre-cleaning toilet seats, which is not unexpected. There was a general trend toward lower levels of contamination with all categories above ‘less than +/-‘ growth decreasing in value post-cleaning. As expected, cleaning the patient rooms produced more ‘no growth’ swabs post terminal cleaning. An increase of 88 ‘no growth’ swabs was seen.

Chapter Five: Results of Practical Analysis Technique

5.1 Introduction

This chapter presents the results of the data collected and categorized using the practical analysis technique as described previously in Chapter 3. The general microbial swabbing results are presented including analysis on housekeeper and surface specific cleaning efficacy. One objective of this project was to determine the location of the biological contamination was most prevalent within the patient's room. These data are presented first. The ability of housekeepers to clean surfaces whether measured by microbial sampling or UV light analysis will be presented. The UV results are presented in a similar fashion to those that were used for microbial swabbing results with a look at general efficacy values as well as housekeeper and surfaces specific values. Both measures of cleaning efficacy are used to determine whether the cleaning agent makes any difference in removing either microorganisms or UV light gel. Analysis was done to investigate if differences exist within room cleaning, specifically between the bathroom and non bathroom surfaces. Lastly, two methods of comparing tests were used to determine if UV light analysis and microbial swabbing are comparable methods of measuring cleanliness.

The practical analysis for microbial swabbing allowed for a background level of contamination after terminal cleaning. It considered growth of less than +/- on blood

agar plates as clean. Both partially removed and fully removed UV gel spots were considered clean in the practical analysis technique.

5.2 Microbial Swabbing Results

A total of 295 pre-clean surfaces were tested for cleanliness by microbial swabbing as described in Chapter 3. A total of 289 surfaces were tested post cleaning. The results can be seen in **Figure 5.1**.

One hundred sixty eight (168) (56.9%) of the 295 pre-clean surfaces were clean; meaning that the swab collected prior to cleaning had no growth or growth less than '+/- growth' as defined in the practical analysis technique. **Figure 5.1** provides a flowchart of the pre and post clean results as determined by microbial swabbing and the practical analysis technique.

Not shown in **Table 5.1** or **Figure 5.1** are the 36 missing surfaces that were not swabbed (combined from both pre and post cleaning). The missing surfaces were often due to furniture being removed for repair or maintenance after a patient is discharged, this included beds, overbed tables, and mobile bed side tables (drawers with handles).

Figure 5.1 Results of swabbing various surfaces in patient room's pre and post cleaning. Results were analysed using the practical analysis technique.

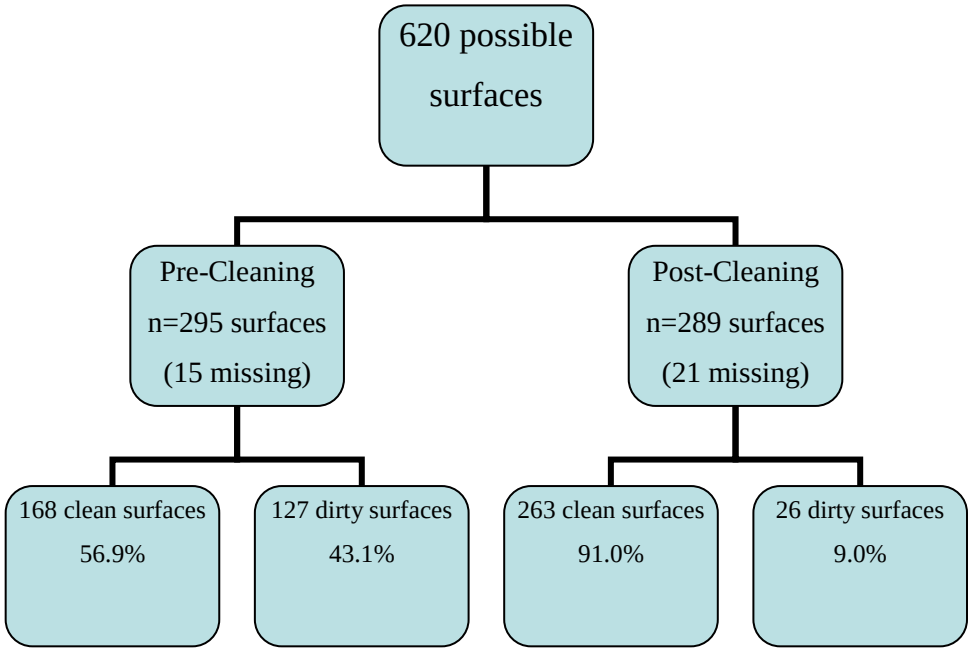


Table 5.1 Post-cleaning swabbing results stratified into not cleaned, cleaned or no cleaning required as according to the definitions in Table 3.1.

	Surfaces Analysed Post-Cleaning (n=288)	Percentage of Total Potential Swabs (Not Cleaned + Cleaned)
Not Cleaned	26	20.5%
Cleaned	101	79.5%
No Cleaning Required	161	N/A

There were 127 surfaces that required cleaning (ie. number of dirty surfaces pre-cleaning). Using the pre and post clean swabbing results, 26 out of the 127 (20.5%, 95%

CI 0.1383 – 0.2854) surfaces were not cleaned by the housekeepers. By definition, these were surfaces that went from dirty to dirty, or clean to dirty as can been seen in **Table 3.1**. Alternatively, 101 out of the 127 (79.5%, 95% CI 0.7146 – 0.8617) surfaces were found to be cleaned by housekeepers using the microbial swabbing technique.

Using a complex combination of the pre and post cleaning results 161 surfaces did not require any cleaning as per the definitions set out in **Table 3.1**. These 3 values do not add up to 289 (ie. the number of post cleaning swabs collected). The 3 values add up to 288, the missing 1 is because a bed side drawer was missing during pre-cleaning and was present during post-cleaning. Since the drawers were present during the post-cleaning, they were swabbed and counted in the 289 surfaces analysed during the post cleaning. However, when calculating the number of surfaces that did not require any cleaning, because the drawers were not present pre-cleaning, they fall under the missing category according to **Table 3.1** and therefore reduce the number of surfaces by 1.

The overall cleaning efficacy by all housekeepers was 79.5% (95% CI 0.7146 – 0.8617). This is the average number of surfaces that are appropriately cleaned by housekeepers when measured using microbial swabbing and analysed using the practical analysis technique. This value does not include the surfaces that were considered clean before the housekeeper ever entered the room and remained clean post-cleaning. Using the confidence intervals for microbial swabbing results, surfaces were statistically more likely to be cleaned than not cleaned.

The results can also be analysed using a two-tailed Student's t-test, which rejected the null hypothesis that the means were the same. Therefore the alternative hypothesis is accepted that the mean number of surfaces cleaned was different than the mean number of non-cleaned surfaces ($p<0.0001$).

5.3 Pre-Cleaning Surface Contamination as Measured by Microbial Swabbing

As shown previously, not all surfaces are cleaned the same, therefore an important factor to consider when cleaning a patient room is knowing where microbial contamination is most likely to occur. This allows the housekeeper to focus their attention and cleaning efforts on the areas of highest concern. Using the microbial swab results from before terminal cleaning took place, the most common contaminated sites can be determined. **Figure 5.2** shows 10 surfaces swabbed in each room and their corresponding pre-clean contamination level as expressed as a percentage.

Figure 5.2 Combined contamination levels from all the pre-clean microbial sampling of 10 high touch surfaces within patient rooms. Data was categorized using the practical analysis technique. Each corresponding percentage value is listed above the column.

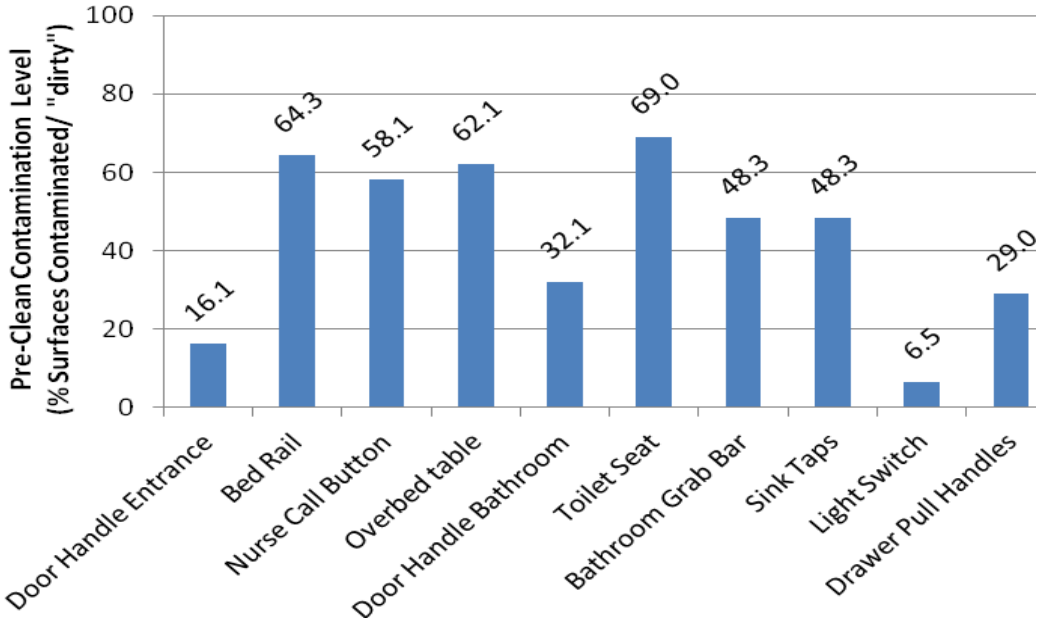


Figure 5.2 shows the various pre-clean contamination rates as measured by microbial swabbing and analysed using the practical analysis technique.

Door handles, whether on the bathroom door or the main door were infrequently contaminated at 32.1% and 16.1%, respectively. The light switch was the least commonly contaminated surface at only 6.5%. The rest of the surfaces (bed rail, nurse call button, overbed table, toilet seat, bathroom grab bar, sink taps) were all close to or above 50% pre-clean contamination rate.

5.3.1 Housekeeper Specific Results

Variability in cleaning efficacy existed among the housekeepers. As shown in **Table 5.2**, 5 housekeepers were able to clean 75% or more of the surfaces that required cleaning. However, 4 housekeepers were below the 75% mark and one housekeeper was close to 60% cleaning efficacy. The 75% is an arbitrary cut-off. Housekeeping administrators could select any cut-off as a goal for housekeeping staff.

The low number of terminal cleans completed by each housekeeper did not allow for accurate statistical analysis. With low numbers confidence intervals became too large and overlap. The same is true when conducting a Student's t-test. Only non statistical trending statements can be made. There appears to be some differences between housekeepers, however, a larger dataset is needed to detect any difference with a reasonable amount of power.

Table 5.2 Microbial swabbing measurement results stratified by housekeeper. Surfaces were categorized as either not cleaned, cleaned, or no cleaning needed, measured and defined using a pre and post cleaning microbial sampling technique.

House-keeper	**Number of Terminal Cleanings (n = 31) (%)**	**Surfaces Not Cleaned (n = 26) (%)**	**Surfaces Cleaned (n =100) (%)**	**Surfaces with No Cleaning Needed (n = 161) (%)**	**Cleaning Efficacy % (cleaned / [cleaned + not cleaned])**
001	2 (6.5%)	0 (%)	4 (4.0%)	13 (8.1%)	100.0
002	1 (3.2%)	1 (%)	2 (2.0%)	4 (2.5%)	66.7
003	**5** (16.1%)	6 (%)	23 (22.8%)	21 (13.0%)	79.3
004	2 (6.5%)	4 (%)	7 (6.9%)	7 (4.3%)	63.6
005	1 (3.2%)	1 (%)	3 (3.0%)	6 (3.7%)	75.0
006	**5** (16.1%)	5 (%)	12 (11.9%)	31 (19.3%)	70.6
007	**5** (16.1%)	5 (%)	13 (12.9%)	28 (17.4%)	72.2
008	**5** (16.1%)	1 (%)	17 (16.8%)	26 (16.1%)	94.4
009	**5** (16.1%)	3 (%)	20 (19.8%)	25 (15.5%)	90.0

5.3.2 Surface Specific Results

Housekeepers may have been better able to clean some surfaces as compared to others. To evaluate this, a table with surface specific cleaning efficacy values was produced and is displayed below in **Table 5.3.** The least cleaned surfaces were the nurse call button (58.8%) and the light switch (33.3%). Due to small sample sizes, the confidence intervals are large and do not facilitate making any statistical statements. Only non statistical trend statements can be made which is that some surfaces seem to be

much less cleaned than others. As with the housekeeper specific information, a larger dataset would be needed to actually determine any statistical differences in surface specific cleaning.

Table 5.3 Cleaning efficacy results stratified by surface. Surfaces were tested for cleanliness using microbial swabbing and analysing the data using practical analysis techniques.

Surface	**Surfaces Not Cleaned (n = 26) (%)**	**Surfaces Cleaned (n =101) (%)**	**Surfaces with No Cleaning Needed (n = 161) (%)**	**Cleaning Efficacy %** (cleaned / [cleaned + not cleaned])
Door Handle (Entrance)	0 (0.0%)	5 (5.0%)	26 (%)	100.00
Bed Rail	1 (3.8%)	17 (16.8%)	9 (%)	94.4
Nurse Call Button	7 (26.9%)	10 (9.9%)	12 (%)	58.8
Overbed Table	1 (3.8%)	17 (16.8%)	8 (%)	94.4
Door Handle (Bathroom)	3 (11.5%)	7 (6.9%)	18 (%)	70.0
Toilet Seat	3 (11.5%)	17 (16.8%)	9 (%)	85.00
Bathroom Grab Bar	3 (11.5%)	11 (10.9%)	15 (%)	78.6
Sink Taps	3 (11.5%)	10 (9.9%)	16 (%)	76.9
Light Switch	2 (7.7%)	1 (1.0%)	28 (%)	33.3
Drawer Pull Handles	3 (11.5%)	6 (5.9%)	20 (%)	66.7

5.4 UV Light Technique Results

In total 286 surfaces were analysed using the UV light technique. This differs from the 289 surfaces analysed using microbial swabbing for two reasons. In one case, the entire UV light analysis portion was missed on a room, eliminating 10 observations. In a second situation, the patient had entered the room, and after discussion with the patient and nurse, the overbed table, bed rail and nurse call bell had been touched and therefore microbial swabs were not collected, but the UV light was analysed.

Observation of the surface using the UV light source after terminal cleaning allowed for the detection of the UV gel. Each observation was classified as: fully, partially or not removed.

Results are shown in seen in **Table 5.4**. Of the 286 surfaces tested, housekeepers fully removed the UV spot on 210 (73.4%, 95% CI 0.6791 – 0.7845) surfaces. Housekeepers partially removed the UV spot on 24 (8.4%, 95% CI 0.0545 – 0.1223) surfaces and failed to remove the spot altogether in 52 (18.2%, 95% CI 0.1389 – 0.2345) on 286 surfaces. Of the 310 potential UV gel spots, 24 (7.7%) were not available for inspection. This was typically due to the pieces of furniture being removed from the room prior to the terminal cleaning beginning. These 24 missing items are not included in any of the following tables.

To calculate cleaning efficacy, the number of UV gel spots fully removed and partially removed were combined and classified as a surface that was cleaned by the housekeeper. The overall cleaning efficacy of housekeepers, measured by the UV light

technique, analysed using the practical analysis technique was 81.8% (95% CI 0.7685 – 0.8611).

5.4.1 Housekeeper Specific Results

As housekeepers work differently, and clean rooms differently, their UV results are going to be different. There is value in knowing if some housekeepers were able to remove the UV gel spots at a more efficient rate than other housekeepers. These results can be seen in **Table 5.4**.

Table 5.4 UV light measurement results stratified by housekeeper. Surfaces were categorized according the housekeepers ability to remove the UV gel. Categories were full, partially, and not removed. Categories were based on pre and post cleaning observation of UV gel under a UV light source.

Housekeeper	**UV Spot Not Removed (n = 52) (%)**	**UV Spot Partially Removed (n = 24) (%)**	**UV Spot Fully Removed (n = 210) (%)**	**Cleaning Efficacy %** ([Partially + Fully Removed] / [Fully + Partially + Not Removed])
001	4 (7.7%)	4 (16.7%)	10 (4.8%)	77.8%
002	1 (1.9%)	1 (4.2%)	5 (2.4%)	85.7%
003	18 (34.6%)	5 (20.8%)	27 (12.9%)	64.0%
004	0 (0.0%)	0 (0.0%)	19 (9.0%)	100.0%
005	2 (3.8%)	4 (16.7%)	4 (1.9%)	80.0%
006	7 (13.5%)	4 (16.7%)	37 (17.6%)	85.4%
007	9 (17.3%)	1 (4.2%)	36 (17.1%)	80.4%
008	2 (3.8%)	1 (4.2%)	36 (17.1%)	94.9%
009	9 (17.3%)	4 (16.7%)	36 (17.1%)	81.6%

Table 5.4 shows the housekeeper specific UV light analysis results. The cleaning efficacy value is a combination of the number of UV gel spots that were either fully or partially removed. In the practical analysis technique, these two categories are combined and considered a cleaned surface.

Housekeeper 004 performed the best, achieving a cleaning efficacy of 100% according to UV light analysis. Housekeeper 003 was the lowest at 64.0%.

As can be seen in **Table 5.4**, only one housekeeper was not able to achieve a cleaning efficacy of greater than 75% which is an arbitrary cut-off. The 95% confidence interval around the lowest efficacy value, housekeeper 004 is 0.4919 – 0.7708 which is a very wide margin. Due to these wide confidence intervals, statistical analysis showed that all housekeepers remove the UV gel spots with the same efficacy. As with other specific analyses, the low sample size does not allow for statistical statements. The trend appears to be that not all housekeepers are able to achieve the same level of UV gel removal, however this statement cannot be made with any statistical support.

5.4.2 Surface Specific Results

As with microbial swabbing, it is important determine if UV gel spots are more efficiently removed from different surfaces. This would indicate that some surface or objects are harder. This could indicate poor design or issues of accessibility to housekeepers. Results of surface specific UV cleaning are shown in **Table 5.5**.

Table 5.5 Cleaning efficacy results stratified by surface. Surfaces were tested for cleanliness using UV light analysis and data was categorized using practical analysis techniques.

Surface	**UV Spot Not Removed (n = 52) (%)**	**UV Spot Partially Removed (n = 24) (%)**	**UV Spot Fully Removed (n = 210) (%)**	**Cleaning Efficacy %** ([Partially + Fully Removed] / [Fully + Partially + Not Removed])
Door Handle (Entrance)	7 (13.5%)	5 (20.8%)	18 (8.6%)	76.7%
Bed Rail	3 (5.8%)	2 (8.3%)	22 (10.5%)	88.9%
Nurse Call Button	4 (7.7%)	2 (8.3%)	23 (11.0%)	86.2%
Overbed Table	0 (0.0%)	0 (0.0%)	25 (11.9%)	100.0%
Door Handle (Bathroom)	10 (19.2%)	3 (12.5%)	15 (7.1%)	64.3%
Toilet Seat	12 (23.1%)	3 (12.5%)	14 (6.7%)	58.6%
Bathroom Grab Bar	2 (3.8%)	3 (12.5%)	24 (11.4%)	93.1%
Sink Taps	2 (3.8%)	3 (12.5%)	24 (11.4%)	93.1%
Light Switch	5 (9.6%)	0 (0.0%)	25 (11.9%)	83.3%
Drawer Pull Handles	7 (13.5%)	3 (12.5%)	20 (9.5%)	76.7%

Table 5.5 shows the results from the UV light analysis. The surface specific cleaning efficacy percentages are calculated using the practical analysis technique which combines the fully and partially removed spots.

Variability exists in the surface specific UV light analysis seen in **Table 5.5**. The poorest cleaning occurred on the toilet seat where only 58.62 of the UV gel spots were removed. The overbed table was the more frequently cleaned surface where 100% of the 25 UV gel spots were removed.

5.5 Comparison of Two Methods for Measuring Cleanliness

Using the practical analysis technique, 2 values of cleaning efficacy were produced through the two different testing methods shown in **Table 5.6**. The first test, microbial swabbing, produce a cleaning efficacy value of 79.5% (95% CI 0.7146 – 0.8617). This value indicates that of the surfaces that required cleaning, the housekeepers were able to successfully clean 79.5% when measured using microbial swabbing and categorizing the data using practical analysis technique.

The second measure of cleaning efficacy was determined by the UV light technique, which gave a value of 81.8% (95% CI 0.7685 – 0.8611); meaning housekeepers were able to partially or fully remove the UV gel on 81.8% of the surfaces they cleaned.

Table 5.6 Overall results from microbial swabbing and UV light analysis including corresponding 95% confidence intervals. Both cleaning efficacy values were calculated using the practical analysis technique.

	Cleaning Efficacy	95% Confidence Interval
Microbial Swabbing	79.5%	0.7146 – 0.8617
UV Light Analysis	81.8%	0.7685 – 0.8611

The first statistical test that can be performed to see if there is any difference is an assessment of the 95% confidence intervals for each value. The two confidence intervals shown in **Table 5.6** and therefore we can conclude with 95% certainty that the two measures of cleanliness are not statistically different.

A Students t-test was used to determine if these two values are statistically different from each other. The null hypothesis is that these cleaning efficacy values are not different from each other. The two-tailed Student's t-test showed that we have no evidence to reject the null hypothesis and therefore conclude that these cleaning efficacy values are not statistically different from each other ($p=0.4401$).

5.6 Effectiveness of Cleaning Agent

A secondary objective of this project was to determine whether the cleaning product had any effect on the cleaning efficacy values. During the data collection period, housekeepers used two different cleaning products. The first cleaning product was a quaternary ammonium chloride (quat) from Wood Wyant™. The second cleaning agent

was a stabilized sodium hypochlorite from Processed Cleaning Solutions™ (PCS). Both are common cleaning products used here in Calgary and the rest of the province.

Substantially more surfaces were cleaned with a quat than the PCS product. Quat cleaners were used on 240 (77.4%) surfaces, while the PCS was used on only 70 (22.6%) surfaces. Wood Wyant™ chemicals are the predominant cleaning product at the Foothills Medical Centre according to the rooms terminally cleaned that were included in this study.

5.6.1 Cleaning Agent Results Measured by Microbial Swabbing

There were 295 surfaces swabbed pre-cleaning. Of these 295 surfaces, 127 of them were classified as dirty and therefore needed to be cleaned. Ninety-five of the 127 were cleaned using the quat product, while the remaining 33 were cleaned using the PCS. **Table 5.7** shows the number of surfaces considered clean and not cleaned as measured by the microbial swabbing technique. **Table 5.7** does not include the 168 surfaces that were considered clean pre-cleaning.

The proportion of surfaces categorized as clean using the quat was 83.2% (95% CI, 0.7409 – 0.9005). The proportion of surfaces considered clean using the PCS was 66.7% (95% CI, 0.4817 – 0.8203). The confidence intervals overlap and therefore using the available data, cleaning agent does not appear to have an affect on microbial cleanliness. A two-tailed Student's t-test gives a separate conclusion. The p-value for the t-test is 0.0452, which provides evidence to reject the null hypothesis and accept the alternative

hypothesis that the two means are statistically different from each and that the cleaning efficacy of PCS is statistically less effective than the quat product.

Table 5.7 Results of microbial swabbing used to measure cleanliness of various surfaces, stratified by cleaning product. This table only includes the surfaces that were considered dirty pre-clean and therefore required cleaning.

Cleaning Product	**Not Clean (n = 27) (%)**	**Clean (n = 101) (%)**	**Cleaning Efficacy %** (clean / [clean + not clean])
Quaternary Ammonium Chloride	16 (59.3%)	79 (78.2%)	83.2%
Processed Cleaning Solution	11(40.7%)	22 (21.8%)	66.7%

5.6.2 Cleaning Agent Results Measured by UV Light Technique

A total of 286 surfaces were analysed using the UV light technique. Using the practical analysis technique, the results were stratified by cleaning agent as shown in **Table 5.8**.

The proportion of surfaces categorized as cleaned using the quat was 80.0% (95% CI, 0.7471 – 0.8529). The proportion of surfaces considered cleaned using PCS was 87.8% (95% CI, 0.8000 – 0.9573). The overlapping confidence intervals indicate there is no evidence to suggest a difference in cleaning ability by the 2 chemicals when measured using the UV light technique. A two-tailed Student's t-test reached the same conclusion (p=0.1498) and does not provide evidence to reject the null hypothesis that the means are the same for the two cleaning products.

Table 5.8 Results of UV light technique to measure cleanliness stratified by cleaning product. Partially removed UV spots have been combined with fully removed UV spots and are considered a clean surface.

Cleaning Product	**Not Clean (n = 52) (%)**	**Clean (n = 234) (%)**	**Cleaning Efficacy %** (clean / [clean + not clean])
Quaternary Ammonium Chloride	44 (84.6%)	176 (75.2%)	80.0%
Processed Cleaning Solution	8 (15.4%)	58 (24.8%)	87.8%

5.7 Bathroom versus Non Bathroom Surfaces

The data collected allow an evaluation of the hypothesis that housekeepers clean bathrooms with more rigor than the rest of the patient room. This view originates from the common belief that bathrooms harbour more bacterial contamination than the rest of the patient room. Data was extracted to examine if there was a difference in cleanliness between the bathroom surfaces (toilet seat, bathroom door handle and bathroom grab bar) and non bathroom surfaces (main door handle, light switch, tap handles, nurse call bell, bed rails, cabinet drawers and overbed table) after terminal cleaning was complete. This data was also further stratified by the technique used to measure cleanliness (microbial swabbing versus UV light technique).

5.7.1 Bathroom/Non-Bathroom Comparison using Microbial Swabbing Technique

Of the 127 surfaces that were classified as dirty pre-cleaning and therefore required cleaning, 83 (65.4%) were non-bathroom surfaces and the remaining 44 (34.6%) were located within the bathroom. These data are shown in **Table 5.9**.

The proportion of non-bathroom surfaces considered clean as measured by microbial swabbing technique was 79.5% (95% CI, 0.6924 – 0.8759). Inside the bathroom, this proportion was 79.5% (95% CI, 0.6469 – 0.9019). The two confidence intervals in **Table 5.9** overlap and therefore there is no evidence to support a hypothesis that the housekeepers clean the bathroom differently than the rest of the patient's room when evaluated using microbial swabbing techniques. The two-tailed Student's t-test supported this claim (p=1.0).

Table 5.9 Cleanliness results for bathroom and non bathroom surfaces as measured using the microbial swabbing technique.

Surface Location	**Not Clean (n = 26) (%)**	**Clean (n = 101) (%)**	**Cleaning Efficacy** (clean / [clean + not clean])
Non Bathroom Surfaces	17 (65.4%)	66 (65.4%)	79.5%
Bathroom Surfaces	9 (34.6%)	35 (34.6%)	79.5%

5.7.2 Bathroom/Non-Bathroom Comparison using UV Light Technique

Of the 286 UV gel spots analysed, 200 (69.9%) non-bathroom surfaces were collected and analysed compared to the 86 (31.1%) within the bathroom. These data are shown in **Table 5.10**.

The proportion of clean surfaces outside of the bathroom, as measured with UV light technique was 86.0% (95% CI, 0.8119 – 0.9081). Inside the bathroom, this proportion was lower at 72.1% (95% CI, 0.6261 – 0.8157). As with the microbial swabbing comparison, the confidence intervals in **Table 5.10** overlap and therefore we cannot conclude that the housekeepers clean the bathroom any differently than the rest of the room when evaluating using the UV light technique. A two-tailed Student's t-test supported this conclusion (p=0.055). Both statistical values border their significant/non-significant cut-off and therefore with a larger sample size, different conclusions may emerge.

Table 5.10 Cleanliness results for bathroom and non bathroom surfaces as measured using the UV light technique. Fully removed and partially removed UV results are combined.

Surface Location	**Not Clean (n = 52) (%)**	**Clean (n = 234) (%)**	**Cleaning Efficacy** (clean / [clean + not clean])
Non Bathroom Surfaces	28 (53.8%)	172 (73.5%)	86.0%
Bathroom Surfaces	24 (46.2%)	62 (26.5%)	72.1%

5.8 Is UV Light Analysis an Accurate Measure of Microbial Cleanliness?

The UV light technique is often used as a proxy for microbial cleanliness. Therefore it is important to determine whether these two methods are actually representative of each other and more specifically, if UV light technique is representative of microbial cleanliness. One clue to their possible incompatibility is that housekeeper 004 had the highest score according to UV light analysis (100%) but had the lowest microbial sampling efficacy score (63.6%).

A Cohen's kappa statistic was calculated as a measure of agreement between the 2 sets of results. For example, when UV light labels the surface as 'not clean', and microbiologically the surface is considered 'clean', there is poor agreement. When both techniques come to the same conclusion, there is perfect agreement. For UV light technique to be an appropriate proxy for measuring microbial cleanliness, they need a higher level of agreement between the two sets of results (a kappa close to 1.0) (20). A two by two table was used to visualize these data (**Table 5.11).** To properly calculate a kappa statistic, a value is needed for each specific surface (one from microbial swabbing, and one from UV light analysis). Therefore only 127 surfaces could be tested, which is the number of surfaces analysed using the microbial swabbing technique. The row totals in **Table 5.11** do not match previously cited figures as this includes only the UV light results which have a corresponding microbial swab result.

Table 5.11 A two by two table showing the results of the two techniques of examining surface cleanliness used in this paper (microbial sampling and UV light technique).

		Microbial Swabbing Results	
		Cleaned (n=101)	Not Clean (n=26)
UV Light Results	Fully + Partially Removed (n=108)	88	20
	Not Removed (n=19)	13	6

Using the above figures, a kappa statistic of 0.1134 (95% CI 0.0 - 0.3736) is found. This is a poor kappa statistic and represents poor agreement between the two measures of cleanliness. This statistic indicates that when using the practical analysis technique, UV light analysis is not a good proxy for bacterial contamination even when the cleaning efficacy values appear to be similar. Therefore, the purpose of UV light analysis should be refined to not be a quasi-measure of how microbiologically clean a surface is.

Positive predictive value (PPV) and negative predictive value (NPV) was used to evaluate the relationship between the two methods of measuring cleanliness. These two tests treat the microbial swabbing as the gold standard, which means that the microbial swabbing results are taken as a true measure of contamination. Implications of this

assumption are shown in section 7.10.1. The PPV for the data shown in Table 5.11 is 0.815 (95% CI, 0.784 - 0.853) and the NPV is 0.316 (95% CI, 0.142 – 0.535).

Chapter Six: Results of Strict Analysis Technique

6.1 Introduction to Results

Similar to the previous chapter, this section presents the results of the data collected and analysed using the strict analysis technique. One objective of this project was to determine where the biological contamination was occurring within the patient's room. These data are presented first. The ability of housekeepers to clean surfaces whether measured by microbial sampling or UV light are presented and analysed. Housekeeper and surface specific rates are investigated using both methods of measuring cleanliness. Both measures of cleaning efficacy are used to determine whether cleaning agent makes any difference in removing either microbial contamination or UV gel spots. An analysis of these data is used to determine if any difference exists within room cleaning (ie. bathroom vs. non bathroom surfaces). Techniques are used to determine if UV light technology is a good proxy for evaluating microbial cleanliness when the data is analysed using the strict analysis technique

At the end of this chapter, results from the practical analysis technique and the strict analysis technique will be compared used standard statistical methods.

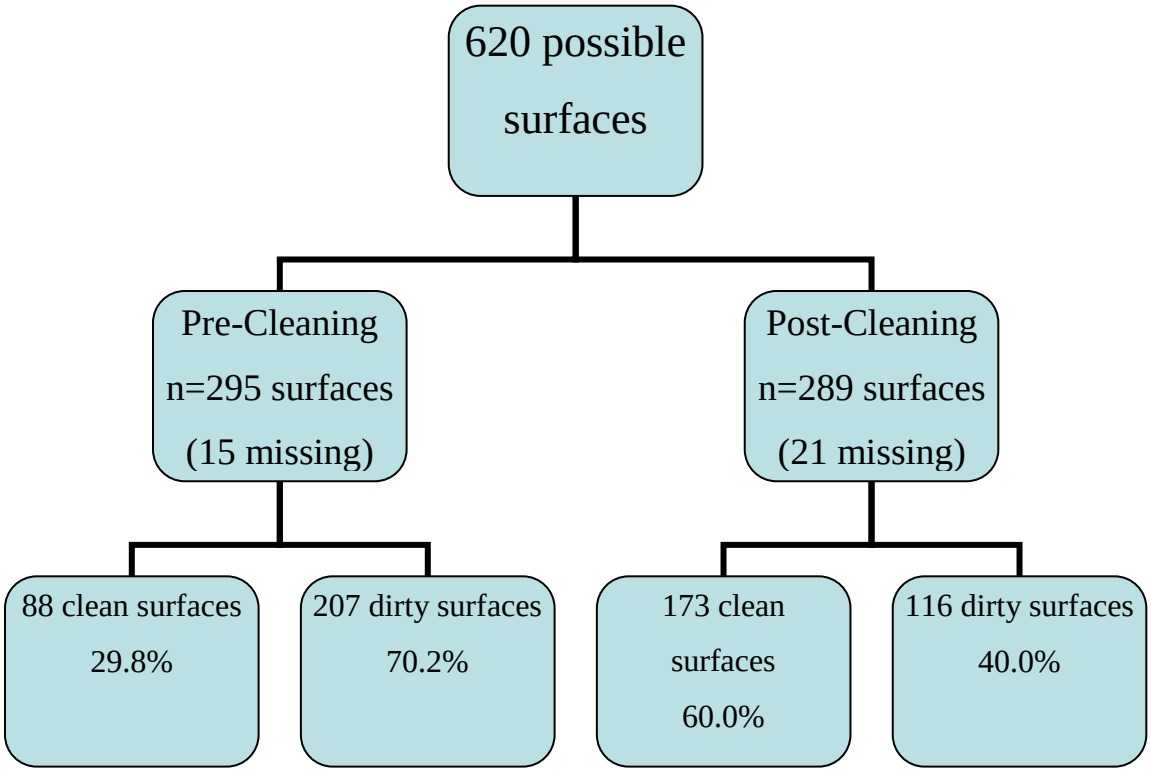
The strict analysis technique was a more stringent analysis of the data when compared to the practical analysis discussed in the previous chapter. For a surface to be considered clean, no level of microbial growth was allowed on post cleaning blood agar plates. In the UV light analysis, the partially removed UV gel spots were moved from clean to dirty.

6.2 Microbial Swabbing Results

In total, 295 pre-clean surfaces were analysed using microbial swabbing technique described in Chapter 3 (data shown in **Figure 6.1**). Eighty-eight (87)(29.8%) of these surfaces were considered clean; meaning the swab collected pre-cleaning had no growth. There were 15 (5.1%) missing swab results from the microbial swabbing technique. The missing swabs were most often the result of furniture being moved in or out of the room between terminal cleanings.

Also shown in **Figure 6.1** are the 289 post-clean swabs collected. Of these 289 swabs, 173 (60.0%) were clean and the remaining 116 (40.0%) were classified as dirty. Post-cleaning there were 21 missing swabs. These missing swabs are not included in any analysis.

Figure 6.1 Results of swabbing various surfaces in patient room's pre and post cleaning. Results were analysed using the strict analysis technique.



Using a combination of the pre and post cleaning microbial swabbing results categorized using the strict analysis technique, 220 were either cleaned or not cleaned. These data are shown in **Table 6.1**. Although only 207 surfaces were considered dirty pre-cleaning, 220 surfaces had a *change* in cleanliness. The additional 13 (220-207=13) surfaces were clean prior to a housekeeper entering the patient room. After terminal cleaning, these surfaces were considered dirty. Therefore according to **Table 3.1** are considered not cleaned. This result is not an anomaly of the data or the collection

process. It is possible for housekeepers to contaminate surfaces if they clean improperly (move from dirty surfaces to clean surfaces or use improperly diluted disinfectants).

Of the 220 surfaces analysed post-cleaning, 111 of the surfaces were cleaned. This produces a cleaning efficacy value of 50.5% (95% CI 0.4365 – 0.5724). Alternatively, 109 of the 220 surfaces were not considered cleaned by the housekeepers which is 49.5% (95% CI 0.4277 – 0.5635). It is important not to confuse surfaces considered 'cleaned' and surfaces considered 'clean' post-cleaning. Surfaces that are considered 'cleaned' take into consideration their pre-clean contamination status. Surfaces that are considered 'clean' post-cleaning is only a measure of post-cleaning level of contamination and do not consider pre-cleaning state.

Table 6.1 Microbial swabbing measurement results stratified by surface. Surfaces were categorized as clean or dirty, measured and defined microbial swabbing and the strict analysis technique.

	Surfaces Analysed Post-Cleaning (n=288)	Percentage of Total Potential Swabs (Not Cleaned + Cleaned)
Not Cleaned	109	49.5%
Cleaned	111	50.5%
No Cleaning Required	68	N/A

The 3 values in **Table 6.1** will not add up to 289 (ie. the number of post cleaning swabs collected). The 3 values add up to 288, the missing 1 is because a bed side drawer

was missing during pre-cleaning and was present during post-cleaning. Since the drawers were present during the post-cleaning, they were swabbed and counted in the 289 surfaces analysed during the post cleaning. However, when calculating the number of surfaces that did not require any cleaning, because the drawers were not present pre-cleaning, they fall under the missing category according to **Table 3.1** and therefore reduce the number of surfaces by 1.

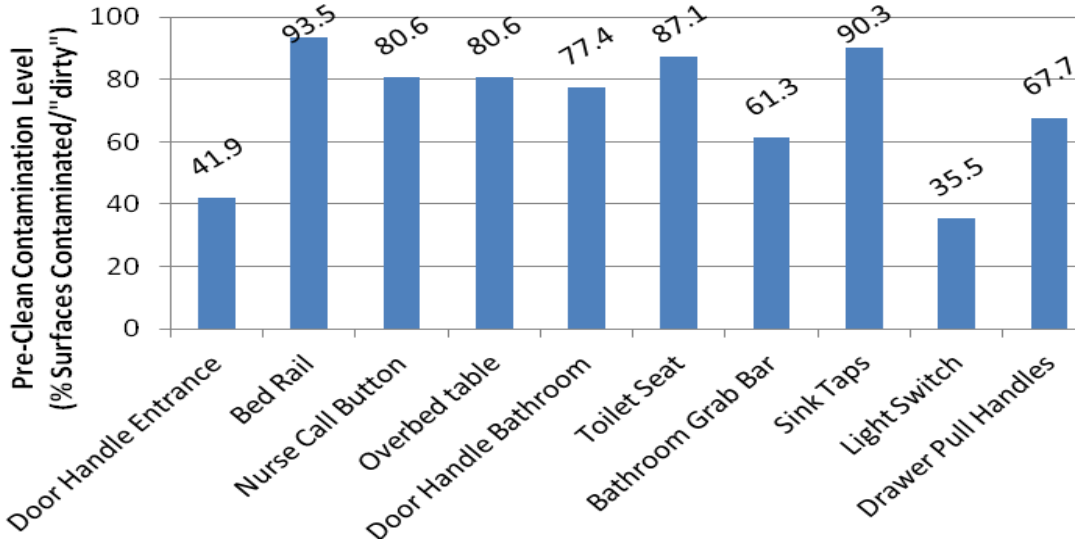
The overall cleaning efficacy value of 50.5% represents the housekeeping staff's ability to remove microbial contamination on surfaces. This does not include the surfaces that were considered clean before cleaning began and remained cleaned post-cleaning. The confidence interval surrounding the cleaning efficacy value (0.4365 – 0.5724) overlaps with the confidence interval surrounding the mean surfaces not cleaned (0.4277 – 0.5635) and therefore the data show that housekeepers are not able to produce a higher number of cleaned surfaces as non-cleaned surfaces.

A two-tailed Student's t-test was used to determine if housekeepers were able to clean more surfaces than they were unable to clean. The test provided no evidence to reject the null hypothesis that the mean number of clean surfaces is the same as the mean number of not cleaned surfaces ($p=0.7667$). Therefore, the data shows that housekeepers did not produce more clean surfaces statistically.

6.3 Pre-Cleaning Surface Contamination as Measured by Microbial Swabbing

One of the important factors to consider when cleaning a patient's room is knowing where microbial contamination occurs. Using the pre-clean microbial swab results, the most commonly contaminated sites can be determined. **Figure 6.2** shows the 10 surfaces swabbed in each room and their corresponding contamination level as expressed by a percentage. As opposed to **Figure 5.2** in the previous chapter, surfaces with any amount of growth during microbial testing were considered dirty or contaminated.

Figure 6.2 Combined contamination levels from all the pre-clean microbial sampling of 10 high touch surfaces within patient rooms. Classification of "contaminated" was any surface with any amount of growth before cleaning.



Patient bed rails (93.5%) were the most commonly contaminated surface according to **Figure 6.2.** This was followed by the sink taps (90.3%) and toilet seats (87.1%). The least contaminated surfaces prior to cleaning were the door handles at room entrance (41.9%) and the light switches (35.5%).

6.3.1 Housekeeper Specific Results

Housekeepers had various levels of cleaning efficacy values specific to their own practice. These data are shown in **Table 6.2**. Individual housekeeper cleaning efficacy scores varied between 20.0% and 66.7%. Stratifying the data in 9 ways reduces the individual sample sizes to a point where statistical statements cannot be made. Trending statements are more appropriate. Is this case there is quite a large spread between housekeepers (20.0% to 66.7%) that indicates that not all housekeepers clean patient rooms the same. In addition, no housekeepers were able to achieve a cleaning efficacy of 75% or greater and only 4 housekeepers were able to manage a value of greater than 50%.

Table 6.2 Microbial swabbing measurement results stratified by housekeeper. Surfaces were categorized as either not cleaned, cleaned, or no cleaning needed, measured and defined using a pre and post cleaning microbial sampling technique.

Housekeeper	**Number of Terminal Cleanings (n = 31) (%)**	**Surfaces Considered Not Cleaned (n = 109) (%)**	**Surfaces Considered Cleaned (n =111) (%)**	**Surfaces with No Cleaning Needed (n = 68) (%)**	**Cleaning Efficacy %** (cleaned / [cleaned + not cleaned])
001	2 (6.5%)	9 (8.3%)	6 (5.4%)	2 (2.9%)	40.0
002	1 (3.2%)	4 (3.7%)	1 (0.9%)	2 (2.9%)	20.0
003	5 (16.1%)	14 (12.8%)	25 (22.5%)	11 (16.2%)	64.1
004	2 (6.5%)	7 (6.4%)	5 (4.5%)	6 (8.8%)	41.7
005	1 (3.2%)	4 (3.7%)	5 (4.5%)	1 (1.5%)	55.6
006	5 (16.1%)	22 (20.2%)	16 (14.4%)	10 (14.7%)	42.1
007	5 (16.1%)	23 (21.1%)	9 (8.1%)	14 (20.6%)	29.1
008	5 (16.1%)	10 (9.2%)	20 18.0(%)	14 (20.6%)	66.7
009	5 (16.1%)	16 (14.7%)	24 (21.6%)	8 (11.8%)	60.0

6.3.2 Surface Specific Results

Some surfaces may be easier to clean, or be made of a material that is easier to clean. To evaluate this, a table with surface specific cleaning efficacy values was produced and this data is shown in **Table 6.3.** The surfaces that were cleaned the least often were the drawer pull handles (34.78%, 95% CI 0.1638 - 0.5723) and the entrance door handle (37.50%, 95% CI 0.1520 – 0.6456). Only 5/10 (50%) of the surfaces were

cleaned more than 50% of the time by housekeepers. Two surfaces, the bathroom grab bar and the sink taps were cleaned more than 70% of the time.

Due to small sample sizes, the confidence intervals are large and do not facilitate making any statistical statements. Only non statistical trend statements can be made which is that some surfaces appear to be cleaned with variable efficacy. As with the housekeeper specific information, a larger dataset would be needed to actually determine any statistical differences in surface specific cleaning.

Table 6.3 Cleaning efficacy results stratified by surface. Surfaces were tested for cleanliness using microbial swabbing and analysing the data using strict analysis techniques.

Housekeeper	**Surfaces with No Cleaning Needed (n = 68) (%)**	**Surfaces Not Cleaned (n = 109) (%)**	**Surfaces Cleaned (n = 111) (%)**	**Cleaning Efficacy %** (cleaned / [cleaned + not cleaned])
Door Handle (Entrance)	15 (22.1%)	10 (9.2%)	6 (5.4%)	37.5
Bed Rail	2 (2.9%)	15 (13.8%)	10 (9.0%)	40.0
Nurse Call Button	5 (7.4%)	13 (11.9%)	11 (9.9%)	45.8
Overbed Table	3 (4.4%)	10 (9.2%)	13 (11.7%)	56.5
Door Handle (Bathroom)	4 (5.9%)	11 (10.1%)	13 (11.7%)	54.2
Toilet Seat	3 (4.4%)	15 (13.8%)	11 (9.9%)	42.3
Bathroom Grab Bar	11 (16.2%)	5 (4.6%)	13 (11.7%)	72.2
Sink Taps	2 (2.9%)	8 (7.3%)	19 (17.1%)	70.4
Light Switch	17 (25.0%)	7 (6.4%)	7 (6.3%)	50.0
Drawer Pull Handles	6 (8.8%)	15 (13.8%)	8 (7.2%)	34.8

6.4 UV Light Technique Results

Results from the UV light technique are shown **Table 6.4**. In total, 286 surfaces were analysed using the UV light technique. Of these 286 surfaces, housekeepers were able to fully remove the UV spot on 210 (73.4%, 95% CI 0.6791 – 0.7845) of them. Housekeepers were able to partially remove the UV spot on 24 surfaces (8.4%, 95% CI 0.0545 – 0.1223) and failed to remove the spot altogether in 52 of the 286 surfaces (18.2%, 95% CI 0.1389 – 0.2315). As with microbial sampling, there are missing UV spot data that are not shown in **Table 6.4**. Of the potential 310 UV spots, 24 surfaces were not available to analyse using the UV light technique because pieces of furniture were removed from the room before the post clean data collection could take place.

To calculate cleaning efficacy using the UV light results, only the number of UV spots that were fully removed were classified as cleaned. Housekeepers were able to fully remove 210 of the 286 UV spots analysed (shown in **Table 6.4)**. Using this strict analysis technique, a cleaning efficacy value of 73.4% (95% CI 0.6791 – 0.7845) was found.

6.4.1 Surface Specific Results

It is possible that housekeepers do not remove the UV gel spots equally from all surfaces within the patient room. The data may show that housekeepers have a hard time removing the UV gel from one surface but not from another. This could indicate poor design or materials that hold onto the UV gel more or others. It may also show that the

housekeeper missed cleaning the surface altogether. **Table 6.4** shows the break down of the UV light analysis data by surfaces and allows for a more in depth look at what surfaces housekeepers are cleaning or not cleaning. The cleaning efficacy values varied between 53.57% for the bathroom door handle, and 100% for the overbed table.

Table 6.4 Cleaning efficacy results stratified by surface. Surfaces were tested for cleanliness using UV light analysis and data was categorized using strict analysis techniques.

Housekeeper	**UV Spot Not Removed (n = 52) (%)**	**UV Spot Partially Removed (n = 24) (%)**	**UV Spot Fully Removed (n = 210) (%)**	**Cleaning Efficacy %** (Fully Removed / [Fully + Partially + Not Removed])
Door Handle (Entrance)	7 (13.5%)	5 (20.8%)	18 (8.6%)	60.0
Bed Rail	3 (5.8%)	2 (8.3%)	22 (10.5%)	81.5
Nurse Call Button	4 (7.7%)	2 (8.3%)	23 (11.0%)	79.3
Overbed Table	0 (0.0%)	0 (0.0%)	25 (11.9%)	100.0
Door Handle (Bathroom)	10 (19.2%)	3 (12.5%)	15 (7.1%)	53.6
Toilet Seat	12 (23.1%)	3 (12.5%)	14 (6.7%)	48.3
Bathroom Grab Bar	2 (3.8%)	3 (12.5%)	24 (11.4%)	82.8
Sink Taps	2 (3.8%)	3 (12.5%)	24 (11.4%)	82.8
Light Switch	5 (9.6%)	0 (0.0%)	25 (11.9%)	83.3
Drawer Pull Handles	7 (13.5%)	3 (12.5%)	20 (9.5%)	66.7

6.4.2 Housekeeper Specific Results

Cleaning efficacy rates of housekeepers measured by their ability to remove UV gel spots are show below in **Table 6.5.**

As with the other stratified data presented for this project, the values vary from 54.0% cleaning efficacy for housekeeper 003 and 100.0% for housekeeper 004. These data show that there appears to be a difference in how each housekeeper works and is able to clean the rooms. Due to small sample sizes for each housekeeper, wide confidence intervals are produced. These wide confidence intervals would show that all housekeepers remove the UV gel spots with the same efficacy. As with other specific analyses, the low sample size does not allow for statistical statements. The trend appears to be that not all housekeepers are able to achieve the same level of UV gel removal, however this statement cannot be made with any statistical support.

Table 6.5 UV light measurement results stratified by housekeeper. Surfaces were categorized according the housekeepers ability to remove the UV spot. Categories were full removed, partially removed and not removed. Categories were based on pre and post cleaning observation of UV spot under a UV light source.

Housekeeper	**UV Spot Not Removed (n = 52) (%)**	**UV Spot Partially Removed (n = 24) (%)**	**UV Spot Fully Removed (n = 210) (%)**	**Cleaning Efficacy %** (Fully Removed] / [Fully + Partially + Not Removed])
001	4 (7.7%)	4 (16.7%)	10 (4.8%)	55.6
002	1 (1.9%)	1 (4.2%)	5 (2.4%)	71.4
003	18 (34.6%)	5 (20.8%)	27 (12.9%)	54.0
004	0 (0.0%)	0 (0.0%)	19 (9.0%)	100.0
005	2 (3.8%)	4 (16.7%)	4 (1.9%)	40.0
006	7 (13.5%)	4 (16.7%)	37 (17.6%)	77.1
007	9 (17.3%)	1 (4.2%)	36 (17.1%)	78.3
008	2 (3.8%)	1 (4.2%)	36 (17.1%)	92.3
009	9 (17.3%)	4 (16.7%)	36 (17.1%)	73.5

6.5 Comparison of Two Methods for Measuring Cleanliness

Using the strict analysis technique, 2 estimates of cleaning efficacy were produced through the two different testing methods. The results of these tests are shown in **Table 6.6**. The first test, microbial swabbing, produced a cleaning efficacy value of 50.5% (95% CI 0.4365 – 0.5724). This value indicates that of the surfaces that required

cleaning, the housekeepers were able to successfully clean 50.5% when measured using microbial swabbing and categorizing the data using strict analysis technique.

The second measure of cleaning efficacy was determined by the UV light technique, which gave a value of 73.4% (95% CI 0.6791 – 0.7845); meaning housekeepers were able to fully remove the UV gel on 73.43% of the surfaces they cleaned.

The first statistical test performed to see if there was any difference is an assessment of the 95% confidence intervals for each value. As can be seen **Table 6.6**, the two confidence intervals do not overlap and therefore we can conclude with 95% certainty that the two measures of cleanliness are statistically different from each other.

A two-tailed Student's t-test was used to determine if these two values are statistically different from each other. The null hypothesis is that these cleaning efficacy values are not different from each other. The two-tailed Student's t-test showed that we have evidence to reject the null hypothesis and therefore conclude that these cleaning efficacy values are statistically different from each other ($p<0.0001$).

Table 6.6 Overall results from microbial swabbing and UV light analysis including corresponding 95% confidence intervals. Both cleaning efficacy values were calculated using the practical analysis technique.

	Cleaning Efficacy	95% Confidence Interval
Microbial Swabbing	50.5%	0.4365 – 0.5724
UV Light Analysis	73.4%	0.6791 – 0.7845

6.6 Effectiveness of Cleaning Agent

A secondary objective of this project was to determine whether the cleaning product had any effect on the cleaning efficacy values. During the data collection period, housekeepers used two different cleaning products. The first cleaning product was a quaternary ammonium chloride (quat) from Wood Wyant™. The second cleaning agent was a stabilized sodium hypochlorite from Processed Cleaning Solutions™ (PCS). Both are common cleaning products used here in Calgary and the rest of the province.

Substantially more surfaces were cleaned with quat than the PCS product. Quat cleaners were used on 240 (77.4%) surfaces, while the PCS was used on only 70 (22.6%) surfaces. Wood Wyant™ chemicals are the predominant cleaning product at the Foothills Medical Centre according to the rooms terminally cleaned that were included in this study.

6.6.1 Cleaning Agent Results Measured by Microbial Swabbing

There were 295 surfaces swabbed pre-cleaning. Of these 295 surfaces, 220 (74.6%) of them had a change in their state of cleanliness as defined in **Table 3.1**. One-hundred seventy three (173)(78.6%) of the 220 were cleaned using the quat product, while the remaining 47 (21.4%) were cleaned using the PCS. **Table 6.7** shows the number of surfaces considered cleaned and not cleaned as measured by the microbial swabbing technique.

The proportion of surfaces categorized as cleaned by the quat chemical, measured by microbial sampling was 49.7% (95% CI, 0.4226 – 0.5716). The proportion of surfaces considered clean using the PCS was 53.2% (95% CI, 0.3892 – 0.6746). Overlapping confidence intervals indicate that there is no evidence to conclude there is any difference in the cleaning ability of the two chemicals used by housekeepers at FMC when measured using microbial swabbing and using the strict analysis technique. A two-tailed Student's t-test was performed and provided no evidence to reject the null hypothesis that the means of the two cleaning products are any different (p=0.6704).

Table 6.7 Results of microbial sampling technique to measure cleanliness stratified by cleaning agent.

Cleaning Product	**Not Clean (n = 109)**	**Clean (n = 111)**	**Cleaning Efficacy** (clean / [clean + not clean])
Quaternary Ammonium Chloride	87 (79.8%)	86 (77.5%)	49.7%
Processed Cleaning Solution	22 (20.2%)	25 (22.5%)	53.2%

6.6.2 Cleaning Agent Results Measured by UV Light Technique

A total of 286 surfaces were analysed using the UV light technique. Using the strict analysis technique, the results were stratified by cleaning agent as shown in **Table 6.8**.

Table 6.8 shows the number of surfaces considered cleaned by the UV light technique, stratified by cleaning agent. The proportion of surfaces categorized as clean using the quaternary ammonium chloride was 71.8% (95% CI, 0.6538 – 0.766). The proportion of surfaces considered clean using the PCS was 78.8% (95% CI, 0.6698 – 0.8789). The confidence intervals for the two cleaning chemicals overlap and therefore, when measured using the UV light technique, there is no evidence to conclude one chemical is better than the other. A two-tailed Student's t-test was performed and provided no evidence to reject the null hypothesis that the means of the two cleaning products are any different (p=0.2589).

Table 6.8 Results of UV light technique to measure cleanliness stratified by cleaning agent. Partially removed UV spots are considered not clean.

Cleaning Product	**Not Clean (n = 76)**	**Clean (n = 210)**	**Cleaning Efficacy** (clean / [clean + not clean])
Quaternary Ammonium Chloride	62 (81.6%)	158 (75.2%)	71.8%
Processed Cleaning Solution	14 (18.4%)	52 (24.8%)	78.8%

6.7 Bathroom versus Non Bathroom Surfaces

The data was extracted to examine if there was a difference in cleanliness between the bathroom surfaces (toilet seat, bathroom door handle and bathroom grab bar) and non bathroom surfaces (main door handle, light switch, tap handles, nurse call bell, bed rails, cabinet drawers and overbed table). This data was also further stratified by technique used to measure cleanliness (microbial swabbing versus UV light technique).

6.7.1 Bathroom Comparison using Microbial Swabbing

Two-hundred twenty surfaces were either cleaned or not cleaned according to the microbial swabbing results. One hundred fifty two (152) (69.1%) total surfaces outside of the bathroom were collected and were labelled as either cleaned or not cleaned. This is compared to the 68 (30.9%) within the bathroom. These data are shown in **Table 6.9**.

The proportion of clean surfaces outside of the bathroom, as measured by microbial swabbing technique was 48.7% (95% CI, 0.4073 – 0.5663). Inside the bathroom, this proportion was slightly higher at 54.4 (95% CI, 0.4257 – 0.6625). The two confidence intervals overlap and therefore we have no evidence to support a hypothesis that the housekeepers clean the bathroom differently than the rest of the patients room when evaluated using microbial swabbing techniques. A two-tailed Student's t-test was performed to analyse the two means. There was no evidence to reject the null hypothesis that these two means are the same ($p=0.4346$).

Table 6.9 Cleanliness results for bathroom and non bathroom surfaces as measured using the microbial sampling technique.

	Not Clean (n = 109)	**Clean (n = 111)**	**Cleaning Efficacy** (clean / [clean + not clean])
Non Bathroom Surfaces	78 (71.6%)	74 (66.7%)	48.7%
Bathroom Surfaces	31(28.4%)	37 (33.3%)	54.4%

6.7.2 Bathroom Comparison using UV Light Technique

Two-hundred eighty six (286) surfaces were analysed using the UV light technique. Two hundred (200) (69.9%) total UV gel spots outside of the bathroom were analysed compared to the 86 (30.1%) within the bathroom. These data are shown in **Table 6.10**.

The proportion of clean surfaces outside of the bathroom, as measured by UV light technique was 78.5% (95% CI, 0.7215 – 0.8398). Inside the bathroom, this proportion was lower at 61.6% (95% CI, 0.5051 – 0.7192). The confidence intervals do not overlap and therefore we can conclude that the housekeepers clean the bathroom differently than the rest of the room when evaluating using the UV light technique. Specifically, it appears that the housekeepers clean the surfaces outside of the bathroom better than within the bathroom. A two-tailed Student's t-test was used to assess the null hypothesis that the two means are the same. The test provided evidence to reject the null hypothesis in favour of the alternative hypothesis that the means are in fact different from each other (p=0.0030).

Table 6.10 Cleanliness results for bathroom and non bathroom surfaces as measured using the UV light technique counting only fully removed UV spots as clean.

	Not Clean (n = 76)	**Clean (n = 210)**	**Cleaning Efficacy** (clean / [clean + not clean])
Non Bathroom Surfaces	43 (56.5%)	157 (74.8%)	78.5%
Bathroom Surfaces	33 (43.3%)	53 (25.2%)	61.6%

6.8 Is UV Light Analysis an Accurate Measure of Microbial Cleanliness?

The UV light technique is often used as a proxy for microbial cleanliness, it is important to determine whether these two methods are actually representative of each other and more specifically, if UV light technique is representative of microbial cleanliness.

A Cohen's kappa statistic was calculated as a measure of agreement between the 2 sets of results. For example, when UV light labels the surface as 'not clean', and microbiologically the surface is considered 'clean', there is poor agreement. When both techniques come to the same conclusion, there is perfect agreement. For UV light technique to be an appropriate proxy for measuring microbial cleanliness, they need a higher level of agreement between the two sets of results (a kappa close to 1.0) (20). A two by two table was used to visualize these data (**Table 6.11).** To properly calculate a kappa statistic, a value is needed for each specific surface (one from microbial swabbing, and one from UV light analysis). Two hundred seventeen (217) surfaces can be tested.

Although the UV light analysis had a higher sample size, data included needs to have corresponding microbial cleaning efficacy values to be included in **Table 6.11.** The data in **Table 6.11** represents the maximum amount of data that can be included in the 2x2 table.

Table 6.11 A two by two table showing the results of the two techniques of examining surface cleanliness used in this paper (microbial sampling and UV light technique) categorized using the strict analysis technique.

		Microbial Swabbing Results	
		Clean (n=110)	Not Clean (n=107)
UV Light Results	Clean (n=158)	83	75
	Not Clean (n=59)	27	32

Using the above figures, a kappa statistic of 0.0539 (95% CI 0.0 - 0.1876) is found. This is a poor kappa statistic and represents poor agreement between the two measures of cleanliness. This statistic indicates that when using the strict analysis technique, UV light analysis is not a good proxy for bacterial contamination. Therefore, the purpose of UV light analysis should be refined to not be a quasi-measure of how microbiologically clean a surface is.

Positive predictive value (PPV) and negative predictive value (NPV) was used to evaluate the relationship between the two methods of measuring cleanliness. These two tests treat the microbial swabbing as the gold standard, which means that the microbial

swabbing results are taken as a true measure of contamination. Implications of this assumption are shown in section 7.10.1. The PPV for the data shown in Table 6.11 is 0.525 (95% CI, 0.782 - 0.568) and the NPV is 0.542 (95% CI, 0.426 – 0.655).

6.9 Comparing the Strict and Practical UV results

By moving the partially removed UV spot surfaces from cleaned to not cleaned produced different results. The next step was to compare these two values to determine whether they are statistically different from each other. To compare the values, 95% confidence intervals are calculated and compared. They are presented below in **Table 6.12**.

Table 6.12 Cleaning efficacy values and corresponding 95% confidence intervals for microbial swabbing and UV light analysis stratified by both methods of categorizing the data (practical and strict analysis techniques).

	Cleaning Efficacy Statistic	
	Microbial Swabbing % (95% CI)	UV Light Analysis % (95% CI)
Practical Analysis Technique	79.5% (0.7146 – 0.8617)	81.8 (0.7685 – 0.8611)
Strict Analysis Technique	50.5% (0.4365 – 0.5724)	73.4 (0.6791 – 0.7845)

The above table shows some interesting findings. The 95% confidence intervals for the two UV light analysis cleaning efficacy values overlap. This indicates that there

is no statistically significant difference between results from either the practical or strict analysis technique when using the UV light technique to measure cleanliness. When viewing the confidence intervals for the microbial swabbing data, they do not overlap. This observation indicates that the results are statistically different and depend on the type of data analysis method is used. Therefore these two analysis techniques, practical and strict are coming to separate conclusions and cannot be used interchangeably.

Chapter Seven: Discussion

7.1 Introduction

This section discusses results from this project and how they are applicable to hospitals and health care facilities. Discussed first is the housekeeper recruitment results and difficulties encountered. The categorization scheme of the UV light analysis and microbial swabbing results is then examined. The objectives of the study are then reviewed in light of the results. The use of UV light analysis technique by a housekeeping department is discussed and how administrators can adjust their interpretation of results to give a more valuable outcome. The results and feasibility of using microbial swabbing as a technique to test housekeeper efficacy is discussed including both the advantages and disadvantages of the process. Disagreement between the two measures of cleaning efficacy (UV light analysis and microbial swabbing) and its impact is then discussed. Additionally, the selection of cleaning product, that could have adjusted cleaning frequencies and methods to review work done by housekeepers is discussed. The use of an educational intervention will be presented. Lastly, final recommendations for housekeeping departments are made using the findings from this project.

An extensive section on improvements to the study design and data collection will help to direct any future research. Additionally comments on the Hawthorne effect and how it may or may not have affected this study is discussed. Finally, the obstacles and problems encountered will be reviewed and ideas of how to prevent them are presented.

7.2 Review of Housekeeper Recruitment

A total of 12 housekeepers were recruited into this study. The goal of the research team was to recruit 16 housekeepers into the study. The recruiting process took longer than the expected 2-3 weeks. The recruiting phase lasted from November 24, 2010 until January 27, 2011, a total of approximately 2 months.

The main difficulties recruiting housekeepers was a language barrier between the recruiter and the housekeeping staff. The documents given to the housekeepers (Appendix A) had been written in a level that would be easy to understand for those with English as a second language. However, the research team made the observation that the 4 page document that required signatures by the participants and a witness may have been intimating and affected housekeeper's willingness to enrol in the study. Housekeeping supervisors who were aware and familiar with the research would often help to assure the housekeeping staff that the research would not be detrimental to their employment. No data was collected on how many housekeepers were approached and subsequently decided not to participate. One solution to this problem would be to prepare much less formal documents that outlined the research goals and expectations of the participants. This however would need approval from the research ethics board.

Another potential issue with recruitment was the time in which recruiters were present. A research team member would visit the housekeeping office during shift change when many of the employees were present. This allowed the maximum exposure to potential participants, however it may have been detrimental to the recruiting process.

At this point, housekeepers had to either quickly leave the housekeeping offices to start their shift in one area of the hospital, or were on their way home after a long shift. This meant that many staff members were in a rush to leave the housekeeping offices and therefore did not have time to consider participating in this research project. In light of this issue, future research aimed at recruiting housekeepers should consider recruiting at staff meetings where all staff will be present. In addition to increased exposure time, the housekeeping supervisors and directors could be present to help assure the staff that this research would not be used to judge their job performance.

The primary objective of this study was to improve ways to educate housekeeping staff members. The difficulty in recruiting housekeepers will parallel difficulties in educating housekeepers. Housekeepers were too busy to consider participation in a study, and therefore they will most likely also be too busy to listen to educational sessions. Housekeeping administrators should consider implementing mandatory educational periods into housekeepers shifts (ie. 1 hour per month for example).

Of the 12 housekeepers that were recruited into the study, data was collected on 9 of them. One of the 3 missing housekeepers adjusted their shift schedule to work nights and therefore researchers were not able to collect data from this housekeeper. The other two housekeepers which did not contribute any data had not made any change in their employment. Inquiring with a housekeeping supervisor, it turned out that the remaining 2 housekeepers were rarely assigned to terminal cleanings; they were mostly assigned to

daily cleaning which was not included in the research study. They should not have been included as participants in the first place.

7.3 Data Categorization

Two methods of categorizing the UV light and microbial data were used in this project; termed practical and strict analysis technique. Many other iterations of the data could have been used, however as they get more complicated, the likelihood a housekeeping department adopting one would likely decrease. Methods of interpreting the data need to be straight forward and easily completed by housekeeping departments. Both techniques presented in this study would be easily adoptable and interpreted by housekeeping departments in hospitals or health care facilities.

7.3.1 Practical Analysis Technique

The first method of categorizing the data was given the name the practical analysis technique. This name was applied as this classification allowed for a higher likelihood of meeting the requirement of cleanliness. This technique applied the label of "clean" to more surfaces than the strict analysis technique. The liberal use of the "clean" label allows for more human error and deviations in cleaning. It also allows for growth of organisms that may not be pathologically important to humans. Growth of these organisms on surfaces aren't necessarily a bad thing, however one may argue that if they can grow on a surface, so can other potentially pathogenic organisms.

In this analysis technique, UV gel spots that were partially removed are considered cleaned. Partially removed UV gel spots show that the housekeeper attempted to clean the surface a therefore should be given credit. In the practical analysis technique, 2 of the 127 (1.6%, 95% CI, 0.0019 – 0.0557) UV spots analysed were partially removed and the surface was not cleaned according to the microbial swabbing results. On the other hand, 9 out of 126 (7.1%, 95% CI, 0.0329 – 0.1302) UV gel spots were partially removed and considered clean as per microbial swabbing results. These values are similar and not statistically significant according to their overlapping confidence intervals and therefore housekeepers should not be given credit as the surface is just as likely to be clean as it is to be dirty when the UV gel spot is partially removed.

The next logical question is then how can this be considered dirty if it is just as likely to be clean. Although true, in environmental cleaning, it is safer to underestimate cleanliness than to overestimate. Overestimating cleanliness leads to more contaminated surfaces, and potentially more infections and therefore partially removed UV gel spots should be considered dirty.

The practical analysis technique also allows for a baseline level of background contamination on surfaces. A low level of contamination is acceptable on surfaces and actually expected. However this assumption depends on what type of microorganisms make up the surface contamination. A low background level of contamination with MRSA or *Clostridium difficile* is much more dangerous than a similar level of Bacillus species as Bacillus is not as harmful of a human pathogen. An additional issue that must

be considered is that some patients, such as those who are naturally or chemically immunosuppressed are at a greater risk of infection from seemingly innocuous background contamination. In this situation, a partially cleaned room can be harmful to the patient.

7.3.2 Strict Analysis Technique

The second method of classifying the various data was termed the strict analysis technique. As the name implies, this analysis was strict with its use of the "clean" label for surfaces.

One of the differences between the two techniques was moving the partially removed UV gel spots from clean to dirty. The reason for the change is that the UV gel spot is easily removed with a wet rag and mechanical force, therefore a partially removed spot shows a suboptimum mechanical cleaning of the surface. Although unknown at the time of classification, as mentioned in the previous section, partially removed UV gel spots are just as likely to be dirty as they are to be clean. Therefore the inclusion of the partially removed UV gel spot as a dirty surface carries some merit in the strict analysis technique.

The second and major difference between the practical and strict analysis techniques was the interpretation of the microbial swabbing data. In the practical analysis technique, a low background level of contamination was allowed and considered clean; this was not the case in the strict analysis technique. The reason for this strict level

of microbial cleanliness threshold is that the cleaning products used by housekeepers have the ability to reduce the surfaces to a state of no growth as evidenced by the cleaning efficacy score of 50.5%; this represents the number of surfaces that went from any growth to no growth. A designation of 'no growth' is not considered a sterile surface, just a surface in which the bacteria able to grow on the sheep blood agar have been killed or removed; other bacteria may however still be present. In addition to bacteria that do not grow on blood agar, there is also a concept of the lowest level of detection. There exists a level of bacteria that is too low to detect most likely because the methods used to detect it are not sensitive enough (ie. Swab material holds onto a certain level of bacteria). Davidson and colleagues looked at recovery of bacteria on a stainless steel surfaces. They inoculated a known amount of bacteria onto the surface and used swabs to recover the bacteria. When the surface was dry, they recovered only 0.1% of bacteria. With a wet surface, this number increased to between 0.33% and 8.8% (26). This gives confidence that a strict technique is needed as the recovery rates of swabbing is so low and therefore a surface with no growth may actually be full of bacteria.

In a health care setting, even a low background level of contamination can be dangerous and therefore the strict analysis technique is beneficial, especially in areas specializing in transplants, intensive care, burns and oncology. The strict analysis technique would also be well suited to nursing unit currently experiencing an outbreak in which environmental contamination may prolong the outbreak.

Both methods of analysing UV light or microbial swabbing data presented in this project would provide value to housekeeping departments. They would both allow supervisors to audit the work conducted by the housekeeping staff. However, the practical analysis technique leaves two areas in which bacteria and other microorganisms could use to spread from patient to patient. These gaps are the low level of background contamination and allowing partially removed UV gel spots to be considered clean. These gaps are not present in the strict analysis technique. Housekeeping departments implementing an audit using either UV light analysis or microbial swabbing may want to consider a strategic approach of beginning with the practical analysis technique and moving to the strict technique when housekeepers have shown improvement or using strict techniques on high risk units or those experiencing an outbreak. An important part of any auditing process is how the data is handled and used. Housekeeping departments must develop tools to use the audit data and use it to help improve cleaning in hospitals. The purpose of collecting the data must be to improve cleanliness in the future, it must not be to simply collect data for the sake of collecting data.

7.4 Surface Contamination

Using microbial swabbing results and the practical analysis technique, the pre-cleaning surface contamination was investigated. Surfaces or objects that are close to the patient or often used were the most commonly contaminated (toilet seat 69.0%, overbed

table 62.1%, call button 58.1% and bed rails 64.3%). These surfaces are touched by the patient and increased contact results in increased contamination rate.

The light switch was infrequently contaminated (6.5%). The door handle on the main entrance was also not commonly contaminated (16.1%). This is not unexpected as the main door is often left open to allow nursing staff to enter and exit frequently and therefore the door handle may not be commonly touched.

When using the strict analysis technique to analyse the pre-clean data, frequency of contamination expectantly increased on all the surfaces as the threshold for cleaning is much lower than the practical analysis technique. The door handles and the light switch remained the least commonly contaminated (41.9% and 35.5%, respectively), and the near patient space surfaces (bed rail 93.5%, nurse call button 80.6%, toilet seat 87.1%) remained some of the most frequently contaminated surfaces.

Housekeepers are trained to focus on high touch surfaces in addition to other areas of the patient room like the floor and walls. The objective of evaluating the pre-clean contamination of surfaces within the patient room was to possibly identify areas that may not require as frequent cleaning when compared to other surfaces. However in the practical analysis technique, 6 of the 10 surfaces had close to or greater than 50% contamination rates. In the strict analysis technique, all surfaces were contaminated greater than 35% of the time, and 5 were contaminated greater than 80% of the time. The 3 surfaces with the least amount of contamination (door handles for main entrance and bathroom, and light switch) also happen to be small and easy to clean and eliminating

them from the cleaning routine would not drastically alter the time it takes to clean a patient room. Therefore the results of the microbial swabbing have not provided any indication that a change to the cleaning routine is statistically necessary or beneficial. However, the low cleaning efficacy scores for the toilet seat and nurse call button, which are both highly touched surfaces indicate some education could be used to increase compliance with cleaning. Housekeepers should continue to clean the 10 surfaces tested within this study in addition to other surfaces routinely cleaned.

7.4.1 Surfaces Not Requiring Cleaning

In the practical analysis technique, 168 of 295 (56.9%) of the pre-clean swabs were not included in the analysis due to the high threshold of clean. If a low background level of bacterial contamination is acceptable and the housekeepers are not expected to reduce the levels of contamination below this, than it shows that the environment is fairly clean following discharge of a patient. However, the methods used to sample the environment are not perfect and therefore not all bacteria are being picked up from the surface during swabbing. This would indicate that this study has underestimated the level of contamination and therefore what we have considered clean may actually be dirty. In addition, immunocompromised patients may require only a few microorganisms to actually cause illness and therefore, even the low background level of contamination may be dangerous. This provides an argument for measuring housekeeper efficacy using the strict analysis technique.

The issue of where the clean/dirty threshold occurs is an important one. Using the strict analysis technique, only 88 of the 295 (29.8%) pre-clean swabs meet the requirement of “clean”. This is much less than the 168 of 295 (57.9%) pre-clean swabs that were considered clean in the practical analysis technique. Allowing a low background level of contamination in the practical analysis technique lowers the expectations of the housekeepers and this may not be necessary. The results show that housekeepers have the ability to clean well and meet the strict analysis technique requirements: one housekeeper achieved 100% cleaning rate. When evaluating the raw microbial data, 106 surfaces went from having any growth to no growth on sheep blood agar. This finding provides an argument against implementing a practical analysis technique which allows a background level of contamination.

Housekeeping departments are encouraged to adopt more strict techniques of evaluating their staff. Housekeepers have the tools available to them to reduce the contamination levels beyond those used in the practical analysis technique. By adopting the practical analysis technique, or a technique similar, housekeeping departments are not utilizing their staff to the levels they have shown to be able to achieve.

7.5 Cleaning Products

The two chemicals compared were quaternary ammonium chloride (Wood Wyant) and a stabilized sodium hypochlorite (PCS). Using either the practical or the strict analysis technique and regardless of the methods used to test cleaning efficacy

(microbial swabbing or UV light analysis) neither cleaning product came out ahead. There was a potential difference using the practical analysis technique and microbial swabbing. However, these differences were significant only when a two-sample test of proportion were used, and were not significantly different when analysing the confidence intervals.

Although one significant finding was found, it is not enough to overwhelmingly support one product or the other. Under the strict analysis technique, 75 of 217 (34.5%) of the surfaces had the UV gel removed, but were still considered contaminated as per the microbial swabbing. This indicated the housekeeper had cleaned the surface, but did not remove the contamination. This piece of data supports the theory that there is more to cleaning than simply applying a chemical to the surface. The mechanical action of cleaning is likely an important part of the process as well.

A potential complication of the cleaning product evaluation is the non-random assignment of cleaning products to units. At the Foothills Medical Center, a quat is the primary product used on nursing units. Units using PCS are typically nursing units that have experienced an outbreak or have an endemic level of hospital acquired infections or colonizations. This could mean that units using PCS also have a higher level of microbial surface contamination, and therefore the results are skewed by this fact. The environmental challenge, due to the higher level of contamination, presented to PCS may be higher than that of the quat. To properly evaluate these two chemicals, one would

need to randomly assign cleaning products to nursing units to reduce the amount of bias that may be present from various levels of contamination.

7.6 Bathroom versus Non Bathroom Surfaces

The various locations of the surfaces tested allowed for an evaluation of whether housekeepers systematically cleaned one area of the hospital better than the other. Specifically, this project looked at whether the housekeepers cleaned the bathroom surfaces any different than the surfaces found outside of the bathroom. As with the analysis of cleaning products, mixed results were found when comparing bathroom and non-bathroom surfaces. The only significant difference was found when using the UV light analysis as the evaluation tool and categorizing the data using the strict analysis technique. All other combinations found no statistical significance.

The fact that this significance only appeared once indicates that it may not be a strong relationship, if any. Due to the lack of consistency, no conclusions on whether housekeepers clean one area better than another should really be made. This should be investigated with further research and a larger data set would most likely answer this question better.

7.7 UV Light Analysis

Beginning with the practical analysis technique, which grouped partially removed UV gel spots with the fully removed spots, the cleaning efficacy was 81.8% was found.

Housekeepers were able to partially or fully remove the UV gel spot on 234 out the 286 surfaces analysed. As discussed in section **7.3.1**, partially removed UV gel spots do not appear to indicate a clean surface with any validity. Therefore, this value of 81.8% is most likely an overestimate and not a good measure of how well the housekeeper cleaned the surface (as defined by a surface with low microbial contamination). The results from the strict analysis technique, which consider partially removed UV gel spots as dirty, are more likely a better estimate of actual cleanliness.

When analysing the housekeeping data using strict analysis technique, a cleaning efficacy value of 73.4% was found; housekeepers were able to remove 210 UV gel spots of the 286 spots analysed.

The use of UV gel has become a popular technique to evaluate housekeeper's ability to clean a patient room. The benefits of UV gel for a housekeeping department is that it is easy to implement, easy to measure and interpret the results. The disadvantage of the UV gel is that it is not actually measuring surface contamination; it is a proxy for surface contamination. UV light analysis is really a measure of the mechanical cleaning ability of the housekeeper. The idea of UV gel spots makes sense; the physical removal of the UV gel spot indicates that cleaning took place and therefore the bacteria theoretically should also be removed. However, more goes into decontamination of surfaces than simply wiping a rag over a surface. The disinfectant used has to be applied a specified amount of time, as well as at the correct concentration for the disinfectant to

have the ability to kill or remove the microorganisms of interest. This is in addition to the use of a clean rag. These are only a few factors that define proper cleaning.

Fellow researchers have used the UV light analysis to evaluate cleaning practices in their respective hospitals. In a Canadian study, authors found a baseline cleaning level of 23% using the UV light technique, much lower than the efficacy for both the practical and strict analyses. The researchers evaluated high touch surfaces similar to the 10 described in this project. With interventions, they were able to improve their score to 80%. The major difference was that this paper evaluated daily cleaning and not terminal cleaning (6).

In a larger study, Carling and colleagues evaluated cleaning on 1400 surfaces using the UV light technique. A baseline rate of 47% cleaning efficacy was found, but is hard to compare to the data presented here. Carling's group evaluated the UV gel spots after 2-3 terminal cleanings (16). However, the FMC housekeeping staff were able to achieve a higher percentage of UV gel removal after one terminal cleaning, regardless of analysis technique used. This is likely due to differences in housekeeper training and ability.

In a larger study by Carling (17), over 20 000 objects were evaluated before interventions were in place. The baseline rate was 48% cleaning efficacy which is less that that found in the current project herein.

7.8 Microbial Swabbing Analysis

In the practical analysis evaluation of the microbial swabbing results, an overall cleaning efficacy of 79.5% was found (95% CI 0.7146 – 0.8617). This was based on the swabbing results from 127 of the 289 surfaces sampled. A total of 163 surfaces had a pre-clean contamination value that fell below the threshold of what was considered dirty. These surfaces could not be labelled as either cleaned or not cleaned post-cleaning if they were considered clean before cleaning occurred. This leaves a large proportion of the data out of the analysis (57.28%).

The other method used in this study to evaluate housekeeper cleaning efficacy was the strict analysis technique. This technique found a cleaning efficacy of 50.5% (95% CI 0.4365 – 0.5724). This value was based upon 220 samplings. Only 88 (or 29.8%) of pre-clean swabs were considered clean. This is a much smaller percentage of data that is not used in the analysis when compared to the 163 swabs in the practical analysis technique.

Comparing the 95% confidence intervals of the two values of cleaning efficacy allows an investigation into whether the evaluation methods result in different outcomes. The confidence intervals surrounding the two values do not overlap and therefore we can conclude with statistical significance that the two classification methods, practical and strict, result in different outcomes. In addition, a two-sample test of proportion examining whether there was any difference between the means from the two methods of

analysis found evidence to suggest these values are not statistically similar ($p<0.0001$). The values produced by these methods are statistically different.

Microbial swabbing is a great tool to determine how well housekeepers are cleaning a surface. The goal of housekeeping is to produce a space that is both visually clean and safe for patient use, meaning pathogenic bacteria and other microorganisms have been removed. Evaluating visual cleanliness is an easy task that can be done by any housekeeping department. Evaluating the safety of a surface is much more difficult. Methods such as UV light analysis and ATP bioluminescence have all been developed to try to answer the question of how well is a surface cleaned biologically. Each method has its pros and cons, but at the root of it all, neither of these measure the actual microbial load. Microbial swabbing measures the actual presence or absence of bacteria on a surface. The method is not perfect, there are issues regarding how to properly pick up the microorganisms, how to properly transfer the organisms to the growth media, what growth media to use among other. At the end of it all, swabbing measures something that is as close to surface contamination as one can get. The key disadvantage is the time to receive to results. Bacteria, viruses and fungi take time to grow, and therefore the results of microbial swabbing are not immediately available like with UV light analysis or ATP bioluminescence. The immediate results of ATP bioluminescence and UV light analysis allow housekeeper supervisor to provide direct feedback to housekeepers. In addition, microbial swabbing requires laboratory time, of which housekeeping departments may not have available access to. The testing completed in this project was also only aerobic,

meaning only bacteria that can survive in an oxygen rich environment were detected. Some bacteria are facultative anaerobes, and even strict anaerobes that may not be able to compete on the blood agar plate with aerobic organisms and therefore not be detected. One example is the important *Clostridium difficile* which is anaerobic and therefore creates spores when exposed to oxygen. These pathogenic spores were not tested for, but were presumably present on surfaces within some patient rooms (2).

7.9 Analyses Using Both Student's t-Test and Confidence Intervals

Student's t-test and confidence interval analysis are both forms of hypothesis testing. One could elect to use only one of the methods, however presenting both allows for two types of comparisons. As outlined in two important papers (34,74) presenting p-values generated by Student's t-test provides only a yes/no type of answer. Is the difference significant or not? The addition of confidence intervals allows for a comparison of the size of the difference (how much or how little they overlap) and accuracy of the test statistic (how large are the intervals). Presenting both together allows for a more accurate evaluation of the data.

7.10 Agreement Between Methods

Kappa statistics were calculated for each method of categorizing the data; the practical and strict analysis techniques. In each case, a poor kappa statistic was found. Carling in his original paper on UV light analysis states that *"[UV light analysis] has the*

potential to quantitatively assess cleaning and disinfecting practices."(16) The results presented in this project question the statement made by Carling. The kappa statistics have shown that the results from UV light analysis have little to do with how well a surface is cleaned when tested using microbial swabbing. Therefore, an improvement in UV cleaning efficacy scores does not necessarily indicate an improvement in the microbial contamination. This project does not provide evidence to completely reject the use of UV light analysis for use in health care facilities. However its utility should be investigated and possibly reassessed. Quite possibly, the UV gel spots can be used as a training tool to ensure that housekeepers are mechanically cleaning all the surfaces they need to.

More in depth training should be used to teach housekeepers how to properly clean a surface including contact time of cleaning product or correct use of a rag, however UV gel should not be a part of this portion of the training.

Comparing methods of cleaning hospital surfaces has been done previously. In an article by Cooper and colleagues, they found no difference in the fail rates between ATP bioluminescence and aerobic colony counts. However the authors did not evaluate individual comparisons of surfaces (ie. Using a kappa statistic) and simply compared overall failure rates for groups of surfaces. A further investigation similar to the one seen in this project may reveal that ATP bioluminescence and aerobic colony counts come to separate conclusions and are not comparable.

An earlier article by Griffith *et al.,* (40) evaluated 3 methods, visual inspections, ATP bioluminescence and microbial sampling. They found a significant difference in fail rates between visual inspection and the other 2 techniques. They did not find a significant difference in ATP and microbial sampling results and therefore conclude that ATP can be used as a measure of microbial contamination. The authors failed to correctly evaluate the results obtained by the ATP and microbial sampling results as done in this project.

A similar study that focused on published audit tools found similar findings; visual inspections did not correlate with ATP or microbial sampling. They concluded that since the ATP and microbial sampling results were statistically the same, ATP bioluminescence could be used (60).

A very well designed study was published in 2011 by Mulvey *et al.*, (65). The authors identified the issue of comparing general values of cleanliness for various audit techniques. The authors used a receiver operating characteristic (ROC) curve to compare the two techniques. This statistical method provided weak evidence for substituting microbial sampling with ATP bioluminescence.

To truly evaluate these techniques, authors must look, using a kappa or similar technique such as ROC curves, to see if measurement techniques are coming to the same conclusion on individual surfaces. A general comparison of overall efficacy is not sufficient as demonstrated by the results presented in this current project.

7.10.1 Microbial Swabbing as the Gold Standard

When calculating PPV and NPV, microbial swabbing was used as the gold standard of testing and therefore the UV light analysis was compared to the results returned by the swabbing. Using the microbial swabbing as a gold standard is acceptable, however, the techniques many faults point to the fact that possibly using a kappa statistic may be preferred. Many factors play a role in how well microbial swabbing tests surface contamination. The swab material, shape, size, swabbing technique, moisture level all play a role in the swabs ability to pick up microorganisms from a surface. Once the swab has picked up the microbial contamination, it then has to release it when desired and various materials have various success. Further to this, selection of the agar media also plays a role in how representative swabbing is of contamination of surfaces. With all the potential drawbacks microbial swabbing has, can it really be considered the gold standard? It is currently the gold standard because it is the best method we have. However, to achieve the best swabbing possible, researchers would need to employ various types of swabs, moistened with different buffers and plated onto many different types of agar mediums. This is not practical for most studies and therefore we are left with the basic cotton swab and blood agar media. The kappa statistic does not make any assumptions as to whether one testing method is better than the other, it simply determines if they are reaching the same conclusion, which we found is not true when comparing microbial swabbing and the UV light analysis technique.

7.11 Future Research

As mentioned, the microbial cleaning efficacy results of 50.5% and 79.5% are statistically different from each other. However, the question remains, is one value 'good' and the other 'bad'. For example, is a housekeeper that can achieve an efficacy level of 50.5% doing a good job? Is a housekeeper that achieves 79.5% doing a good job? It is easy to tell that the 79.5% housekeeping is doing a better job than the 50.5% housekeeper, but is this good enough? What should be the goal of housekeepers be when it comes to microbial swabbing cleaning efficacy scores? Quite obviously, the higher the score the better, but where should the cut off between good and bad be placed? Unfortunately, these questions cannot be answered with the data collected in this study.

The interpretation of the data collected in this study has lead to some interesting findings but also more questions that could be the subject of future research. The first and maybe the most obvious research to follow would be to perform the same study but with stronger, more quantitative microbial sampling methods. A common method used in environmental contamination research is to quantify the data into colony forming units (CFUs) in a given amount of space, typically 1 square centimetre (24). Colony forming units provide a measure of the amount of viable bacteria on a surface and therefore provide an estimate of the amount of contamination. It also allows for a more accurate comparison between different surfaces or between the same surface before and after some type of intervention. The method used in this study could be considered semi-quantitative and therefore it could be argued that comparisons between surfaces are not

entirely accurate. However, since the same method was used throughout the entire study, any amount of error would be carried through each sample and therefore decreases the effect it has on the results. In addition to improving the quantitative ability to measure contamination on common hospital surfaces, future research would also benefit from specifically detecting common human pathogens such as MRSA, VRE, *C. difficile* and various Gram-negatives. This is commonly practiced however it is a more expensive process which requires more laboratory resources.

As mentioned, the results outlined in this study do not provide strong enough evidence to completely end the current use of UV light analysis for detecting the cleanliness of surfaces in hospitals. The methods could be improved with research that included a focused objective and stronger techniques which may either support or refute the conclusions outlined in this study. With more robust swabbing techniques, the research could be re-done to determine if the findings in this paper are supported or not.

Ideally, a follow up project would recruit more housekeepers at multiple facilities allowing more data to be collected. In addition to a larger sample size, improved detection and quantification of surface bacteria would strengthen any conclusions. Knowing whether the UV light analysis is a good technique to measure cleanliness is an important piece of information for hospital housekeeping departments. UV light analysis will always be a good measure of mechanical cleaning by housekeepers; however research needs to conclude whether or not this truly corresponds to microbial cleanliness as well.

The benefits of this research are that a wide range of surfaces and areas were included. As discussed in Chapter 3, patient rooms from various buildings (different designs, age and materials) were included. Although not incorporated into the analysis due to low sample size, it may be beneficial to one day include this type of information. A second benefit is that this project shows that collaboration between infection prevention and control and housekeeping departments can be accomplished. It takes work on behalf of both parties, but it can be accomplished. To help improve collaboration, both sides need to be invested in the research so they are motivated to participate to help gather data. If the research is a priority to both departments, obstacles such as heavy workload resulting in less communication may disappear.

A strong benefit of this study is the number of surfaces tested. Although not the most seen in the literature (see reference 17) the number of swabs and UV gel spots collected allow for appropriate analysis. Methods could be improved to increase the accuracy of the microbial swabs collected, however, even in *in vitro* conditions, recovery rates are still very low (26).

Having one researcher and one laboratory technician perform all the duties removed some error that might have been introduced if multiple parties were performing the same duties. For example, one researcher collected all the microbial swabs and therefore was able to ensure that each surface was swabbed in the same manner (location, pressure, size, time).

7.12 Hawthorne Effect

The Hawthorne Effect is a well known issue with any type of observational data collection. The theory is that when participants of any type of research know they are being observed they will often change their behaviour. The classic example in health care is that health care workers will increase their hand washing performance when they know someone is evaluating this. In the research describe herein, every attempt was made to blind the housekeepers to the data collection. There were two situations where this failed. In the first situation, the housekeeper arrived to the room before the pre-clean data collection had been completed. Therefore, the housekeeper was aware of the data being collected. In the second situation, a participant made the comment that they had seen some UV gel that was not well hidden and knew an investigator had been in there. To see if this had a great effect on the results, the data from those two individual cleans were reviewed. Without being able to conduct any analysis on them, they appeared to not be any different from the rest of the specific housekeeper's results.

A few conclusions regarding the Hawthorne Effect can be postulated. First, for the Hawthorne Effect to effect behaviour, the participant needs to know how to improve the required skill. For example, if the housekeeper did not know they needed to clean the bathroom, then it would make no difference if someone was watching them or not. Secondly, the Hawthorne Effect will only alter the behaviour when the participant is concerned about the outcome. For example, if a housekeeper does not care whether they get a cleaning efficacy result of 10% or 90%, then someone observing their job may not

affect their results. These are two observations, made knowingly without quantitative support or evidence. They are made to hopefully encourage research into the Hawthorne Effect on housekeepers.

7.13 Lesson's Learned

Obstacles faced along the timeline of the project helped to improve future research undertaking by the research staff. These lessons are valuable in producing better data for the scientific community.

7.13.1 Notification of Terminal Cleans

During the course of data collection, 31 terminal cleanings were evaluated. This represents a small proportion of the terminal cleans performed each day at the Foothills Medical Centre. At most, 5 terminal cleans were collected from any individual housekeeper. This also represents a small percent of terminal cleans performed by individual housekeepers. Many more terminal cleanings could have been collected given optimal circumstances, however many things stood in the way of this.

The research staff member responsible for collecting the data also worked full time with the department of Infection Prevention and Control at the Foothills Medical Centre. This work often prevented data from being collected as the full time employment was a priority. A dedicated researcher that could devote more hours to collecting data would have resulted in more results. In this research presented, there was no option to hire a dedicated researcher as no funding was secured for this purpose.

Another factor that prevented more data from being collected was the process of having housekeeping supervisors notify the research team of potential terminal cleans. As discussed, research staff did not have access to the software used by housekeeping to track and assign terminal cleanings. Therefore, they had to rely on housekeeping supervisors to alert the team when a cleaning became available. Some housekeeping supervisors were more willing to help progress the research and were proactive about alerting the research staff. In addition to this hurdle, the housekeeping department experiences waves of increased cleaning activity. Many patient discharges occur in the morning after physicians have made their rounds and agreed to discharge the patient. Therefore mid morning to early afternoon are very busy times for the housekeeping department. This is a period when most terminal cleanings take place, but it also happens to be the period of time when the housekeeping supervisors are the busiest and therefore may not have a spare moment to alert the research staff. Helping out with this research was also done as a favour by the supervisors and therefore was not top priority when faced with a very busy cleaning schedule. Many terminal cleanings that potentially could have been included were missed due to the nature of the housekeeping schedule. Despite this, the housekeeping supervisors were an integral part of this research and it could not have been completed without them. Once again a solution to this would have been to have a dedicated research staff member. This member could have been present in the housekeeping office during the day and therefore acted as a visual reminder of the research enabling more data to be collected.

The graduate experience is meant to be a large learning experience. When first starting out, the graduate student may initially believe the largest learning objectives come from the data and the results obtained. Although the result chapters are full of worthwhile information, some of the most important learning's from this project lie in what it takes to successfully run a study. The administration of this project was not perfect, and actually probably far from it, however that is ok. The lesson's gathered from the project around how to properly run a study are valuable pieces of information and valuable lessons learned.

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Appendix A

Alberta Health Services

TITLE: Measuring the Effectiveness of Terminal Cleaning by Housekeepers at the Foothills Medical Center.

SPONSOR: None

INVESTIGATORS: Dr. Elizabeth Henderson, Craig Pearce, Dr. Thomas Louie, Frank Galetta, Nancy Alfieri, and Dr. Theresa Kline

403-944-4373

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Take the time to read this carefully and to understand any accompanying information. You will receive a copy of this form.

BACKGROUND

While staying at the hospital, some patients leave behind some germs and bacteria when they leave. There is some evidence to show that the next person to stay in the room might pick up these germs or bacteria and can become sick. To help stop this, hospitals clean each room after each patient leaves. This is called discharge room cleaning. The researchers are interested in finding out how effective this discharge room cleaning is.

After a patient leaves their room, the researchers will enter that room and use cotton swabs to test for any germs or bacteria. The hospital housekeepers will then complete their usual discharge cleaning. After the cleaning is complete, the researchers will once again use cotton swabs to test for germs or bacteria. By looking at the before and after number of germs and bacteria, the researchers will be able to determine how effective this discharge cleaning is.

The researchers will test approximately 50 patient rooms during the course of this research project.

WHAT IS THE PURPOSE OF THE STUDY?

The researchers are interested in how effective discharge cleaning is so they can try to improve it. The researchers will be looking at what objects are often not cleaned after a patient leaves a room, and therefore they can talk to housekeepers and help them improve discharge cleaning.

Alberta Health Services

The researchers will also be looking at what type of patient leaves behind the most germs and bacteria. For example, a person that cannot get up to use the bathroom might leave behind more germs than someone that can walk to the bathroom.

WHAT WOULD I HAVE TO DO?

Half way through the study, an investigator will review your results with you. They might point out some areas in the patients room that require more cleaning.

WHAT ARE THE RISKS?

There is no risk to you by participating in this study.

WILL I BENEFIT IF I TAKE PART?

If you agree to participate in this study there may or may not be a direct benefit to you. If you are in the study because you have been identified as a housekeeper at the Foothills Hospital, your job will not change and there is no guarantee that this research will help you. The information we get from this study may help us to provide better discharge cleaning in the future at Foothills Hospital.

DO I HAVE TO PARTICIPATE?

You do not have to participate. Participation is completely voluntary. If you do choose to participate, you may withdraw at any time. To do so, dial the phone number on the first page of this consent form and inform the researcher you would like to withdraw. You do not need to provide any reasons for your withdrawal. Once you withdraw, none of your information will be included in the research. Withdrawing will not affect your job at the Foothills Hospital or with Alberta Health Services.

If any new information becomes available, that might affect your participation in this research, you will be informed immediately.

WILL I BE PAID FOR PARTICIPATING, OR DO I HAVE TO PAY FOR ANYTHING?

You will not be paid for participating. You will also not have to pay anything to participate.

Alberta Health Services

WILL MY RECORDS BE KEPT PRIVATE?

Researchers listed on the first page of this form will have access to the cleaning results. However, only Craig Pearce, the student researcher will know what rooms you cleaned. The other researchers will not know who cleaned each room, they will only know if the room was clean or dirty.

To keep your identity safe, Craig Pearce will assign you a 3 digit code (for example 617). This code will be used to identify you to the other researchers. For example, "Housekeeper #617 cleaned room 1802 on April 8, 2010. They cleaned it very well." The other researchers, and also your supervisors will not know that you are in fact housekeeper #617, and therefore they will never know how well you cleaned the room.

According to University of Calgary policy, all information collected must be kept for 12 years. All records will be stored in the Infection Prevention and Control offices at the Foothills Hospital. They will be locked up and only accessible to the investigators named on the first page of this letter.

IF I SUFFER A RESEARCH-RELATED INJURY, WILL I BE COMPENSATED?

In the event that you suffer injury as a result of participating in this research, no compensation will be provided to you by the University of Calgary, Alberta Health Services or the Researchers. You still have all your legal rights. Nothing said in this consent form alters your right to seek damages.

SIGNATURES

Your signature on this form indicates that you have understood to your satisfaction the information regarding your participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time without jeopardizing your health care. If you have further questions concerning matters related to this research, please contact:

Alberta Health Services

Dr. Elizabeth Henderson (403) 944-4373

Or

Dr. Thomas Louie (403) 944-4766

If you have any questions concerning your rights as a possible participant in this research, please contact The Director, the Office of Medical Bioethics, at the University of Calgary at 403-220-7990.

Participant's Name	Signature and Date
Investigator/Delegate's Name	Signature and Date
Witness' Name	Signature and Date

The University of Calgary Conjoint Health Research Ethics Board has approved this research study.

A signed copy of this consent form has been given to you to keep for your records and reference.

Appendix B

Pre 1 2 3 4 5 Post 1 2 3 4 5

Data Collection Form

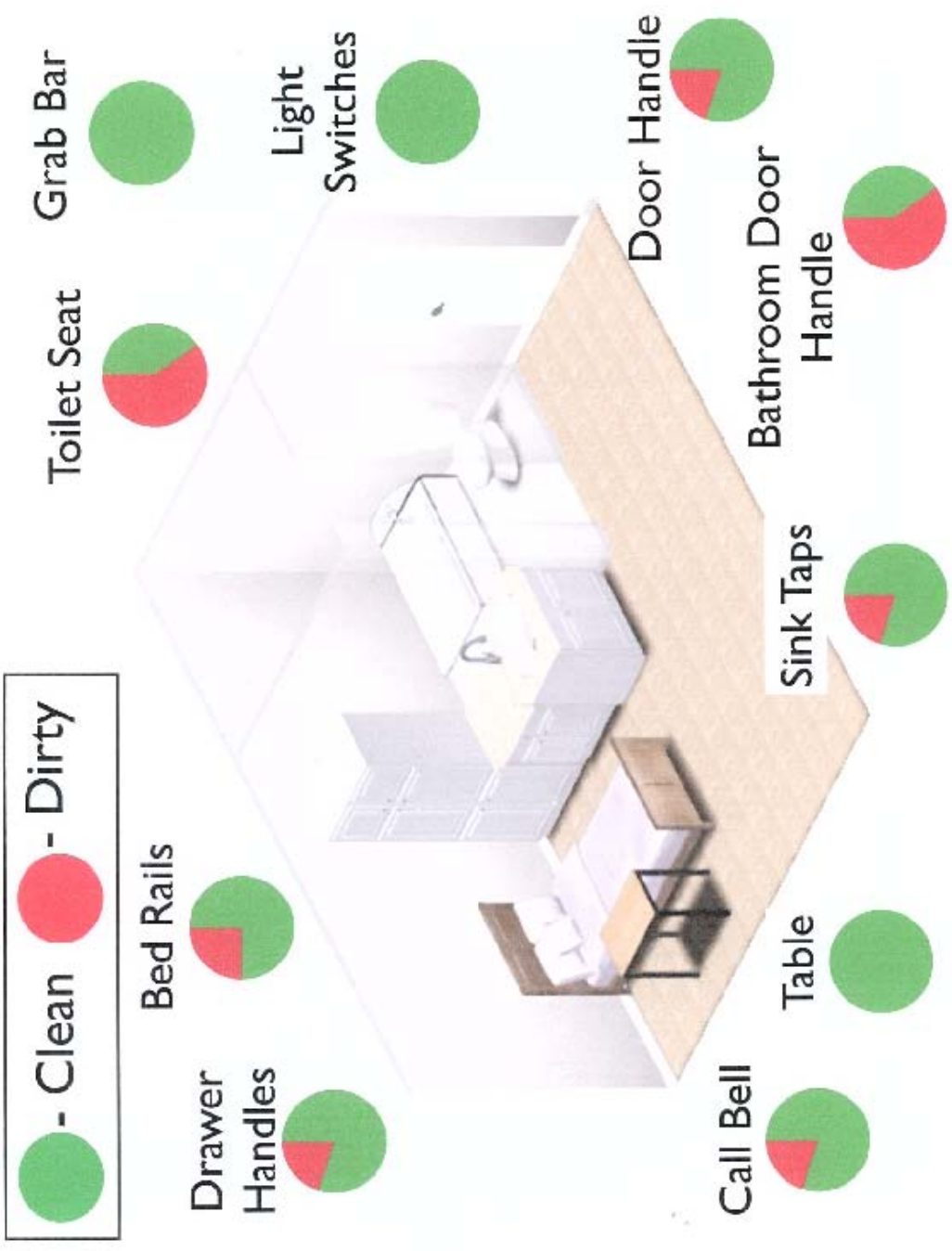
Cleaning Information
Date of Cleaning _dd_/_mm_/_yyyy_ Housekeeper:_____
Start of Cleaning: ____:____ am pm End of Cleaning: ____:____ am pm
Cleaning Solution (circle one): PCS Quats
Isolation Sign Present: Yes No (circle one) Contact Droplet Airborne

Room Information
Room Number:_____ Unit Number:_____
General comment on *pre*-clean condition: _____
_____
General comment on *post*-clean condition: _____
_____

Swab Information
UV Definitions: 'Clean', no dye remains, 'Partially Clean', some dye remains, 'Not Clean', all dye remains

Swab	UV Result (circle one)
A - Door handle (main)	Clean I Partially Clean I Not Clean
B - Bed rail and headboard	Clean I Partially Clean I Not Clean
C - Nurse call button	Clean I Partially Clean I Not Clean
D - Overbed table	Clean I Partially Clean I Not Clean
E - Door handle (bathroom)	Clean I Partially Clean I Not Clean
F - Toilet seat	Clean I Partially Clean I Not Clean
G - Bathroom grab bar	Clean I Partially Clean I Not Clean
H - Sink taps	Clean I Partially Clean I Not Clean
J - Light switch	Clean I Partially Clean I Not Clean
K - Drawer pull handles	Clean I Partially Clean I Not Clean

Appendix C


- Clean
- Dirty
Grab Bar
Toilet Seat
Light Switches
Bed Rails
Drawer Handles
Door Handle
Bathroom Door Handle
Sink Taps
Table
Call Bell

Appendix D

Appendix E

Craig Pearce
203 – 329 19 Ave SW
Calgary AB
T2S 0E1
June 17, 2010

To the Conjoint Health Research Ethics Board,

RE: Amendment to the project titled "Measuring the effectiveness of terminal cleaning by housekeepers at the Foothills Medical Centre"

Ethics ID# E-23026

I have a few amendments to the application submitted in the winter of 2010. They are outlined below for your review.

- Two consent forms have been attached for review. The first consent form is for housekeepers at FMC so we can track their specific cleaning progress and results. The second consent form is for patients at the FMC to access their medical records. Approval from health records has been obtained; the internal tracking number is #2567.
- In addition to swabbing the patient rooms for bacteria, we will also place a small amount of ultraviolet dye on selected surfaces. This UV dye is invisible to the naked eye but visible under special lighting conditions. The dye is removed by the mechanical actions of cleaning, therefore, if the UV dye remains on the surface once the cleaning is complete, we know that the housekeeper did not clean the surface. This analysis is different from swabbing as the UV dye indicates if cleaning was attempted, and the microbial swabbing indicates if the cleaning was successful in killing bacteria on the surface. These two outcomes are separate from one another; you can clean a surface but not kill any bacteria if the wrong concentrations of chemicals are used. The outcome measures of the UV dye analysis are surfaces that will be considered cleaned, partially cleaned or not cleaned, depending on the amount of UV dye left on the surface.
- Also attached are two data collection documents. The first is a brief chart review that we will use to extract and document characteristics of patients admitted to the study. The second document is a data collection for each cleaning event. This form records the details regarding each cleaning, and also identifies the swabs that were taken and the results of the UV dye analysis.
- We would also like to add Ms. Nancy Alfieri to the application as a co-investigator. She will have access to the information abstracted as listed in Section E - #3 and #7.

Thank you for considering these changes,

Craig Pearce

Appendix F

Alberta Health Services

TITLE: Measuring the Effectiveness of Terminal Cleaning by Housekeepers at the Foothills Medical Center.

SPONSOR: None

INVESTIGATORS: Dr. Elizabeth Henderson, Craig Pearce, Dr. Thomas Louie, Frank Galetta, Nancy Alfieri, and Dr. Theresa Kline

403-944-4373

This consent form is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Take the time to read this carefully and to understand any accompanying information. You will receive a copy of this form.

BACKGROUND

While staying at the hospital, some patients unknowingly leave behind some germs and bacteria when they leave. There is some evidence to show that the next person to stay in the room might pick up these germs or bacteria and can become infected. To help prevent this, hospitals clean each room thoroughly after each person leaves. This is called terminal room cleaning. The researchers are interested in finding out how effective this terminal room cleaning is.

Once you leave your hospital room, the researchers will enter your room and use cotton swabs to test for any germs or bacteria. The researchers will test for germs and bacteria on 10 high touch surfaces within the hospital room. The hospital housekeepers will then complete their usual terminal cleaning. After the cleaning is complete, the researchers will once again use cotton swabs to test for germs or bacteria. By looking at the before and after number of germs and bacteria, the researchers will be able to determine how effective this terminal cleaning is.

The researchers will also review your health record to look for possible factors that could lead to more germs or bacteria being spread. This would include things like your mobility during your stay, if you suffered from some diarrhea or if you had any infections caused by germs or bacteria.

The researchers will test approximately 50 patient rooms during the course of this research

Alberta Health Services

project.

WHAT IS THE PURPOSE OF THE STUDY?

The researchers are interested in how effective terminal cleaning is so they can try to improve it. The researchers will be looking at what objects are often not cleaned during after a patient leaves a room, and therefore they can talk to housekeepers and help them improve terminal cleaning. The researchers will also be looking at what type of patient leaves behind the most germs and bacteria. For example, a person that cannot get up to use the bathroom might leave behind more germs than someone that can walk to the bathroom.

WHAT WOULD I HAVE TO DO?

You will not have to do anything during your stay at the Foothill Hospital except allow us to review your health record (chart) so we can see what your health status has been during this stay. The entire research will take place once you are discharged from your hospital room. The researchers do ask for your permission to review your health record. The researchers will focus only on your most current stay at the Foothills Hospital. The researchers will not need to contact you or ask you any questions.

WHAT ARE THE RISKS?

There is no risk to you by participating in this study.

WILL I BENEFIT IF I TAKE PART?

If you agree to participate in this study there may or may not be a direct benefit to you. If you are in the study because you have been identified as a patient at the Foothills Hospital, your condition may be improved during the study but there is no guarantee that this research will help you. The information we get from this study may help us to provide cleaner rooms in the future for patients that are admitted to Foothills Hospital.

DO I HAVE TO PARTICIPATE?

You do not have to participate. Participation is completely voluntary. If you do choose to participate, you may withdraw at any time. To do so, dial the phone number on the first page of this consent form and inform the researcher you would like to withdraw. You do not need to provide any reasons for your withdrawal. Once you withdraw, none of your information will be included in the research. Withdrawing will not affect the care you receive from Foothills

Alberta Health Services

Hospital, or any other health care provider. Typical reasons for withdrawal might be that that patient would not like their health records reviewed, or they would not like their room tested for germs and bacteria.

If any new information becomes available, that might affect your participation in this research, you will be informed immediately.

WILL I BE PAID FOR PARTICIPATING, OR DO I HAVE TO PAY FOR ANYTHING?

You will not be paid for participating. You will also not have to pay anything to participate.

WILL MY RECORDS BE KEPT PRIVATE?

The only people that will have access to your health records are investigators named on the first page of this consent form. The Conjoint Health Research Ethics Board will also have access.

To help keep your records private, the researchers will review your records in the hospital. The researchers will not record your name, personal health number, address, or any other items that could link these records to you. Each patient participating will be assigned a random number. This number will be used to refer to participating patients.

According to University of Calgary policy, all information collected must be kept for 12 years. All records will be stored in the Infection Prevention and Control offices at the Foothills Hospital. They will be locked up and only accessible to the investigators named on the first page of this letter.

SIGNATURES

Your signature on this form indicates that you have understood to your satisfaction the information regarding your participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time without jeopardizing your health care. If you have further questions concerning matters related to this research, please contact:

Dr. Elizabeth Henderson (403) 944-4373

Or

Dr. Thomas Louie (403) 944-4766

If you have any questions concerning your rights as a possible participant in this research, please contact The Director, the Office of Medical Bioethics, University of Calgary at 403-220-7990.

Participant's Name	Signature and Date
Investigator/Delegate's Name	Signature and Date
Witness' Name	Signature and Date

The University of Calgary Conjoint Health Research Ethics Board has approved this research study.

A signed copy of this consent form has been given to you to keep for your records and reference.

Appendix G

Appendix H

Craig Pearce
208-2233 34 Ave Sw
Calgary, AB
T2T 6N2

November 24, 2010

To the Conjoint Health Research Ethics Board,

RE: Amendment to the project titled "Measuring the effectiveness of terminal cleaning by housekeepers at the Foothills Medical Centre"

Ethics ID# E-23026

I have outlined changes to the project your review.

- After consultation with a biostatistician, sample size has changed due to a clustering effect. The investigation will recruit 16 housekeepers from FMC. From each housekeeper, we will collect data from 5 of their terminal cleans that occur within a patients room. A short, educational intervention will then occur where the housekeepers will be shown results from their particular rooms. The investigator will highlight areas of success and areas requiring more attention. Once this is complete for each housekeeper an additional 5 terminal cleans will be followed.
- Due to the modification in the previous point, a change needed to be made to the housekeeper consent form. A revised form is attached and the modified sections are highlighted in grey. The change is under the "What Would I Have To Do?" section on page 2

Thank you for considering these changes,

Craig Pearce

Appendix J

Appendix K

Appendix L