University of Alberta

Barriers and Bridges to Infection Prevention and Control in the Netherlands and Canada: Two Comparative Case Studies

by

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Faculty of Nursing

Spring, 2011
Edmonton, Alberta

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Abstract

The overall aim of this research was to explore why some hospitals are more successful than others at reducing the acquisition rates of multidrug-resistant organisms. Using a socio-ecological perspective on health systems adapted from works in ecological restoration, ecosystems management, and healthcare, a participatory comparative case study design was employed. The study was collaboratively conducted on a surgical unit at a Netherlands hospital with very low rates of multidrug-resistant organisms and a surgical unit in a Canadian hospital with higher rates of these pathogens. The cases were selected on the basis that they were both academic health sciences centres of similar size in publicly funded systems; yet, they reported differing rates of MDRO infections. Research methods included a total of six unit observations, nine practitioner-led photo walkabouts of the units (n=13), six photo elicitation focus groups with practitioners (n=26), and the review of relevant policies and procedures and related infection prevention and control data.

Common findings across both cases include the perceived importance of engaged leadership, the presence of environmental design issues, a lack of antibiotic prescribing restrictions, and the frequent use of workarounds that may be problematic for infection prevention and control. Disparate findings between cases include differences in ratios of hospital beds per capita, bed occupancy rates, staffing practices, equipment cleaning processes, bed cleaning systems (centralized versus manual) and the presence, in one hospital, of an active grass roots Hygiene in Practice group engaging practitioners in several ongoing

activities to promote infection prevention and control. There is a lack of comparable findings between the two cases on hand hygiene audit protocols, surveillance strategies, reporting of acquisition rates, and the nature and extent of high risk populations for community-acquired methicillin-resistant *Staphylococcus aureus* in the two hospitals' catchment areas. The findings and methodological challenges identified in this study suggest that case selection in future comparative infection prevention and control case studies should be based on an expanded list of criteria. These criteria should include comparable audits, surveillance, and reporting practices and comparable demographic and other relevant data, such as data on the agricultural practices within and demographic attributes of vulnerable populations within the hospital catchment areas.

Acknowledgements

I would like to acknowledge and thank all the participants for their contributions to this study. I am tremendously grateful to and acknowledge my dissertation committee for their guidance, valuable feedback and critique of my work. I am grateful to my supervisor, Dr. Patricia Marck for her thorough feedback and guidance throughout this journey. Thank you for your support and for constantly challenging my thinking. I am also deeply thankful to Dr. Anne Sales, Dr. Geoffrey Taylor, Dr. Naomi Krogman and Dr. Patricia W. Stone for sharing your expertise and for your conscientious feedback on my work.

I would like to acknowledge the funding support received from the University of Alberta Provost Doctoral Entrance Award (2006 & 2007), the University of Alberta Mary Louise Imrie Graduate Award (2008), the Registered Nurses' Association of Ontario Nursing Education Initiative (2006-2009), The Ottawa Hospital Susan Robblee Bursary Award (2010), the Canadian Patient Safety Institute, the Registered Nurses' Foundation of Ontario Award (Rolling Stones/CPI Award) for the Advancement of Professional Practice in Infection Control (2008) as well as my graduate research assistantships opportunities with Dr. Patricia Marck, Faculty of Nursing, University of Alberta.

I also want to extend a special thank you to my husband who has encouraged me and inspired me to keep going. I am eternally grateful to my mother, to whom I could always rely on her for support and guidance. She did whatever she could to help.

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List of Abbreviations

ABHR	Alcohol-based hand rub
CDI	*Clostridium difficile* infections
ESBL	Extended spectrum beta-lactamases
FG	Focus group
HAI	Healthcare-associated infections
ICP	Infection control professional
IP&C	Infection prevention and control
MDRO	Multidrug-resistant organisms
MRSA	Methicillin-resistant *Staphylococcus aureus*
PW	Photo walkabout
VRE	Vancomycin-resistant *enterococci*

CHAPTER 1: Introduction and Overview

Why do some hospitals appear to be more successful than others at preventing the acquisition of multidrug-resistant organisms (MDRO)? What are the similarities and the differences in infection prevention and control (IP&C) in these hospitals that can impact the rate of MDRO in hospitals? In this dissertation, a comparative case study approach using a socio-ecological perspective on health systems adapted from works in ecological restoration, ecosystems management, and healthcare was employed to achieve a participatory, collaborative approach to the design, conduct, and analysis of the barriers and bridges to IP&C in two hospital surgical units in different countries as well as formulate future recommendation for practice, research, education, and policy. In this introductory chapter, I provide a brief background and overview of the study's conceptual framework, methods, and data analysis, a description of the mixed paper dissertation format, and a summary of the five dissertation papers.

Background

Patient safety is a significant issue facing healthcare systems across the world. In Canada, "between 9,250 and 23,750 people per year experience a preventable adverse event and later die; more than the number who die from breast cancer, motor vehicle and transport accidents, and HIV combined" (CIHI, 2004). In 2004, a landmark study on the incidence of adverse events among patients in acute care hospitals in Canada suggested that approximately 7.5% of the almost 2.5 million adult medical and surgical admissions were associated with an adverse event resulting in death, disability or prolonged hospital stay (Baker et al., 2004). Healthcare-associated infections (HAI) are one of the most frequent and severe complications of hospitalization, and are in Canada, the fourth leading cause of in-hospital death (Baker et al., 2004). It is estimated that 250,000 Canadian patients who are admitted to hospital every year acquire infections and every year, more than 8,000 die from those infections (Zoutman et al., 2003). Internationally, HAI affect over 1.4 million people at any time (World Health Organization, 2002).

Infection control in the acute care environment is one of the most important issues in modern healthcare. HAI and more specifically, MDRO infections are an important patient safety issue in healthcare settings (Burke, 2003) and they are often linked to increased length of stays, mortality, and costs adversely affecting patients and health professionals (Brooklyn Antibiotic Resistance Task Force, 2002; Song et al., 2003; Cosgrove, 2006). Though the importance of infection control is well recognized and numerous research studies and best practice guidelines have been published on this topic, infections rates of MDRO are on the rise in Canada (Zoutman et al., 2005); and IP&C remains a challenge. In contrast, the control of healthcare-associated methicillin-resistant *Staphylococcus aureus* (MRSA), one of the MDRO is "reported to be optimal in the Scandinavian countries [and also in the Netherlands], where strict barrier precautions are in place along with active surveillance programs" (West et al., 2006, p.236). Some European countries such as the Netherlands have been recognized as world leaders at minimizing MDRO infection rates, in particular MRSA (Vriens et al., 2002).

To develop a better understanding of what may be shaping the apparent differences in the prevention of MRSA and other MDRO between Canadian hospitals and the Netherlands hospitals, where they have been recognized as leaders in the area of infection control, I conducted two in-depth comparative case studies within university affiliated tertiary centres, using methodology outlined by Yin (2003), Tellis (1997), and Stake (2006). Specifically, I investigated the socio-ecological context for IP&C on a surgical unit in an acute care tertiary hospital in the Netherlands that reported rates of MDRO below 1% and on a surgical unit in an acute care tertiary hospital in Canada which reported higher rates of these pathogens. These cases were selected to better understand the conditions influencing IP&C practices in these two countries.

Multidrug-resistant organisms (MDRO)

MDRO are defined as “microorganisms, predominantly bacteria that are resistant to one or more classes of antimicrobial agents” (Siegel et al., 2006, p.5). This research focused particularly on the following most common MDRO: methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBL), and *Clostridium difficile* infections (CDI). Although certain MDRO, such as MRSA and VRE are described to be resistant to only one agent, these are frequently resistant to most available antimicrobial agents (Siegel et al., 2006). Certain gram-negative bacilli (GNB), including those producing extended spectrum beta-lactamases (ESBL) and others that are resistant to multiple classes of antimicrobial agents such as *Clostridium difficile*, are of concern in the acute care setting.

Transmission of MDRO

The implementation and adherence to an IP&C program, including appropriate antibiotic usage, are important factors that affect the transmission of MDRO in the healthcare setting (Bonten et al., 1998). In a 1998 study, Bonten and colleagues also studied the concept of ‘colonization pressure’ (number of other colonized patients), in addition to the effects of compliance with infection control practices and antibiotic use on the acquisition of VRE and concluded that ‘colonization pressure’ was also an important factor affecting the acquisition of VRE in a medical ICU. As well, Merrer and colleagues (2000) showed a strong influence of ‘colonization pressure’ on the acquisition of MRSA in medical ICU patients. According to several researchers, the results of hand cultures suggest that MDRO are carried from one person to another via the hands of health professionals (Duckro et al., 2005; Bhalla et al., 2004; Almuneef et al., 2001; Lee et al., 1994). The contamination of hands can occur during contact with an infected patient or during contact with environmental surfaces (Bhalla et al., 2004; Almuneef et al., 2001). These study findings confirm that proper hand hygiene practices are an important component to the overall IP&C strategies to reduce the transmission of MDRO. The strategies to reduce the transmission of MDRO involve efforts from all interdisciplinary team members including nurses, infection control professionals (ICP), physicians, senior leaders and management, and other health professionals.

MDRO infection control literature

Researchers have implemented infection control interventions to study their impact on the rate of MDRO transmission. These interventions targeted improvements in several areas including: hand hygiene, use of contact precautions, active surveillance cultures, education, enhanced environmental cleaning, and improvements in communication within and between healthcare organizations about patients with MDRO infections. Several of these studies have shown either a reduction or no increase in MRSA transmission rates in the Netherlands and Scandinavian countries after the implementation of aggressive and sustained infection control interventions (e.g. active surveillance cultures; preemptive use of contact precautions upon admission until proven culture negative; and, in some instances, closure of units to new admissions) (Verhoef et al., 1999; Salmenlinna et al., 2000; Voss et al., 1994). A study in 30 healthcare facilities in the United States showed a reduction of VRE transmission rates following the development of a task force to create an effective region-wide infection control intervention including active surveillance cultures and isolation of infected patients. The overall prevalence rate of VRE in the participating facilities decreased from 2.2% in 1997 to 0.5% in 1999 (Ostrowsky et al., 2001). In addition, two outbreak studies showed similar results with the implementation of multiple interventions. The first, an investigation over a 13-month period resulted in controlling and eventually eradicating VRE from a burn unit with the implementation of aggressive culturing, environmental cleaning, and barrier isolation (Falk et al., 2000). The second study demonstrated the control of a VRE outbreak in a NICU over a 3-year period through the implementation of active surveillance cultures, mandatory in-service education as well as other infection control measures such as the use of alcohol-based hand rubs (Sherer et al., 2005).

Many studies and guidelines have been published in the last ten years to support the implementation of multiple interventions in preventing and controlling MRSA, VRE, and other MDRO (Siegel et al., 2006). Although these published studies have shown successful reductions or elimination of MDRO, several factors including the difference in definitions, in study design, in outcomes, in confounding variables, and in period of follow-up, have limited the ability to draw general conclusions from these results. Additionally, the studies are largely descriptive or quasi-experimental (Harris et al., 2004) with no explicit theory articulated about IP&C as the basis for the research design. The use of theory-driven research, which is often lacking in both patient safety literature (Shojania et al., 2002; Marck, 2005; Auerback et al., 2007) and infection control literature (Backman et al., 2008; Backman et al., in press; Macdonald, 2004) to date is needed to assist researchers to design studies which more accurately reflect the real world and possibly, at some point, more accurately predict how specific interventions in particular doses and contexts might affect outcomes. Given the lack of theoretically driven studies to date in the field, it has not been possible to determine which individual interventions or specific combinations of interventions are most effective in reducing the incidence of MDRO. One promising theoretical line of inquiry is supported by Struelens' recommendation to take a broad socio-ecological approach to the study and management of IP&C.

This call for a socio-ecological perspective is well supported by other experts including Ali (2004), Gloubeman (2001), Macdonald (2004), and Waldvoegl (2004), who all argue that a host of inter-related social and environmental factors play a critical role in the emergence and trajectory of infectious diseases in 21st century societies and their health systems.

A socio-ecological approach to research in nursing and healthcare

A socio-ecological approach (Lockett et al., 2005; Edwards et al., 2004; Anderson et al., 2005; Lausten, 2006) provides "a framework for understanding the diverse personal and environmental factors and the interrelationships among these factors that influence a given health problem" (Stokols, 1996 in Edwards et al., 2004, p.45). This perspective incorporates knowledge from social, economic, political, and cultural influential factors (Edwards et al., 2004).

Various socio-ecological lenses have been employed to study a variety of health systems safety issues. In community health, Lockett et al. (2005) used photographic methods to look at the social and environmental factors that influenced seniors' choices of walking routes. The results showed that the most frequent safety issues for walking seniors were related to insufficient time to cross intersections, failure of drivers to stop at crosswalks, unsafe stairs and entranceways, and poor maintenance of sidewalks. Anderson and colleagues (2005) proposed the use of complexity theory and case study methods to study healthcare organizations. Organizations are dynamic, living social systems (Capra, 2000 in Anderson et al., 2005), that are "not constituted merely by the sum of its components, but also by the intricate relationships between these components" (Cilliers, 1998 in Anderson et al., 2005). Anderson and colleagues argued for a system approach to study healthcare organizations as integrated wholes. Colon-Emeric et al. (2006) applied the use of complexity theory with a case study method to describe how connections among staff impact the care planning process in four nursing homes. The results showed an association between greater connection among staff and the innovation of care planning.

In related work, Marck and colleagues have adapted socio-ecological thinking from community health (Edwards et al., 2004), ecological restoration (Higgs, 1991, 1997, 1999, 2003), and ecosystems management (Gunderson et al., 1995, 2001; Holling, 1998) to build theory-driven research related to the safety and integrity of healthcare environments in a variety of areas. Ecological restoration is defined as the "process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration International Science & Policy Working Group, 2004, p. 3). The research of Gunderson and colleagues (1995, 2001) focuses on understanding barriers and bridges to better ecosystem management and the refinement of a socio-ecological perspective on complex adaptive systems. Their original case study approach laid the groundwork for "how to break down barriers and build new bridges for a sustainable future of these complex, adaptive systems of humans and nature" (1995, p.532).

For Higgs (1997, 2003), the principles of good ecological restoration include those of 'ecological effectiveness', 'ecological efficiency', and 'ethical cultures by design'. Ecologically effective restorations consist of repairs that increase the integrity of the system and maintain fidelity to the history of the place. Ecologically efficient restorations focus on the set up of sustainable safe margins for error and for levels of productions. The generation of ethical cultures by design centers on the engagement in communal work that improves the way we care for each other and the places we share. These principles are viewed as important when studying and repairing the ecological integrity of damaged ecosystems.

To date, Marck and colleagues have drawn on these schools of socio-ecological thinking to examine hospital medication safety in Canada (Marck et al., 2006b) and in Brazil (Raduenz et al., 2010), home care medication safety (Marck et al., 2010), organizational ethics (Hofmeyer et al., 2008; Marck, 2004a; Marck, 2004b), and the use of restorative visual research methods (Marck et al., 2010; Marck et al., 2008). Common to all these projects is the use of participatory, multidisciplinary restorative visual methods to engage one or more of practitioners, managers, students, and clients in the collaborative study of healthcare safety issues with a socio-ecological lens.

Struelens (1998) contends that an innovative multidisciplinary collaborative effort is needed to provide a more comprehensive and concise approach for healthcare organizations to reduce the MDRO burdens in an efficient and cost-effective manner. A socio-ecological perspective on IP&C includes attention to the human-environmental context within which infectious agents are generated and transmitted. Macdonald (2004) proposed the use of an integrative model of environmental health to study infectious diseases. The model by Dixon and Dixon (2002) is divided up into the physiological domain, the vulnerability domain, the epistemological domain, and the health protection domain. Each domain provides an answer to a specific question. The physiological domain describes what the problem is, the vulnerability domain describes who is affected, the epistemological domain explains how everyone knows about the problem being studied, and the health protection domain describes what people can do about it. Macdonald (2004) argues for a broader view on infectious diseases, with a shift from the current focus on the treatment of the disease itself to a more global ecological initiative for integrated disease prevention.

In Backman et al. (2008), we also call for a more integrative approach to IP&C research. Thus, an integrative approach using socio-ecological thinking from the fields of ecological restoration, ecosystems management, and health systems research guided my case study approach to the phenomena of managing MDRO in today's healthcare environments.

Research Question and Objectives

My overall guiding question for this research study was: What are the differences and the similarities in the conditions for IP&C on (1) a surgical unit in an acute care tertiary hospital in the Netherlands that reported rates of MDRO below 1%; and (2) a surgical unit in an acute care tertiary hospital in Canada which reported higher rates of these pathogens?

In both hospital settings, my research objectives were to:

1. observe the overall work environment including IP&C practices on the target surgical units;

2. analyze the policies and procedures aimed at the prevention and minimization of MDRO in their respective hospital and unit environments;
3. analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environments; and
4. collect monthly specific IP&C related anonymized data on the target surgical units and in the two facilities overall for a duration of 12 months including: nurse-to-patient ratios, occupancy rates, a descriptive nature of the patient population, the hospital architecture (e.g. proportion of single bed rooms, shared bathrooms, etc), description of hand hygiene audit methods including the frequency of audits and hand hygiene adherence rates, and definitions and acquisition rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBL) and *Clostridium difficile* infections (CDI).

Methods

This study was informed by socio-ecological thinking, principles of good ecological restoration, and a critical realist view of science. A participatory, integrative approach to science as it has been conducted in restoration research (Higgs, 2003) and ecosystems management (Gunderson et al., 1995), and subsequently adapted to nursing and health systems research (Marck, 2006a; Marck, 2006b) was used. The scientific methods that exemplify a restorative approach to research include the use of multiple source of data as fits the research questions, working with local decision-makers to design the research and identify relevant sources of data, observing and sharing findings with the practice communities about their local customs and work pattern, documenting daily practices, and inviting practitioners and other local experts to lead the collection of relevant data (Marck, 2006a; Marck et al., 2006c; Edwards et al., 2004; Higgs et al., 1999).

In this comparative case study research design, data were collected concurrently and analyzed iteratively to provide a comprehensive answer to the research question. The purpose of this approach was to gain an in-depth understanding of each case through careful analysis of multiple sources of information (Yin, 2003; Tellis, 1997). Further details on the methods are provided in Chapter 3 (Dissertation Paper 2).

Setting and sampling strategies

Two case studies were conducted between April and December 2008, the first on a surgical unit at a Netherlands hospital that reported rates of MDRO below 1%; and the second on a surgical unit at a Canadian hospital that has higher rates of these pathogens. These two hospitals were selected to better understand the nature of IP&C practices in two hospitals in different countries on the basis that they were both academic health sciences centres of similar size in developed countries with publicly funded systems; yet, they reported differing rates of MDRO infections. In the Netherlands, the MRSA prevalence rate was reported as being less than 1% (Muto et al., 2003). The ‘search and destroy’ strategy for MRSA has been associated with successful reductions in the acquisition of MRSA and has been identified as a key feature in the overall success of the Netherlands in limiting MDRO spread (Verhoef et al., 1999; Wertheim et al., 2004; Vos, 2009). In Canadian hospitals, the overall incidence of MRSA was on the rise from 0.65 in 1995 to 11.04 cases per 10,000 patient-days in 2007 (Simor et al., 2010). These overall observations suggested that a socio-ecological perspective on hospital practices might reveal critical differences that were possibly linked to the differences in acquisition rates.

The first case study was conducted on a 34-bed surgical unit at a Netherlands hospital consisting of orthopedic, cosmetic, urology, general surgery, and no off-service patients. The second case was conducted on a 40-bed unit at a Canadian hospital with a general surgery, otolaryngology, and ophthalmology population as well as off-service patients due to overcapacity issues. The sampling strategies that were used in this study to meet the research objectives were as follows:

- **Nurses, physicians, housekeeping staff, and other health professionals working on the study unit at both hospitals (Objective 1)**

I observed the work and work environment of nurses, physicians, housekeeping staff, and other hospital staff on three different days in each target unit to gain an initial perspective of the overall environment and IP&C practices. The nurses, physicians, housekeeping staff, and other hospital staff on the units were informed that the study was taking place. The observations collected were shared with them and with the hospital in aggregate form only and not linked to any individuals.

- **IP&C policies and procedures (Objective 2)**

I collected all policies and procedures relevant to IP&C practices on the unit and within the hospital including those pertaining to hand hygiene, facility design, laboratory techniques and protocols, cleaning schedules and protocols, infection control education and training for staff, observation or audit tools, reporting of MDRO, isolation procedures, screening processes, surveillance, and antibiotic usage.

- **Management, health professionals and clinical support staff (Objective 3)**

In order to generate an initial list of IP&C issues for the photographic unit walkabouts, I discussed the possible issues with the ICP and the unit manager. Using the initial problem list as a starting point, I then asked the following three groups below to participate in a practitioner-led photo walkabout and photo narration of their perceptions of the concerns and strengths on their unit in relation to infection control. The three groups in each organization were:

- **Management:** an ICP and a unit leader (e.g. unit manager or team leader)
- **Health professionals:** a senior nurse and a physician
- **Clinical support staff:** a member of the housekeeping staff

Following collection and preparation of the photos and narrative text in ATLAS.ti version 5.3 software (ATLAS.ti Scientific Software Development GmBH, Berlin), I recruited practitioners for each of the focus groups to participate in the review and further comment on the images and narratives collected during the walkabout. The three focus groups in each organization, which included individuals at different levels of the organizations (e.g. managers, staff (nurses, housekeeping, etc), physicians) and across disciplines (e.g. nursing, food, transportation, engineering services, housekeeping), were conducted with:

- **Management:** an ICP, the unit leader, a housekeeping manager, managers of engineering/planning, dietary, and transportation services
- **Health professionals:** a senior nurse, a nurse educator, a physician, and other health professionals
- **Clinical support staff:** housekeeping staff, staff from engineering/planning, dietary, and transportation services

The rationale for conducting separate focus groups with management, health professionals, and clinical support staff was to help maximize participation and avoid any power imbalances within the groups. As Cote-Arsenault and Morrison-Beedy (2005) explain, “groups should not be comprised of members with differing levels of power (e.g. supervisors and employees)” (p.174). These individuals should be divided in separate groups because it is more likely that the individuals “with less power [would] participate less fully or openly” (Cote-Arsenault and Morrison-Beedy, 2005, p.175).

- **Specific IP&C related data (Objective 4)**

I collected aggregated, anonymized IP&C related data for the units and the hospitals for a period of twelve months. The data included nurse-to-patient ratios, occupancy rates, descriptive nature of the patient population (e.g. type of population), hospital architecture (e.g. proportion of single bed rooms, shared bathrooms, etc), description of hand hygiene audit methods, frequency of audits and hand hygiene adherence rates, and definitions and acquisition rates of MRSA, VRE, ESBL, and CDI.

Data collection

In keeping with a restorative approach, the following data collection strategies were employed to better understand the conditions of the respective workplaces in terms of IP&C:

- **Observation of staff and housekeeping on the units (Objective 1)**

I observed and documented the work and work environment of staff and housekeeping on three different days in each target unit to gain an initial perspective on the overall environment and IP&C practices. I documented my observations as field notes in my study notepad.

- **Documentation of local policies and procedures (Objective 2)**

I collected and analyzed the policies and procedures relevant to IP&C practices within the organization.

- **Participatory photo walkabouts with practitioners' photo narration, Photo elicitation focus groups with written comments, and field notes (Objective 3)**

In both hospitals, I used photographic research methods including practitioner-led unit walkabouts with photo narration and photo elicitation focus groups. A practitioner-guided "ecological tour' of the unit enabled me to foster community participation and tap into the local expertise and local ecological knowledge that practitioners have about the places where they work in order to assess their infection control environment. Photo narration corresponds to the practitioner's 'story' and the 'history' behind the photographs. Photo elicitation is "an approach where photographs taken by the researcher or participants are used to elicit, draw out, evoke responses from participants" (Harper, 2002, p. 20). In restoration science, Rhemtulla and Higgs have used repeat photography, photo elicitation, and photo narration to document historical changes in Jasper National Park over time and foster citizen engagement in the critical examination and awareness of their surroundings in citizen forums where they reviewed the photos together (photo elicitation) and shared stories about how things had changed over time (using photo narration to develop historical continuity about a place) (Rhemtulla et al, 2002). Staff were informed about the unit observations, and informed consent was obtained from all the participants in the photo walkabouts and focus group sessions at both hospitals (Appendix A: The Netherlands Hospital Consent Form and B: Canadian Hospital Consent Form).

A restorative approach to photographic research methods was first adapted from restoration science by testing the use of repeat photography, photo elicitation, and photo narration to study medication safety in an acute medical unit of a large teaching hospital (Marck et al., 2006b). Specifically, Marck and al. worked with practitioners to design and pilot a multifaceted medication safety intervention which included the design and testing of a medication safety checklist, the implementation of several changes to medication safety practices and processes and structures, practitioner-led unit walkabouts to collect repeat (pre and post-intervention) photographs of unit medication safety issues, and the use of photo elicitation and photo narration to collaboratively design and evaluate practitioners' perceptions of the intervention. In this study, I further adapted these methods to study the socio-ecological conditions for IP&C on the target units as outlined below.

Across the two study units, I conducted a total of nine participatory, audio-taped unit walkabouts to identify, photograph, and collect their narratives of the barriers and facilitators to IP&C in their environments (Appendix C: Protocol for Collecting Photo Narrations and D: Protocol for Collecting Visual Data). All photographs were tracked using a spreadsheet (Appendix E: Photograph Database Tracking Tool). Photographs for the focus groups were selected based on the established selection criteria for the study (Appendix F: Selection Criteria for Focus Group Photographs).

I conducted a total of six focus groups (Appendix G: Moderator's Guide) with participants, three on each study unit. I elicited input from the teams on the strengths and limits of their IP&C program on their unit and in their hospital. The participants also provided their written comments (Appendix H: Modified Digital Photograph Scoring Tool). Each group then discussed each picture and their comments as a group. Based on the "story" of IP&C that the participants generated, I asked them to offer their ideas about (a) what was working well, and (b) what could be improved in terms of IP&C on their unit and in their hospital. To augment these sources of data, I also completed field notes about my own observations of group dynamics and the setting for both the photo walkabouts and the photo elicitation sessions.

- **Collection of specific IP&C related data (Objective 4)**

I collected aggregated, anonymized IP&C related data for the units and the hospitals. The data included: nurse: patient ratios, bed occupancy rates, the descriptive nature of the patient population of each study unit, the details of the hospital architecture (e.g. proportion of single bed rooms, shared bathrooms, etc), and the description of hand hygiene audit methods and adherence rates (if available). I also collected the definitions and prevalence rates of MRSA, VRE, ESBL, and CDI for each hospital overall. The findings are discussed in detail in Chapters 4, 5, and 6 (Dissertation Papers 3, 4, and 5).

Data analysis

Fuller descriptions of the data analysis procedures are outlined in Chapters 3 and 6 of the dissertation. In brief, the data analysis for each case study was performed by ongoing, iterative examination and interpretation of the data in order to reach tentative conclusions based on the data and preliminary findings that were generated (Yin, 2003). ATLAS.ti version 5.3 software (ATLAS.ti Scientific Software Development GmBH, Berlin) was used to support the qualitative analysis of the data and assisted with the development of an integrative interpretation of all the findings.

The data were analyzed iteratively to inform each phase of the research study. Each document was added to ATLAS.ti as primary documents (e.g. field notes of unit observations, transcripts and field notes of the photo walkabouts, select photographs from the walkabouts, transcripts and field notes of the focus groups, and written comments obtained during the focus groups) then coded, compared, and contrasted. A list of codes is available in Appendix I. As the qualitative data analysis progressed, potential links were developed between various groupings of data, the codes assigned, and emerging theory (including various socio-ecological frameworks (for example, Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006c), any relevant literature, the policies and procedures, prevalence rates, and any other institutional documents. An example of the initial draft of the data matrix for case study #1 is available in Appendix J. For the specific steps of the data analysis, please refer to Appendix K and L (Original and Revised Protocol for the Analysis of the Visual and Written Text) and Chapter 3 (Dissertation Paper 2). Once the preliminary analysis was completed, an initial draft of the themes (Appendix M: Preliminary Themes and Codes for Case Study #1) was sent to local experts in both study sites for their review and feedback. The feedback is available in Appendix N (Examples of Local Experts' Responses to the Preliminary Themes (Case Study #1). In addition, the overall final themes are discussed in Chapters 4 and 5 (Dissertation Papers 3 and 4).

Following the individual case study analyses, a cross-case synthesis technique (Yin, 2003; Stake, 2006) was used to analyze and compare the case studies. The evidence for each case was displayed in tables and cross-case conclusions were drawn based on the overall pattern (similarities and differences) found in the data. An example of the cross-case data table is available in Appendix O. Further details on the analytic steps are described in Chapter 3 (Dissertation Paper #2). The comparative case study findings are discussed in Chapter 6 (Dissertation Paper #5).

Rigor

In case study research, the commonly used tests to ensure rigor are construct validity, internal reliability, external validity, and reliability (Yin 2003). The following criteria were identified prior to the study start and used in order to ensure that the results of the study were valid and reliable:

External validity and reliability

Comprehensive case study protocols were created for the conduct of the practitioner-led unit walkabouts, collection of photographs, and photo narrations (Appendix C, D and E), and the conduct of the focus groups (Appendix F and G) to ensure that the data collection procedures could be repeated. As well, a protocol was developed for the analysis of the visual and written text (Appendix K: Original Protocol for the Analysis of the Visual and Written Text and Appendix L: Revised Protocol for the Analysis of the Visual and Written Text). The data analysis protocol was revised based on my reflections of the research and ongoing discussion with my supervisor.

Construct validity and internal reliability

Multiple sources of evidence were used in this research to strengthen the validity and reliability of developing interpretations of the data. Word tables of the initial analysis were generated and reviewed with my supervisor (Appendix J: Draft of the Data Matrix for Case Study #1). Preliminary data analyses were also shared with my committee members as well as three PhD student colleagues and a post-doctoral fellow for feedback. A sample of scheduled dates confirming the review of sample data with my supervisor, committee members, local experts, and other PhD students is available in Appendix P. Local experts in both study settings reviewed an electronic version of my case reports. I incorporated their feedback as indicated into the final analysis.

To maintain the actual "chain of evidence" (Yin, 2003), the data were organized and documented using version codes and track changes. I also maintained a researcher's journal to capture my ongoing research related decision-making processes. My journal also served as an audit trail, to document and to track my ongoing reflections and thoughts about my data collection and data analysis. It was not used as a source of data. Examples of journal entries are available in Appendix Q.

Ethical Issues

This study was approved by the Health Research Ethics Boards of the University of Alberta, Edmonton, Alberta and the ethics committees of both the Canadian and the Netherlands hospitals. The following are the main ethical considerations that were accounted for in this study:

Participation in the study is on a voluntary basis

An information letter and consent form was distributed to all participants indicating that participation was voluntary and that there were no consequences for not participating in the study (Appendix A: The Netherlands Hospital Consent Form and B: Canadian Hospital Consent Form).

Confidentiality

I informed the participants that anonymity was not feasible in focus groups settings; however, no names of participants were used in the notes, analysis or publications. Confidentiality was discussed with participants prior to the initiation of the focus group. Participants were reminded that confidentiality cannot be guaranteed in a focus group setting and that the participants should avoid any discussions related to the content outside the group. Attendance was voluntary; no staff member would have been penalized in any way should they have chosen to refrain from taking part. Only the investigator and the investigator's supervisor have access to the audio recordings and transcripts. Information provided during the focus groups were not linked to any individual participants in the data analysis and reports of this research. Any identifying data provided by group participants were removed from the transcriptions. All study documents are locked in my home office.

Photography

No participants or patients were photographed as part of this study. Provision had been made that if an individual were to be photographed, a written consent would have been obtained.

Dissertation Papers

This doctoral dissertation is written in a mixed format which includes versions of a published peer reviewed article (1), a submitted manuscript which is under review (1), and unpublished papers (3). The unpublished papers will be submitted to peer reviewed journals upon completion of the doctoral defence. The five papers are:

1. Paper #1, Chapter 2 (in press; accepted July 29, 2010 to the *American Journal of Infection Control*): An integrative review of infection control programs for multidrug-resistant organisms in acute care hospitals

2. Paper #2, Chapter 3 (for submission in Fall 2011): Methodological insights on conducting comparative case study research
3. Paper #3, Chapter 4 (under review, submitted September 20, 2010 to the *Journal of Hospital Infection*): The results of the first case study on a surgical unit at a Netherlands hospital
4. Paper #4, Chapter 5 (for submission in Spring 2011): The results of the second case study on a surgical unit at a Canadian hospital
5. Paper #5, Chapter 6 (for submission in Spring 2011): The comparative case study analysis

A brief synopsis of each paper is outlined below.

Paper #1 (Chapter 2): An Integrative Review of Infection Control Programs for Multidrug-Resistant Organisms in Acute Care Hospitals: A Socio-Ecological Perspective

Dissertation Paper 1 was accepted for publication in the *American Journal of Infection Control* (Backman et al., in press) and a version of this paper is included in this dissertation with the permission of the journal (Appendix R).

In Paper 1, I conducted an integrative review of infection prevention and control programs (IP&C) for MDRO. The purpose of the review was to review and critique the literature on the relationship between an IP&C program and MDRO rates in acute care hospitals. Studies including original research published between January 1, 1998 and May 14, 2009, were identified through MEDLINE, CINAHL, EMBASE, PUBMED, The Cochrane Library, and expert consultation. A comprehensive search strategy was developed with a librarian to find studies that covered the main subject areas of this integrative review. Of the 1382 papers retrieved, 47 were reviewed and 32 studies met the inclusion criteria. The interventions in the included studies were assessed using the Tier 1/Tier 2 framework.

The studies, included in the review, employed a wide variety of interventions and a range of quasi-experimental designs. Numerous methodological limitations were noted, and overall, the evidence of a relationship between MDRO IP&C programs and the rates of MDRO was weak. However, the overall evidence does support the use of multiple interventions to reduce the rates of MDRO in acute care hospitals, and multiple studies employing active surveillance cultures were associated with reduced MDRO infections. Future individual reports of outbreaks and intervention studies should be written in a standardized manner using the recommended Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) guidelines. Further research is needed on the proposed Tier 1/Tier 2 framework clearly indicating all the interventions implemented.

Paper #2 (Chapter 3): Conducting Comparative Case Studies with a Socio-Ecological Lens: Insights from an Infection Prevention and Control Study

A version of the Dissertation Paper 2 will be submitted to the *International Journal of Qualitative Methods*.

In Paper 2, I share the insights I have gained throughout this research on the use of this kind of comparative case study approach to study IP&C in acute care hospitals. A summary of previous case study research work, examples of our case study research findings and insights gained while conducting comparative case study research were presented. I conclude that some key elements required to successfully conduct comparative case study research include careful selection of the cases, clear attention to rigor, the use of multiple methods to study the system as a whole, and specific protocols in place for the collection, analysis, and reporting of the data. I also argue that a comparative case study approach allows one to view and compare the context and the socio-ecological dynamics of different organizations (in this case, two hospital surgical units) and that there are benefits to this methodological approach to studying ways to reduce infections.

Paper #3 (Chapter 4): Barriers and Bridges to Infection Prevention and Control: Results of a Case Study of a Netherlands' Surgical Unit

A version of the Dissertation Paper 3 was submitted to the *Journal of Hospital Infection* and is under review.

In Paper 3, I discuss the findings from the first case study in IP&C, which was conducted on a surgical unit at a Netherlands hospital that reported successful reductions in the acquisition of targeted MDRO. Using the socio-ecological perspective on health systems I have outlined, I conducted unit observations (n=3), review of relevant policies and procedures, five practitioner-led photo walkabouts of the unit (n=7), three photo elicitation focus groups with practitioners (n=13), and the review of related IP&C data. The findings indicate some conditions and processes present that may influence the low acquisition of MDRO, including the 'search and destroy' active surveillance strategy, low occupancy rates, a centralized bed cleaning system, and the presence of an active grass roots Hygiene in Practice group which engages practitioners in several ongoing activities to promote IP&C on the units. These findings suggest there is merit in further exploring the potential benefits of such health system practices for optimal prevention and control of MDRO in modern hospital environments. Further research on the benefits of practitioner-led community of practices on IP&C practices such as the Hygiene in Practice group is also recommended. Additional case studies to compare theses practices to other acute care hospital around the world would be a valuable way to better understand what IP&C programs are most effective in which contexts, and for what reasons.

Paper #4 (Chapter 5): Barriers and Bridges to Infection Prevention and Control: Results of a Case Study of a Canadian Surgical Unit

A version of the Dissertation Paper 4 will be submitted to the *Canadian Journal of Infection Control* in the Spring of 2011.

In Paper 4, I discuss the findings from the second case study to identify the barriers and bridges for IP&C on a surgical unit at a large urban Canadian hospital. Using the same methodological approach as for the first case study, I conducted unit observations (n=3), review of relevant policies and procedures, four practitioner-led photo walkabouts of the unit (n=6), three photo elicitation focus groups with practitioners (n=13), and the review of related IP&C data. The findings indicate that despite active management support for IP&C, many challenges exist in the hospital environment. Key barriers included high patient occupancy rate, hospital design, the use of workarounds to adapt to these challenges, several common problematic practices and the culture of the team or organization. These findings confirm many challenges for IP&C that have been outlined in other literature for contemporary acute care environments. For example, to reduce the use of problematic workarounds, staff must be engaged in health system and organizational decision making processes that affect their workload, workflow and daily practices on the unit. Yet, the existence of problematic gaps between clinical, organizational, and health system governance has been identified as an issue for safety in healthcare. Additional research is needed to further our knowledge on how communities of researchers, practitioners, managers, and policy makers can collaboratively engage in studying and assessing their environments to design and implement meaningful, sustainable IP&C improvements.

Paper #5 (Chapter 6): Barriers and Bridges to Infection Prevention and Control on a surgical unit at a Netherlands' and a Canadian Hospital: A Comparative Case Study Analysis

A version of the Dissertation Paper 5 will be submitted to the *American Journal of Infection Control* in the Spring of 2011.

In Paper 5, I compare the findings of the Netherlands case study and the Canadian case study to develop insights and recommendations. Common findings identified across both cases include the perceived importance of engaged leadership, the presence of environmental design issues, a lack of antibiotic prescribing restrictions, and the frequent use of workarounds that may be problematic for IP&C. Disparate findings between the cases include differences in ratios of hospital beds per capita, bed occupancy rates, staffing practices, equipment cleaning processes, bed cleaning systems (centralized versus manual), and the presence, in one hospital, of an active grass roots Hygiene in Practice group engaging practitioners in several ongoing activities to promote IP&C. There is a lack of comparable findings between the two cases on hand hygiene audit protocols (observations versus product measurement), surveillance strategies (high risk versus universal screening), in reporting of acquisition rates (prevalence versus incidence rates), and the nature and extent of high risk populations for community-acquired methicillin-resistant *Staphylococcus aureus* (e.g. people in contact with pigs, veal calves or other livestock versus drug users, homeless people, and prisoners) in the two hospitals' catchment areas. The findings and methodological challenges identified in the comparative exercise suggest that case selection in future comparative IP&C case studies should be based on an expanded list of criteria. These criteria should include comparable audit, surveillance and reporting practices and comparable demographic and other relevant data, such as data on the agricultural practices within and demographic attributes of vulnerable populations within the hospital catchment areas.

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CHAPTER 2: An Integrative Review of Infection Control Programs for Multidrug-Resistant Organisms in Acute Care Hospitals: A Socio-Ecological Perspective

A version of this chapter has been accepted for publication. Backman C., Taylor G., Sales A., Marck P.B. (in press; accepted July 29, 2010). An Integrative Review of Infection Control Programs for Multidrug-Resistant Organisms in Acute Care Hospitals: A Socio-Ecological Perspective. *American Journal of Infection Control.*

Background

Multiple interventions and strategies are required to reduce the rates of healthcare-associated infections (HAI) in acute care hospitals. Multiple interventions are needed because of the multi-factorial nature of HAI and the ethical issues with conducting randomized controlled trials in this field (Siegel et al., 2006). Research in infection prevention and control (IP&C) should focus on the most effective set of interventions with the least amount of interventions necessary (Aboelela et al., 2007). A variety of interventions have been used in an attempt to eradicate or control MDRO. Some of the interventions that have been documented in the literature as being successful in the prevention and control of MDRO transmission include (1) improvements in hand hygiene, (2) the use of contact precautions, (3) active surveillance cultures (ASC), (4) staff education, (5) enhanced environmental cleaning, and (6) better sharing of information between healthcare organizations regarding patients' MDRO status. Although numerous studies and guidelines have been published on the prevention and control of MDRO where multiple interventions were used to reduce or eliminate MDRO infections, there is no definitive set of evidence-informed control measures that

A version of this chapter was accepted for publication in the American Journal of Infection Control.

can be widely used (Siegel et al., 2006). The evidence to date has led to the development of recommendations for a two tiered program for the prevention and control of HAI, in particular, for the prevention and transmission of MDRO.

An IP&C program is defined as “a multidisciplinary program that includes a group of activities to ensure that recommended practices for the prevention of HAI are implemented and followed by healthcare personnel, making the healthcare setting safe from infection for patients and healthcare personnel” (Siegel et al., 2006, p.50). The Tier 1/Tier 2 program consists of the following two tiers: routine prevention and control measures (Tier 1) and intensified interventions (Tier 2). The interventions in the first Tier are a basic set of MDRO infection control measures that are designed to help recognize the problem, involve administrators and provide methods to manage unknown carriers of MDRO. If the rates of the targeted MDRO are not decreasing after the implementation of Tier 1 interventions, an organization would move to the Tier 2 intensified interventions, utilizing active surveillance cultures to identify patients colonized or infected with a targeted MDRO, among other control efforts. The Tier 2 measures are only undertaken after the Tier 1 interventions of routine prevention and control fail to reduce the targeted MDRO rates. It is recommended that one or more of the second Tier interventions be implemented if (1) there are no reductions in the incidence of MDRO with the use of routine control measures; or (2) there is the presence of a first case or outbreak of a MDRO on the unit or within the hospital. If the rates do not decrease, additional interventions can be implemented as needed. Continued monitoring is extremely important to determine whether the selected control measures are effective and if other additional measures are necessary. In part, the two tiered approach consists of various interventions that can be selected based on the needs of the healthcare organization. Further details of the categories, which consist of administrative measures, education and training of healthcare personnel, judicious use of antimicrobial agents, surveillance, infection control precautions to prevent transmission, environmental measures, and decolonization can be found in the CDC Guidelines on the Management of Multidrug-Resistant Organisms In Healthcare Settings (2006). No research studies have published specifically on the use of the two-tiered program to date.

We searched for original research published between January 1, 1998 and May 14, 2009 to better understand the impact of a MDRO IP&C program on the rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBL) and *Clostridium difficile* infection (CDI) in acute care hospitals. We used the following approaches to achieve this objective:

1. Review and critique the evidence on the relationship between MDRO IP&C programs and the rates of MRSA, VRE, ESBL and CDI in acute care hospitals using the Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) guidelines (Stone et al., 2007; Cooper et al., 2007);
2. Use the Tier 1/Tier 2 framework (Siegel et al., 2006) to evaluate the content of the IP&C programs included in the review; and

A version of this chapter was accepted for publication in the American Journal of Infection Control.

3. Offer recommendations for future research direction in the field.

For purposes of this review, we defined an IP&C program as including two or more IP&C interventions. We used the Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) statement to review and critique the evidence. This provides a standard method for the transparent reporting of outbreaks and intervention studies (Stone et al., 2007; Cooper et al., 2007). The ORION guidelines were developed by a multidisciplinary group of UK researchers to improve the standards of reporting for intervention studies and outbreak reports in the field of infection control. They provide recommendations on measures to avoid bias and techniques for appropriate statistical analysis.

Methods

We conducted an integrative review (Whittmore et al., 2005) using the ORION guidelines to evaluate the strength of the scientific evidence. Since most papers in the field have relatively weak study design, we conducted an integrative review because it allowed the inclusion of study designs such as quasi-experimental studies in the review. The included intervention studies were assessed using the Tier 1/Tier 2 framework (Siegel et al., 2006) which consists of the evidence-informed control measures for the prevention and transmission of MDRO.

Search strategy

The lead author (CB) identified studies including original research published between January 1, 1998 and May 14, 2009 through the MEDLINE, CINAHL, EMBASE, PUBMED, and The Cochrane Library electronic databases,

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and through expert consultation. We developed a comprehensive search strategy with the assistance of a librarian to find studies that covered the main subject areas of this integrative review. The MEDLINE search strategy included all English language articles with an extensive list of key search terms provided in Table 2-1. We then translated the MEDLINE search strategy for use in the PUBMED, EMBASE and the CINAHL databases. We searched the Cochrane database using the text words MRSA, VRE, CDI and ESBL.

Selection criteria

We included only studies that had interventions with evaluation, and assessed the relationship between IP&C programs and rates of MRSA, VRE, ESBL and / or CDI in acute care hospitals. We excluded studies that focused on disease-specific rather than organism-specific infections such as bloodstream infections, respiratory infections, urinary tract infections, surgical-site infections, and ventilator-associated pneumonias because their focus was not primarily on the reduction of MDRO incidence. A further concern with these studies is that their focus was often more on disease or organ-specific intervention “bundles” which were not comprehensive IP&C programs. We also excluded purely descriptive or observational studies because they did not report on a program of IP&C, which requires active intervention. In addition, studies that did not fit the criteria of an IP&C program (e.g. involved only a single intervention) were excluded. We also excluded studies with weak study design, including only those with either a randomized controlled trial (RCT) or quasi-experimental design. A complete list of the inclusion and exclusion criteria is provided in Table 2-2.

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Abstract Appraisal

The first author (CB) appraised all the abstracts according to the inclusion and exclusion criteria (Table 2-2).

Full article appraisal, data extraction and outcome measures

The first author (CB) reviewed the manuscripts if the abstract did not provide sufficient information. Two researchers (CB and GT) appraised the original research studies (47 articles) that met the inclusion criteria using the ORION statement. Following the initial round of independent reviews, all co-authors discussed the results that diverged between the first and second reviewers to ascertain the rationale for disparate appraisals between the reviewers. Where there was disagreement, all co-authors reviewed the study against the eligibility criteria. Following this discussion phase, all co-authors agreed that 15 studies initially included were excluded for reasons of study design (n=8), outcomes (n=2), single intervention (n=3) and discredited (e.g. non-evidence-based) interventions or processes (n=2) leaving a total of 32 studies.

Results

Characteristics of the studies

Of the 1382 papers retrieved, 47 were reviewed and 32 studies met the inclusion criteria. The flow diagram of the search results is presented in Figure 2-1.

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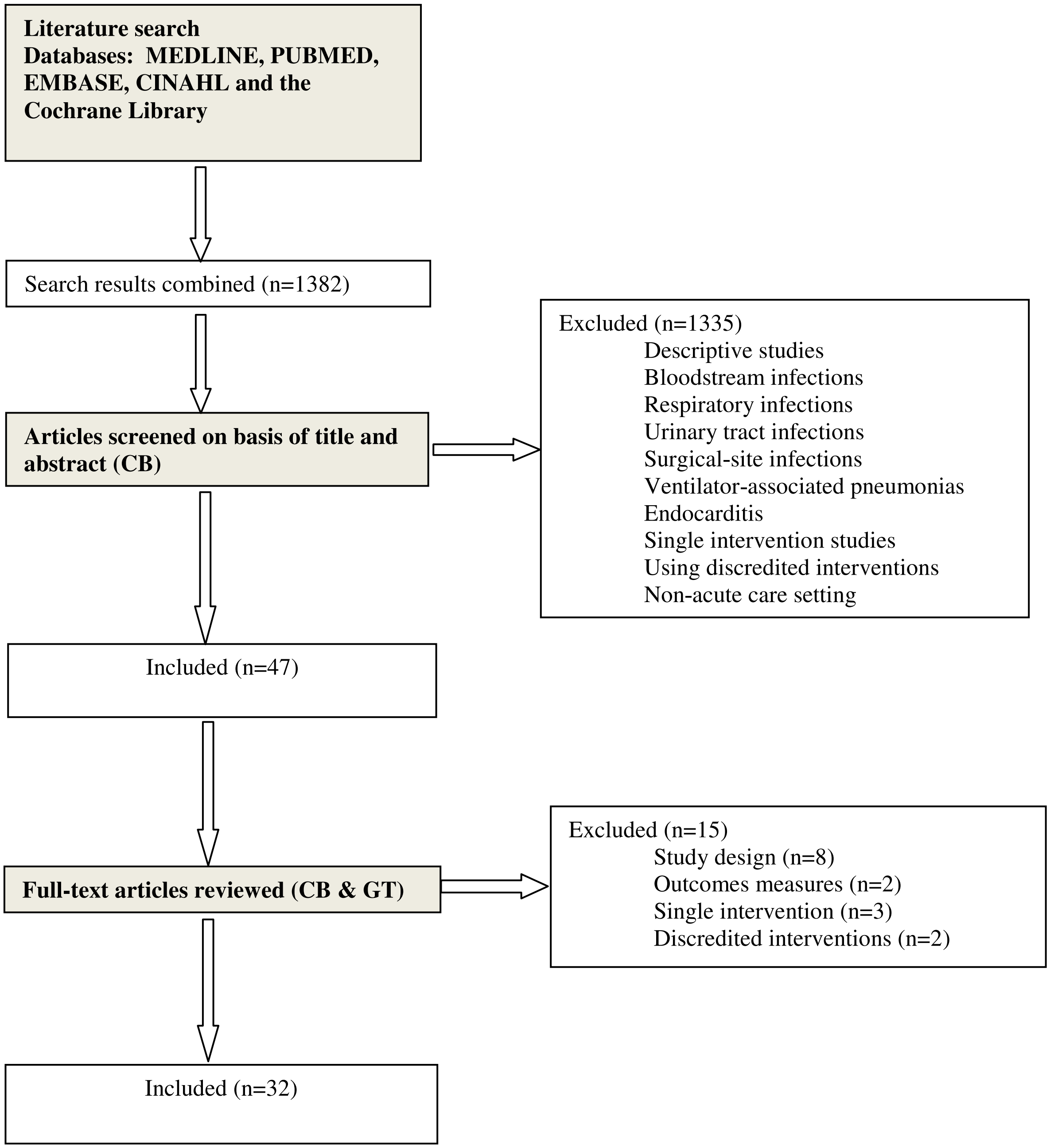
Figure 2-1: Flow Diagram (Search Results)



The eligible original studies included: 27 (84.4%) interrupted time series, 3 (9.4%) pre and post-intervention without a control group and 2 (6.3%) pre and post-intervention with a control group. The details of the review following the 22-item ORION checklist are available in Table 2-3.

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Quality of studies

Although all the 32 studies were quasi-experimental studies, only 2 (5.9%) studies provided sample size calculations (Karas et al., 2008; Harbarth et al., 2008) and only 5 studies reported confounding factors (Muder et al., 2008; Liebowitz et al., 2008; Harrington et al., 2007; Fowler et al., 2007; Curran et al., 2006). In addition, while 27 used an interrupted time series design and two were controlled pre and post-intervention designs, three were pre and post-intervention without control groups. We retained these studies because they met all other criteria for inclusion.

Classifying the interventions using the Tier 1/Tier 2 framework

The interventions in the included studies were assessed using the Tier 1/Tier 2 framework which consists of seven categories: administrative measures, education and training of healthcare personnel, judicious use of antimicrobial agents, surveillance, infection control precautions to prevent transmission, environmental measures, and decolonization. A summary of the interventions found in each category are found in Table 2-4.

A total of 5 studies had 5 of the 7 interventions (Zafar et al., 1998; Johnson et al., 2005; Tomic et al., 2004; YoonChang et al., 2007; Montecalvo et al., 1999); 3 studies had 4 of the 7 interventions (Hayden et al., 2006; Masaki et al., 2001; Wernitz et al., 2005); 16 studies had 3 of the 7 interventions (Karas et al., 2008; Gillespie et al., 2007; Liebowitz et al., 2008; Harbarth et al., 2008; Moreira et al., 2007; Fowler et al., 2007; Huang et al., 2006; Grayson et al., 2008; Muder et al., 2008; Curran et al., 2006; Pittet et al., 2000; Barakate et al., 1999;

Cosseron-Zerbib et al., 1998; Carling et al., 2003; Robicsek et al., 2008; Shitrit et al., 2006) and 8 studies had 2 of the 7 interventions (Trautmann et al., 2007; Trick et al., 2007; Apisarnthanarak et al., 2006; Eveillard et al., 2001; Harrington et al., 2007; Mahamat et al., 2007; Girou et al., 1998; Lucet et al., 2005). Overall, the majority of the studies had only three of the recommended Tier 1/Tier 2 interventions. No studies had Tier 2 administrative measures, education and training, judicious use of antimicrobial agent interventions, surveillance, infection control precautions or environmental measures. However, 9 (28.1%) studies used patient decolonization as an intervention (Karas et al., 2008; Robicsek et al., 2008; Moreira et al., 2007; Girou et al., 1998; Shitrit et al., 2006; Johnson et al., 2005; Tomic et al., 2004; Wernitz et al., 2005; Masaki et al., 2001). Decolonization, which is the antimicrobial treatment of colonized individuals, is not a measure that is sufficiently effective to necessitate routine prevention and control (Tier 1) and is often left for circumstances of high prevalence or outbreaks of MRSA (Siegel et al., 2006).

Limitations

Due to the large number of research articles on MDRO in the literature, the search strategy was limited to articles that had the key search terms in the title or abstract. The selection of articles was also limited to English. It was difficult to generalize the findings because different sets of interventions were used in the individual studies reviewed.

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Discussion

Overall, the studies all resulted in a reduction in MDRO counts or infections. However, much of the literature reviewed used relatively weak non-descriptive study designs—usually interrupted times series—making it difficult to draw causal inference and generalizable conclusions on the program approach to prevention and control of MDRO. Randomized controlled trials, considered the gold standard for clinical interventions are absent in this field. Several factors presented threats to the validity of the studies reviewed, including differences in the populations studied, differences in the definition of events, differences in study design, differences in interventions, differences in outcomes measures, and differences in the period of follow-up. Since our objective was to assess a programmatic approach to MDRO control rather than single interventions, all studies used more than one intervention concurrently or sequentially resulting in complex interactions between multiple simultaneous interventions. This made it difficult to differentiate the respective impact of each intervention. In addition, the actual number of interventions included ongoing IP&C practices (e.g. ASC) that could have also affected the results. A clear structure for reporting these outbreak and intervention studies, such as the use of the ORION guidelines (Stone et al., 2007; Cooper et al., 2007) is needed to ensure consistency in publishing and reporting of the studies.

Although numerous studies were published where two or more interventions were used, there were perhaps surprisingly no studies that presented a complete IP&C program as defined by Siegel et al. (2006) to reduce or eliminate

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MDRO infections. Most studies reviewed included only Tier 1 measures, with ASC and decolonization the only Tier 2 interventions. As discussed earlier, the use of decolonization is often limited to outbreak situations because of its limiting factors such as: the potential toxicities of antimicrobial agents in asymptomatic patients, the need for surveillance cultures to identify the colonized individuals, the need for follow-up cultures to ensure eradication, the possibility of re-colonization and/or resistance to mupirocin and the cost. A further issue is that the two-tiered recommended approach is currently based solely on expert opinion. There is not enough evidence to sustain a conclusion on program effectiveness of this approach. Researchers should strive for research on programs of prevention and control, since the majority of hospitals already have an IP&C program in place.

This suggests a way forward. Research on IP&C programs should focus on developing each category of the Tier 1/Tier 2 framework and use and evaluate them as needed. The comprehensive two tiered approach ensures continued attention to all MDRO. The approach recommends less strict measures in settings where little or no transmission of MDRO is occurring and more strict precautions, including active surveillance cultures, in circumstances where transmission is present. Siegel et al. (2006) suggest that a two tiered program helps to select the appropriate MDRO control measures based on the hospital's assessment, the prevalence of MDRO and the feasibility. IP&C researchers should design and implement studies to evaluate program effectiveness. This is analogous to other public health programs to contain infectious diseases such as tuberculosis and

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sexually-transmitted infection programs where research is carried out on program effectiveness (CDC, 2006).

Implications for Practice and Future Research

While it is unclear which bundles of interventions are effective, there is a clear suggestion that multiple simultaneous interventions can be effective in reducing MDRO infections. In addition, despite the limitations of interrupted time series, multiple studies employing active surveillance cultures were associated with reduced MDRO infections. It seems unlikely that the strongest study designs (e.g. randomized control trials of multiple interventions used in bundles) will be performed anytime soon due to the complex nature of the interventions. Researchers should strive for the most rigorous research designs possible which employ control and intervention groups.

Future individual reports of outbreaks and intervention studies should be written in a standardized manner following the ORION guideline recommendations. More focused and comprehensive research on the interactions among and between various variables that influence the outcome of MDRO is needed. Also, research is needed on the Tier 1/Tier 2 framework clearly indicating all the interventions implemented. The current published studies in this review and in the overall field of infection control (Backman et al., 2008; Macdonald, 2004) do not use theory-based research designs. Theory-based research is important to help build science and develop a generalizable knowledge or evidence base (Sales et al., 2006). Struelens (1998) recommends, and we support, taking a socio-ecological theory approach in future IP&C research. Other experts including Ali (2004), Gloubeman (2001), Macdonald (2004) and Waldvogel (2004) also suggest that a host of socio-ecological factors play an important role in the development of infectious diseases in 21st century. An in-depth case study approach could help better understand the interrelationships between each of the components of an IP&C program that may impact MDRO infections in acute care hospitals.

Conclusion

"The hospital environment is a complicated ecosystem and many interventions are needed for optimal infection control" (Curtis et al., 2008, p. 215). We are unable to demonstrate strong evidence of a relationship between MDRO IP&C programs and the rates of MRSA, VRE, ESBL and CDI. Although we cannot exclude other plausible explanations for the reduction of the acquisition of MDRO because of major methodological weaknesses in the published literature, the overall evidence appears to support the use of multiple interventions to reduce rates of MDRO in acute care hospitals.

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Table 2-1: MEDLINE Search Strategy

Database: MEDLINE

Review period: until May 14 2009

1 "antibiotic resistant organism$".ti,ab. (173)
2 *drug resistance, microbial/ or *drug resistance, multiple/ (15611)
3 *drug resistance, bacterial/ (4704)
4 *staphylococcus aureus/ (18870)
5 *staphylococcal infections/ or *pneumonia, staphylococcal/ or *staphylococcal skin infections/ (25004)
6 "methicillin resistant staphylococcus aureus".ti,ab. (6830)
7 "meticillin resistant staphylococcus aureus".ti,ab. (144)
8 "MRSA".ti,ab. (6309)
9 *Vancomycin Resistance/ (1147)
10 "VRE".ti,ab. (1071)
11 "vancomycin resistant enterococci".ti,ab. (1326)
12 *Clostridium difficile/ or *Clostridium Infections/ (4152)
13 "Antimicrobial resistan$".ti,ab. (4499)
14 "multiresistant organism$".ti,ab. (72)
15 or/1-14 (67772)
16 "acute care".ti,ab. (7833)
17 hospital$.ti,ab. (542482)
18 exp Hospitals, Urban/ or exp Hospitals, Teaching/ or exp Hospitals, Rural/ or exp Hospitals, Community/ or exp Hospitals, University/ or exp Hospitals, General/ or exp Hospitals, Private/ or exp Hospitals, Public/ (78622)
19 exp Inpatients/ (7095)
20 or/16-19 (579327)
21 health promotion/ (33344)
22 promot$.ti,ab. (347772)
23 program$.ti,ab. (351983)
24 initiative$.ti,ab. (22820)
25 campaign$.ti,ab. (15513)
26 strateg$.ti,ab. (286976)
27 intervention$.ti,ab. (289523)
28 or/21-27 (1183538)
29 and/15,20,28 (1402)
30 limit 29 to english language (1261)
31 limit 30 to animals (64)
32 limit 31 to humans (43)
33 30 not (31 not 32) (1240)

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Table 2-2: Inclusion and Exclusion Criteria

	Inclusion	Exclusion
Period	▪ January 1 1998 – May 14 2009 ▪ English language only	
Population / Setting	▪ Acute care hospitals	▪ All other settings
Intervention	▪ All infection prevention and control interventions/programs **with 2 or more interventions**	▪ Single intervention studies ▪ Using discredited interventions
Outcome	**Organism-specific colonization or infection:** ▪ Methicillin-Resistant *Staphylococcus aureus* (MRSA) ▪ *Vancomycin resistant enterococci* (VRE) ▪ extended spectrum beta-lactamases (ESBLs) ▪ *Clostridium difficile associated diarrhea*	**Disease-specific infections:** ▪ Bloodstream infections ▪ Respiratory infections ▪ Urinary tract infections ▪ Surgical-site infections ▪ Ventilator-associated pneumonias ▪ Endocarditis
Study design	1. INTERVENTION STUDIES (Experimental) <u>with control group</u> ▪ Randomized experiments ▪ Quasi-experiments (nonrandomized) o Pre and post with control group o Interrupted time series (at least 3 data points before and 3 data points after the intervention) 2. INTERVENTION STUDIES (Experimental) <u>without control or comparison group</u> ▪ Pre and post without control group ▪ Interrupted time series 3. REVIEWS OF RESEARCH (only if they clearly defined the parameters of their search strategy, including inclusive dates of the review, databases searched, and search terms used)	1. OBSERVATIONAL STUDIES (Non-experimental) ▪ Cohort (retrospective and prospective) ▪ Case control ▪ Case series ▪ Cross-sectional ▪ Ecological 2. REVIEWS that did not clearly defined the parameters of their search strategy, including inclusive dates of the review, databases searched, and search terms used 3. EXPERT OPINION OR CONSENSUS 4. EDITORIAL LETTER 5. GUIDELINE IMPLEMENTATION 6. COMMENTARY 7. OUTBREAK REPORTS

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Table 2-3: Results following the 22-item ORION checklist

Item #	ORION Checklist Item	Results	Studies
1.	**Title / Abstract**	Each study (references 1-32) provided a title and abstract which described the article as an intervention study and provided a brief description of the interventions and main outcome.	All studies
		Only 18 (56.3%) specified the design of the intervention study in the abstract.	Muder et al. 2008; Liebowitz et al. 2008; Robicsek et al. 2008; Harbarth et al. 2008; Mahamat et al. 2007; Harrington et al. 2007; Shitrit et al. 2006; Huang et al. 2006; Curran et al. 2006; Johnson et al. 2005; Lucet et al. 2005; Barakate et al. 1999; Yoonchang et al. 2007; Montecalvo et al. 1999; Fowler et al. 2007; Trick et al. 2007; Apisarnthanarak et al. 2006; Carling et al. 2008
2.	**Introduction / Background**	All studies (references 1-32) provided an introduction with a rationale for the study as well as scientific or local clinical background information.	All studies
		The organism was described as endemic in 15 (46.9%) studies.	Muder et al. 2008; Liebowitz et al. 2008; Robicsek et al. 2008; Shitrit et al. 2006; Johnson et al. 2005; Lucet et al. 2005; Wernitz et al. 2005; Masaki et al. 2001; Barakate et al. 1999; Girou et al. 1998; Tomic et al. 2004; Hayden et al. 2006; Montecalvo et al. 1999; Fowler et al. 2007; Gillespie et al. 2007
		as epidemic in two (6.3%) studies	Mahamat et al. 2007; Cosseron-Zerbib et al. 1998
		as both endemic and epidemic in one (3.1%) study	Moreira et al. 2007
		not mentioned in 14 (43.8%) studies	Karas et al. 2009; Grayson et al. 2008; Harbarth et al. 2008; Trautmann et al. 2007; Harrington et al. 2007; Huang et al. 2006; Curran et al. 2006; Pittet et al. 2000; YoonChang et al. 2007; Zafar et al. 1998; Trick et al. 2007; Apisarnthanarak et al. 2006; Carling et al. 2003; Eveillard et al. 2001
3.	**Type of paper**	As per the inclusion and exclusion criteria for the review, all 32 studies (100%) were interventions studies (pre	All studies

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Item #	ORION Checklist Item	Results	Studies
		and post with a control group, pre and post without a control group and interrupted times series). Also, the studies included two or more infection control interventions as per our inclusion criteria.	
4.	**Dates**	71.9% of studies (23) had clear start and finish dates	Karas et al. 2008; Grayson et al. 2008; Harbarth et al. 2008; Trautmann et al. 2007; Modeira et al. 2007; Mahamat et al. 2007; Harrington et al. 2007; Fowler et al. 2007; Won YoonChang et al. 2007; Trick et al. 2007; Shitrit et al. 2006; Huang et al. 2006 ; Hayden et al. 2006; Apisarnthanarack et al. 2006; Lucet et al. 2005; Wernitz et al. 2005; Tomic et al. 2004; Masaki et al. 2001; Barakate et al. 1999; Montecalvo et al. 1999; Cosseron-Zerbib et al. 1998; Girou et al 1998; Eveillard et al. 2001
		3 of 32 studies (9.4%) had no clear start and finish dates	Curran et al. 2006; Carling et al. 2003; Gillespie et al. 2007
		6 studies (18.8%) did not provide the finish dates	Muder et al. 2008; Liebowitz et al. 2008; Robicsek et al. 2008; Johnson et al. 2005; Pittel et al. 2000; Zafar et al. 1998
5.	**Objectives**	All studies had a clear objective (references 1-32). The objectives were mainly to evaluate, determine or investigate the impact of two or more interventions on MRSA, VRE, *C-difficile* or ESBL infection rates.	All studies
6.	**Design**	27 (84.4%) were interrupted time series	Karas et al. 2008; Liebowitz et al. 2008; Grayson et al. 2008; Robicsek et al. 2008; Trautmann et al. 2007; Modeira et al. 2007; Mahamat et al. 2007; Harrington et al. 2007; Fowler et al. 2007; Won YoonChang et al. 2007; Shitrit et al. 2006; Huang et al. 2006; Curran et al. 2006; Hayden et al. 2006; Apisarnthanarack et al. 2006; Johnson et al. 2005; Lucet et al. 2005; Wernitz et al. 2005; Tomic et al. 2004; Carling et al. 2003; Pittel et al. 2000; Barakate et al. 1999; Montecalvo et al. 1999; Zafar et al. 1998; Cosseron-Zerbib et al. 1998; Girou et al 1998; Gillespie et al. 2007
		3 (9.4%) were pre and post without a control group	Muder et al. 2008; Masaki et al. 2001; Eveillard et al. 2001

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Item #	ORION Checklist Item	Results	Studies
		2 (6.3%) were pre and post with a control group	Harbarth et al. 2008; Trick et al. 2007
7.	**Participants**	Participants were defined as the patients and/or healthcare worker in the studies (references 1-32).	All studies
8.	**Setting**	All studies (100%) were conducted in acute care hospitals as per our inclusion criteria.	All studies
9.	**Interventions** The types of interventions divided into CDC's seven categories.	18 (56.25%) had administrative measures	Gillespie et al. 2007; Liebowitz et al. 2008; Harbarth et al. 2008; Moreira et al. 2007; Fowler et al. 2007; Hayden et al. 2006; Zafar et al. 1998; Huang et al. 2006; Grayson et al. 2008; Muder et al. 2008; Curran et al. 2006; Johnson et al. 2005; Pittet et al. 2000; Barakate et al. 1999; Cosseron-Zerbib et al. 1998; Tomic et al. 2004; YoonChang et al. 2007; Carling et al. 2003
		20 (62.5%) had education	Gillespie et al. 2007; Karas et al. 2008; Liebowitz et al. 2008; Grayson et al. 2008; Moreira et al. 2007; Curran et al. 2006; Hayden et al. 2006; Johnson et al. 2005; Masaki et al. 2001; Pittet et al. 2000; Tomic et al. 2004; YoonChang et al. 2007; Montecalvo et al. 1999; Cosseron-Zerbib et al. 1998; Zafar et al. 1998; Trick et al. 2007; Apisarnthanarak et al. 2006; Carling et al. 2003; Eveillard et al. 2001; Fowler et al. 2007
		8 (25.0%) had the use of antimicrobial agents	Liebowitz et al. 2008; Harbarth et al. 2008; Montecalvo et al. 1999; Wernitz et al. 2005; Fowler et al. 2007; Apisarnthanarak et al. 2006; Carling et al. 2003; YoonChang et al. 2007
		17 (53.1%) had surveillance	Karas et al. 2008; Muder et al. 2008; Harbarth et al. 2008; Cosseron-Zerbib et al. 1998; Robicsek et al. 2008; Trautmann et al. 2007; YoonChang et al. 2007; Shitrit et al. 2006; Huang et al. 2006; Tomic et al. 2004; Montecalvo et al. 1999; Zafar et al. 1998; Harrington et al. 2007; Barakate et al. 1999; Mahamat et al. 2007; Lucet et al. 2005; Wernitz et al. 2005
		24 (75.0%) had infection control precautions	Gillespie et al. 2007; Muder et al. 2008; Robicsek et al. 2008; Harbarth et al. 2008; Grayson et al. 2008; Hayden

Item #	ORION Checklist Item	Results	Studies
			et al. 2006; Harrington et al. 2007; Shitrit et al. 2006; Huang et al. 2006; Pittet et al. 2000; Curran et al. 2006; Johnson et al. 2005; Lucet et al. 2005; Wernitz et al. 2005; Masaki et al. 2001; Cosseron-Zerbib et al. 1998; Girou et al. 1998; Tomic et al. 2004; YoonChang et al. 2007; Montecalvo et al. 1999; Zafar et al. 1998; Trick et al. 2007; Eveillard et al. 2001; Barakate et al. 1999
		7 (21.9%) had environmental measures	Mahamat et al. 2007; Johnson et al. 2005; Masaki et al. 2001;Hayden et al. 2006; YoonChang et al. 2007; Montecalvo et al. 1999; Zafar et al. 1998
		9 (28.1%) had decolonization	Karas et al. 2008; Robicsek et al. 2008; Moreira et al. 2007; Girou et al. 1998; Wernitz et al. 2005; Shitrit et al. 2006; Johnson et al. 2005; Tomic et al. 2004; Masaki et al. 2001
10.	**Culture & Typing**	23 studies mentioned laboratory techniques used	Karas et al. 2008; Muder et al. 2008; Liebowitz et al. 2008; Robicsek et al. 2008; Harbarth et al. 2008; Modeira et al. 2007; Mahamat et al. 2007; Gillespie et al. 2007; YoonChang et al. 2007; Shitrit et al. 2006; Curran et al. 2006; Johnson et al. 2005; Lucet et al. 2005; Wernitz et al. 2005; Tomic et al. 2004; Masaki et al. 2001; Eveillard et al. 2001; Pittel et al. 2000; Barakate et al. 1999; Montecalvo et al. 1999; Zafar et al. 1998; Cosseron-Zerbib et al. 1998; Girou et al 1998
		2 studies used polymerase chain reaction tests	Robicsek et al. 2008; Harbarth et al. 2008
11.	**Infection related outcomes**	In nine studies, the primary outcome measure was MRSA infection rates	Muder et al. 2008; Robicsek et al. 2008; Harbarth et al. 2008; Trautmann et al. 2007; Moreira et al. 2007; Harrington et al. 2007; Johnson et al. 2005; Wernitz et al. 2005; Gillespie et al. 2007
		In eight other studies, the primary outcome measure was the percentage of MRSA cases.	Mahamat et al. 2007; Lucet et al. 2005; Pittet et al. 2000; Barakate et al. 1999; Cosseron-Zerbib et al. 1998; Tomic et al. 2004; Apisarnthanarak et al. 2006; Carling et al. 2003
		In another four studies, bacteraemia cases were the primary outcome.	Karas et al. 2008; Shitrit et al. 2006; Masaki et al. 2001; Girou et al. 1998
		In four other studies, it was the VRE infection rates.	Hayden et al. 2006; YoonChan et al. 2007; Montecalvo et al. 1999; Carling et al. 2003

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Item #	ORION Checklist Item	Results	Studies
		In another three studies, it was MRSA bacteraemia rates	Liebowitz et al. 2008; Grayson et al. 2008; Huang et al. 2006
		In another three it was CDI infection rates	Fowler et al. 2007; Zafar et al. 1998; Carling et al. 2003
		Finally, the outcome measures for the remaining studies were: MRSA colonization rates	Karas et al. 2008
		number of MRSA isolates	Curran et al. 2006
		VRE colonization rate	Montecalvo et al. 1999
		incidence of antibiotic-resistant organism (ARO)	Trick et al. 2007
		incidence rates of ESBL	Apisarnthanarak et al. 2006
		both incidence rates of MRSA and ESBL	Eveillard et al. 2001
12.	**Economic**	Although no formal economic analysis was undertaken, only one of the studies provided some costing information.	Curran et al. 2006
13.	**Potential Threats to Validity**	Among the 32 studies, 5 reported confounding factors.	Muder et al. 2008; Liebowitz et al. 2008; Harrington et al. 2007; Fowler et al. 2007; Curran et al. 2006
14.	**Sample size**	Only 2 (5.9%) studies provided sample size calculations.	Karas et al. 2008; Harbarth et al. 2008
15.	**Statistical methods**	4 studies used descriptive statistics	Gillespie et al. 2007; YoonChang et al. 2007; Eveillard et al. 2001; Zafar et al. 1998
		6 studies used non-parametric testing	Karas et al. 2009; Lucet et al. 2005; Tomic et al. 2004; Carling et al. 2003; Barakate et al. 1999; Cosseron-Zerbib et al. 1998
		9 studies used parametric testing	Muder et al. 2008; Liebowitz et al. 2008; Robicsek et al. 2008; Trautmann et al. 2007; Mahamat et al. 2007; Fowler et al. 2007; Trick et al. 2007; Huang et al. 2006; Curran et al. 2006
		12 studies used parametric and non-parametric testing	Harbarth et al. 2008; Moreira et al. 2007; Harrington et al. 2007; Shitrit et al. 2006; Hayden et al. 2006; Apisarnthanarak et al. 2006; Johnson et al. 2005; Wernitz et al. 2005; Masaki et al. 2001; Pittet et al. 2000; Montecalvo et al. 1999; Girou et al. 1998
		1 study did not present any statistical analysis	Grayson et al. 2008
16.	**Recruitment**	8 (25.0%) studies took place	Muder et al. 2008; Robicsek et al.

Item #	ORION Checklist Item	Results	Studies
		in the United States	2008; Hayden et al. 2006; Zafar et al. 1998; Huang et al. 2006; Montecalvo et al. 1999; Trick et al. 2007; Carling et al. 2003
		five (15.6%) in the United Kingdom	Karas et al. 2008; Liebowitz et al. 2008; Curran et al. 2006; Mahamat et al. 2007; Fowler et al. 2007
		five (15.6%) in Australia	Grayson et al. 2008; Harrington et al. 2007; Johnson et al. 2005; Barakate et al. 1999; Gillespie et al. 2007
		four (12.5%) in France	Lucet et al. 2005; Cosseron-Zerbib et al. 1998; Girou et al. 1998; Eveillard et al. 2001
		two (6.3%) in Switzerland	Harbarth et al. 2008; Pittet et al. 2000
		two (5.9%) in Germany	Trautmann et al. 2007; Wernitz et al. 2005
		one (3.1%) in Korea	YoonChang et al. 2007
		one (3.1%) in Israel	Shitrit et al. 2006
		one (3.1%) in Thailand	Apisarnthanakak et al. 2006
		one (3.1%) in Brazil	Moreira et al. 2007
		one (3.1%) in Japan	Masaki et al. 2001
		one (3.1%) in Slovenia	Tomic et al. 2004
17.	**Outcomes & estimation**	6 studies did not present any graphical or table summary	Mahamat et al. (2007); Harrington et al. (2007); Gillespie et al. (2007); Fowler et al. (2007); Curran et al. (2006); Montecalvo et al. (1999)
18.	**Ancillary analyses**	There were no mentions of unplanned analyses in any of the studies.	
19.	**Adverse events**	Not applicable	
20.	**Discussion**	Evidence was assessed against hypothesis in all the studies	All studies
21.	**Generalisability**	The results are difficult to generalize as different sets of interventions were used in the studies.	All studies
22.	**Overall evidence**	Overall, the studies showed a reduction in MDRO counts or infections. It was not possible to find out which intervention had the most impact.	All studies

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Table 2-4: Classification of the Interventions using the Tier 1/Tier 2 Framework

Studies	Administrative measures	Education and training of healthcare personnel	Judicious use of antimicrobial agents	Surveillance	Infection control precautions to prevent transmission	Environmental measures	Decolonization
Muder et al. 2008	the Toyota Production System to monitor adherence to an infection control program			active surveillance cultures (ASC) for MRSA	standard precautions and contact precautions		
Fowler et al. 2007	implementation of an antibiotic policy	a program of audit and feedback of antibiotic usage and CDI rates	development of a narrow-spectrum antibiotic policy				
Liebowitz et al. 2008	(1) implementation of an antibiotic policy (2) attendance of a senior microbiologist at ward rounds and antibiotic prescribing advice	education on antibiotic usage was also a theme that emerged in the studies, and included: formal lectures to describe the rationale behind new antibiotic guidelines and the appropriate use of antibiotics	discouraging the use of ciprofloxacin and second and third generation cephalosporins throughout the hospital				
Curran et al. 2006	(1) implementation of an antibiotic policy (2) commissioning a cohort area	online hand hygiene education program for all healthcare workers			contact isolation		
Gillespie et al. 2007	the empowerment of staff through feedback of MRSA rates	increased infection control presence in the ICU to help educate and promote hand hygiene awareness			placement of alcohol/chlorhexidine handrub at the tables at the foot of the bed in addition to the bedside equipment tables and use of drinks trolley and door monitors as physical		

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Studies	Administrative measures	Education and training of healthcare personnel	Judicious use of antimicrobial agents	Surveillance	Infection control precautions to prevent transmission	Environmental measures	Decolonization
					barriers at the entrance of the intensive care unit		
Harbarth et al. 2008	a computerized MRSA alert system		adjusting perioperative antibiotic prophylaxis of MRSA carriers	active surveillance cultures (ASC) for MRSA	(1) contact isolation (2) standard precautions and contact precautions		
Grayson et al. 2008	a hand hygiene campaign	a hand hygiene culture-change training program			the introduction of an alcohol hand rub (ABHR)		
Hayden et al. 2006	a hand hygiene campaign	(1) educational sessions for nurses to assist housekeepers (2) education on environmental cleaning was reinforced and included: in-services to housekeeping staff about the importance of environmental cleaning			the introduction of an alcohol hand rub (ABHR)	environmental audits or observations	
Johnson et al. 2005	a hand hygiene campaign	continuous education of healthcare workers on appropriate hygiene procedures			the introduction of an alcohol hand rub (ABHR)	cleaning of shared ward equipment	decolonization
Huang et al. 2006	a hand hygiene campaign			active surveillance cultures (ASC) for MRSA	the introduction of an alcohol hand rub (ABHR) contact isolation		
Moreira et al. 2007	early identification of MRSA infected	education of the staff regarding					decolonization

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Studies	Administrative measures	Education and training of healthcare personnel	Judicious use of antimicrobial agents	Surveillance	Infection control precautions to prevent transmission	Environmental measures	Decolonization
	or colonized patients labeled with a bed-identification tag for contact isolation	nosocomial infections					
YoonChang et al. 2007	prompt reporting to physicians	hand hygiene and contact precautions education of healthcare workers	restriction of antibiotic prescription to infectious disease physicians	rectal samples for VRE	contact isolation	(1) environmental cultures (2) terminal chlorine disinfection of isolation rooms	
Cosseron-Zerbib et al. 1998	prompt reporting to physicians	education of the staff regarding nosocomial infections		active surveillance cultures (ASC) for MRSA	contact isolation		
Tomic et al. 2004	promotion of hand hygiene	education sessions regarding the correct use of the alcohol/chlorhexidine hand hygiene solution		active surveillance cultures (ASC) for MRSA	standard precautions and contact precautions		decolonization
Carling et al. 2003	Institutional support for the antibiotic management program including funding of a full-time pharmacist and a one-quarter-time infectious diseases physician	ongoing educational programs for both resident and staff physicians	a prospective antibiotic monitoring procedure leading to individualized therapeutic recommendations				
Pittet et al. 2000	strong institutional commitment to implement behavioral changes among healthcare workers and funding to implement the program,	hand hygiene educational posters			increased availability of ABHR		

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Studies	**Administrative measures**	**Education and training of healthcare personnel**	**Judicious use of antimicrobial agents**	**Surveillance**	**Infection control precautions to prevent transmission**	**Environmental measures**	**Decolonization**
	including an additional nurse for four months						
Barakate et al. 1999	refurbishment of a ward			routine pre-operative screening for MRSA colonization	(1) contact isolation (2) standard precautions and contact precautions		
Zafar et al. 1998	enforcement of a revised isolation policy which includes universal precautions, the centralization of the sterilization department and the installation of a cart-washer	education of the staff regarding nosocomial infections		active surveillance cultures (ASC) for MRSA	triclosan soap for handwashing	environmental cleaning	
Trick et al. 2007		an interactive education program and a hand hygiene poster campaign			the increased availability of ABHR		
Karas et al. 2008		staff education on screening for MRSA		active surveillance cultures (ASC) for MRSA			decolonization
Masaki et al. 2001		education of the staff regarding nosocomial infections			(1) contact isolation (2) standard precautions and contact precautions	cleaning of hospital floors	decolonization
Eveillard et al. 2001		education of the staff regarding nosocomial infections			standard precautions and contact precautions		
Apisarnthanarak et al. 2006		monthly education of medical students and residents	an antibiotic control program which included antibiotic order forms, bedside discussion				

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Studies	Administrative measures	Education and training of healthcare personnel	Judicious use of antimicrobial agents	Surveillance	Infection control precautions to prevent transmission	Environmental measures	Decolonization
			s among pharmacists, clinical microbiologists and attending physicians				
Montecalvo et al. 1999		patient education which consist of patient orientation about VRE with an explanatory brochure	consultation services with infectious diseases specialists about use of antimicrobial agents	perianal cultures for VRE	(1) contact isolation (2) standard precautions and contact precautions (3) assignment of staff/patient cohorts	environmental cultures	
Wernitz et al. 2005			administering systematic antibiotics in accordance with the resistance profile	admission screening for MRSA carriage by nasal swabs	(1) contact isolation (2) standard precautions and contact precautions		decolonization
Robicsek et al. 2008				active surveillance cultures (ASC) for MRSA	contact isolation		decolonization
Trautmann et al. 2007				active surveillance cultures (ASC) for MRSA			
Shitrit et al. 2006				active surveillance cultures (ASC) for MRSA	contact isolation		decolonization
Mahamat et al. 2007				(1) admission screening for MRSA carriage by nasal swabs (2) discharge screening for MRSA carriage by full body		(1) environmental cultures (2) environmental audits or observations (3) terminal chlorine disinfection of isolation	

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Studies	Administrative measures	Education and training of healthcare personnel	Judicious use of antimicrobial agents	Surveillance	Infection control precautions to prevent transmission	Environmental measures	Decolonization
				swabs		rooms	
Lucet et al. 2005				admission screening for MRSA carriage by nasal swabs	(1) the introduction of an alcohol hand rub (ABHR) (2) standard precautions and contact precautions		
Harrington et al. 2007				an MRSA surveillance feedback program that used statistical process control charts	the introduction of an alcohol hand rub (ABHR)		
Girou et al. 1998					standard precautions and contact precautions		decolonization

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A version of this chapter was accepted for publication in the American Journal of Infection Control.

CHAPTER 3: Conducting Comparative Case Studies with a Socio-Ecological Lens: Insights from an Infection Prevention and Control Study

A version of this chapter will be submitted for publication. Backman, C., Krogman, N., Marck, P.B. (for submission in Fall 2011). Conducting comparative case studies with a socio-ecological lens: Insights from an infection prevention and control study. Prepared for submission to the *International Journal of Qualitative Methods.*

Background

Healthcare-associated infections (HAI) are one of the most frequent and severe complications of hospitalization, and are in Canada, the fourth leading cause of in-hospital death (Baker et al., 2004). It is estimated that 250,000 Canadian patients who are admitted to hospital every year acquire infections and every year, more than 8,000 die from those infections (Zoutman et al., 2003). Internationally, HAI affect over 1.4 million people at any one time (World Health Organization, 2002). HAI are transmitted in several ways: person to person contact, environmental contamination, air, water, intravenous and oral routes, and surgical procedures. Research to date supports the use of multiple interventions such as administrative support, education, judicious use of antimicrobial agents, surveillance, infection control precautions, environmental measures, and decolonization to prevent and control multidrug-resistant organisms (MDRO) (Siegel et al., 2006).

Using a socio-ecological perspective to conduct comparative case study research offers an innovative approach to understanding infection prevention and control (IP&C) with a whole system lens. A socio-ecological approach on health systems informed this research design and provided a framework to better

A version of this chapter will be submitted for publication to the International Journal of Qualitative Methods in the Fall of 2011.

understand the complexity of implementing effective IP&C. A socio-ecological perspective provides “a framework for understanding the diverse personal and environmental factors and the interrelationships among these factors” (Edwards et al., 2004, p.45), enabling us to more accurately interpret and manage whole systems change (Edwards et al., 2007; Stokols, 1996). In socio-ecological terms, the term whole systems may be conceptualized as nested cycles of system development, degradation, or restoration (Edward et al., 2007; Gunderson et al., 2002; Holling, 1998; Marck et al., 2006a).

Struelens (1998) and other infectious diseases experts including Ali (2004), Gloubeman (2001), Macdonald (2004), and Waldvoegl (2004), all support the notion that social and environmental factors play a critical role in the emergence and trajectory of infectious diseases in the 21st century. Backman et al. (2008; in press) called for the use of an integrative approach to conduct IP&C research. As an integrative approach to studying health system issues, a comparative case study research design informed by a socio-ecological perspective is appropriate to gain an in-depth understanding of the phenomena and provide a more holistic approach for managing HAI, and more specifically, MDRO in various healthcare environments.

The key advantages of comparative case studies include contextual comparisons of complex human situations where the investigator has little control, and opportunities to observe specific relationships within cases that are not easily isolated into simple variables. A good comparative case study is one where readers gain a greater understanding of the conditions under which certain

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interactions, or behaviors are likely, and a more nuanced understanding of the potential to change various smaller parts of a larger system to produce a ‘desired’ outcome. Other criteria for a sound comparative case study include careful selection of the cases, adequate reliability and validity checks to accept the study findings (e.g. use of multiple sources of evidence, a case study protocol, and feedback from local experts), and appropriate data analysis procedures (Yin, 2003).

The purpose of this paper is to share the insights gained on a comparative case study approach used to better understand the conditions that can improve IP&C. First, previous case study research work will be summarized. Then, we will discuss our research experience including the methodology, methods, study design, data collection and analysis, and some examples of our case study research findings. Following this discussion, the insights gained while conducting comparative case study research will be presented.

Previous Case Study Research Work

The case study approach has been used previously to study systems sciences by authors such as Anderson et al. (2005), Colon-Emeric et al. (2006), Gunderson et al. (1995), Waltner-Toews et al. (2000) and Waltner-Toews (2001). The unique perspective provided by each of these authors influenced the development of the case study methodology to study IP&C. Case studies are particularly amenable to study systems, given the ability to document the interaction of various individuals or groups working with each other, and with others outside the immediate context, to reach organizational goals. For example,

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Gunderson et al. (1995) used a case study approach to study barriers and bridges to better ecosystem management across several countries, leading to the refinement of an integrative complex systems theory that describes how organizations use social learning to adapt to new problems. Waltner-Toews et al. (2000) defined ecosocial systems as “complex systems, with people firmly embedded as an integral element” (p.23). Waltner-Toews (2001) took an ecosystem approach, to study the transmission of tropical and emerging diseases, and to address the contextual factors of human interaction that can reduce disease rates. Of particular relevance to the present study is Anderson et al. (2005)’s work, who used complexity theory and case study methods to study healthcare organizations. From this perspective, organizations are dynamic, living social systems (Capra, 2000 in Anderson et al., 2005), that are “not constituted merely by the sum of its components, but also by the intricate relationships between these components” (Cilliers, 1998 in Anderson et al., 2005, p.671). Anderson et al. argued for a complex systems’ approach to study healthcare organizations as integrated wholes. Anderson used direct observations, interviews with individuals at different levels in the organization, and reviews of survey reports as the key qualitative methods to understand the intricate relationships and the integration of the healthcare organization as a whole. Also, Colon-Emeric et al. (2006) applied the use of complexity theory with a case study method to describe how connections among staff impact the care planning process in four nursing homes. The results showed an association between greater connection among staff and the innovation of care planning.

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In previous infection control related work, Struelens (1998) contended that an innovative multidisciplinary collaborative effort was needed to provide a more comprehensive approach for healthcare organizations to reduce the MDRO burden in an efficient and cost-effective manner. A socio-ecological perspective on IP&C includes attention to the human-environmental context within which infectious agents are generated and transmitted. Macdonald (2004) proposed the use of an integrative model of environmental health to study infectious diseases. The model by Dixon and Dixon (2002) is divided up into the physiological domain, the vulnerability domain, the epistemological domain, and the health protection domain with each domain addressing a specific question. The physiological domain describes the nature of the problem, the vulnerability domain describes who is affected, the epistemological domain explains how people come to understand the effects on health and the health protection domain describes what people can do about it. The issue of infections in a healthcare setting is multi-factorial and can be linked to the various domains. This suggests that an integrative approach as outlined by Struelens (1998), Macdonald (2004) and Dixon and Dixon (2002) could enable us to see the interrelationships and their potential contributions to infections. More specifically, the use of case study research can help understand the multi-factor context of IP&C more effectively. Macdonald (2004) argues for a broader view on infectious diseases, with a shift from the current focus on the treatment of the disease itself to a more global ecological initiative for integrated disease prevention.

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Methodology

The data collection and analysis of this study were rooted in the philosophical assumptions of critical realism and influenced by the socio-ecological and ecological restoration perspectives. With a critical realist view, the study of IP&C requires an understanding of this complex phenomenon within its context where there is constant interchange between the study subject and its environment (Clark et al., 2008; McEvoy et al., 2006).

In this study, a socio-ecological perspective was adapted from the work of Lockett et al. (2005), Edwards et al. (2004), Anderson et al. (2005), Lausten (2006) and Marck (2005, 2006a, 2006b, 2006c). This perspective incorporates knowledge from social, economic, political, and cultural influential factors (Edwards et al., 2004). The methodological approach for this study also draws on knowledge from the field of ecological restoration, largely based on the previous work done by Higgs (1991, 1997, 1999, 2003), and on work by Gunderson et al. (1995, 2001, 2002), Holling (1998), and others in ecosystem management.

Ecological restoration is defined as the "process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration International Science & Policy Working Group, 2004, p.3). The principles of good ecological restoration include 'ecological effectiveness', 'ecological efficiency' and 'ethical cultures by design' (Higgs, 1997, 2003). For Higgs, 'ecologically effective' restorations consist of repairs that increase the integrity of the system and maintain fidelity to the history of the place. 'Ecologically efficient' restorations focus on the set up of sustainable safe

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margins for error and for levels of productions. The notion of generating 'ethical cultures by design' centers on the engagement in communal work that improves the way we care for each other and the places we share. These principles are important when studying and repairing the ecological integrity of damaged ecosystems. This restorative form of social-ecological thinking has been adapted to study and improve the safety of healthcare environments, particularly in the area of medication safety research (Marck, 2005, 2006a; Marck et al., 2010, 2006b, 2006c).

A socio-ecological approach on health systems which draws on work in the fields of ecosystems management (Gunderson et al., 1995), economics (Ostrom, 2006), restoration management (Higgs 1991, 1997, 1999, 2003) and health systems research (Marck et al., 2006a; Marck et al., 2006b) informed this research design. The intent of this participatory research approach was to generate and share scientific and local knowledge about the places we inhabit within the larger context of understanding socio-ecological systems as a whole (Gunderson et al., 2001; Edwards et al., 2007, Rhemtulla et al., 2002; Marck et al., 2006a). The core elements of the proposed framework (adapted from Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006c) used to guide the research are those of (1) citizen science, (2) place ethic, (3) engaged practice, and (4) adaptive learning and growth.

The first element, *citizen science,* refers to the use of a participatory and collaborative approach to the design and conduct of the research and the analysis and sharing of study findings. The conduct of citizen science refers to individuals

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working collaboratively with communities, governing bodies and others to collectively conduct research, generate evidence and share knowledge in order to understand and support desirable systems change (Irwin, 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck, 2006a; Marck et al., 2006a, 2006b, 2006c; Edwards et al., 2007). In the present study, this included using a participatory and collaborative approach to the design, conduct and analysis of IP&C research, involving members of the community in data collection, data analysis, and knowledge exchange wherever feasible and appropriate, seeking multiple sources of data, and using a variety of methods to develop integrative knowledge about local places as well as the larger system (Irwin, 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck et al., 2006b).

From the original perspective of environmental writer, Buell (1995), adapted to restoration science by Higgs (1999, 2003) and subsequently expanded to health systems research (Marck et al., 2008; Marck, 2004a; 2004b), a *place ethic* is shown in the ways that individuals treat and support each other and the places they share. Place ethic refers to the importance of fostering a deep understanding of and respect for the history, culture, knowledge and rituals of communities. In this research, thinking about place ethic includes inquiring about what people see as important in the care of each other and their environment, how they reinforce and support each other to value IP&C, and whether respect for historical knowledge informs how a place functions over time.

The concept of *engaged practice* refers to the creation, implementation and evaluation of sound practices that are evidence-informed (Higgs, 1991, 1997,

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1999, 2003; Marck et al., 2006c, 2008). This includes self monitoring and adjustment of daily IP&C practices (e.g. audits, equipment checks), using local feedback processes to continually improve workflow, work design, and processes at the individual, team, and healthcare community levels.

The idea of *adaptive learning and growth* refers to the development and use of knowledge translation strategies that disseminate learning across individuals, teams, organizations and system levels to drive sustainable changes (Gunderson et al., 2002; Gunderson et al., 1995; Higgs, 1997, 2003; Marck et al., 2006c, 2008; Walker et al., 2002). For the field of IP&C, the learning at issue might be related to the management of MDRO, screening policies, resource allocation decisions, staff and public education, or other aspects of sound evidence-informed reduction of HAI.

Methods

Study Design

Two comparative case studies were conducted between April and December 2008: the first on a surgical unit at a Netherlands' hospital and the second case study involving a surgical unit at a Canadian hospital. The objective of the study was to understand the differences and the similarities in the conditions for IP&C on (1) a surgical unit in an acute care hospital in the Netherlands that reported rates of MDRO below 1%; and (2) a surgical unit in a Canadian hospital which reported higher rates of these pathogens.

In this comparative case study research design, data were collected concurrently and analyzed iteratively to gain an in-depth understanding of each

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case through careful analysis of multiple methods as a whole (Yin, 2003; Tellis, 1997).

Case Selection

The two hospital were selected based on their differences in their rates of MDRO infections, where in the Netherlands, the methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence rate was reported as being less than 1% (Muto et al., 2003) and whereas the overall incidence of MRSA in Canadian hospitals from 1995 to 2007, increased from 0.65 to 11.04 cases per 10,000 patient-days (Simor et al., 2010). The units were selected on the basis that they were both surgical units with similar populations, both in academic, tertiary care referral centres of similar size. These observations suggested that exploring hospital practices on these units in these two countries might reveal critical differences that might shed light on their different acquisition rates.

Data Collection

To better understand the conditions of the respective workplaces in terms of IP&C, the following data collection strategies were used: observations of staff on the unit, practitioner-led photo walkabouts (Marck et al., 2006b; Marck et al., 2008; Higgs, 2003) and photo elicitation focus groups (Marck et al., 2006b; Marck et al., 2010), the review of relevant policies and procedures, and the collection of other specific IP&C data such as acquisition rates of MDRO.

Observations of the work and work environment of nurses, physicians, housekeeping staff and other hospital staff in each target unit were done to gain an initial perspective on the overall environment and IP&C practices. The nurses,

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physicians, housekeeping staff and other hospital staff on the units were informed that the study was taking place and that the observations collected will be shared with them and with the hospital in aggregate form only and not linked to any individuals.

In both hospitals, photographic research methods were used including practitioner-led photo walkabouts with photo narration and photo elicitation focus groups. A practitioner-guided “ecological tour’ of the unit enabled us to foster community participation and tap into the local expertise and local ecological knowledge that practitioners have about the places where they work in order to assess their infection control environment. In the social sciences, one common definition of photo elicitation is “an approach where photographs taken by the researcher or participants are used to elicit, draw out, evoke responses from participants” (Harper, 2002, p. 20). Photo narration corresponds to the practitioner’s ‘story’ and the ‘history’ behind the photographs. In restoration science, Rhemtulla et al. (2002) and Higgs (2003) have used repeat photography, photo elicitation, and photo narration to document historical changes in Jasper National Park over time and foster citizen engagement in the critical examination and awareness of their surroundings in citizen forums where they reviewed the photos together (photo elicitation) and shared stories about how things had changed over time (Rhemtulla et al., 2002). These visual stories of a place and its inhabitants provide the historical narrative continuity which enables participants to re-consider the past, re-assess the present, and re-imagine different possible futures for the place they share (Marck et al., 2008; Marck et al., 2006b; Higgs,

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2003). In this study, the practitioner-led photo walkabouts and photo narration enabled participants to share their perceptions of the concerns and strengths on their unit in relation to infection control. The participants in the walkabouts at each hospital included an infection control professional, a team leader and/or unit manager, a clinical nurse, a physician and two members of the housekeeping staff. In photo elicitation focus groups, individuals at different levels of the organizations (e.g. managers, staff (nurses, housekeeping, etc), physicians) and across disciplines (e.g. nursing, food, transportation, and engineering services, housekeeping), were recruited to participate in the review and further comment on the select photographs and narratives collected during the walkabouts. The three focus groups were: (1) management: infection control professionals, unit managers, managers of engineering/planning, dietary, housekeeping and transportation services, (2) health professionals: nurses, physicians, and other health professionals and (3) support staff: staff from engineering/planning, dietary, housekeeping and transportation services. The three separate focus groups: management, health professionals and clinical support staff, were created to help maximize participation and avoid any power imbalances within the groups. As Cote-Arsenault and Morrison-Beedy (2005) explain “groups should not be comprised of members with differing levels of power (e.g. supervisors and employees)” (p.174). These individuals should be divided in separate groups because it is more likely that the individuals “with less power [would] participate less fully or openly” (Cote-Arsenault and Morrison-Beedy, 2005, p.175).

Policies and procedures relevant to IP&C practices on the unit and within the hospital were reviewed including hand hygiene, facility design, cleaning protocols, infection control education and training for staff, observation or audit tools, reporting of HAI, isolation procedures, screening processes, surveillance and antibiotic usage.

Aggregate, anonymized monthly IP&C related data for the units and the hospitals for a period of twelve months were collected. The data included: staffing ratios, bed occupancy rates, descriptive nature of the patient population, hospital architecture (e.g. proportion of single bed rooms, shared bathrooms), description of hand hygiene audit methods, frequency of audits and hand hygiene adherence rates (if available), and definitions and acquisition rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI). The multiple sources of data and their purposes are presented in Table 3-1 below.

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Table 3-1: Multiple Data Sources

Data Collection Methods	Sources of Data	Purpose
Observations of staff on the units	Field Notes	To observe the overall practices and the workflow of the unit.
Photo Walkabouts	Photographs Photo narration transcripts Field notes	To obtain through narration and photographs, the practitioner's perceptions on the strengths and weaknesses of their clinical unit in relation to infection control.
Focus Group	Focus group transcripts Written comments Field notes	To review and further comment on the images and narratives collected during the walkabouts. The participants also provided written comments.
Local policies and procedures aimed at the prevention and minimization of MDRO	Documents	To provide a better understanding of the existing policies and procedures.
Specific IP&C data	Descriptive data	To provide a better understanding of the existing practices and infection rates.
Follow-up correspondence	Field notes	To obtain feedback from local experts.

Data Analysis

The data were analyzed iteratively to inform each phases of the research study. The management and analysis of the written and visual data were supported by Atlas.ti ver 5.3 software (ATLAS.ti Scientific Software Development GmBH, Berlin). As a first step, all written and visual texts were sequentially reviewed for accuracy, completeness, and initial impressions in the following order:

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- Field notes of unit observations
- Transcripts and field notes of the photo walkabouts
- Photographs from the walkabouts
- Transcripts of the photo walkabouts in relation to each of the photographs
- Transcripts and field notes of the focus groups
- Transcripts of the focus groups with the photographs
- Written comments obtained during the focus group

In the second read through, select photographs and related transcripts were re-examined, and any visual or narrative text that seemed significant for whatever reason was noted or underlined, with no particular coding assigned. Comments were written in the margin to identify the rationale for highlighting particular parts of images, words or phrases. The rationale for this step was to deepen the analytical process by reviewing the transcripts and the photographs again in order to identify various aspects of the data, not only looking at individual parts, but at the data as a whole.

On the third reading, preliminary "codes" were assigned in Atlas.ti to categorize the comments that appeared to relate to similar themes or ideas, allowing the review of the data again and grouping together similar thoughts repeating this step several times. If a comment spoke to more than one important theme, it was assigned to more than one code. At this point in time, cross-reference in atlas.ti was done with selected visual images and portions of images with the preliminary codes and relevant written text.

On the fourth read of the visual data and related written texts, using the "query tool", preliminary "super codes" (themes) to combine many of the preliminary "codes" (exemplars) were created. "Super codes" are at a more theoretical level of abstraction and relate to theoretical concepts that are derived from repeated themes and connections in qualitative data. At this point in time, the links (if any) between the preliminary "super codes" derived were reviewed against the following:

- various socio-ecological frameworks (for example, Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006c),
- any other relevant literature (for example, IP&C research),
- the field observation notes, and
- the policies, procedures, infection rates, and any other institutional documents

First, the qualitative data analysis was started, then, as the themes were identified, the other IP&C related data were included when needed to better understand the whole picture. Based on this stage of analysis, the first author developed "theoretical memos" of the "working hunches" about the potential links between various groupings of data, the codes assigned, and emerging theory (socio-ecological or otherwise) about IP&C. For example, one of the themes identified was "*nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment*". This theme was drawn from the multiple sources of data (e.g. observations, the photo walkabouts and the focus groups). As the first author proceeded with the case study analysis, local and external experts were contacted to obtain critiques of the analysis. The proposed socio-ecological framework to study IP&C (adapted from Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006c) guided but did not limit the coding, categorization and theming of the qualitative data.

Following the individual case study analyses, a cross-case synthesis technique (Yin, 2003; Stake, 2006) was used to compare the two case studies. The technique involved displaying the most significant evidence for each case in tables to draw cross-case conclusions based on the overall pattern, including the similarities and differences found in the data. The data were also examined across cases for linkages with the evolving framework. The steps taken to conduct the comparative case study analysis are further outlined below.

As the first author (CB) proceeded with the comparative case study analysis, the co-authors and external experts were engaged to obtain ongoing critiques of the analysis. The case reports, including all the major themes and relevant findings, were reviewed. Subsequently, the main findings for the comparative case study report were identified in light of key relevant evidence from each of the cases, the proposed framework for studying IP&C (adapted from Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006a), and relevant literature. Based on the study objectives, cross-case conclusions were drawn based on the findings for each case study. The preliminary comparative case analysis was then reviewed by local and external experts and their feedback was incorporated into an overall integrative and comprehensive comparison between the two cases.

Findings from the Research Experience

> Most available analytic techniques have us break a system into smaller bits, study the bits, and, when we believe that we understand the bits, put them all back together again and draw some conclusions about the whole (Anderson et al., 2005, p. 271).

The case study approach using a socio-ecological perspective allows researchers to take a deep look at the data as an integrated whole. In my study, a common theme across the two cases was: *nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.* In

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both cases, nurses adapted various practices (or workarounds) to address the environmental design issues of their unit (Amalberti et al., 2006). For example, it is often difficult to know if the equipment stored in hallways is clean or dirty.

In the first case study, the lead author observed, during the field observations, a nurse setting up an IV pump in the hallway. Another nurse was plugging the blood pressure machine after taking a patient's vital signs into the wall plug located in the hallway (Observations, P2, 22).

Figure 3-1a: The Netherlands hospital - Equipment in hallway (MGMT-47)

These observations led to a discussion with some of the nurses about the lack of appropriate storage space available on the unit, and how in response to this, health professionals store both clean and dirty equipment and carts in the hallway (Figure 3-1a).

Similarly, in the second case, during the unit observations, the first author observed the equipment such as walkers, wheelchairs, chairs, scales, lifts, blood

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pressure machines, oxygen tanks, and bags of dirty linen, carts with pillows and gowns, isolation carts and linen carts in the hallway (Observations, P1, 21). Due to the lack of appropriate storage space on the unit, staff reported that it was necessary to store the equipment in the hallway as illustrated in Figure 3-1b, below.

Figure 3-1b: Canadian hospital - Equipment in hallway (C-NS-04)

Some comments received during the photo walkabouts included:

> As I walk down this corridor, one of the first things that strikes me is there's an awful lot of stuff stored in the corridor as opposed to in discreet areas and I presume some of that stuff, like bed linen, etc., is going to be used for patients and it's sitting here out in the breeze... (PW physician, P7, 15) and see all this clutter here? This is because of the lack of storage space that they have to put [away] these carts, poles, and pumps in the hallway (PW housekeeping manager, P5, 36).

A significant issue for infection control is that the equipment in the hallway can be clean or dirty.

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Another example of a workaround is the large amount of extra supplies found in the patient room. In the second case study, extra supplies taken into the room cannot be reused for another patient, thus, due to the lack of storage; they are often kept in the patient's room, on the window sill for the duration of the patient's stay (Figure 3-2a). During the walkabout with the clinical manager and the infection control professional, the participant said that:

> The equipment on, you know like the...window sill that is a practice that you know I haven't had a chance to, look into but that's something I'm going to have to work with the staff. And I think because it can be waste 'cause when this patient is discharged...all that should be thrown in the garbage (PW clinical manager and ICP, P4, 800).

Figure 3-2a: Canadian hospital – Supplies in patient room (C-MG-34)

However, in the first case study, the nurse participant explained during a photo walkabout, the use of the wound dressing cart to minimize stocking up in the patient room and going back and forth to the clean utility room in order to get the appropriate supplies for their patient (Figure 3-2b).

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Figure 3-2b: The Netherlands hospital - Wound dressing cart and linen cart in hallway (MGMT-10)

The participant described that:

> ... we put [the cart] outside the rooms and most of the time we have one cart for three, four rooms but we put it, we never take it inside the room because when you do it, it's, it can be full of bacteria (PW nurse, P9, 87). Essentially, when the dressing packages [are taken] from the cart, and [brought] in the patient room, they don't put [them] back on the cart (FG support staff, P10, 707). [The cart] is mobile. It's everything in one place. You go to the room and you get everything; it's faster ... (FG health professionals, P11, 809).

This approach could help in eliminating the extra supplies that are stored in the patient room.

In both case studies, these examples of practices adapted to work around the design issues are similar. The lack of storage space for equipment and carts creates challenges for maintaining a clean environment and thus has pressed healthcare providers to modify and adapt different practices in order to perform their work. The various methods used in the comparative case study such as the observations, photo walkabouts and focus groups allowed the different infection-related practices, otherwise normalized in day-to-day operations of space use, and cleaning practices not only impact many members of the healthcare team but are systemic in nature.

Discussion

Overall, there are several skills and elements that are required to conduct this type of in-depth comparative case study analysis. First, the cases should be carefully selected. Sufficient time and effort should be placed on the investigation of the research sites in order to ensure that the environments are comparable. For example, in our study, although the cases were selected based on the following criteria: hospital type (e.g. academic tertiary care referral centres), number of beds, population type on the patient unit and their visible differences in acquisition rates of MDRO (MRSA, VRE, ESBL, and CDI), there were many key findings discovered during the data collection that were not comparable (e.g. surveillance strategies, reporting of prevalence versus incidence rates). Thus, it was difficult to compare some key empirical elements between the two cases because of the different IP&C data collection and reporting methods carried out by each hospital. For example, because the case study hospitals used different antibiotic resistant measures (total prevalence count of isolates for one case and nosocomial incidence rates for the other), the data were converted to prevalence rates to allow for comparison. This limited the possibility of determining the proportion of MDRO that were hospital-acquired versus imported or community-acquired.

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In order to ensure that the results of this study were valid and reliable, comprehensive case study protocols were developed for the multiple sources of evidence to ensure that the data collection procedures can be repeated. As well, a protocol was developed for the analysis of the visual and written text. In addition, a secure, password protected, online repository was created to track all the data. The data were also organized and documented using version codes and track changes in order to maintain the actual “chain of evidence” (Yin, 2003). The repository provided a place for all the data in one location in order to document every change, decision or derivation from the steps listed in the study to increase the reliability of the study in a systematic way. The first author also developed a specific spreadsheet-based database to track all the photographs. A researcher’s journal was also maintained to capture my ongoing research related decision-making processes. My journal served as an audit trail, to document and to track my ongoing reflections and thoughts about my data collection and data analysis. Also, local leaders in both settings reviewed the preliminary analysis based on summaries of aggregate data gathered from their respective hospital units. Their feedback were incorporated into the final analysis and recommendations generated from the research study. Organizations should aim at adopting best practices at the national and international level (i.e. World Health Organization, Organisation for Economic Co-operation and Development (OECD), etc.) in order to facilitate better comparison of data. Collaborative or standardized data that are comparable would provide better information to drive health policy changes.

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Multiple lenses (or methods) from various viewpoints were essential in obtaining a comprehensive analysis of IP&C practices in different healthcare organizations. Case study research provided us with an approach to use multiple methods in order to study a system as a whole.

By using different data collection methods, it was possible to get an overall representation of the state of IP&C in each hospital that would have otherwise remained hidden from using only one of the methods alone. The field observations exposed the first author to the overall practices and the workflow of each unit. Also, the photo walkabouts elicited participants' stories about the strengths and weaknesses of their clinical unit in relation to infection control. The focus groups facilitated reflection on the images and documented narratives gathered during the walkabouts, fostering more open disclosure about the observations to which participants perhaps had hunches, but had yet to put into words, in regards to IP&C. It was also useful to obtain additional information from the participants' written comments during the focus groups. The other overall IP&C related data provided a better understanding of the existing practices, policies, procedures and infection rates in each environment. However, only one clinical unit at each hospital was studied in this research, which means that the findings, while qualitatively rich and analyzed with a whole systems perspective, need to be interpreted cautiously. It is possible that hospital-wide or even country wide factors could account for some of the differences in rates.

Overall, the outcomes of the analysis for each individual case study consisted of a series of illustrative descriptions integrating both the qualitative and other sources of data of each case. An iterative process was essential in conducting the analysis of the case studies because it enabled us to go back and forth and review the data. The comparative case study analysis provided a comprehensive and systematic approach to identify the key similarities and differences as well as the non-comparable aspects between the two cases.

Conclusion

I conclude that some key elements required to successfully conduct comparative case study research include careful selection of the cases, clear attention to rigor, the use of multiple methods to study the system as a whole, and specific protocols in place for the collection, analysis and reporting of the data. I also argue that a comparative case study approach allows one to view and compare the context and the socio-ecological dynamics of different organizations (in this case, two hospital surgical units) and that there are benefits to this methodological approach to studying ways to reduce infections. The results can contribute valuable knowledge about the factors which need to be taken into account when designing future infection control intervention studies and support the development of feasible policy and practice in light of the evidence on IP&C that is available to date.

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A version of this chapter will be submitted for publication to the International Journal of Qualitative Methods in the Fall of 2011.

Running head: CASE STUDY #1

CHAPTER 4: Barriers and Bridges to Infection Prevention and Control: Results of a Case Study of a Netherlands' Surgical Unit

A version of this chapter was submitted for publication. Backman, C., Marck, P.B., Krogman, N., Taylor, G., Sales, A., Bonten, M.J.M., Gigengack-Baars, A.C.M. (submitted on September 20, 2010; under review). Barriers and bridges to infection prevention and control: Results of a case study of a Netherlands' surgical unit. *Journal of Hospital Infection.*

Introduction

Infection control in the acute care environment is one of the most important issues in modern healthcare. Healthcare-associated infections (HAI) are not only a potential burden on patients in terms of increased morbidity and length of stay but also an economic burden on the healthcare system (Brooklyn Antibiotic Resistance Task Force, 2002; Song et al., 2003; Cosgrove, 2006). However, although the importance of infection control is well recognized and numerous research studies and best practice guidelines have been published on this topic, infection rates of multidrug-resistant organisms (MDRO) are on the rise in Canada and in the United States (Zoutman et al., 2005), and infection prevention and control (IP&C) remains a challenge.

In contrast to the North American situation, the "control of MRSA infections [one of the MDRO] is reported to be optimal in the Scandinavian countries [and also in the Netherlands], where strict barrier precautions are in place along with active surveillance culture (ASC) programs" (West et al., 2006, p.236). Some European countries such as the Netherlands have been recognized as world leaders at minimizing MDRO infection rates, in particular MRSA (Vriens et al., 2002). Yet, strong evidence on the most effective approaches for

A version of this chapter was submitted for publication to the Journal of Hospital Infection.

achieving good adherence to the simplest measures, such as hand hygiene, remains elusive, and further knowledge of what drives individuals, organizations and health systems towards sustainable IP&C practices does not yet exist in the research literature (Backman et al., 2008). To develop a better understanding of what may be shaping the prevention of MRSA and other MDRO, a case study was conducted in April 2008 on a surgical unit at a Netherlands hospital that reported a successful reduction in the acquisition of targeted MDRO.

The objectives of the research were:

1. To observe the overall work environment including IP&C practices on the target surgical unit;
2. To analyze the policies and procedures aimed at the prevention and minimization of MDRO in the hospital and unit environments;
3. To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and
4. To collect monthly specific IP&C related anonymized data on the target surgical unit and in the facility overall for a duration of 12 months, and the acquisition rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI).

In this paper, we discuss the key findings of the Netherlands hospital case study and offer recommendations for policy, practice and future research.

A version of this chapter was submitted for publication to the Journal of Hospital Infection.

Methods

The need for more theoretically driven research in IP&C in order to strengthen the rigor and usefulness of evidence for IP&C has been recognized in the literature (Backman et al., 2008; Struelens, 1998; Ali 2004; Glouberman, 2001; Macdonald, 2004; Waldvoegl, 2004). One promising theoretical line of inquiry is supported by Struelens' (1998) recommendation to take a broad socio-ecological approach to the study and management of IP&C. This socio-ecological perspective is well supported by others including Ali (2004), Gloubeman (2001), Macdonald (2004) and Waldvoegl (2004), who all argue that a host of inter-related social and environmental factors play a critical role in the emergence and trajectory of infectious diseases in 21st century societies and their health systems.

In this study, a socio-ecological approach on health systems informed this research design and provided a framework to better understand the complexity of implementing effective IP&C. A socio-ecological perspective provides "a framework for understanding the diverse personal and environmental factors and the interrelationships among these factors" (Edwards et al., 2004, p.45), enabling us to more accurately interpret and manage whole systems change (Edwards et al., 2007; Stokols, 1996). In socio-ecological terms, the term whole systems may be conceptualized as nested cycles of system development, degradation, or restoration (Edward et al., 2007; Gunderson et al., 2002; Holling, 1998; Marck et al., 2006a).

A whole systems' perspective on IP&C is compatible with the participatory methods of citizen science that engage communities in collectively

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studying and assessing the socio-ecological conditions of their environments in order to collaboratively design and implement useful, sustainable repairs (Marck et al., 2006a; Marck et al., 2006b; Edwards et al., 2007). For the purposes of this study, citizen science is conceptualized as a collaborative process between researchers and participants where members of the community are involved in data collection and data analysis to conduct research and generate evidence (Irwin, 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck et al., 2006b). This research approach draws on related work in the fields of ecosystems management and research (Gunderson et al., 1995), economics (Ostrom, 2006), restoration management (Higgs, 1991, 1997, 1999, 2003) and health systems (Marck et al., 2006a; Marck et al., 2006b). It involves seeking multiple sources of data and using a variety of methods to develop integrative knowledge about local places as well as the overall system as a whole (Gunderson et al., 2001, Rhemtulla et al., 2002, Edwards et al., 2007, Marck et al., 2006a).

Using a socio-ecological perspective and the concept of citizen science as theoretical guideposts, core elements of a proposed socio-ecological framework for studying IP&C were defined (Stokols, 1996, Waldvogel, 2004, Struelens, 1998, Marck et al., 2006a) and used to inform the research design and conduct of the study (See Table 4-1).

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Table 4-1: Core elements of a proposed socio-ecological framework for studying IP&C

Core Elements	Definitions
Citizen science	The notion of citizen science refers to individuals working collaboratively with communities, governing bodies and others to conduct research and generate evidence (Marck et al., 2006a; Marck et al., 2006b; Edwards et al., 2007). This includes using a participatory and collaborative approach to the design, conduct and analysis of IP&C research, involving members of the community in data collection and data analysis wherever feasible and appropriate and seeking multiple sources of data (including sources of indigenous or local knowledge) and using a variety of methods to develop integrative knowledge about local places as well as the larger system (Irwin, 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck et al., 2006b).
Place ethic	According to Lawrence Buell (1995) and Higgs (1999, 2003), a place ethic is shown in the ways that individuals treat and support each other and the places they share. Place ethic refers to the importance of fostering a deep understanding of and respect for the history, culture, knowledge and rituals of communities. In this research, thinking about place ethic includes inquiring about what people see as important in the care of each other and their environment, how they reinforce and support each other to value IP&C, and whether respect for historical knowledge informs how a place functions over time.
Engaged practice	The concept of engaged practice refers to the creation, implementation and evaluation of sound practices that are evidence-informed (Higgs, 1991, 1997, 1999, 2003; Marck et al., 2006a). This includes self monitoring and adjustment of daily IP&C practices (e.g.: audits, equipment checks), using local feedback processes to continually improve workflow, work design, and processes at the individual, team, and healthcare community levels.
Adaptive learning and growth	The idea of adaptive learning and growth refers to the development and use of knowledge translation strategies that disseminate learnings across individuals, teams, organizations and system levels to drive sustainable changes (Gunderson et al., 2002; Gunderson et al., 1995; Higgs, 1997; Higgs, 2003; Marck et al., 2006a; Walker et al., 2002). This includes evidenced-informed management of MDRO, screening policies, resource allocation decisions about patient care staffing, housekeeping, availability of equipment and supplies, staff and public education policies and funding.

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This framework informed but did not constrain the collection and analysis of the data.

Setting and Case Study Selection

The hospital is a 1042-bed tertiary care major teaching and referral center providing general and specialized services for the population of its city and the surrounding area. In 2008, the hospital had approximately 31,420 admissions, 22,564 emergency room visits and over 336,000 outpatient visits. The patient average length of stay was 7.7 days. The hospital occupancy rate was about 80% at any given time. There were 10,668 employees in 2008 including 2,560 nurses. This hospital was chosen because it reported less than 1% MDRO prevalence rates (Muto et al., 2003). The case study was conducted on a 34-bed unit, with 6 (18%) single-bed rooms, comprising mainly of orthopedic, cosmetic, urology and general surgery patients. Ethical approval was obtained through the University of Alberta Health Ethics Review Board and the hospital's Medical Ethics Review Committee.

Data Collection and Analysis

Data were collected and analyzed from multiple sources to gain an in-depth understanding of the case (Yin, 2003; Tellis, 1997) from a socio-ecological perspective on health systems. The photographic research methods used, which were adapted from previous work in ecological restoration (Higgs, 2003) and health systems research (Marck et al., 2008; Marck et al., 2006b) consisted of practitioner-led audio-taped photo walkabouts with photo narration and communal photo elicitation forums. Participant guided ecological tours of the

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hospital helped to foster community participation, local expertise and indigenous ecological knowledge that practitioners have about the places where they work. Unit observation sessions (n=3) were also performed by one of the authors (CB) and field notes were recorded on the work environment of the unit to gain an initial perspective of the overall environment and IP&C practices. In addition, policies and procedures relevant to IP&C practices (n=11) were collected in order to gain a better understanding of the existing practices. Aggregated, anonymized IP&C related data were collected including: monthly prevalence rates for MRSA, VRE, CDI and ESBL (January-December 2008), yearly hand hygiene compliance rates (2005-2008) and yearly antibiotic usage (2005-2007).

Five practitioner-led photo walkabouts and photo narrations (n=7 participants) of their perceptions of the concerns and strengths on their unit in relation to infection control were conducted. The individuals who participated in separate photo walkabouts included the infection control professional (ICP), a unit leader and unit manager, a senior nurse, a physician, and two members of the housekeeping staff (n=7). A total of 194 photographs were taken. Following the walkabouts, three separate photo elicitation focus groups (n= 13 participants) were conducted to review and discuss the images and narratives collected during the walkabout. The three groups were management, health professionals and clinical support staff. The participants were asked to provide written comments on each photograph and then each group discussed each picture as a whole. Informed consent was obtained from all the participants in the photo walkabouts and focus group sessions. Field notes were recorded after each photo walkabout and each photo elicitation session to note researcher perceptions about the environment at these times of data collection as well as participant dynamics during data collection. A summary of data collection methods is provided in Table 4-2.

Table 4-2: Data Collection Methods

Methods	**Participants**	**Data**
Unit observations (3 sessions)	All staff on the unit	Field notes
Photo walkabouts (5)	7 participants	Photographs (194) Transcripts Field notes
Photo elicitation focus groups (3)	13 participants 1. Management (5) 2. Health professionals (6) 3. Clinical support staff (2)	Transcripts Written comments Field notes
IP&C policies and procedures (11)	provided by infection control	Documents
Hand hygiene compliance rates	provided by infection control	Compliance rates over 4 years (2005-2008)
Antibiotic usage rates	provided by infection control	Rates over 3 years (2005-2007)
MRSA, VRE, CDI and ESBL counts	provided by infection control	Prevalence counts for 12 months (Jan-Dec 2008) Prevalence rates calculated by CB and verified by local expert

An iterative data analysis process was conducted to inform data collection and analysis throughout successive phases of the research. Atlas.ti version 5.3 software (ATLAS.ti Scientific Software Development GmBH, Berlin) was used to support the management and analysis of the written and visual data. The qualitative data analysis was initiated first then, as the themes became identifiable, the other findings were integrated to better understand the qualitative data. The proposed socio-ecological framework for IP&C (Table 4-1) informed the evolving interpretations of the qualitative data, but did not constrain the coding, categorization or eventual theming of the data that occurred.

The rigor of this study was supported by several measures. Observer bias was minimized by using multiple methods to gather and verify evidence on the policies, practices and surveillance data on IP&C at the study site. Each photo walkabout and focus group session was audio-taped, transcribed, and then verified to ensure accuracy. Follow-up with local experts including some participants, the manager of infection control and a physician-lead in infectious diseases, was also executed to ensure accuracy of the data collected. Furthermore, the observation field notes, photo walkabout and focus group findings were compared with findings from the other data sources of organizational policies, prevalence rates, and other relevant data (such as bed occupancy rates) as the iterative data analysis progressed. In addition, a researcher's journal was kept to capture reflections on all the research related activities.

Results

In the course of the analysis of the case study, six major themes were derived from the iterative analysis:

(1) Considerable IP&C challenges were inherent to the design of the clinical unit;
(2) Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment;
(3) Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces;
(4) Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices;

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(5) The use of knowledge about IP&C supported adaptive learning and growth; and
(6) In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

Each theme is illustrated with a variety of findings below.

Theme 1: Considerable IP&C challenges were inherent to the design of the clinical unit.

The environmental design, which was evidently complex, refers to the features of the physical environment or physical space (such as configuration, layout, organization, and other attributes) and the organization of the work (the nature, flow and safety of work). Workplace design refers to the design of the work environment, the physical space, and the accessibility of equipment; the work design is how the staff organizes their work, including the routines and the workflow on the unit. Both are central to understanding human factors, which is "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance" (International Ergonomic Association, website).

An example of the workplace design is the presence of a sink for staff use at the entrance of each room (Figure 4-1).

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Figure 4-1: Hand Hygiene station outside of patient room (MGMT-2)

A wall mounted soap dispenser, paper towels, a garbage container with lid, a wall mounted alcohol-based hand rub (ABHR) dispenser, and gloves in various sizes are present. The ABHR dispensers can only be found mounted on the wall near the sinks outside the patient rooms, in the dirty utility room and the medication room. There are no additional ABHR dispensers on the unit (Observations, P1, 26).

Another example of workplace design is the garbage cans. One participant described his concerns about the garbage bins with lids:

> Here, you washed your hands and you throw away the paper towel and you have to touch the lid of the dirty waste box again and in fact you have dirty hands again. Afterwards, you should use the ABHR. You shouldn't have to touch anything (FG management, P12, 446).

This participant clearly recognized that hands can potentially become contaminated when opening or closing waste baskets.

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Another participant raised a similar issue, showing the participant's awareness of the way the taps are designed and the potential for disease transmission:

> … to open the tap you cannot come with your elbow to the [handle]…you have to use your hands instead of using your elbow as it should be, so it's too short... I think that the handles should be longer so you can move [them] more easily (FG management, P12, 474).

In addition, some linen carts hold both clean and dirty linens (Figure 4-2).

Figure 4-2: Linen cart with clean linen and dirty laundry bags (IC-50)

During the photo walkabout, the nurse mentioned: "the clean towels and the dirty ones touch each other" (PW nurse, P9, 361). This design makes it difficult to encourage staff to wash their hands after touching the dirty linen and then taking the clean one.

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Theme 2: Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.

Workarounds are defined by Amalberti and colleagues (2006) as the "adaptation of procedures by workers to deal with the demands of the work" (p. i67). These procedures are often adapted to bypass or avoid a problematic feature of the system that jeopardizes people's chance of completing their work safely within optimal timeframes and resources. Amalberti's theory on workarounds relates to how people naturally migrate to the boundaries of what are considered acceptable practices and sometimes violate those boundaries in order to adapt to system features that constrain their ability to accomplish their work. According to Amalberti, workarounds are an inevitable feature of complex systems, and what we need to do is figure out how to facilitate the safest possible adaptations within the context of individual practice and evolving system constraints. Amalberti also distinguishes between adaptive workarounds at the boundaries and workarounds that constitute problematic violations of safety principles.

One example of workarounds was the equipment stored in the hallway. During the observations, a nurse was setting up an IV pump in the hallway and another nurse was plugging in the blood pressure machine after taking a patient's vital signs into the wall plug located in the hallway (Observations, P2, 22). Clearly, the lack of storage on the unit forces staff to store the clean and dirty equipment in the hallway.

In another instance, a participant explained the use of the wound dressing cart to minimize going back and forth to the clean utility room in order to get the appropriate supplies for their patient (Figure 4-3). The participant described that the carts stay:

> ... outside the rooms and most of the time a cart [is shared between] three [or] four rooms; [the cart] is never take[n] inside the room because it can get [contaminated] (PW nurse, P9, 87).

Essentially, when:

> ... the dressing packages [are taken] from the cart, and [brought] in the patient room, they don't put [them] back on the cart (FG support staff, P10, 707).

When dressing packages are only taken from a cart, never returned to it even if unused, this minimizes the potential for cross-contamination.

> [The cart] is mobile. It's everything in one place. You go to the room and you get everything; it's faster (FG health professionals, P11, 809).

Figure 4-3: Wound dressing cart and linen cart in hallway (MGMT-10)

The cart's availability also minimizes trips back and forth to the central clean utility room that would otherwise take place to obtain supplies and invite more opportunities for contamination.

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Other examples of relevant workarounds included the flow of clean versus dirty equipment in the hallway. During the photo walkabout with a nurse, she explained that the equipment in this hallway is clean (Figure 4-4) and the equipment in the other hallway is dirty. The staff is aware of this process and when they need a patient table, for example, they know which side of the hallway to obtain a clean table *(PW nurse, P9, 201).*

Figure 4-4: Clean equipment in this hallway (NURS-12)

Another workaround is the lack of ABHR present at the point of care, requiring staff members to go out of the room to clean their hands. During my walkabout with a physician participant, the issue of hand hygiene compliance was discussed in relation to non-single patient rooms:

> The only problem [is] that they have to wash their hands every, every time they care for a patient and then go to another. That maybe... that's a risk [of] having more patients in a room. If you have one patient in a room then you go out and you wash your hands. If you have four patients in a room, you go to one patient then to the other… (PW physician, P8, 78).

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During my walkabout with the infection control professional, the participant explained the workflow of staff when they enter a single patient room as follows:

> ... it should be in fact because you have to wash here; take off your gloves, put on ABHR but there's no ABHR here [chuckles]; go out to the sluice (anteroom); take off the other things and disinfect your hands again with ABHR. So in fact there should be ABHR at this place … (PW ICP, P6, 383).

In these situations, due to system constraints, staff members are required to leave the room to clean their hands between patients, in order to avoid the kind of safety violation that Amalberti and colleagues (2006) discuss.

Another common workaround was noted during the walkabout with the unit manager, which is the lack of space in the patient room for nurses to do their work. Nurses have to use the patient's bedside table for their equipment and supplies (Figure 4-5). The participant described what she saw on the patient's bedside table when she entered a patient room.

> Bottles of water, something to clean the wound, yogurt, dirty gloves and some dirty water and soap and I don't know what this is… [but] this makes me a bit sad (PW unit manager, P7, 1080). And also when you wash your patient and it's finished then you [should] move the basin and then you do the wound. Not do two things at once because I see a lot of hand cloths and also wound [supplies] (FG health professionals, P11, 793).

Figure 4-5: Patient's bedside table (MGMT-38)

By this photograph (Figure 4-5), it is evident that nurses need more space to work. It can be difficult for nurses to organize and do their work because there is very little space to set up the necessary supplies and thus increasing the changes for poor infection control practices.

Theme 3: Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces.

In the first set of national interdisciplinary safety competencies established for Canada, Frank et al. (2008) contend that the notion of a culture of patient safety is associated with "attitudes, activities and enduring ethical values that are conducive to the safe delivery of patient care" (p. 5). Several exemplars of organizational and team culture that were relevant to IP&C became evident in the course of the research; these are detailed below.

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For example, during the walkabout with a participating physician and infection control professional, they explained that there is a change room on the unit where staff can:

> ... put on, [and] take off their own clothes and put on their hospital [uniform] before they start working (PW physician and ICP, P8, 456).

During a follow-up, a key informant said:

> Only a few staff members (<5%) wear their uniform outside the hospital. It's a rare occurrence. Most nurses change uniforms in the hospital (key informant).

This routine and highly consistent separation of work and street clothing is a notable example of a shared practice, within the group.

Shared values are also an important concept in the workplace. This refers to the individuals sharing similar beliefs within the group. During my observations on the unit, there is a table in the four-patient bed room which allows patients to sit together (Figure 4-6).

Figure 4-6: 4 bed patient room (IC-24)

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During a follow-up with a key informant, the physician asserted that there have not been any issues with cross-contamination based on environmental investigations of patients interacting together on the unit. Therefore, this type of activity amongst patients was seen as promoting well-being and providing a sense of community amongst patients and families.

The unit team also regularly engaged in shared meals. During my observations, the nurses had their meals and coffee breaks in the staff lounge located on the unit when everyone was ready to go on break. During my observations on the unit, I observed that eight nurses were in the staff room taking their break together (Observations, P1, 18). During the walkabout with the physician, he explained that:

> ... this is where the nurses…drink their coffee, [the] lounge (PW physician, P8, 354).

This simple activity provides an environment where nurses are encouraged to interact and communicate with each other. It also has a potential impact on infection prevention as it limits staff leaving the unit. A key informant during a follow-up discussion also said:

> ... the evening meals and coffee breaks are used in the lounge on the ward. During lunch all the nurses (and staff) go in two shifts to the restaurant of the hospital (key informant).

Culture is also reflected by the kinds of communication that occur within a team; effective communication is important in order to obtain optimal patient outcomes (Frank et al., 2008). During my observations, the list of patient names, color coded by medical specialty, with the respective nursing assignment was found posted on the wall in front of the nursing station (Observations, P1, 19).

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Staff can refer to it to find out which patient is in an isolation room and physicians and other health professionals can clearly verify the nursing assignment when they arrive on the unit.

Another clear communication strategy is the isolation card that is found posted underneath the room number. The card reads "barrière-box" isolation with gloves and gowns symbols (Observations, P1, 19). A participant said that:

> ... with the isolation room you have this card so everybody who enters the room knows that this is happening and what you have to wear (PW housekeeping staff, P5, 95).

As a support staff participant noted:

> ... it's too complex; there are too many different kinds of situations, so we always go to the nurse. [We ask] the nursing people in the hospital which things we have to do. And they tell us, we have to wear gloves, you have to put a mask on, or whatever … (FG support staff, P10, 1199).

In contrast, an example of ineffective communication was discussed by another participant who stated that:

> There's not enough information to the staff about infection control measures during a [patient] transport. They wear gowns and gloves when they're in the room but they don't tell the staff what to do during transport, so they're not informed (FG Management, P12, 121).

Clear mechanisms to promote effective communication amongst staff therefore need to be in place to minimize the likelihood of adverse events and to ultimately create and support a culture of safety (Frank et al., 2008).

Theme 4: Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices.

In the field of ecological restoration (Higgs, 1991, 1997, 1999, 2003) and in health systems research (Marck et al., 2008; Marck et al., 2006a), engaged practice refers to the vigilance, attentiveness and awareness of one's practices and each other's practices in order to reinforce and actively use what one learns to foster better treatment of each other and the places we share. Within healthcare, the concept of communities of practice, where groups of professionals work on initiatives to create, implement and evaluate evidence-based care improvements, may be thought of as one key forum for engaged practice.

A key grass root Hygiene in Practice (HIP) group, which consists of nurse representatives of every surgical unit and an infection control professional, oversees and implements several activities to promote the use of good hygiene precautions in the hospital. During a follow-up discussion, key informants said:

> The HIP group is an initiative of the surgical units and the infection control professional. The infection control professional attends the meetings of the HIP group every month and together they make plans on activities and education. It has great value because of the cooperation (key informant #1). Local initiatives are stimulated by the working group. They learn to look at their working procedures through the eyes of an infection control professional (key informant #2).

An example of their initiative includes the patient-specific storage box for wound care products (Figure 4-7):

> This is a box in use. Personal wound products for the patient and they're stored in here…(PW management, P7, 1138). So every patient when they need a lot of bandage gets a…green box (PW management, P7, 704). I like this very much; material needed for one patient is stored in a closed box. The box can be disinfected. No cart is necessary in the room (FG management, written comments, P20, 16).

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Figure 4-7: Green storage box for patient (MGMT-41)

Another example of a simple yet vital HIP initiative is the poster indicating what cleaning product to use (Figure 4-8). In the dirty utility room, there are two signs: one with photographs of items that should be disinfected with 80% ethanol (stethoscopes, commodes, basins and blood pressure cuffs); the other with photographs of items to clean with soap and water (patient side table, oxygen mount, IV pole, and IV pumps) (Observations, P1, 59).

> Everything is [designed] to make everything so clean as possible. Hygiene is very important. And easy, easy as possible for the users. You know what I mean? (PW management, P7, 938). Look with the posters over here, disinfect with alcohol, wash well the stethoscope…everything which comes in contact with the patient, direct contact... so also the remote control for the TV, and remote control for the bed. It’s disinfected with alcohol ‘cause it’s in contact with patient (PW management, P7, 820).

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Figure 4-8: Cleaning posters (MGMT-29)

Another example is the established processes to handle soiled equipment on the unit. On the counter in the dirty utility room (Figure 4-9), everything is:

> ... soiled and when it's clean it's in the cupboards. Wheelchairs, stretchers, they [are] all cleaned here or in the patient room. And they clean it with the disinfecting liquid so alcohol or chloride solution. The nurses have to clean all the equipment…that's used with the patient. Housekeeping staff is only cleaning chairs and tables (PW infection control professional, P6, 593).

However, there is an assistant on the unit during the day shift and a medical student on the evening shift who both help the nurses with the cleaning of equipment and other specified tasks. While this process has significant implications for nursing workload, the roles of all staff are clearly defined which promotes engaged practices.

Figure 4-9: Dirty utility room (IC-43)

Another example of engaged practice is the cleaning checklist posted on the unit (Figure 4-10). One of the participants said during a focus group that:

> I think it's a good example [the checklist of what needs to be cleaned] how to work as a team (FG health professionals, P11, 223).

Figure 4-10: Cleaning checklist (NURS-20)

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This checklist, developed by the Hygiene in Practice Group (HIP group), supports the concept of engaged practice as it provides clear awareness and expectations relating to cleaning regimens between the team members.

Furthermore, another sound engaged practice discovered during the walkabout with the manager of the unit is the use of stethoscopes. Nurses and physicians do not wear stethoscopes around their neck. The stethoscopes are provided by the hospital and are kept with the blood pressure machine at all times. Although studies have shown that stethoscopes have a high rate of bacterial contamination (Zuliani Maluf et al., 2002; Jones et al., 1995; Marinella et al., 1997; Smith, 1996; Sanders, 2005), research has not shown that these organisms are transmitted to patients. However, the practice of keeping the stethoscopes with the blood pressure machines encourages appropriate cleaning of the stethoscopes with 80% ethanol after each patient use (PW management, P7, 316).

Theme 5: The use of knowledge about IP&C supported adaptive learning and growth.

The theme of adaptive knowledge use refers to the development and translation of knowledge into lessons for individuals, teams, organizations and systems to drive sustainable change (Gunderson et al., 2002, Gunderson et al., 1995, Higgs, 1997, Higgs, 2003, Marck et al., 2006a, Walker et al., 2002). This adaptive knowledge is critically linked to the ongoing education, training and feedback that are necessary to encourage IP&C within healthcare.

An example of adaptive learning and growth is the evidence-informed education provided by the grass roots HIP group that is built on current staff knowledge and experience, and is geared to address gaps in practice. All surgical wards have a nurse participating in this group. Many comments were received on the educational poster created by the HIP group (Figure 4-11). For example, a comment included:

> Clear, practical information and pictures, gives good information, better because of the photographs! (FG support staff, written comments, P13, 13).

Figure 4-11: Poster (HIP group) (NURS-19)

Training and education on hand hygiene is provided to units upon request by the unit manager or the infection control department. There were no hospital-wide hand hygiene programs or campaigns underway in the hospital during the study period. Monitoring of hand hygiene compliance was calculated based on product consumption and not on hand hygiene observations.

Another example is the local feedback shared amongst team members about potential improvements. For instance, one of the participants suggested that:

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> … the [IV] cart [should have] a cover… before you start you can, grab things and lay them on top and you can…you can clean after it's off (FG health professionals, P11, 839).

Also, it was noted by a different participant that:

> The IV cart (Figure 4-12) should be covered to protect against dust (FG health professionals, written comments, P29, 9).

Figure 4-12: IV cart (IC-20)

These suggestions brought forward by staff themselves are important to the development of sustainable solutions.

Theme 6: In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

The concept of engaged leadership as a critical form of IP&C governance emerged as a key finding in my study in a variety of ways. At the Netherlands hospital, the infection control department, consisting of 1.32 FTEs per 250 beds, supports the overall IP&C activities of the hospital. The IP&C program reports to the Infection Prevention Committee who advises the Board of Directors on the

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infection control policies. This committee meets every two months and discusses all infection control-related issues. If necessary, the IP&C policies are reviewed and revised accordingly. The Infection Control Committee then reports the changes to the Board of Directors for endorsement. Twice a year an infection rate (prevalence study) of nosocomial infections is calculated. These results are provided to the management teams of each specialty involved, and to the Board of Directors. Furthermore, the Board of Directors receives a copy of the annual report of the IP&C department (which includes all the work completed by the IP&C department in the last year as well as details of any outbreaks that have occurred, etc.).

On a national level, the study hospital is one of the participating hospitals in an initiative called "Nethmap" lead by the Dutch Foundation of the Working Party on Antibiotic Policy (SWAB), in collaboration with the National Institute for Public Health and the Environment of the Netherlands (RIVM). Nethmap is based on data provided by ongoing surveillance on the use of antimicrobial agents and on the prevalence of resistance to relevant antimicrobial agents in the community and in the hospital. Each hospital is responsible to report their data to RIVM who then reports it to the European Antibiotic Resistance Surveillance System (EARSS), a network of national surveillance and information systems providing data on antimicrobial resistance in Europe.

A health system level policy supported by management is the 'search and destroy' active surveillance strategy for MRSA. The 'search and destroy' strategy for MRSA is a screening strategy that is aimed at high risk patients only, defined

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as patients who come from foreign countries or patients who have been in contact with pigs or cattle. These patients are screened on admission for carriage of MRSA (Dutch Working Party on Infection Prevention 2007d). Patients are automatically placed on isolation precautions until the test results are available. In 2008, the number of patients screened for MRSA and VRE on admission is presented in the Table 4-3.

Table 4-3: Number of patients screened for MRSA and VRE (Jan-Dec 2008)

# of patients screened	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA	21	12	20	16	6	12	11	12	7	9	11	9
VRE	59	9	5	0	2	0	3	1	1	0	0	1

Each patient screened is placed on isolation precautions until the laboratory results are available. MRSA positive patients are administered topical decolonization which includes nasal mupirocin ointment and chlorhexidine body washing for five days. If MRSA is present in the throat or perineum, other systemic antimicrobial are also given.

High risk patients are also screened for gram negatives (including extended spectrum beta-lactamases). Additional monthly screenings are done for amoxicillin-resistant *Enterococci* (ARE), VRE and resistant gram negative strains in the intensive care, hematology and nephrology units. Monthly screenings are also done for gram negative strains resistant to Tobramycin and Gentamycin in the intensive care and medium care units. Further analyses of the count of micro-organisms isolates are also performed.

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A yearly report of the antibiotic usage by specialty is provided by pharmacy. The yearly percentage of antibiotic usage for 2005-2007 is provided in Table 4-4.

Table 4-4: Percentage of Total Antibiotic usage for 2005-2007

Year	Aminoglycoside Antibacterials	Beta-lactamantibacterials, Penicillins	Macrolides and Lincosamides	Other Antibacterials	Other Beta-Lactam Antibacterials	Quinolone Antibacterials	Sulfonamides and Trimethoprim	Tetracyclines
2007	4.54%	28.13%	9.33%	7.25%	33.17%	8.67%	8.27%	0.64%
2006	4.12%	29.37%	8.37%	7.75%	31.39%	9.58%	8.77%	0.65%
2005	4.62%	29.79%	8.72%	7.71%	30.73%	8.57%	9.23%	0.64%

The hospital also provides a booklet consisting of guidelines on antibiotic usage for physicians. The microbiologists act as consultants to all the physicians in the hospital. However, physicians are free to prescribe antibiotics at their discretion, which ultimately affects the efficacy of the process.

Another example of a health system level policy in place at the Netherlands hospital is the central process used for bed cleaning to reduce the risk of bacteria survival on bed surfaces. A physician participant pointed out:

> … a bed that's going off the unit to be cleaned... It's going to be washed... in this building; it's like a car wash … (PW physician, P8, 272).

As another participant noted:

> What a good system...beds are cleaned well at the central bed cleaning department (FG health professionals, written comments, P26, 08).

Furthermore, management also provides staff uniforms, and the hospital takes the responsibility in washing them and placing them back in the staff's

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lockers. During my unit observations, the nursing, transport and housekeeping staff wore a similar white uniform. A nurse mentioned that:

> Each nurse is provided with a total of six uniforms. They are each identified with a tag with personal information. The hospital takes the responsibility of washing them and placing them back in the nurse's locker. There are designated places around the hospital where nurses can drop off their uniform for cleaning (Observations, P3, 27).

The physician explained that:

> … in the hospital there are special delivery rooms where [staff] can put their [uniform] in it and they have a name on it so when it's washed, it would be put back into their own lockers so they can get it back. Every nurse has a special number of [uniforms] which is enough to do the whole week of work. And you can change your clothes everyday; that's what they're supposed to do (PW physician, P8, 468).

Another example that is seen as significant to the participants is the policy on the use of isolation gowns. During the photo walkabout, the participant explained that staff re-use cotton gowns for contact isolation (Figure 4-13):

> … and change it every shift, so three times a day (PW ICP, P6, 203). For strict isolation, [staff] have to use a disposable gown and change it every time (PW ICP, P6, 203).

In a follow-up email with a key informant, it was reported that they had not, during any environmental investigations on the units, detected any cross-contamination with respect to the re-use of cotton gowns during a shift. The key informant said:

> In contact isolation, reusable gowns [are used] during one shift, [however] they [are] change[d] earlier when dirty. It works well and [it] is cost effective since disposable gowns are very expensive (key informant).

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Figure 4-13: Cotton isolation gowns (IC-11)

Another management practice that participants consider significant for IP&C implications is staffing practices. On the study unit, the overall number of Full-Time Equivalents (FTEs) is found in Table 4-5 and staffing ratios in Table 4-6.

Table 4-5: Number of Full-Time Equivalents (FTEs) on the Unit

Staff	**FTEs**
Registered nurses	32
Ward-assistant	1
Housekeeping staff	1
Nutritionist	1
Physiotherapist	1
Occupational therapist	0
Pharmacist	1
Team leaders	2
Unit clerks	1-2
Advance nurse	1
Medical students (MST –ers)	1

Table 4-6: Staffing Ratios on the Unit

Shifts		**Nurse-Patient Ratios**
Weekdays:		
	Day shift:	12: 34
	Evening shift:	5: 34
	Night shift:	2: 34
Weekends:		
	Day shift:	10 : 34
	Evening shift:	4: 34
	Night shift:	2: 34

In Table 4-6 (above), the night shift staff is comprised of only two registered nurses for the 34-bed unit. During a follow-up email, a key informant said:

> … if there are many patients on isolation or patients with a high workload, than an extra assistant or an extra medical student is called in to work on the ward (key informant).

Another example during my observations is that urinals and bed pans used by patients were found to be cleaned and disinfected, using the two cleaning machines (Figure 4-14) available in the dirty utility room (Observations, P1, 34).

Figure 4-14: Bedpan washer (IC-40)

According to the Dutch Working Party on Infection Prevention, it is essential that bedpans and urinals are cleaned and disinfected appropriately using bedpan washers (Dutch Working Party on Infection Prevention 2007b). Furthermore, there are also several other environmental measures in place such as strict cleaning protocols including routine and terminal cleaning and a dedicated housekeeping staff on the unit.

Overall, the hospital reports a prevalence count of patients identified with MRSA, VRE, CDI, and ESBL isolates per month. The hospital does not regularly calculate infection rates for these organisms. Thus, the estimated prevalence rates were calculated by using the proportion of cases or prevalence count of patients, over the total population at a given time. The prevalence rates are outlined in Tables 4-7 to 4-10.

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Table 4-7: Hospital- and Community-Acquired MRSA Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA Patient count	3	2	1	1	1	1	1	1	2	0	4	1
Average patient count at midnight	599	615	593	603	565	602	576	516	556	586	598	600
Prevalence rate (1,000 pt days)	5.01	3.25	1.69	1.66	1.77	1.66	1.74	1.94	3.60	0	6.69	1.67

Table 4-8: Hospital- and Community-Acquired VRE Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VRE Patient count	3	0	0	0	0	0	0	0	0	1	0	0
Average patient count at midnight	599	615	593	603	565	602	576	516	556	586	598	600
Prevalence rate (1,000 pt days)	5.0	0	0	0	0	0	0	0	0	1.7	0	0

Table 4-9: Hospital- and Community-Acquired CDI Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CDI	3	5	2	2	3	2	0	1	3	3	1	5
Average patient count at midnight	599	615	593	603	565	602	576	516	556	586	598	600
Prevalence rate (1,000 pt days)	5.0	8.13	3.37	3.32	5.31	3.32	0	1.94	5.40	5.12	1.67	8.33

Table 4-10: Hospital- and Community-Acquired ESBL Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E. coli	13	4	8	9	10	6	9	11	11	15	11	12
K. oxytoca	1	1	2	0	1	1	0	1	1	2	1	1
K. pneumoniae	1	1	0	2	1	3	4	5	1	8	5	7
Average patient count at midnight	599	615	593	603	565	602	576	516	556	586	598	600
Prevalence rate (1,000 pt days)	25	9.76	16.9	18.2	21.2	16.6	22.6	32.9	23.4	42.7	28.4	33.3

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Discussion

The findings indicate that there are considerable IP&C challenges inherent to the complexity of the hospital environment. Staff employed a wide variety of workarounds or used temporary fixes to adapt to these challenges, and organizational and team cultures were integral to the way that practices were enacted within the workplace. Staff who engaged in the unit's practice activities tended to monitor and support the use of recommended practices, and there were several exemplars of using knowledge about IP&C to support adaptive learning and growth. Also, in the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

Findings in the study support the search and destroy strategy for MRSA well documented in the literature (Verhoef et al., 1999; Wertheim et al., 2004; Vos et al., 2009) as one of the major bridges or facilitators to IP&C. In the case study, the monthly MRSA prevalence rate for 2008 ranged from 0-0.67% which is consistent with the rate of less than 1% (Muto et al., 2003) published in the literature. The control measures in the search and destroy strategy included preemptive isolation of patients, repeated screening of staff for MRSA, repeated attempts at decolonization of MRSA positive patients and staff and high levels of environmental cleaning.

Monthly screenings for VRE were also performed in the intensive care, hematology, and nephrology units. The monthly VRE prevalence rate in 2008 ranged from 0-0.5%. The CDI prevalence rate ranged from 0-0.8% and although

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additional screening on high risk patients for ESBLs was performed, the monthly ESBL prevalence rate was somewhat higher, 0.98%-4.27%.

Although MRSA, VRE and CDI rates may be below 1%, other pathogens such as ESBL may not appear to be as controlled. A comprehensive infection prevention control program for all MDRO should focus on the control of many pathogens simultaneously, including those pathogens that have not yet been identified.

Another factor that can have an impact on the rate of MDRO is the occupancy rate which was reported as approximately 80%. Studies have shown that lower occupancy rates are linked to lower infection rates (National Audit Office, 2004). In a study in Northern Ireland, the bed occupancy rate was found to have a significant positive correlation with MRSA rates in hospitals (Cunningham et al., 2005). Also, another study by Borg (2003) found a significant correlation between the bed occupancy rate and the MRSA infection rates. Similarly, Borg and colleagues (2008) concluded that periods of high occupancy levels were associated with higher MRSA incidence rates. In another study by the Department of Health in the UK (2007), concluded that hospitals with higher than 90% occupancy rates had a 10.3% greater incidence of MRSA infection than those with occupancies below 85%. Furthermore, "in the UK, the House of Commons Committee of Public Accounts has repeatedly noted that high levels of bed occupancy are not consistent with good control of infections" (Orendi, 2008, p.1401). Thus, the results of our case study support the notion that the bed occupancy rate can provide a useful measure of a hospital's ability to prevent and control the acquisition of MDRO infections.

Another bridge to IP&C is the support provided by management for the Hygiene in Practice (HIP) group. This grassroots group incorporates sound IP&C practices into the workplace. The group also provides support amongst individuals to value IP&C in the workplace, thus fostering the organizational and team culture of safety by promoting group norms in favor of good practice. Furthermore, the group promotes adaptive learning and growth by developing and translating knowledge to minimize poor IP&C practices. According to a study by the Plexus Institute (2009), healthcare workers who take ownership of the infection control issues on a unit can significantly improve MDRO rates (Plexus Institute 2009). While we are well aware of the benefits of the support from IP&C experts, it is worth exploring which kind of community of practice (e.g. unit-based practitioner-led or IP&C-led) have a greater influence on IP&C practices.

A further support for IP&C is the high level of environmental cleaning. This includes the central bed washing system which consists of the thorough washing of all hospital beds after patient discharge. According to the Dutch Working Party on Infection Prevention Bed and Accessories guidelines (2007a), “machine cleaning is preferred to manual cleaning” because of the consistency in the cleaning procedure, the high temperatures for washing and rinsing, the heavy work of manually washing a bed and the better tracking mechanism of clean beds throughout the hospital. It is worthwhile exploring this practice in further details.

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Despite the recommended IP&C practices in place, some barriers were evident. For example, the findings clearly showed the presence of environmental design challenges which can have a great impact on IP&C by creating a wide range of workarounds that are often adapted by staff to curtail the challenging care environment (Farrow et al., 2009). As Amalberti and colleagues (2006) argue, staff naturally migrate to the boundaries and violate the acceptable practices in order to adapt to a system that is not amenable. For example, staff will less likely clean their hands if they do not have proper access to soap and water or an ABHR (Haas et al., 2008; Pittet et al., 2000). In this case study, the ABHR dispensers were only located outside the patient rooms. According to the WHO Guidelines on Hand Hygiene in Health Care (2009), the ABHR dispensers should be located in the patient rooms at point of care. In addition, others support that the dispensers should also be placed in many convenient and accessible locations for staff (Creedon, 2005, Suresh et al., 2007, Harbarth et al., 2002).

Other environmental design issues that pose barriers to IP&C were also observable, such as garbage bins that require handling to open, hand operated taps, multi-bed rooms with shared toilets, and lack of storage space. It is likely that similar design issues abound in most acute care hospitals. Rathert and colleagues (2009) recommend that organizations examine how the implementation of policies and procedures influence the work and work environment of nurses in order to avoid unfavourable workarounds. It is a tribute to the empowerment and ingenuity of the staff that they innovate workarounds to try to deal with these systemic barriers and support effective control of MDRO.

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For example, due to the lack of storage space on the unit, a form of workaround was developed to identify the clean versus the dirty equipment in the hallway. Clean equipment is placed in one dedicated hallway and the dirty equipment is placed in the other. This method allows staff on the unit to know which equipment is dirty and which is clean thus avoiding using dirty equipment for another patient.

The method used to monitor adherence to hand hygiene practices is the unit-based consumption of ABHR. There are no recommendations on how to monitor compliance of hand hygiene in the Dutch guideline of hand hygiene for staff (Dutch Working Party on Infection Prevention, 2007c). However, the recommended method to monitor hand hygiene compliance, according to the WHO Guidelines on Hand Hygiene in Health Care, is by direct observations. Product consumption monitoring cannot determine if hand hygiene is performed correctly and at appropriate times. It may also not properly reflect the overall product consumption by healthcare providers, as it may also include the amount of product used by visitors and/or patients (World Health Organization, 2009).

Furthermore, although a report of the antibiotic usage by physician is provided by the pharmacy department on an annual basis, physicians are permitted to prescribe antibiotics at their discretion. This may limit the efficacy of the process. More stringent guidelines on the restrictive use of antibiotics are needed as there is a trend for hospital pathogens to become more resistant in the future (Struelens, 2003).

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There were several limitations to this study. It is possible, for instance, that staff may have altered their behavior from normal practices during unit observations. Furthermore, the prevalence counts of MRSA, VRE, CDI and ESBL, the rates of hand hygiene product usage and antibiotic data were collected by hospital personnel not supervised by the researcher, limiting the ability to assess the rigor of data collection. In addition, the focus of this study was on a specific clinical unit of the hospital. I attempted to address these limitations by incorporating multiple methods of data collection and by taking a broad socio-ecological system approach to study IP&C on the unit. However, if feasible, it would be preferable in future case studies to collect all data across sites through one researcher and study entire organizations or perhaps even regions to obtain a more comprehensive picture of some aspects of the complex phenomena of IP&C.

Conclusion

This case study provided in-depth knowledge of the socio-ecological conditions present on a surgical unit at a Netherlands hospital that reported rates of MDRO below 1%. These findings suggest there is merit in further exploring the potential benefits of such health system practices for optimal prevention and control of MDRO in modern hospital environments. Further research on the benefits of practitioner-led community of practices on IP&C practices such as the Hygiene in Practice group is also recommended. Additional case studies to compare theses practices to other acute care hospital around the world would be a valuable way to better understand what IP&C programs are most effective in which contexts, and for what reasons.

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CHAPTER 5: Barriers and Bridges to Infection Prevention and Control: Results of a Case Study of a Canadian Surgical Unit

A version of this chapter will be submitted for publication. Backman, C., Marck, P.B., Krogman, N., Taylor, G. Sales, A., Roth, V.R. (for submission in Spring 2011). Barriers and bridges to infection prevention and control: Results of a case study of a Canadian surgical unit. Prepared for submission to the *Canadian Journal of Infection Control.*

Introduction

In a point prevalence study of Canadian major teaching hospitals, 10.5% of hospitalized patients were experiencing an infection acquired while in hospital (Gravel et al., 2007). Furthermore, the incidence rate of methicillin-resistant *Staphylococcus aureus* (MRSA) in Canadian hospitals increased from 0.46 to 8.04 per 1,000 admissions between 1995 and 2006 (CNISP, 2007). While MRSA infection rates decreased in US hospitals over a 4-year period between 2005 and 2008 (Kallen et al., 2010; Perencevich et al., 2010), healthcare-associated infections (HAI) are nevertheless a cause of increased morbidity, length of stay and cost to the healthcare system (Brooklyn Antibiotic Resistance Task Force, 2002; Song et al., 2003; Cosgrove, 2006).

The evidence to date supports the use of multiple interventions to prevent and control methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococci* (VRE) and other multidrug-resistant organisms (MDRO) (Siegel et al., 2006). Recent reviews of hand hygiene interventions (Backman et al., 2008) and infection prevention and control (IP&C) programs (Backman et al., in press) support earlier calls for the use of a socio-ecological approach to improve our understanding of the system for IP&C as a whole (Struelens, 1998;

A version of this chapter will be submitted for publication to the Canadian Journal of Infection Control in the Spring of 2011.

Waldvogel, 2004). To advance the development of a socio-ecological perspective on hospital IP&C, two case studies were conducted, one in April 2008 at a Netherlands hospital, a facility reporting rates of MDRO below 1% and a second study between September and December 2008 on a surgical unit at a Canadian hospital which reported higher rates of these pathogens. The purpose of this paper is to discuss the Canadian case study results.

Objectives

The aim of the research was to better understand the conditions for IP&C practices within this Canadian acute care environment. The specific objectives of this study were:

1. To observe the overall work environment including IP&C practices on the target surgical unit;
2. To analyze the policies and procedures aimed at the prevention and minimization of MDRO in the hospital and unit environments;
3. To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and
4. To collect specific IP&C related data on the target surgical unit and in the facility overall for a duration of 12 months, and the acquisition rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI) .

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Methods

The socio-ecological perspective of this study draws on related work in the fields of ecosystems management and research (Gunderson et al., 1995), economics (Ostrom, 2006), restoration management (Higgs, 1991, 1997, 1999, 2003) and health systems research (Marck et al., 2006a; Marck et al., 2006b). A socio-ecological perspective provides "a framework for understanding the diverse personal and environmental factors and the interrelationships among these factors" (Edwards et al., 2004, p.45). In the present study, this socio-ecological lens was applied to a participatory approach of citizen science deliberately aimed at fostering the reciprocal sharing of scientific and local indigenous knowledge throughout and after the life of individual studies, allowing scientists and communities to develop integrative knowledge about local places as well as about systems as a whole (Gunderson et al., 2001; Edwards et al., 2007; Rhemtulla et al., 2002; Marck et al., 2006a). This conception of citizen science assumes a collaborative process between researchers and participants in conducting the research, including how the data is collected and analyzed and how research findings are shared (Irwin 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck et al., 2006b).

Setting and Case Study Selection

Canada's publicly funded healthcare system offers universal coverage for medically necessary healthcare services for all Canadians. According to 2007 Organisation for Economic Co-operation and Development (OECD) data, the total expenditure on health in Canada was 10.1% of the gross domestic product. In

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that same year, the number of practicing physicians was 2.18 and nurses 9.02 per 1 000 population (OECD, 2007). In 2005, Canada's average bed occupancy rate was 95%, one of the highest bed occupancy rates among the OECD countries.

Many national organizations are involved in IP&C efforts across Canada. The Community and Hospital Infection Control Association of Canada (CHICA-Canada) is a national association of infection control professionals. The Public Health Agency of Canada (PHAC) collaborates in the Canadian Nosocomial Infection Surveillance Program (CNISP), a national initiative to monitor HAI in select Canadian healthcare organizations. The Association of Medical Microbiology and Infectious Disease Canada is a national association representing physicians and researchers specializing in the fields of medical microbiology and infectious diseases. The Canadian Patient Safety Institute leads the *Safer Healthcare Now!* initiative and Accreditation Canada establishes the standards for IP&C including a number of surveillance requirements, process audit requirements, education of staff, patients and visitors in IP&C and plans for the control of outbreaks and pandemics.

Following the 2003 outbreak of Severe Acute Respiratory Syndrome (SARS) in Ontario, recommendations led to the implementation of Regional Infection Control Networks to help coordinate IP&C activities and promote standardization across the province and also to the development of a Provincial Infectious Diseases Advisory Committee (PIDAC), a multidisciplinary scientific advisory group that provides advice on IP&C related practices to the Chief Medical Officer of Health. In 2008, hospitals in Ontario started to publicly report

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MRSA, VRE bacteraemia and CDI cases. This information is accessible via the Ontario Ministry of Health and Long-Term Care website.

In 2008, the population of the city where the study was conducted was 898,150. There were a total of 1,598 acute care beds amongst the adult acute care hospitals in the city. This equates to 1.77 bed per 1,000 population, which is effectively half the national average of 3.5 acute care hospital beds per 1,000 population in Canada (OECD, 2007).

The hospital where the study was conducted is part of one of the fourteen Local Health Integrated Networks (LHINs) in the province of Ontario. As established in 2006, the Ontario Ministry of Health and Long-Term Care describes the LHINs as "not-for-profit corporations that work with local health providers and community members to determine the health service priorities of their regions. LHINs are responsible for planning, funding and managing health services in their communities" (Ontario Ministry of Health and Long-Term Care, 2006). The hospital where the research was conducted is a 1,174-bed multi-site urban tertiary hospital; only 100 beds (9%) are in single rooms. In 2008-2009, there were a total of 126,850 emergency visits, 938,209 ambulatory care visits and 46,426 admissions. In the same year, the hospital employed 1,183 physicians and 12,029 staff, including, 3,489 registered nurses (RN) and 314 registered practical nurses (RPN). The case study was conducted on a surgical, ear, nose and throat (ENT) and ophthalmology 40-bed unit that also included off service patients due to the overcapacity issues at the hospital. The unit was selected based on its

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population type in order to allow better comparison with the Netherlands case study.

Design

A case study approach (Yin 2003; Tellis 1997) using a socio-ecological perspective on health systems was used. In keeping with a socio-ecological view of systems, multiple methods were used to explore the conditions for IP&C. The methods included unit observations, practitioner-led audio-taped photo walkabouts with photo narration (Marck et al., 2006b; Marck et al., 2008; Higgs, 2003) and communal photo elicitation forums (Marck et al., 2006a; Marck et al., 2006b; Marck et al., 2010), the review of relevant organizational documents, and the collection of other IP&C related data such as MDRO incidence and prevalence rates, bed occupancy rates, staffing ratios and governance structure for conducting organizational IP&C.

The photographic research methods, adapted from previous work in ecological restoration (Higgs, 2003) and health systems research (Marck et al., 2008; Marck et al., 2006b), consisted of practitioner-led audio-taped photo walkabouts with photo narration and communal photo elicitation forums. The photographic research methods helped to engage the local participants to share their ecological knowledge of the unit.

Data Collection

Following ethical review and approval from the University of Alberta Health Ethics Review Board and the hospital's Research Ethics Board, three unit observation sessions were performed to gain an initial perspective of the overall

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environment and the IP&C practices. During these observations, field notes were taken by the lead researcher (CB) on the work and the work environment of nurses, physicians, housekeeping staff and other hospital staff on the unit.

Subsequently, four practitioner-led photo walkabouts with photo narrations were conducted with an infection control professional and clinical manager, a senior nurse, a physician and two members of the housekeeping staff (n=6) to obtain individual perceptions of the infection control related issues and strengths on their unit.

Following the photo walkabouts, three separate photo elicitation focus groups were conducted to review and further comment on the photographs and narratives collected during the walkabout (n=13). The photo elicitation sessions were held with managers (n=4), health professionals (n=5) and clinical support staff (n=4). During these sessions, participants were asked to provide written comments and also to share with the group their thoughts as select walkabout photographs and related potential themes and issues were presented for discussion. Staff were informed about the unit observations, and informed consent was obtained from all participants in the photo walkabouts and focus group sessions. Field notes were recorded after each photo walkabout and each photo elicitation session to note researcher perceptions about the environment at these times of data collection as well as participant dynamics during data collection. In addition, the hospital's infection control policies and procedures were collected from the IP&C department to gain a better understanding of the existing policies. Monthly IP&C

related surveillance data were collected for a period of twelve months. The data collection methods are provided in Table 5-1.

Table 5-1: Data Collection Methods

Methods	**Participants**	**Data**
Unit observations (3 sessions)	All staff on the unit	Field notes
Photo walkabouts (4)	6 participants	Photographs (155) Transcripts Field notes
Photo elicitation focus groups (3)	13 participants 1. Management (4) 2. Health professionals (5) 3. Clinical support staff (4)	Transcripts Written comments Field notes
IP&C policies and procedures (23)	provided by infection control	Documents
Hand hygiene compliance rates	provided by decision support	Compliance rates over 1 year (April 2008-March 2009)
MRSA, VRE, and CDI incidence and prevalence counts and prevalence counts for ESBL	provided by decision support	Incidence and prevalence counts for 12 months (Jan-Dec 2008) Incidence and prevalence rates calculated by CB and verified by local expert

There were no data on antibiotic usage collected for this hospital as the data were not available.

Data Analysis

The data analysis was an iterative process that informed the collection and analysis of the data throughout the research study. Atlas.ti version 5.3 software (ATLAS.ti Scientific Software Development GmBH, Berlin) was used to support

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the analysis. Once the themes were identified from the qualitative analysis, the other IP&C findings were integrated to provide a better picture of the overall analysis. Step-by-step details of the data analysis are outlined in Table 5-2.

Table 5-2: Data Analysis Steps

Steps	Details
1	All the written and visual text was sequentially reviewed for accuracy, completeness, and initial impressions in the following order: • Field notes of unit observations • Transcripts and field notes of the photo walkabouts • Photographs from the walkabouts • Transcripts of the photo walkabouts in relation to each of the photographs • Transcripts and field notes of the focus groups • Transcripts of the focus groups with the photographs • Written comments obtained during the focus group
2	Select photographs and related transcripts were re-examined, and any visual or narrative text that seemed significant for whatever reason was noted or underlined, with no particular coding assigned. Comments were written in the margin to identify the rationale for highlighting particular parts of images, words or phrases.
3	Preliminary "codes" were assigned in atlas.ti to categorize the comments that appeared to relate to similar themes or ideas, allowing the review of the data again and grouping together similar thoughts repeating this step several times. If a comment spoke to more than one important theme, it was assigned to more than one code. At this point in time, cross-reference in atlas.ti was done with selected visual images and portions of images with the preliminary codes and relevant written text.
4	Using the "query tool", preliminary "super codes" (themes) to combine many of the preliminary "codes" (exemplars) were created. "Super codes" are at a more theoretical level of abstraction and relate to theoretical concepts that are derived from repeated themes and connections in qualitative data. At this point in time, the links (if any) between the preliminary "super codes" derived were reviewed against the following: • various socio-ecological frameworks (for example, Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006), • any other relevant literature (for example, IP&C research), • the field observation notes, and • the policies, procedures, infection rate reports, and any other institutional documents
5	"Theoretical memos" were developed on the "working hunches" about the potential links between various groupings of data, the codes assigned, and emerging theory (socio-ecological or otherwise) about IP&C. The data were also examined for linkages with the evolving framework.

The core elements of the proposed socio-ecological framework for studying IP&C informed but did not limit the coding, categorization and theming of the qualitative data. To strengthen the rigor of the study, multiple methods were used to minimize bias from the researchers' preconceptions. A researcher's journal was used to record the researcher's reflections on all the research related activities. Local experts reviewed the data collected to ensure accuracy of the information. Each photo walkabout and focus group session was audio-taped and transcribed verbatim. The transcripts were then verified to ensure accuracy. In addition, the study field notes and transcripts were compared with the other data sources (organizational policies, incidence and prevalence rates, and other relevant IP&C data) where applicable.

Results

Five overall themes were derived from the study findings as follows:

(1) Considerable IP&C challenges were inherent to the design of the clinical unit;

(2) Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment;

(3) Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces;

(4) Common practices posed barriers to sound IP&C; and

(5) In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

Each theme with supporting data is discussed in detail below.

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Theme 1: Considerable IP&C challenges were inherent to the design of the clinical unit.

Joseph (30), Joseph et al. (31) and Ulrich et al. (32) support the notion that the design of the acute care environment such as the workplace design (e.g. unit layout) and the work design (e.g. the organization of work, workflow) and other attributes, have an impact on the IP&C practices. On the study unit, an example of a positive workplace design is the location of the hand hygiene materials on the unit. In the alcove between two patient rooms, there is one sink for staff use which is stocked with a wall mounted soap dispenser, paper towels, a garbage container with no lid, and gloves on a rack in various sizes (Figure 5-1). A wall mounted alcohol-based hand rub (ABHR) dispenser is located between the doors of two patient rooms. In addition, dispensers are also located near the two clean utility room, and elevators (Observations, P1, 30). There is also a container with hydrogen peroxide disinfectant wipes mounted on the wall outside each patient room to clean equipment and surfaces (Observations, P1, 31).

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Figure 5-1: Alcove outside patient rooms (C-HK-24)

During a walkabout, the physician participant explained that:

> ... we do have sinks outside each pair of rooms and we also have dispensers for ABHR for hand cleaning. Obviously just looking around doesn't tell us how well they're used or not used, and my understanding from various people I know in the area is that to get good sterilization of your hands you need to wash or use the ABHR, but it would be interesting to see what the utilization of that is ... (PW physician, P7, 49).

Based on the results of the hand hygiene observations available between April 2008 and March 2009, the hand hygiene compliance rates were 50.3% before patient contact and 64% after patient contact in the hospital overall.

Another design issue on the unit is the shallow sink and gooseneck spout (Figure 5-2). During the focus group with management, a participant identified that:

> … if you go to all the sinks, they'll have either face cloths or towels next to them because of the splashing … (FG management, P9, 405).

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Figure 5-2: Water splashing on side of sink (C-MG-59)

The overall design of the unit also presents some notable barriers to maintaining IP&C. For example, during the walkabout with the housekeeping manager, the participant explained that the:

> ... building is a unique building in that it was designed with the Friesian model of health care (e.g. everything is closer to the patients with nurse servers); however the support services groups are strapped because they put one central housekeeping room for soiled utility that everybody puts their soiled stuff so we can never put a clean cart... So instead of having just one centralised or a number of centralised storage rooms for stock, the Friesian model has what's called a nurse server. So this picture...demonstrates the Friesian model of a hospital design so having all the supplies closest to the room, for the nurse (Figure 5-3). The challenge from an infection control point of view is how often is this cleaned? (PW housekeeping manager, P5, 56).

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Figure 5-3: Nurse server (C-HK-25)

The housekeeping manager also added that staff:

> ... have to leave the unit to go to the soiled utility room and I would like for your analysis to remark the distance that a worker has to travel no matter who it is, to bring something soiled and so that begs the question because it's not easy access, are people just dumping soiled equipment in the hallway ... (PW housekeeping manager, P5, 1094).

There is, however, on the unit, dedicated small dirty holds (Figure 5-4) outside of each patient room, which are used for placing small soiled items.

Figure 5-4: Dirty hold (C-NS-08)

During the focus group with the support staff, a participant explained that:

> ... the dirty hold, at least that's accessible for [when] you have something dirty… And it is labelled. Yeah, it's labelled, it's clear. So even visitors, if they're looking around for something they know that it's a dirty area ... (FG support staff, P8, 664).

Overall, the unit design presented several inherent challenges to optimal IP&C, including lack of storage space, absence of a dirty utility room and shallow sinks. In turn, as the next theme illustrates, many of these design challenges appear to be linked to the development of workarounds.

Theme 2: Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.

Amalberti et al. (2006) define workarounds as the "adaptation of procedures by workers to deal with the demands of the work" (p. i67). They explain that staff naturally migrate to the boundaries of acceptable practice and deliberately deviate from standard procedures to adapt to the deficiencies of complex, over-burdened healthcare systems that cannot reliably respond to ongoing, competing demands. Drawing on examples from other industries as well as from healthcare and earlier related theoretical work in safety science (Amalberti, 2001; Rasmussen, 1997), Amalberti and colleagues (2006) note that the cumulative impact of specific workarounds is often only recognized when major incidents occur, arguing that such incidents arise when a significant proportion of workers and the system as a whole have both migrated beyond the point of safe functioning.

One relevant workaround at the study site is the storage of a mix of clean and dirty equipment in the hallway in response to the lack of appropriate storage space on the unit (Figure 5-5). The equipment includes walkers, wheelchairs, chairs, scales, lifts, blood pressure machines, oxygen tanks, bags of dirty linen, carts with pillows and gowns, isolation carts and linen carts in the hallway (Observations, P1, 21). During the walkabout with the physician, the participant explained that:

> As I walk down this corridor, one of the first things that strikes [me] is there's an awful lot of stuff stored in the corridor as opposed to in a discreet area. Some of that stuff is bed linen [that] is going to be used for patients and it's sitting here out in the breeze and I don't know if that's significant or not ... (PW physician, P7, 15).

Similarly, during the walkabout with the housekeeping manager, the participant pointed out the following:

> See all this clutter here? This is because of the lack of storage space that they have to put these carts and poles and pumps in the hallway. On a positive side at least it's all on one side (PW housekeeping manager, P5, 36).

Figure 5-5: Equipment stored in hallway (C-NS-04)

During the focus group with management, a participant explained that there is:

> ... no label to say whether [the equipment is] clean or dirty. And usually you get a bad surprise when you pull up the seat and you see, I guess [this commode] has not been cleaned. It's just the general principles of the clean should be put away somewhere as opposed to just out there [in the hallway] (FG management, P9, 443).

According to a key informant, housekeeping is expected to put a "clean" label on the equipment and nursing is then to remove it upon use. However, it was also shared that this process has not been audited to see how well this is followed.

Another similar example of the clean-dirty workaround issue was discussed during the focus group with management (Figure 5-6). A participant explained that:

> It's excellent; the only thing is that it's only as good as, as long as the nurse takes off the sign once it's been used, right. Because housekeeping's not going to go re-clean that until that sign's off. But someone has to, there's a human element; someone has to actually remove the sign to say

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> I've used it. Ideally this should be stored in a clean hold somewhere, because obviously anyone coming by can touch it with soiled hands so that's the only thing ... (FG management, P9, 495).

Figure 5-6: Lift in hallway with clean sign (C-MG-52)

Another workaround of concern relates to the inherent constraints of the work space. For instance, one nurse participant explained during a walkabout that:

> ... you have physio using the hallway to do physiotherapy with the patients. Hanging on to the side rails because there's no physio room...and there's not enough [space] in the patients' rooms to do physio. Most of the physio is done in the hallway using the side rails. I don't know how often [the side rails are] washed by housekeeping (PW nurse, P6, 395).

According to a key informant, physiotherapists are expected to ensure that the patients' hands are cleaned with ABHR before bringing them out of the room to minimize this type of contamination.

Another workaround which participants highlighted was the use of hallway isolation carts on the unit which are not available for every room (Figure 5-7). During the focus group with management, a participant explained that:

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> … there are isolation carts for isolation rooms but we always have to come back to routine. You should have [personal protective equipment] available routinely for all patients in an ideal world … (FG management, P9, 359).

During the walkabout with the clinical manager and the infection control professional, the participant explained that:

> ... if your piece of [personal protective equipment] is not nearby, it always makes it [less likely for] people [to] actually go into the main supply room to get [one] so it does seem like a really good idea, to have everything within easy reach because accessibility makes a difference in terms of whether or not it'll be used (PW clinical manager and ICP, P4, 65).

Figure 5-7: Isolation cart (C-MG-18)

A workaround which drew considerable discussion was the placement of the isolation gowns (Figure 5-8). A participant explained that the isolation gowns are:

> … fairly well segregated because the clean ones are usually in a bag like that...on a cart... and then the dirty ones are in a bin like you can just see in that patient's room there. There's no signage to tell you that and the way the gowns look here to anybody coming in casually could easily think

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> those were the dirty ones but I guess if you work around here…we know it's pretty standard. There are times when there's a lot of patients on isolation who have got contact precautions in which case sometimes you have to go running around looking for gowns and, and masks and the caps but most of the time they're outside the room (PW physician, P7, 214).

Figure 5-8: Gowns on cart in hallway (C-MG-04)

Another participant explained the challenge with the isolation gowns as follows:

> The gowns come in a plastic bag and you would take it, I don't know if you notice but the dirty is in the blue and the clean was in a clear bag so but if you don't know that right? (PW clinical manager and ICP, P4, 452).

According to a key informant, the isolation signs direct visitors to speak to a nurse before entering the room (so the nurse can assist with their personal protective equipment). However, it was acknowledged that this may not be happening consistently. Furthermore, this informant observed that while staff may know which gowns are clean and which are dirty:

> ... there's also patients, not just staff that are going to get stuff there, it's visitors, family so...you really want to make sure 'cause where I could see a problem like a bag like that there from a visitor perspective if there's nobody around... "Oh that's clean." ...they might go in that dirty bag and get, there is that risk right? (PW clinical manager and ICP, P4, 452).

In addition, a participant explained that the clean versus dirty isolation gowns are not easily identifiable.

> My problem with the gowns is that we don't know if they're clean or not, we don't know if the table underneath was clean or not. You know like, usually they're in bags, right, and we just like take them out of the bags (FG support staff, P8, 399).

Another problematic workaround relates to access to supplies during the provision of patient care. During the focus group with management, a participant explained that is:

> ... what we'll find is that if it's not there, people won't go run and get it, right. So if it's droplet with the visor but there's none there, they'll put just the regular one but the whole point is to protect the eyes. This is where you need to have things easily accessible and available, and a sign so that it's clear what needs to be used because the visitors are often using also the wrong things (FG management, P9, 339).

According to a key informant, visitors should not enter an isolation room without speaking to a nurse; however, it was also stated that this is not enforced.

Another workaround of concern which was identified by a participant during the walkabout with the clinical manager and the infection control professional is the practice of leaving equipment in patient rooms (Figure 5-9). As this individual expressed:

> ... the equipment on... the window sill. [This] is a practice that you know I haven't had a chance to look into but that's something I'm going to have to work with the staff. Also I think it can be waste[ful] 'cause when this patient is discharged...all that should be thrown in the garbage (PW clinical manager and ICP, P4, 800).

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Figure 5-9: Extra supplies on window sill and patient table (C-MG-34)

During the same walkabout, the same participant went on to observe:

> Here's an example of big supplies at the bed [side], see there's a shelf there with a bunch of supplies (Figure 5-10), but it's again, it's in a shared room so it's not good, it's not best practice really, there should not be, or there should be minimal supplies and you should be sure that it goes with that one particular patient...like people should not be stocking up in the rooms (PW clinical manager and ICP, P4, 1580).

Figure 5-10: Extra supplies on a shelf in patient's room (C-MG-71)

An additional workaround is the placement of the housekeeping cart in the hallway (Figure 5-11) because of the lack of a housekeeping storage area. During the walkabout with the housekeeping manager, the participant identified that

> ... this cart is a little bit something that we could improve on if we had storage space when the housekeeper's on break they could put their cart in the utility room ... (PW housekeeping manager, P5, 48).

Figure 5-11: Housekeeping cart stored in hallway (C-HK-04)

Another example of a problematic workaround is the linen cart in the hallway (Figure 5-12). During the focus group with management, a participant explained that:

> ... the thing is like who's helping themselves to linen? Everybody, visitors, patients... Oh I don't like this [towel], I'm putting it back and I'll take another [one]. So it's just that it's open and accessible, it really should be in [a storage room]… At this point, once people touch it, we don't know if it's clean or dirty anymore. And the pillows could fall on the ground and then get [dirty]… Of course they're going to put [the pillows] right back on the chair. And then the cleaned or soiled commode by the way, is it clean, or is it dirty? It's not being used now so if I need it I'm going to grab it, right (FG management, P9, 439).

Figure 5-12: Linen cart in hallway (C-NS-16)

To recapitulate, many workarounds were identified by participants including the storage of a mix of clean and dirty equipment in the hallway, the constraints of the work space, the placement of isolation gowns, the access to supplies during the provision of patient care, leaving equipment in patient rooms, and the placement of the housekeeping and linen cart in the hallway. The prevalence of these workarounds suggests that they are seen as inevitable within the overall culture of the unit. This has implications for the next theme, which is that participants see their team and unit cultures as closely linked with IP&C in their care environment.

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Theme 3: Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces.

Siegel et al. (2007) argue that a culture of safety refers to “a work environment in which a shared commitment to safety on the part of management and the workforce is understood and maintained” (p.S94). In the Canadian framework of inter-professional safety competencies, Frank et al. (2008) describe a culture of patient safety linked with “attitudes, activities and enduring ethical values that are conducive to the safe delivery of patient care” (p. 5). Several exemplars that potentially promote or hinder the organizational and team culture on the study unit are described below.

The first exemplar of unit culture relates to the observable tendency of unit staff to congregate in apparent effort to promote teamwork. For example, although there were computers spread around the unit and in some areas outside patient rooms, nurses frequently migrated to the nursing station to chart and share information with each other and other team members (Observations, P1, 34). I also observed nurses socializing and eating chocolate received from a family at the nursing station (Observation, P1, 34). During the walkabout with the clinical manager and the infection control professional, the participant explained that:

> What I tend to do ‘cause I believe in team building...and recognition and things like that, I encourage the staff to use the conference room to have these type of things, either drinks or food and then clean up after please (PW clinical manager and ICP, P4, 712).

During the same walkabout, this participant added that:

> Staff are also participating and making sure the environment is ah, you know, clean and welcoming, I mean it’s a team effort right? (PW clinical manager and ICP, P4, 1272).

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A cooperative team culture was also apparent during an observation session on the unit, where one nurse from a room called one of the nurses from the nursing station to obtain extra supplies from the clean utility room. She popped her head out from the curtain wearing gloves and mask. The responding nurse went and got the supplies and entered the room to give them to the requesting nurse (Observation, P3, 37).

Examples of communication efforts to promote a safety culture were also demonstrated on the unit. For instance, when a patient was discharged, the isolation sign was left up until the housekeeper cleaned the room. The housekeeping manager explained that:

> On the bottom of each sign, it says that ‘only housekeeping staff can remove the sign…and then when the housekeeper removes it and he does all his checklists, he hands this in as proof that it was done using the proper techniques (PW housekeeping P5, 638).

Another example of a safety-oriented communication was explained by a participant:

> Patient information sheets are available in the manual and on the hospital website, but it’s up to each individual unit how they choose to disseminate that information. If a patient has acquired an infection while in hospital, we provide the patient with this pamphlet or with additional information as needed (PW clinical manager and ICP, P4, 35).

Unfortunately, related focus group written comments on concerns about the patient information sheets (Figure 5-13) included the following:

> If someone were to touch items with soiled hands, this would cause all items to become infected; however these are placed ‘higher’ at eye level; anticipate that this decreases the risk of contamination (FG health professionals written comments, P11, 8).

Figure 5-13: Information pamphlets for patients (C-MG-01)

Just as sharing information could contribute to fostering a culture of safety, not sharing necessary information could hinder it. For example, it appeared that not all nurses were aware of the cleaning practices on the unit. During a photo walkabout with a nurse participant, it was noted that:

> I think it's varied. I think if you talk to different nurses you're going to get a different impression, but most nurses will wipe down their stuff in between patients for sure...but if you're using it just for one patient, I can't take it for granted that it's been done (PW nurse, P6, 487).

Furthermore, during the walkabout with the physician, this participant explained that:

> we do get academic lectures from infectious diseases and certainly when we're talking about things like CDI there usually is some expectation for you to follow the standards in terms of hand washing, but we don't sit down with residents unless that's changed very recently to go over with them to make sure they wash, know how to wash their hands properly and make sure they really, I guess, inculcate a culture of doing that, which is really what you're trying to achieve (PW physician, P7, 206).

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A key informant explained that infection control training (including hand hygiene) is done for all medical students at the start of their clinical work as well as at the residents' annual orientation.

An example of problematic communication was presented by a participant who explained that

> there's a specific code for an isolation patient in the patient tracking system that rarely gets used. I mean if it is used, when the porter picks up the call it says, patient on isolation so he knows right away that he needs to get his [personal protective equipment]. But I mean it's so very rarely used, the [porter] gets to the room and says: I didn't know, nobody told me...the patient wasn't [coded] in the system as an isolation patient (FG support staff, P8, 947).

Overall, these examples suggest that while appropriate communication was used to promote a healthy team culture on the study unit; some problematic communication also exists. These problematic communications amongst other problematic practices can pose barriers to sound IP&C.

Theme 4: Common practices posed barriers to sound IP&C

Participants were concerned with some common practices that did not support recommended infection control practices on the unit. For example, a participant explained that:

> This is an example of a lift that's been cleaned (Figure 5-6, above). Housekeeping has cleaned it and tagged it that it's clean. Staff need to remove [the sign] if it's no longer clean because housekeeping will not re-clean it if that's still on there (PW clinical manager and ICP, P4, 1150).

However, some participants questioned whether or not the practice of removing the sign before use was being followed. For example, one participant asked:

> Would somebody go out, use it and put it back not noticing that little piece of paper was there. Use it, put it back and now it's no longer clean and [the sign] stays there (FG health professionals, P10, 995).

Some participants were concerned that the equipment was not cleaned consistently before and after patient use. A nurse explained that:

> I do believe that it is housekeeping's responsibility to make sure that the equipment is clean, but we don't have time to wait for housekeeping, so we end up doing it...because we need that equipment for other patients relatively quick. But I don't believe that it is the nurses' responsibility to have that housekeeping duty (PW nurse, P6, 603).

One nurse observed that vital signs machines were not always cleaned before use. This participant said:

> I don't think that nurses consistently [clean with hydrogen peroxide disinfectant wipes] in between patients (PW nurse, P6, 505).

Another common practice is staff carrying their stethoscopes around their necks.

> People have to be, their practice of you don't bring your stethoscope into specifically a contact precaution room. There should be dedicated stethoscopes in the room, but if they're not, they're going to take their own, but it has to be cleaned afterwards. I think people forget to clean their stethoscope (PW clinical manager and ICP, P4, 1658).

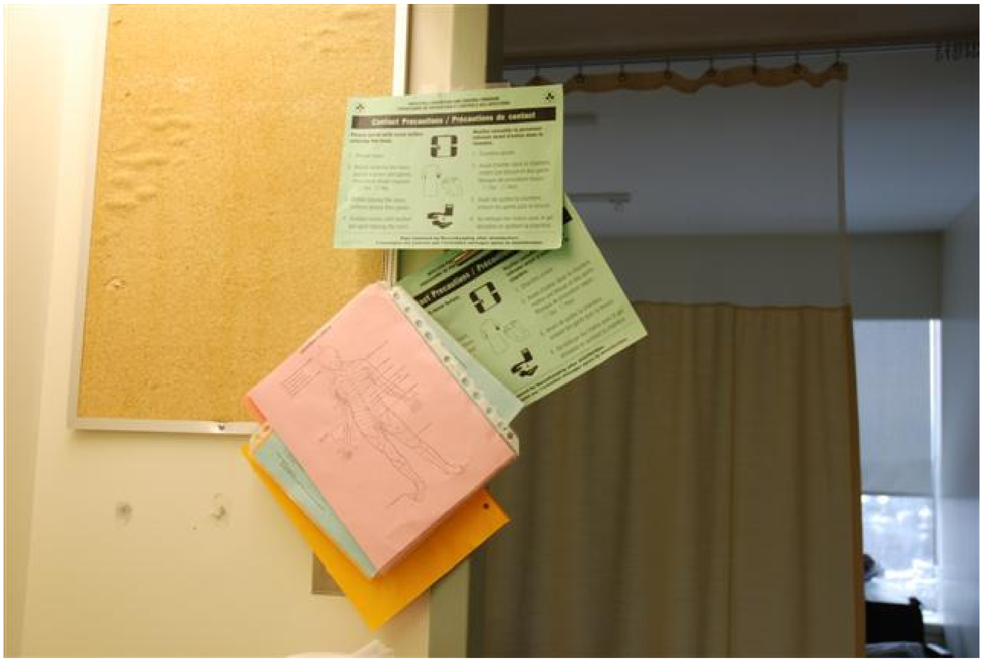
During the focus group with the support staff, a participant explained that:

> The location of the [isolation] sign is not ideal. Sometimes I've seen, you know, I don't know exactly who always puts them up but sometimes they'll be across the room, like with tape... in the middle of the, the doorway. So you'll have like the sign, you know, coming down and then the big piece of tape hanging there, but then you can't miss it because it's in your face (FG support staff, P8, 231).

However, the isolation sign is not always in a consistent location. As illustrated in the Figure 5-14 below:

> The sign [is] not visible enough, as a lay person may take it to be the same as other paper work (belonging to staff) and not read it (WC health professional, P14, 10).

Figure 5-14: Isolation sign (C-NS-06)



Another common problematic practice that was raised during the walkabout with the clinical manager and infection control professional (ICP) is the wearing of isolation gowns outside the patient room. As the ICP participant explained:

> I'm uncomfortable seeing nurses, well any healthcare worker wearing, sometimes they wear isolation gowns to keep warm so it really should be just for isolation and then they'll go into the nursing station, like you'll see them going through the chart, they know they haven't gone into the room yet but I don't know for sure (PW clinical manager and ICP, P4, 1136).

Later during the same walkabout, the clinical manager said:

> Oh, see what I was saying, she's wearing her [personal protective equipment] PPE at the nursing station (PW clinical manager and ICP, P4, 1220).

Similarly, during the walkabout with the nurse participant, it was explained that:

> Right now we have a nurse who was walking in the hallway in an isolation gown...we're not too sure if she's coming out of an isolation room or if she is going into one... I shouldn't say a nurse but an aide walking around, a

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> personal care attendant is walking around the hallways in an isolation gown (PW nurse, P6, 17).

Another example of a potentially problematic disparity in practice was illustrated in the contrast between two nurses' work habits. During the walkabout with the nurse participant, it was observed that:

> You can see the contrast between one nurse who's working outside of room nine today and that counter space and area is all neat and tidy and you have a second nurse working outside of room eight that's more cluttered and with personal belongings and patient medications, scissors, you know water (PW nurse, P6, 369).

Figure 5-15: Counter space outside patient's rooms (C-NS-15)

During this same walkabout, the nurse participant also noted that:

> As far as IV poles, I don't wash them if my patients have been taken off their IV then I bring them to the front, you know I don't clean them before I bring them to the front, I believe that it's housekeeping's responsibility to clean them. If I'm using it for another patient right away then I will clean it (PW nurse, P6, 481).

Furthermore, during the focus group with management, a participant identified that:

> The educator trains all the [staff]. It's a local decision at each how they're going to do this. I know that there is something about isolation carts and standardizing them and we [the infection control professionals] might be involved as consultants but in terms of how this gets done it's I think at a unit level, how they decide to do this (FG management, P9, 355).

To summarize the discussion of this theme, many common practices were identified on the study unit as posing barriers to sound IP&C. The need to address these problematic practices relates to the next theme, which is that participants found engaged leadership important for IP&C.

Theme 5: In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

The fifth and final theme from the findings is encapsulated in participant and visual data that suggest a variety of perceived links between the quality of leadership across system levels and the quality of IP&C within the site. The need for responsive, engaged leadership pertained both to internal organizational and unit personnel, programs, and structures and to external health system decision-making and initiatives that are potentially critical to organizational and unit capacity to effectively manage IP&C.

In terms of clinical leadership and policy development for IP&C, the study hospital IP&C program at the time of the research consisted of 2.72 FTEs per 250 beds is involved with surveillance and outbreak investigation, education, consultation, research and policy and procedure development. The program's organizational structure is found in Figure 5-16.

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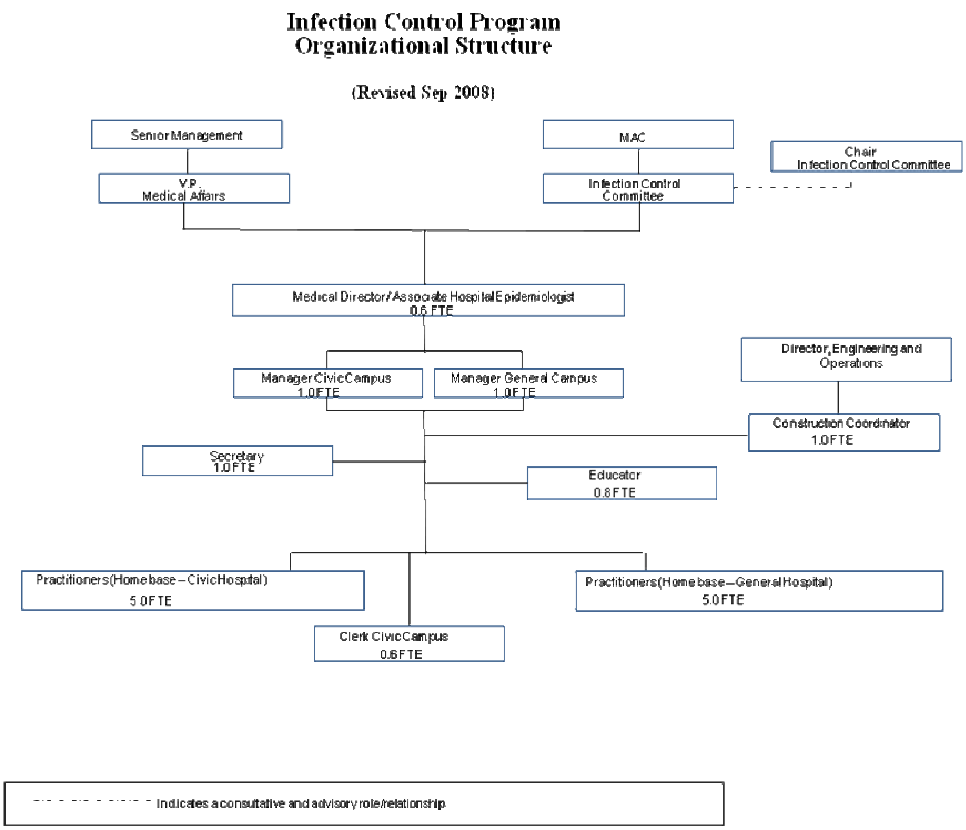
Figure 5-16: Infection Control Program Organizational Structure



The IP&C department reports to senior management via the Vice-President of Medical Affairs. It also reports to the Infection Control Committee, who in turn reports to the Medical Advisory Committee (MAC).

The external reporting structures from the organization onwards on IP&C initiatives and outcomes at the regional, provincial and national levels are depicted below in Figure 5-17.

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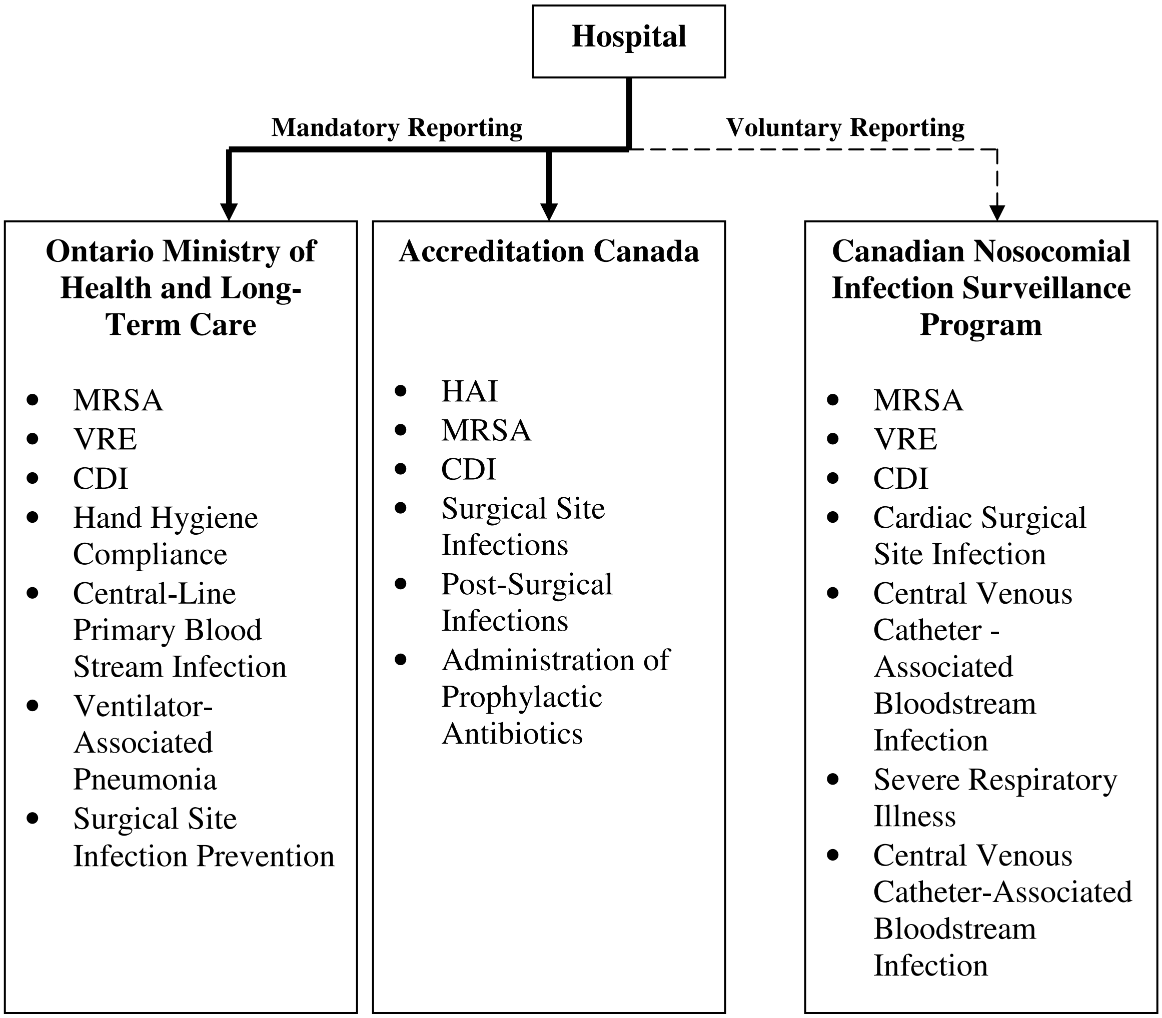
Figure 5-17: External Reporting Structures for IP&C



In terms of relationships between overall health system leadership and internal organizational leadership, participant data confirms that system decision-making and organizational decisions with the potential to affect IP&C are linked. For example, a constant issue that management struggles with is an ongoing mismatch between bed capacity and service demands. At the hospital, the average occupancy rate in 2008 was 98.5%, with frequent occurrences of overcapacity. Bed management meetings are held daily. In attendance are the patient flow

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manager and the unit managers. A clear policy and procedure has been developed to ensure communication and a consistent approach to the issues. Although there were no over-capacity or full-capacity patients admitted to the unit during the study period, when hallway admissions are needed, they have a great impact on the clutter in the hallway, patient crowding, and equipment sharing; they also affect nurse: patient ratios. As the physician participant explained during a photo walkabout:

> The standard is more and more to try and keep the patients separated and but I think because of bed pressure in this hospital it's very difficult sometimes to keep people in separate rooms and also of the architecture demands that we have shared rooms (Figure 5-18) ... (PW physician, P7, 41).

Figure 5-18: 4 bed patient room (C-MG-60)

Another IP&C concern that this participant elaborated on was the increased use of shared bathroom facilities in chronic conditions of overcapacity, stating that:

> Shared bathrooms which [are] another major issue for communicable or spread of infection; with the bed pressures we have …a very mixed group of patients in one area, it's not as if we're able to segregate... particular groups of patients…, there's a lot of overflow from one area to the other (PW physician, P7, 45).

On the unit, the patient-to-toilet ratio varied from 1:1 up to 4:1 ratio in the four bed rooms. This ratio is a key factor in VRE and CDI transmission (Joseph, 2006; Ulrich et al., 2004). A participant explained that:

> ... the infection control recommendation, I know for any new renovations and building that we go on, there's always a cost issue associated with that. I think the cost, for the new parts that are being built, the hospital agreed with one bathroom for two patients, which is a huge improvement over four beds per bathroom (PW clinical manager and ICP, P4, 1384).

Another example of a key intersection between external and internal leadership is illustrated in the link between health system and Ministry funding decisions and internal hospital resource allocation decisions in terms of staffing practices. There are a total of 35.42 FTE registered nurses and 3.62 FTE registered practical nurses on the unit. Further details on staff FTEs and staffing ratios can be found in Table 5-3 and 5-4 respectively.

Table 5-3: Number of Full-Time Equivalents (FTEs) – Study Unit

Staff	**FTEs**
Registered Nurses	35.42
Registered Practical Nurses	3.62
Orderlies	2.4
Housekeeping staff	2
Clinical dietician *(shared within the surgery service)*	0.5
Physiotherapist	1
Occupational therapist *(shared within the surgery service)*	0.5
Rehab assistant	1
Social worker	1
Clerks	4.2
Nurse educator *(shared within the surgery service)*	0.5
Clinical expert nurse *(funding until March 2009)*	2

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Table 5-4: Staffing Ratios – Study Unit

Shifts	Nurse-Patient Ratios
Weekdays:	
Day shift:	1: 4
Night shift:	1: 6
Weekends:	
Day shift:	1: 4
Night shift:	1: 6

Additionally, a local leadership decision supported the introduction in 2008 of MRSA and VRE universal screening for all patients admitted at the hospital. All patients admitted for an inpatient stay were tested at time of admission. The number of patients screened in 2008 for MRSA and VRE within 48 hours of admission is presented in Table 5-5.

Table 5-5: Number of patients screened for MRSA and VRE (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA screens	1573	2113	2267	2422	2460	2367	2494	2501	2522	2620	2410	2593
VRE screens	1550	2080	2241	2396	2444	2338	2478	2477	2519	2595	2381	2560

Routine practices are followed for all patients awaiting the test results except for any patient directly admitted from a facility outside Canada. These patients are placed on contact precautions until the screening results are available. Ongoing surveillance systems supported by management are also in place for other pathogens. In particular, there is ongoing clinical surveillance for new onset diarrhea where-upon patients are promptly put on isolation precautions without waiting for their results.

In 2008, the prevalence rates ranged between 3.9-7.1% for MRSA, 0-1.1% for VRE, 0.2-0.7% for ESBL and 2.0-4.6% for CDI, respectively. Both the incidence and prevalence rates are available in Tables 5-6 to 5-9.

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Table 5-6a: Hospital-Acquired MRSA Incidence Rate (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA	12	8	17	10	10	5	20	21	10	25	18	31
Patient days	33,9 91	32,7 93	34,2 65	33,082	33,658	33,321	32 695	31,636	33,1 31	34,7 74	34,6 86	33,5 96
Incidence rate (per 1,000 pt days)	0.35	0.24	0.50	0.30	0.30	0.15	0.61	0.66	0.30	0.72	0.52	0.92

Table 5-6b: Hospital- and Community-Acquired MRSA Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA Patient count	51	58	54	54	44	43	59	64	65	65	62	77
Average patient count at midnight	1096	1131	1105	1103	1086	1111	1055	1021	1104	1122	1156	1084
Prevalence rate (per 1,000 pt days)	46.5 1	51.2 9	48.8 5	48.97	40.53	38.71	55.94	62.71	58.8 6	57.9 5	53.6 2	71.0 5

Table 5-7a: Hospital-Acquired VRE Incidence Rate (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VRE Patient count	1	0	3	2	0	2	1	0	0	1	3	6
Patient days	33,991	32,7 93	34,2 65	33,082	33,658	33,321	32 695	31,636	33,1 31	34,7 74	34,6 86	33,5 96
Incidence rate (per 1,000 pt days)	0.03	0	0.09	0.06	0	0.06	0.03	0	0	0.03	0.09	0.18

Table 5-7b: Hospital- and Community-Acquired VRE Prevalence Rate (colonized and infected cases) (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VRE Patient count	1	2	4	5	3	5	6	3	0	1	4	12
Average patient count at midnight	1096	1131	1105	1103	1086	1111	1055	1021	1104	1122	1156	1084
Prevalen ce rate (per 1,000 pt days)	0.91	1.77	3.62	4.53	2.76	4.50	5.69	2.94	0	0.89	3.46	11.0 7

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Table 5-8a: Hospital-Acquired CDI Incidence Rate (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CDI	16	9	14	19	17	13	17	19	18	15	15	21
Patient days	33,991	32,793	34,265	33,082	33,658	33,321	32 695	31,636	33,131	34,774	34,686	33,596
Incidence rate (per 1,000 pt days)	0.47	0.27	0.41	0.57	0.51	0.39	0.52	0.60	0.54	0.43	0.43	0.63

Table 5-8b: Hospital- and Community-Acquired CDI Prevalence Rate (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CDI	31	23	26	32	34	38	46	47	48	52	42	41
Average patient count at midnight	1096	1131	1105	1103	1086	1111	1055	1021	1104	1122	1156	1084
Prevalence rate (per 1,000 pt days)	28.27	20.34	23.52	29.02	31.32	34.21	43.62	46.05	43.46	46.36	36.33	37.83

Table 5-9: ESBL Prevalence Rate (Jan-Dec 2008)

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ESBL	2	4	9	6	7	4	5	5	8	6	4	2
Average patient count at midnight	1096	1131	1105	1103	1086	1111	1055	1021	1104	1122	1156	1084
Prevalence rate (per 1,000 pt days)	1.82	3.54	8.14	5.44	6.45	3.6	4.74	4.9	7.24	5.35	3.46	1.85

Discussion

The findings indicate that despite active local leadership for IP&C and ongoing regional, provincial and national initiatives, many challenges exist in the hospital environment. Key barriers included high patient occupancy rate, hospital design, the use of workarounds to adapt to these challenges, several common problematic practices and the culture of the team or organization. At least some of

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these barriers require linked leadership across unit, organizational, and provincial levels, if not beyond.

The first barrier that transcends local leadership, the overcrowding of patients, is a significant issue in Canadian hospitals. This may be due to the number of hospital beds available for the population served. In 2008, there were a total of 1,598 acute care beds amongst the adult acute care hospitals in the city (population = 898,150) 1.77 beds per 1,000 population, virtually half the Canadian average of 3.5 beds per 1,000 population, and lower than the average in the Netherlands (4.3 beds/1,000 population) and in the United States (3.1 beds/1,000 population) (OECD, 2007). Lower occupancy rates for acute care beds should facilitate the control of HAI transmission, as research has shown that high occupancy rates are linked to higher infection rates (National Audit Office, 2004). Cunningham et al. (2005), Borg (2003) and Borg (2008) found a significant correlation between hospital bed occupancy and MRSA infection rates. In another study, hospitals with 90% or higher occupancy rates had higher rates of MRSA than those hospitals with 85% or lower occupancy rates (UK Department of Health, 2007).

Canadian hospitals need to find ways to reduce their occupancy rates so that overcrowding and rapid turnover of patients do not hinder IP&C. Adding more acute care beds to increase the total number of acute care beds per capita is one obvious but expensive response. However, the ongoing debate over emergency and hospital overcrowding suggests there is merit in exploring a more complex mix of measures that includes better access to public health and primary health care, community care, assisted living, and long term care to not only address hospital overcapacity issues in a more sustainable manner, but to also provide more effective IP&C.

Hospital design is another barrier found in this study which crosses local and broader health system levels of leadership and decision-making, combining the effects of building codes, funding decisions, and other external requirements with local governance regarding specific environmental design issues and resource allocations, such as how much money will be spent on providing single rooms as opposed to other competing design features. The hospital's challenging design elements, including few single patient rooms, multi-bed rooms and sizes, low patient-toilet ratio, lack of storage, no housekeeping closet and no dirty utility room on the unit can have an impact on MDRO transmission.

The patient equipment stored in the hallway due to the lack of storage space on the unit can also have an influence on MDRO transmission. For example, it is difficult to know if the equipment in the hallway is clean or dirty. The evidence shows that "patient care devices may transmit pathogens if devices contaminated with blood or body fluids are shared between patients without cleaning and disinfecting between patients" (Siegel et al., 2007, p. S78). In addition, supplies are stored in the patient's room in order to reduce the going back and forth to the clean utility room. Single-bed rooms with private washrooms and sinks and adequate storage space on the unit could help to reduce cross contamination (Joseph, 2006; Ulrich et al., 2004). The Community and Hospital Infection Control Association of Canada (CHICA-Canada) recommends the use of the American Institute of Architects (AIA), the Canadian Standards Association (CSA), the Public Health Agency of Canada (PHAC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) guidelines.

Another barrier to IP&C at the hospital is the communication among members of the staff and family about patients on isolation precautions. The isolation signs are often found in different locations near the room door which may hinder their usefulness. Furthermore, porters or transport personnel are not always aware of the patient's precaution status until they reach the patient's room. Clear and effective communication is needed in order to foster a culture of safety. It is reasonable to question whether nationally or even provincially or regionally standardized signage and signage placement would assist practitioners and the public to collaboratively learn about and use appropriate precautions in a more consistently reliable manner. In addition, we do not currently know the impact of the limited availability of translated IP&C information in multi-cultural Canadian cities.

These findings confirm many challenges for IP&C that have been outlined in other literature for contemporary acute care environments. For example, to reduce the use of problematic workarounds, staff must be engaged in health system and organizational decision making processes that affect their workload, workflow and daily practices, and work environment design on the unit. Yet, the existence of problematic gaps between clinical, organizational and health system governance has been identified as an issue for safety in healthcare. Specifically, in recent research in the United Kingdom, Ramsay et al. (2010) studied the relationships between the organizational management of two key safety issues (medication safety and HAI), external National Health System (NHS) governance (such as external reporting structures and relevant laws, regulations, national initiatives, and funding policies), and local governance (internal organizational oversight such as board decisions, reporting structures, resource allocation, audit and feedback programs, and other mechanisms for intra-organizational accountability). Defining organizational governance as “the systems, processes, behaviours and cultures by which an organization leads and controls its functions to achieve its objectives” (2010, p.1), Ramsay’s research team found more evidence of outcome-oriented external influences on HAI than on medication safety, which related evidence of clearer, more visible local formal leadership and governance for HAI than for medication safety.

Despite the many barriers, some bridges to IP&C exist. In 2008, universal MRSA and VRE screening strategies were implemented at the study hospital. All patients admitted for an inpatient stay were swabbed for MRSA and VRE on admission. Ideally, early identification of patients colonized with MDRO will facilitate prevention of transmission. Most MRSA and VRE guidelines recommend some form of universal (all patients) or targeted (high risk patients) screening on admission (Muto et al., 2003; Coia et al., 2006; Siegel et al., 2006; Dutch Working Party Infection Prevention, 2009) to identify patients who are colonized with MRSA or VRE.

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Another bridge is the availability of hand washing sinks and ABHR on the unit. Hand hygiene is the most important practice to prevent HAI (Boyce et al., 2002). Despite the importance of hand hygiene, research has shown poor compliance with hand hygiene practices among health professionals (Pittet, 2000). One of the barriers to adherence with hand hygiene practices is the inaccessibility to hand hygiene products. Suresh and colleagues (2007) have developed an ergonomic hand hygiene evaluation tool for organizations to assess their environment for appropriate structural characteristics. On the study unit of the Canadian hospital, sinks and ABHR are located outside of each patient room as well as other areas on the unit. Creedon (2005), Suresh et al. (2007) and Harbarth et al. (2002) support the placement of ABHR in many convenient locations on the unit; however, according to WHO (2009), ABHR dispensers should also be placed at point of care for each in-patient bed. At the same time, further research is required to determine the precise mix and dose of hand hygiene interventions that will be most effective for various specific hospital and unit contexts (Backman et al., 2008).

Furthermore, another bridge to IP&C is the clear communication and accountability processes that have been incorporated into the workflow for housekeeping and clinical staff. On the back of the isolation signs there are clear guidelines about the cleaning process for housekeeping staff. This not only provides instructions to the housekeeping staff; it also informs staff that as long as the sign is up, the room is not clean. Once the cleaning process is complete, the housekeeping staff removes the sign and submits it to their supervisor after completion providing accountability for the work done. When the sign is removed, this also communicates to the staff that the room has now been cleaned. This novel yet simple idea creates clear expectation and defines the responsibilities of the staff, thus, promoting a desirable safety competency, which is effective communication amongst team members to contribute to safe patient care (Frank et al., 2008).

Strengths of this study include the rich qualitative detail that was generated by the participatory visual approach, the active engagement of practitioners and managers in the research process and knowledge translation of the findings, and the consistency of responses and recurrence of themes between study participants with very different roles and backgrounds. A limitation to the study is the issue of insider research (Asselin, 2003; Hewitt-Taylor, 2002). In September 2009, the first author became an employee at the hospital. This change took place after the data collection and initial analysis of the case study. In order to guard against insider bias and unethical use of insider information, the first author used a researcher's journal, as well as organized ongoing discussions with committee members and other experts to identify and minimize the influence of insider knowledge in all phases of the study. The clinical research partners at the hospital were also invited to review and give feedback on the case study findings. The analysis was not altered in any way to suppress negative findings or to over-represent results that could be construed as positive.

A further limitation to this research is that it is possible staff may have altered their behavior during the unit observations. Another limitation to the rigor of data collection is that the incidence and prevalence rates and the hand hygiene observations were collected by other hospital personnel not supervised by the researcher. I attempted to address these limitations by incorporating multiple methods of data collection. In addition, the focus of this study was on a specific clinical unit of the hospital. While this last limitation was addressed by taking a broad socio-ecological system approach to study IP&C on the unit, future case studies involving entire organizations or perhaps even regions would provide a more comprehensive picture of some aspects of the complex phenomena of IP&C. In the absence of significant research funding, however, the larger contexts would necessarily yield less qualitative detail.

Conclusion

This in-depth case study provided findings related to existing socio-ecological conditions for IP&C on a surgical unit at a Canadian hospital. Many challenges to mounting an effective, sustainable IP&C program were evident in this acute care environment. Further research using a socio-ecological perspective is needed to better understand IP&C practices as a whole, to meet the goals of improving clinical IP&C practices and reducing multidrug-resistant organism infections. Specifically, additional research is needed to further our knowledge on how communities of researchers, practitioners, managers, and policy makers can collaboratively engage in studying and assessing their environments to design and implement meaningful, sustainable IP&C improvements.

A version of this chapter will be submitted for publication to the Canadian Journal of Infection Control in the Spring of 2011.

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A version of this chapter will be submitted for publication to the Canadian Journal of Infection Control in the Spring of 2011.

CHAPTER 6: Barriers and Bridges to Infection Prevention and Control on a Surgical Unit at a Netherlands Hospital and a Canadian Hospital: A Comparative Case Study Analysis

A version of this chapter will be submitted for publication. Backman, C., Marck, P.B., Krogman, N., Taylor, G. Sales, A., Roth, V.R., Bonten, M.J.M, Gigengack-Baars, A.C.M. (for submission in Spring 2011). Barriers and Bridges to infection prevention and control on a surgical unit at a Netherlands hospital and a Canadian hospital: A comparative case study analysis. Prepared for submission to the *American Journal of Infection Control.*

Introduction

As discussed in Chapter 2, many studies and guidelines have been published in the last ten years that support the implementation of interventions to prevent and control methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE) and other multidrug-resistant organisms (MDRO) (Siegel et al., 2006). Although published studies have shown successful reductions or elimination of MDRO, several factors limit the ability to draw general conclusions from these results, including differences in definitions of MDRO, study design, outcomes, confounding variables, and periods of follow-up (Backman et al., in press). Additionally, the studies in questions are largely descriptive or quasi-experimental in nature (Harris et al., 2004) and have no explicit theory articulated about infection prevention and control (IP&C) as the basis for the research design.

The use of theory-driven research, which is largely lacking in the patient safety literature (Shojania et al., 2002; Marck, 2005; Auerback et al., 2007) and infection control literature (Backman et al., 2008; Macdonald, 2004) is beneficial to build theory which more accurately reflects the real world and can possibly, at

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some point, assist in predicting how intervening in one specific way will affect outcomes. Given the lack of theoretically driven studies to date in the field, it has not been possible to determine which interventions or specific combinations of interventions are most effective in reducing the incidence of MDRO. In pursuit of contributing to the work of building theory about IP&C in complex health systems, a socio-ecological approach on health systems which draws on several fields (Gunderson et al., 1995; Higgs 1991, 1997, 1999, 2003; Marck et al., 2006a; Marck et al., 2006b; Ostrom, 2006) was used to inform this research design. A participatory research approach was employed to generate and share scientific and local knowledge about the places we inhabit within the larger context of understanding socio-ecological systems as a whole (Gunderson et al., 2001; Edwards et al., 2007, Rhemtulla et al., 2002; Marck et al., 2006a).

The core elements of the socio-ecological framework that guided this study, adapted from Stokols (1996), Waldvogel (2004), Struelens (1998) and Marck et al. (2006a), are those of citizen science, place ethic, engaged practice, and adaptive learning and growth. The first element, citizen science, refers to the collaborative approach between researchers and participants to conduct and translate the research into policy and practice (Marck, 2006a; Marck et al., 2006b; Edwards et al., 2007). The second element, place ethic, refers to the need to understand and respect the history, culture, knowledge and rituals of communities (Buell, 1995; Higgs, 1999, 2003), including what they see as key in providing the care for their patients and their environment. The third element, engaged practice, refers to the ongoing use of self monitoring and feedback to develop and incorporate evidence-informed IP&C practices (Higgs, 1991, 1997, 1999, 2003; Marck et al., 2006a) into the way that individuals, teams, and healthcare communities work. Finally, the fourth element, the notion of adaptive learning and growth, refers to the creation and use of strategies to share experiences and learnings with others in order to ensure sustainability (Gunderson et al., 2002; Gunderson et al., 1995; Higgs, 1997, 2003; Marck et al., 2006a; Walker et al., 2002).

The purpose of this paper is to conduct a comparative case study analysis of two hospital units. The two case studies were conducted between April and December 2008, in order to develop a better understanding of what may be shaping the apparent differences in the prevention of MDRO between a hospital in the Netherlands and a Canadian hospital. The first case study was conducted on a surgical unit in an acute care hospital in the Netherlands, which reported rates of MDRO below 1%. The second case study was conducted on a surgical unit at a Canadian hospital, which reported higher rates of these pathogens.

Research Question

The guiding question for this research was: What are the differences and the similarities in the conditions for IP&C between (1) a surgical unit in an acute care hospital in the Netherlands that reports rates of MDRO below 1%; and (2) a surgical unit at a Canadian hospital which reports higher rates of these pathogens?

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Methods

Case Selection

In order to better understand the nature of IP&C practices in two different countries, two hospitals were selected on the basis that they differed in their rates of MDRO infections, where in the Netherlands, the methicillin-resistant *Staphylococcus aureus* (MRSA) prevalence rate was reported as being less than 1% (Muto et al., 2003) and whereas the overall incidence of MRSA in Canadian hospitals from 1995 to 2007, increased from 0.65 to 11.04 cases per 10,000 patient-days (Simor et al., 2010). Both these hospitals were also academic health sciences centres of similar size in publicly funded systems. These observations suggested that exploring hospital practices on these units in these two countries might reveal critical differences that might shed light on their different acquisition rates.

Although these two hospitals are similar in size, with comparable average length of stays, the number of patient rooms with single beds and the total number of acute care beds available per capita are much greater in the Netherlands. Furthermore, the city in the Netherlands is much closer to agricultural production, while the Canadian city is very urban. In addition, the volume of admissions, emergency department visits, and outpatient visits differ greatly. There are also differences in the composition of the healthcare workforce, with almost twice the proportion of practicing physicians per 1,000 population in the Netherlands as in Canada, but only half the proportion of designated infection control professionals

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in the Netherlands hospital as in the Canadian hospital. A summary of statistical information on the two case study contexts is found in Table 6-1.

Table 6-1: Summary of Statistical Information

Elements	The Netherlands Hospital	Canadian Hospital
Country Level (Organisation for Economic Co-operation and Development (OECD) 2007)		
Total national health expenditure	9.8% Gross Domestic Product (GDP)	10.1% Gross Domestic Product (GDP)
Practicing physicians	3.93 per 1,000 population	2.18 per 1,000 population
Nurses	8.69 per 1,000 population	9.02 per 1,000 population
City Level	**2008**	**2008**
Population	294,742	898,150
Total acute care beds (adult)	2,400	1,598
Hospital Level	**2008**	**April 2008 – March 2009**
Operating budget	884 million euro = 1.23 billion Can$	$1.08 billion Can$
Number of beds	1,042 144 patient rooms with single beds (14%)	1,174 100 patient rooms with single beds (8.5%)
Admissions	31, 420	46,426
Emergency Department visits	22,564	126,850
Outpatient visits	336,000	938,209
Average Length of Stay	7.7 days	7.9 days
Employees	10,668 staff 2,560 Registered Nurses	12,029 staff 3,489 Registered Nurses (RN) and 314 Registered Practical Nurses (RPN)
Infection control program staffing	1.32 FTEs per 250 beds	2.72 FTEs per 250 beds
Unit Level		
Number of beds	34 6 rooms with single beds (18%)	40 4 rooms with single beds (10%)

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The first case study was conducted on a 34-bed surgical unit at a Netherlands hospital consisting of orthopedic, cosmetic, urology, general surgery and no off-service patients. The second case study was conducted on a 40-bed unit at a Canadian hospital with a general surgery, otolaryngology and ophthalmology population as well as off-service patients due to overcapacity. These two units were selected for their similar patient populations.

Data Collection

This study involved two comparative case studies. Ethical approval was obtained through the University of Alberta Health Research Ethics Board, the Medical Ethics Review Committee at the Netherlands hospital and the Research Ethics Board of the Canadian hospital.

The data collection methods included:

1. Field observations of the work and work environment of nurses, physicians, housekeeping staff and other hospital staff on the units
2. The collection of policies and procedures relevant to IP&C practices,
3. Practitioner-led photo walkabouts with practitioner photo narrations,
4. Photo elicitation focus groups to review and obtain further discussion about the images and narratives collected during the walkabouts and to collect participants' written comments on each photograph, and
5. The collection of aggregated, anonymized monthly IP&C related data for each hospital for a period of twelve months.

A researcher's journal was maintained throughout the study to document and critically reflect on the approach to data collection and data analysis, but journal entries were not used as data.

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Data Analysis

Following successive iterative analyses of the individual case study data for the two cases (refer to Chapters 4 and 5), a cross-case synthesis technique (Yin, 2003; Stake, 2006) was used to compare and contrast perspectives and analyze themes found in the two case studies. The technique involved displaying the most significant evidence for each case in tables to draw cross-case conclusions based on the overall pattern, including the similarities and differences found in the data. The data were also examined across cases for linkages with the evolving socio-ecological framework for studying IP&C. The steps taken to conduct the comparative analysis are further outlined below.

As the first author (CB) proceeded with the comparative case study analysis, the co-authors and external experts were engaged to obtain ongoing critique of the analysis. The case reports, including all the major themes and relevant findings, were reviewed. Subsequently, the main findings for the comparative case study report were identified in light of key relevant evidence from each of the cases, the proposed socio-ecological framework for studying IP&C (adapted from Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006a), and relevant literature. Based on the study objectives, cross-case conclusions were drawn based on the findings for each case study. The preliminary comparative case study analysis was then reviewed by local and external experts and their feedback was incorporated into an overall integrative and comprehensive comparison between the two cases. In the next section, the results of the iterative data analysis are presented.

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Results

In the initial comparative analysis of the two individual case studies, the following major themes (Table 6-2) were derived for one or both cases:

Table 6-2: Comparison of the Overall Themes

Overall Themes	**Case Study #1 Netherlands Hospital**	**Case Study #2 Canadian Hospital**
Considerable IP&C challenges were inherent to the design of the clinical unit	**X**	**X**
Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment	**X**	**X**
Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces	**X**	**X**
Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices	**X**	
The use of knowledge about IP&C supported adaptive learning and growth	**X**	
Common practices posed barriers to sound IP&C		**X**
In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C	**X**	**X**

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As Table 6-2 illustrates, the two case studies differed in the following themes:

- Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices (Case Study 1 only).
- The use of knowledge about IP&C supported adaptive learning and growth (Case Study 1 only).
- Common practices posed barriers to sound IP&C (Case Study 2 only).

Highlights of the uniqueness of these themes in the respective hospitals are presented below.

Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices.

Findings for this theme were only evident in the Netherlands hospital case study. For example, there was presence of a group called Hygiene in Practice (HIP), consisting of clinical staff, to develop and implement sound IP&C practices on the clinical units across the hospital. This concept of a community of practice provides a forum for engaged practice where groups of professionals work on initiatives to create, implement and evaluate evidence-informed care improvements. This type of community of practice, or any similar forms of communal IP&C practice groups, was not identified in the Canadian hospital.

The use of knowledge about IP&C supported adaptive learning and growth.

At the Netherlands hospital, the evidence-informed IP&C education provided by the grass roots HIP group builds on the current staff knowledge and experience and is geared to address gaps in practice. This kind of coordinated educational initiative provides a strong example of adaptive learning and growth. At the Canadian hospital, there is not a consistent or standardized approach to IP&C education across the organization. IP&C education is provided at a program level to staff by their respective clinical educators. While there is no question that useful learning may be occurring with these non-standardized approaches, it is not possible to accurately assess what standardized learning is actually taking place.

Common practices posed barriers to sound IP&C.

At the Canadian hospital, participants were concerned with some common practices that did not support recommended infection control practices on the unit. For example, some participants were concerned that the patient equipment was not cleaned consistently before and after patient use. At the Netherlands hospital, mechanisms were put in place to ensure that all staff were aware of their responsibilities related to equipment cleaning.

It is difficult to confidently speculate why the themes discussed above were only present in one case study and not the other. Potential explanations may include the differences between the two sites in grass roots involvement in IP&C, in approaches to IP&C education, and in the methods in place to ensure sound IP&C practices.

Despite these different themes between the two individual case studies, the following were common themes across the two cases:

- Considerable IP&C challenges were inherent to the design of the clinical unit.
- Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.
- Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces.
- In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

The key findings for each of these themes are compared in detail below.

Considerable IP&C challenges were inherent to the design of the clinical unit.

At the Netherlands hospital, the 34-bed unit consists of six single bed patient rooms, ten 2 bed patient rooms, and two 4 bed patient rooms, with shared bathrooms in the 2 and 4 bed rooms. Similarly at the Canadian hospital, the 40-bed unit consists of eight single bed patient rooms, twelve 2 bed patient rooms, and two 4 bed patient rooms, also with shared bathrooms for the 2 and 4 bed rooms. Photographs of the 4 bed patient rooms on the study unit at the Netherlands hospital (Figure 6-1 (a)) and at the Canadian hospital (Figure 6-1 (b)) are presented below.

Figure 6-1 (a): The Netherlands hospital - 4 bed patient room (IC-24)
(b): Canadian hospital – 4 bed patient room (C-MG-60)

(a) The Netherlands hospital

(b) Canadian hospital

Although the configurations of these rooms are quite different, both hospitals have 4 bed patient rooms. In the Netherlands, the 4 bed rooms are located in the corners of the unit, with the beds forming a ‘L’ shape; in Canada, the 4 beds face each other with two bays on each wall. Nonetheless, shared bedrooms and bathrooms are a common IP&C problem in most hospitals across the globe (Joseph, 2006; Ulrich et al., 2004).

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An example of a design issue in the Netherlands case study unit that seems to have been addressed in the Canadian case study unit is the garbage bins (Figure 6-2). As one Netherlands participant described his concerns about the garbage bins with lids in the study hospital (Figure 6-2 (a)):

> Here, you washed your hands and you throw away the paper towel and you have to touch the lid of the dirty waste box again and in fact you have dirty hands again. Afterwards, you should use the alcohol-based hand rub. You shouldn't have to touch anything (FG management, P12, 446).

At the Canadian hospital, the garbage bins have no lids (Figure 6-2 (b)).

Figure 6-2 (a): The Netherlands hospital - Garbage bin with lid (IC-22)
(b): Canadian hospital - Garbage bin (C-NS-18)

(a) The Netherlands hospital (b) Canadian hospital

Hands can become contaminated when staff touch the lid of the garbage bin after washing their hands. Cochrane (2003) and Ward (2000) recommend avoiding lids on the garbage bins, otherwise, if lids must be present, the garbage bins should then be foot operated to avoid contamination.

Lack of storage space on the units was another environmental challenge for both case study sites. Both hospitals store equipment in the hallway. At the Netherlands hospital, for example, the photograph in Figure 6-3 (a) below shows the storage of a housekeeping cart, a wound dressing cart, a blood pressure machine, and a dirty linen cart in the hallway. Despite the presence of equipment

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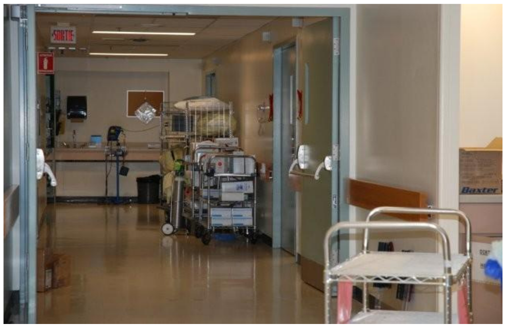
in the hallway, though, the Netherlands hospital has many storage areas on the unit. For example, Figure 6-3 (b) display a photograph of the linen closet. This storage limits the number of individuals who access the linens and thus reduces the chances of cross-contamination.

Figure 6-3 (a): The Netherlands hospital - Equipment in hallway (MGMT-37)
(b): The Netherlands hospital - Linen storage closet (IC-66)

(a) The Netherlands hospital (b) The Netherlands hospital

In the hallway of the Canadian hospital, Figure 6-4 (a) illustrates that there were several carts (e.g. isolation, linen) and blood pressure machine visible. Contrary to the Netherlands hospital, there is no storage area for linen supplies, and thus the cart is kept in the hallway where it is accessible to all the staff, patients, and visitors (Figure 6-4 (b)).

Figure 6-4 (a): Canadian hospital - Equipment in hallway (C-HK-01)
(b): Canadian hospital - Linen cart in hallway (C-NS-16)



(a) Canadian hospital

(b) Canadian hospital

At the Netherlands hospital, there is one dirty utility room on the unit (Figure 6-5 (a)). By contrast, at the Canadian hospital, there are no dirty utility rooms on the unit. There is only a very small dirty hold outside of the patient rooms (Figure 6-5 (b)). During the focus group with the support staff, a participant explained that:

> ... the dirty hold, at least that's accessible for [when] you have something dirty… And it is labelled. Yeah, it's labelled, it's clear. So even visitors, if they're looking around for something they know that it's a dirty area (FG support staff, P8, 664).

Figure 6-5 (a): The Netherlands hospital - Dirty utility room (IC-43)
(b): Canadian hospital - Dirty hold (C-NS-08)

(a) The Netherlands hospital

(b) Canadian hospital

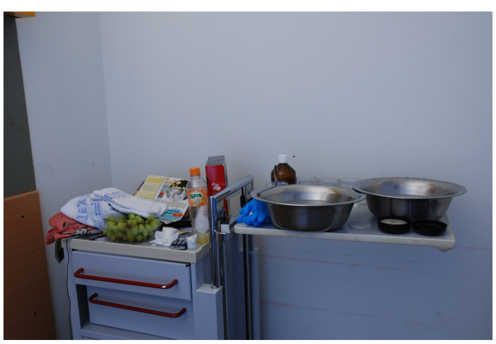
At the Canadian hospital, the dirty utility room is located off the unit near the elevators. The housekeeping manager explained:

> You have to leave the unit to go to the soiled utility room and I would like for your analysis to remark the distance that a worker has to travel no matter who it is, to bring something soiled and so that begs the question because it's not easy access, are people just dumping soiled equipment in the hallway (PW housekeeping manager, P5, 1094).

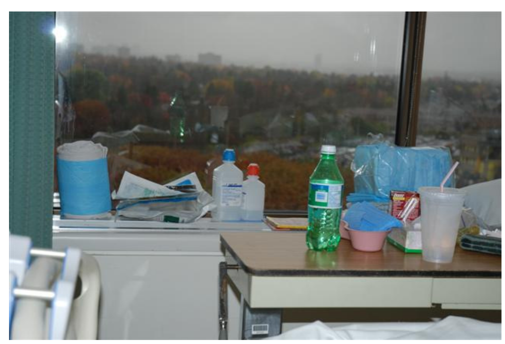
In addition, in both hospitals, there is often very little space for nurses to set up their necessary supplies in order to provide care for the patient. For example, at the Netherlands hospital, the patient's bedside table contains many patient belongings. The nurse had set up two basins to bathe the patient (Figure 6-6 (a)).

Similarly, at the Canadian hospital, patient belongings and extra supplies can be found on the windowsill and bedside table (Figure 6-6 (b)) thus making it challenging for nurses to set up their supplies in the room.

Figure 6-6 (a): The Netherlands hospital - Patient's bedside table (MGMT-38)
(b): Canadian hospital - Patient table (C-MG-34)



(a) The Netherlands hospital



(b) Canadian hospital

It is evident by these photographs that nurses need more space to work as well as adequate, easily cleaned surfaces on which to place patient care equipment.

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Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.

The environmental design of both hospitals creates many challenges to IP&C practices and lead staff to develop and adopt a variety of workarounds (Amalberti et al., 2006). According to Amalberti and colleagues (2006), workarounds in complex healthcare systems may be conceptualized as the "adaptation of procedures by workers to deal with the demands of the work" (p. i67). For example, there is a greater chance that staff will clean their hands if an alcohol-based hand rub (ABHR) or soap and water is conveniently located (Haas et al., 2008; Pittet et al., 2000). At the Netherlands hospital, the ABHR dispensers were only located next to the soap dispenser above the counter outside the patient rooms (Figure 6-7 (a)). At the Canadian hospital, the ABHR dispensers were located outside the rooms between two doors (Figure 6-7 (b)) and also in different locations around the unit (e.g. elevators, outside the clean utility room, nursing station).

Figure 6-7 (a): The Netherlands hospital - ABHR beside soap dispenser (MGMT-34)
(b): Canadian hospital - ABHR outside of two patient rooms (C-MG-10)

(a) The Netherlands hospital (b) Canadian hospital

At both hospitals, due to the lack of ABHR present at the point of care, staff members are required to go out of the room to clean their hands. At the Netherlands hospital, during my walkabout with a physician participant, the issue of hand hygiene compliance was discussed in relation to non-single patient rooms:

> the only problem [is] that they have to wash their hands every, every time they care for a patient and then go to another. That maybe... that's a risk [of] having more patients in a room. If you have one patient in a room then you go out and you wash your hands. If you have four patients in a room, you go to one patient then to the other… (PW physician, P8, 78).

Furthermore, during my walkabout with the infection control professional, the participant explained the workflow of staff when they enter a single patient room as follows:

> It should be in fact because you have to wash here; take off your gloves, put on ABHR but there's no ABHR here [chuckles]; go out to the sluice (anteroom); take off the other things and disinfect your hands again with ABHR. So in fact there should be ABHR at this place… (PW ICP, P6, 383).

Similarly, at the Canadian hospital, during the walkabout with the physician, the participant explained:

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> We do have sinks outside each pair of rooms and we also have dispensers for ABHR for hand cleaning (PW physician, P7, 49).

In these situations, due to system constraints (i.e. location of ABHR), staff members are required to leave the room to clean their hands between patients, in order to avoid the kind of safety violation that Amalberti and colleagues (2006) discuss.

Another workaround is the equipment cleaning process at both hospitals. At the Netherlands hospital, the unit developed a process whereby they stored clean equipment in one hallway (Figure 6-8 (a)) and dirty equipment in another hallway to minimize the chances of someone taking dirty equipment for use with another patient. Furthermore, a checklist was developed at the Netherlands hospital to clearly identify who, when, and how each piece of equipment should be cleaned (Figure 6-8 (b)). This checklist was posted in the dirty utility room of the unit.

Figure 6-8 (a): The Netherlands hospital - Clean equipment in this hallway (NURS-12)
(b): The Netherlands hospital - Cleaning checklist (NURS-20)

(a) The Netherlands hospital

(b) The Netherlands hospital

During the photo walkabout with a Netherlands nurse, she explained that the equipment in this hallway is clean and the equipment in the other hallway is dirty.

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The staff are aware of this process and when they need a patient table, for example, they know which side of the hallway to obtain a clean table (PW nurse, P9, 201).

At the Canadian hospital, some nurses held that the cleaning of equipment is the responsibility of the housekeeping staff. The nursing staff did not seem to be aware of any guidelines indicating who is responsible for cleaning equipment. However, the patient lift below has a sign indicating that housekeeping has cleaned it (Figure 6-9).

Figure 6-9: Canadian hospital - Lift in hallway with clean sign (C-MG-52)

Canadian hospital

Although the labeling is a clear mechanism for accountability at the Canadian case study site, a related critical step seems to be in doubt, which is that staff need to consistently remove the sign once they have used the equipment to ensure that it is not re-used on another patient until it is re-cleaned again. As a participant explained:

> It's excellent; the only thing is that it's only as good as, as long as the nurse takes off the sign once it's been used, right. Because housekeeping's not going to go re-clean that until that sign's off. But someone has to, there's a human element; someone has to actually remove the sign to say I've used it. Ideally this should be stored in a clean hold somewhere, because obviously anyone coming by can touch it with soiled hands so that's the only thing (FG management, P9, 495).

Furthermore, another Canadian participant explained that there is often:

> ... no label to say whether [the equipment is] clean or dirty. And usually you get a bad surprise when you pull up the seat and you see, I guess [this commode] has not been cleaned. It's just the general principles of the clean should be put away somewhere as opposed to just out there [in the hallway] (FG management, P9, 443).

According to a key informant, housekeeping is expected to put a "clean" label on the equipment and nursing is then supposed to remove it upon use. However, this process has not been audited to see how well this is being followed.

Participants viewed organizational and team cultures as integral to the way they enact IP&C practices in their workplaces.

Culture is reflected by the kinds of communication that occur within a team; effective communication is important in order to obtain optimal patient outcomes (Frank et al., 2008). At the Netherlands hospital, a clear communication strategy is the isolation card that is found posted underneath the room number. The card reads "barrière-box" isolation with gloves and gowns symbols (Observations, P1, 19). A participant said that:

> ... with the isolation room you have this card so everybody who enters the room knows that this is happening and what you have to wear (PW housekeeping staff, P5, 95).

An example of effective communication at the Canadian hospital that promotes a culture of safety was demonstrated on the unit. When a patient is discharge, the isolation sign is left up until the housekeeper has cleaned the room. The housekeeping manager explained that:

> On the bottom of each sign, it says that ‘only housekeeping staff can remove the sign…and then when the housekeeper removes it and he does all his checklists, he hands this in as proof that it was done using the proper techniques (PW housekeeping P5, 638).

However, examples of ineffective communication regarding IP&C were also discussed at both study sites. For instance, at the Netherlands hospital, a participant stated:

> There’s not enough information to the staff about infection control measures during a [patient] transport. They wear gowns and gloves when they’re in the room but they don’t tell the staff what to do during transport, so they’re not informed (FG Management, P12, 121).

Similarly problematic communication was presented at the Canadian hospital by a participant who explained:

> There’s a specific code for an isolation patient in the patient tracking system that rarely gets used. I mean if it is used, when the porter picks up the call it says, patient on isolation so he knows right away that he needs to get his [personal protective equipment]. But I mean it’s so very rarely used, the [porter] gets to the room and says: I didn’t know, nobody told me...the patient wasn’t [coded] in the system as an isolation patient (FG support staff, P8, 947).

These examples indicate that sufficiently clear mechanisms to promote effective communication amongst staff are not always in place, a factor that can contribute to the occurrence of preventable adverse events (Frank et al., 2008).

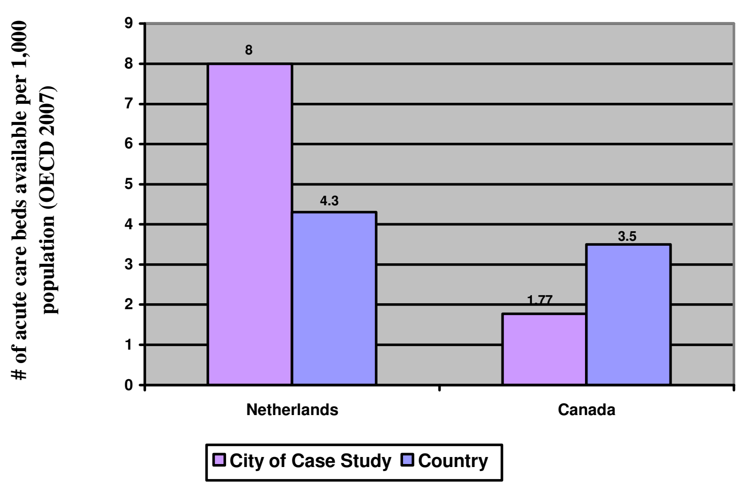
In the face of numerous system constraints, participants viewed engaged leadership as important for IP&C.

As a critical component of organizational governance, engaged leadership was identified in both study sites as important for supporting consistent IP&C practices within an organization. In both hospitals, clear reporting structures are in place. For example, at the Netherlands hospital, the IP&C program reports to the

Infection Prevention Committee who advises the Board of Directors on the infection control policies. At the Canadian hospital, the infection control program reports to senior management via the Vice-president of Medical Affairs. The infection control department also reports to the Infection Control Committee which then reports to the Medical Advisory Committee (MAC).

An example which requires engaged leadership and governance both within and external to individual healthcare organizations, is the management of bed occupancy issues. Overcapacity can be a significant barrier to IP&C in hospitals. The city in the Netherlands has 8.0 acute care beds per 1,000 population, whereas the number of acute care beds is much lower (1.77 beds per 1,000 population) in the Canadian city (Figure 6-10, below).

Figure 6-10: Comparison of the number of acute care beds available



The average bed occupancy rate reported in 2008, at the Netherlands hospital, was estimated at approximately 80% whereas at the Canadian hospital, the average rate was 98.5%. Although, these rates differ slightly in their calculations (e.g. the Netherlands hospital does not factor in bed closures);

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nonetheless, the Netherlands hospital did not appear to have the overcapacity issues that were present in the Canadian hospital during the study period. In order to minimize the impact of high bed occupancies, management has developed policies and procedures at the Canadian hospital. For example, bed management meetings are held daily. In attendance are the patient flow manager and the clinical managers. A clear policy and procedure was developed to ensure communication and a consistent approach to the issues.

Another activity that requires management support is antibiotic prescribing policies. Antimicrobial stewardship is a key process in the prevention and spread of MDRO. At the Netherlands hospital, a yearly antibiotic usage report is published and shared with the department heads. In 2006, the antimicrobial Defined Daily Dose (DDD) was 62.2 per 100 patient-days. They collect comprehensive antimicrobial data including the defined daily dose (DDD) but do not prospectively control antimicrobial use. The Canadian hospital, on the other hand, does not collect DDD data but carries out retrospective reviews of appropriateness use of selected drugs (e.g. vancomycin, meropenem, fluconazole). The designated antimicrobial pharmacy specialist reviews these target antibiotics on a periodic basis and makes a determination about the appropriateness of use. The information is presented to the Antimicrobial Subcommittee of the hospital and antibiotic housestaff education sessions are provided as needed.

It is also evident that management in both study sites supports a variety of environmental cleaning processes, but with some possibly important differences. At the Netherlands hospital, a centralized hospital-wide bed cleaning system is in place. A physician participant pointed out:

> … a bed that's going off the unit to be cleaned... It's going to be washed... in this building; it's like a car wash (PW physician, P8, 272).

As another Netherlands participant noted:

> What a good system...beds are cleaned well at the central bed cleaning department (FG health professionals, written comments, P26, 08).

This preferred method to manual cleaning provides consistent cleaning procedure with high temperatures (Dutch Working Party on Infection Prevention 2007 - Bed and Accessories Guideline). However, at the Canadian hospital, beds are manually cleaned on the unit by the housekeeping staff when a patient is discharged.

Other differences between sites in terms of cleaning policies relate to laundering of staff uniforms. At the Netherlands hospital, staff uniforms are provided and laundered for all nurses and support staff, whereas at the Canadian hospital, porters are provided with uniforms, but nurses wear and launder their own uniforms. Although pathogens such as MRSA, VRE and *Clostridium difficile* infections (CDI) can be isolated from clothes, the research to date indicates that the relationship between contaminated uniforms and the transmission of healthcare-associated infections (HAI) is weak (Dancer, 2010; Steinlechner et al., 2002; Wong et al., 1991; Perry et al., 2001; Loh et al., 2000; Babb et al., 1983; Zachary et al., 2001; Osawa et al., 2003; Treakle et al., 2009; Wilson et al., 2007). Nonetheless, according to the Dutch Working Party on Infection Prevention's guideline on linens (2006a):

> Used linen can be contaminated with all kinds of micro organisms that may or may not be pathogenic to humans. There have been occasional

> cases in which linen probably played a role in the transmission of a pathogen. However, linen may not cause any increased chance of hospital-acquired infection (p.3).

Furthermore, the Dutch Working Party on Infection Prevention's guideline also indicates that:

> Uniforms may not be taken home for washing [because] it is impossible to check whether the cleaning requirements are met when uniforms are washed at home (p.7).

Although the evidence on the relationship between uniform laundering and HAI is very weak, participants at the Netherlands hospital perceived that providing uniforms fostered a positive professional image and stronger infection control culture.

Another example that requires management support is the use of cotton gowns or disposable gowns. At the Netherlands hospital, the cotton gowns for patients on isolation precautions are re-used multiple times for the same patient during a shift. They are hung up in the anteroom (Figure 6-11 (a)) and are replaced after every shift or when they are visibly soiled. There are also disposable gowns that are used for strict isolation. At the Canadian hospital, the isolation gowns are for single use only. The clean gowns are kept in clear plastic bags on a cart in the hallway (Figure 6-11 (b)) and the dirty ones are placed in clear blue bags.

**Figure 6-11 (a): The Netherlands hospital - Cotton isolation gowns (IC-11)
(b): Canadian hospital - Storage of clean cotton gowns on cart in hallway (C-MG-4)**

(a) The Netherlands hospital (b) Canadian hospital

According to the Center for Disease Control and Prevention (CDC) guidelines, a gown should be worn "during procedures and patient-care activities when contact of clothing/exposed skin with blood/body fluids, secretions, and excretions is anticipated" (Siegel et al., 2006, p. 129) however, CDC recommends "not to reuse gowns, even for repeated contacts with the same patient" (p.79). However, the Dutch Working Party's Infection Prevention guidelines on strict isolation (2006b) state: "the apron [or gown] is then taken off in the anteroom, folded inside-out before being disposed of, or hung up inside-out for reuse" (p.1). Thus, the Dutch guideline allows for the reuse of cotton gowns within the same shift for continued same patient care. Further investigation is needed to understand the rationale for the discrepancy between these two contradictory recommendations. Furthermore, this evidence of the influence of national guidelines on organizational policies and practices supports the contention of Ramsay and colleagues (2010) that intra-organizational governance and extra-organizational governance of IP&C are linked.

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There are other differences in management practices in relation to organizational provisions that are made for staff to provide care. For example, stethoscopes are provided by the Netherlands hospital and are kept with the blood pressure machines at the hospital. Staff do not wear a stethoscope around their neck, whereas at the Canadian hospital, which does not provide stethoscopes, it is common practice for practitioners to carry their own stethoscopes and wear them around their necks. The IP&C implications for this practice are not clear. Although, studies have shown that stethoscopes have a high rate of bacterial contamination (Zuliani Maluf et al., 2002; Jones et al., 1995; Marinella et al., 1997; Smith, 1996; Sanders, 2005), research has not shown that these organisms are transmitted to patients.

Staffing practices also differ between the two hospitals. Staff work 8 hour shifts in the Netherlands hospital, whereas in the Canadian hospital, staff work 12-hour shifts. There is also a marked difference in staffing at night between the two study units as per indicated in the Table 6-3 (below). In the Netherlands hospital, there are only two nurses at night on the 34-bed unit. According to a key informant, if there is more workload because of patients on isolation, medical students (MST-ers) can be arranged to provide extra help.

Table 6-3: Staffing on the study units at the Netherlands and Canadian hospitals

	Netherlands Hospital	Canadian Hospital
Unit staffing (Full-Time Equivalent (FTE))	32 FTE RN (34 bed unit)	35.42 FTE RN and 3.62 FTE RPN (40 bed unit)
Unit staff ratios (nurse to patient)	8-hour shifts	12-hour shifts
Weekdays:		
Day	1: 3 (07:30-15:30)	1: 4 (07:30-19:30)
Evening	1: 7 (15:30-23:30)	
Night	1: 17 (23:30-07:30)	1: 6 (19:30-07:30)
Weekends:		
Day	1 : 3 (07:30-15:30)	1: 4 (07:30-19:30)
Evening	1: 9 (15:30-23:30)	
Night	1: 17 (23:30-07:30)	1: 6 (19:30-07:30)

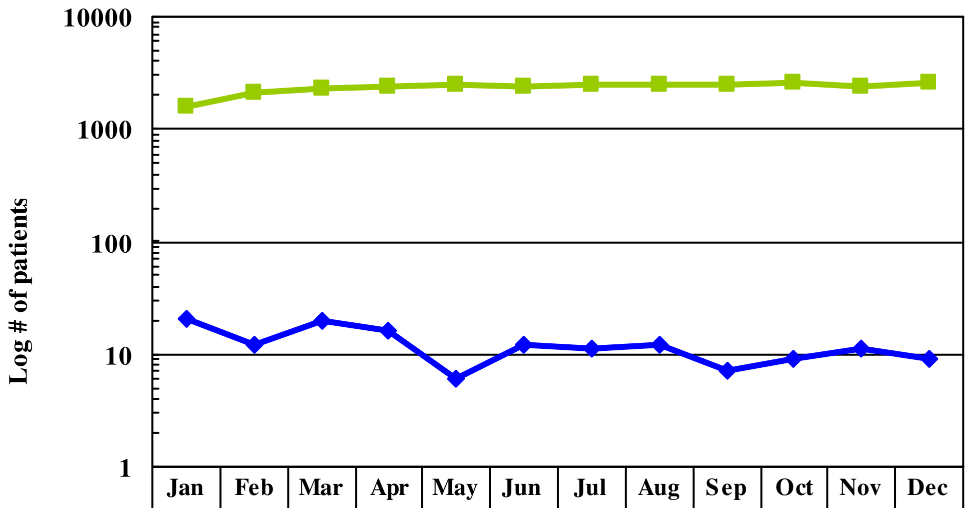
Complicating the ability to compare nurse staffing is the fact that the education for nurses varies in these two countries. In the Netherlands, all nurses are registered nurses (RN). However, there are two different levels of education to obtain the RN designation. Nursing education is offered at level 4 (Middle Vocational Training) that can be followed after four years of secondary school or at level 5 (Higher Professional Training) that can be followed after five years of secondary school. Although level 5 is at a higher academic level than level 4, both programs are approximately four years in duration and lead to the official title of Registered Nurse (Robinson et al., 2007). Furthermore, the qualification structure for nursing is made up of five 'qualification levels'. The competencies at each level are defined based upon three criteria: responsibility, complexity, and transfer. The requirements increase at each qualification level. Specifically for the level 4, it is at the vocational level know as MBOV training (Middelbare Beroepleiding voor Verpleegkundigen) for which a diploma is received. For the level 5, it is at the university level known as HBOV training (Hogere Beroepsopleiding voor Verpleegkundigen) for which a degree is received (Workgroup of European Nurse Researchers). In Canada, a four-year baccalaureate degree for RN and a two-year diploma program for Registered Practical Nurses (RPN) in Ontario and for Licensed Practical Nurses (LPN) in all other provinces became mandatory as an entry-to-practice requirement in 2005 (Baumann et al., 2009).

Another possible explanation for the staffing discrepancies could be that the patient acuity level could differ between the two units. The Netherlands hospital only calculates patient acuity in the ICU using the APACHE tool. At the Canadian hospital, several patient acuity measures are used. Further investigation on the differences in patient acuity levels may be warranted.

Management support for hand hygiene practices are also evident at both study sites, but are different. At the Netherlands hospital, the method used to monitor adherence to hand hygiene is ABHR consumption. Once a year, the alcohol sanitizer usage is measured for each unit based on the total patient days and the number of alcohol sanitizer bottles ordered from pharmacy. At the Canadian hospital, the method used is direct observations of hand hygiene practices by trained observers using a provincial audit tool. Feedback on individual practices is provided to the healthcare providers and management.

Over 10 years ago, the ‘search and destroy’ strategy for MRSA was implemented at the Netherlands hospital. The strategy consists of the screening of high risk patients which includes mainly patients admitted from foreign hospitals and individuals who have come into close contact with live pigs or calves. Screening cultures are taken when MRSA is suspected or to rule out MRSA contamination. In 2008, the Canadian hospital implemented a universal MRSA screening strategy where all patients were swabbed for MRSA and VRE on admission. The number of admitted patients screened for MRSA and VRE in 2008 is presented in Figure 6-12 and Figure 6-13, respectively.

Figure 6-12: Cross-Case Comparison of the number of admitted patients screened for MRSA (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	21	12	20	16	6	12	11	12	7	9	11	9
CAN Hospital	1573	2113	2267	2422	2460	2367	2494	2501	2522	2620	2410	2593

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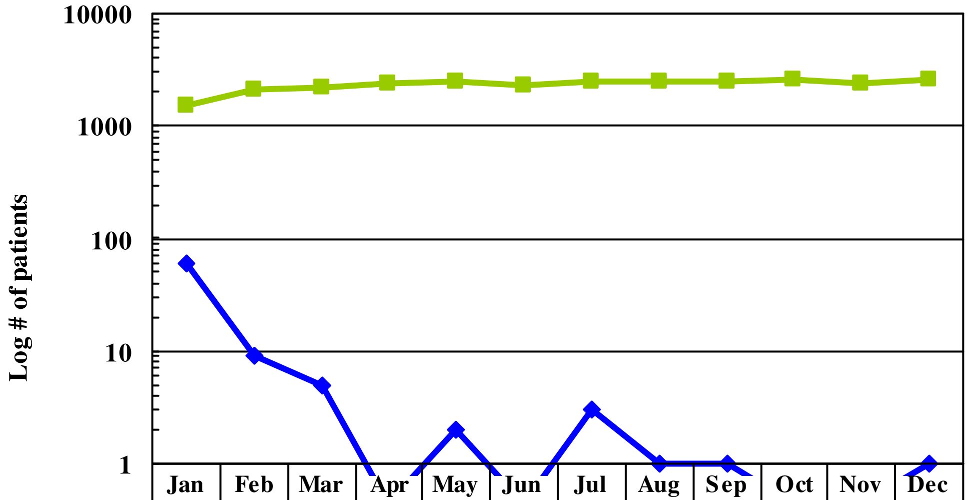
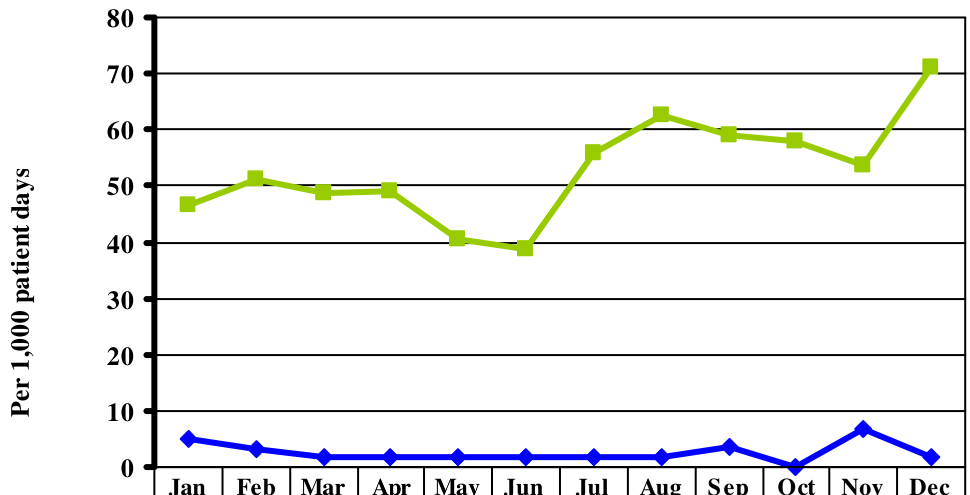
Figure 6-13: Cross-Case Comparison of the number of admitted patients screened for VRE (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	59	9	5	0	2	0	3	1	1	0	0	1
CAN Hospital	1550	2080	2241	2396	2444	2338	2478	2477	2519	2595	2381	2560

The prevalence rates for MRSA, VRE, CDI and extended spectrum beta-lactamases (ESBL) are compared in Figures 6-14 to 6-17.

Figure 6-14: Cross-Case Comparison of MRSA Prevalence Rates (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	5.01	3.25	1.69	1.66	1.77	1.66	1.74	1.94	3.6	0	6.69	1.67
CAN Hospital	46.51	51.29	48.85	48.97	40.53	38.71	55.94	62.71	58.86	57.95	53.62	71.05

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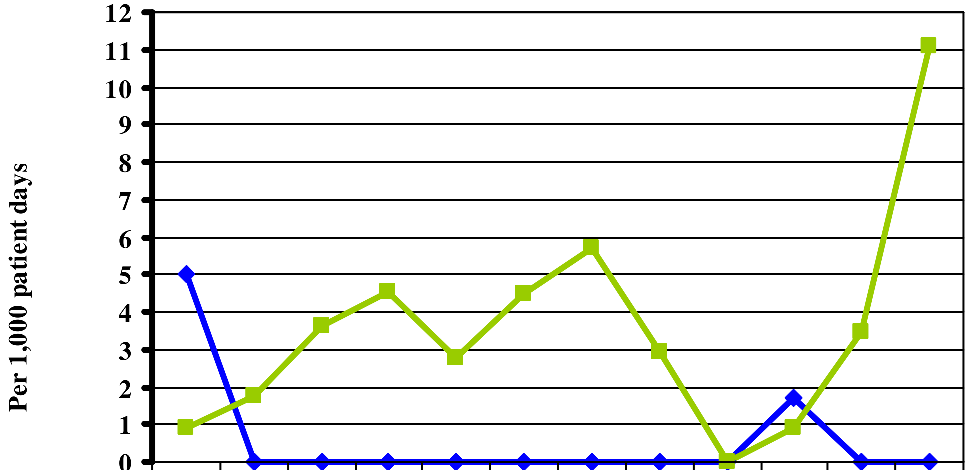
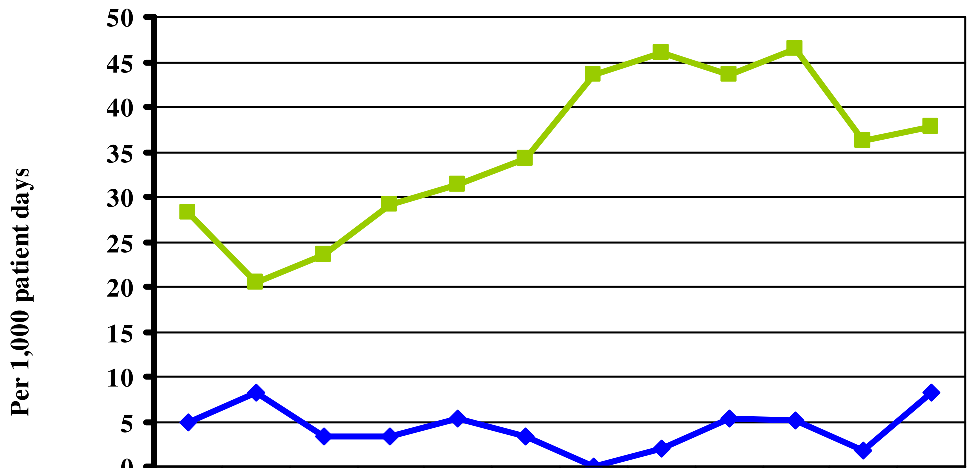
Figure 6-15: Cross-Case Comparison of VRE Prevalence Rates (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	5	0	0	0	0	0	0	0	0	1.7	0	0
CAN Hospital	0.91	1.77	3.62	4.53	2.76	4.5	5.69	2.94	0	0.89	3.46	11.07

Figure 6-16: Cross-Case Comparison of CDI Prevalence Rates (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	5	8.13	3.37	3.32	5.31	3.32	0	1.94	5.4	5.12	1.67	8.33
CAN Hospital	28.27	20.34	23.52	29.02	31.32	34.21	43.62	46.05	43.46	46.36	36.33	37.83

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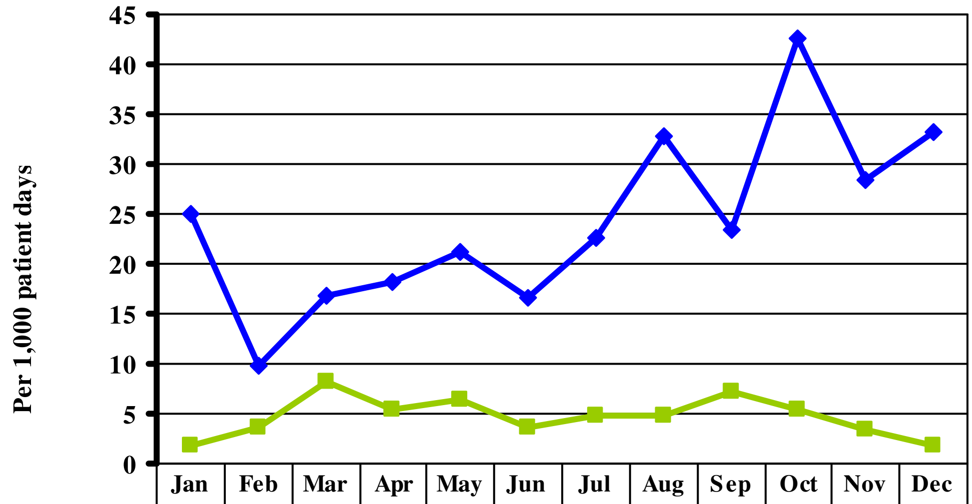
Figure 6-17: Cross-Case Comparison of ESBL Prevalence Rates (Jan-Dec 2008)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NETH Hospital	25	9.76	16.9	18.2	21.2	16.6	22.6	32.9	23.4	42.7	28.4	33.3
CAN Hospital	1.82	3.54	8.14	5.44	6.45	3.6	4.74	4.9	7.24	5.35	3.46	1.85

During the study, only high risk patients at the Netherlands hospital were screened whereas at the Canadian hospital, all patients were screened on admission. One of the challenges in comparing rates between these two hospitals is that more cases are identified with universal screening, thus potentially reporting a higher number of carriers than with high risk screening only.

Discussion

A socio-ecological approach on health systems informed this research design and was presented as a framework to understand the whole system for IP&C. The key findings provide a starting point to better understanding the system for IP&C through the practitioners' experiences in these two organizations and demonstrate that there are several similar and different practices in place for IP&C in both hospitals, as well as a lack of comparable data between the two cases.

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Common findings across both cases include the perceived importance of engaged leadership, a lack of antibiotic prescribing restrictions, the presence of environmental design issues and the frequent use of workarounds that may be problematic for IP&C. Emerging research suggests that engaged leadership and board involvement is associated with improved patient outcomes (Vaughn et al., 2006; Jiang et al., 2008; Ramsay et al., 2010). Other organizations and experts have also examined board engagement related to quality (Baker et al., 2010; Rose et al., 2006; Slessor et al., 2008; Institute for Healthcare Improvement, 2008). In addition to these studies and reports, healthcare safety experts argue that senior leaders and boards need to engage with their healthcare organizations in ways that enable them to gain a better understanding of the quality issues that characterize their environments (Baker et al., 2010; Donaldson, 2001; Conway, 2008). This engagement includes working with practitioners and other stakeholders to help develop more effective means of monitoring and addressing the "ability to deliver safe, effective, high quality care within organizations with the right cultures, the best systems and the most highly skilled and motivated workforces" (Donaldson, 2001, p. 8). Both hospitals have reporting structures that provide IP&C related information to the Board of Directors. What is less clear and warrants further study in future work is, as Ramsay et al. suggest (2010), the precise nature of the inter-relationships between internal governance, external governance, and incidence of HAI.

Furthermore, the appropriate use of antimicrobial agents (antimicrobial stewardship) is critical in reducing the emergence of antimicrobial-resistant organisms. Although the Netherlands hospital produces an antibiotic usage report on a yearly basis, and the Canadian hospital carries out retrospective reviews of the appropriateness use of selected antibiotics, neither hospital has any mechanisms in place to restrict antibiotic use. As hospital pathogens become more resistant, stringent guidelines need to be implemented to support the judicial use of antibiotics (Struelens, 2003).

Another common finding across both cases is the environmental design issues which often lead healthcare providers to use workarounds. Overall, the design of the unit can have a strong influence on the risk of MDRO contamination. Joseph (2006) and Ulrich et al. (2004) recommend single patient-bed rooms each with private washrooms as well as appropriate storage on the unit for all new construction. In addition, both organizations should ensure adequate access to ABHR or soap and water at point of care in order to reduce cross contamination in multiple patient rooms. According to the WHO (2009), the ABHR dispensers should be located at point of care. In addition, Creedon (2005), Suresh et al. (2007) and Harbarth et al. (2002) support the notion that ABHR dispensers should be located in many convenient locations around the unit.

When looking at the whole system for IP&C in the context of particular environmental design constraints, and where hospital staff reinforce norms of vigilance to prevent cross contamination, there are multiple conditions or activities at the Netherlands hospital that differ from the Canadian hospital which may have an impact on the lower MDRO prevalence rates. These conditions or activities include differences in ratios of hospital beds per capita, bed occupancy rates, staffing practices, equipment cleaning processes in place, bed cleaning systems (centralized versus manual) and the presence of an active grass roots Hygiene in Practice group engaging practitioners in several ongoing activities to promote IP&C. Given these clear differences between the two study sites, it is important to try to generate further evidence-informed rationale for these and other interventions such as laundering staff uniforms and providing stethoscopes to staff in order to guide health system leaders who need to decide where to allocate finite resources.

Research has shown that bed occupancy rates can have a significant impact on the rate of MDRO infections (National Audit Office, 2004; Cunningham et al., 2005; Borg, 2003; Borg et al., 2008). Studies have shown that occupancy rates higher than 90% have higher MRSA infection rates than those with rates below 85% (Department of Health in the UK, 2007; Orendi, 2008). In 2008, the bed occupancy rate was approximately 80% in the Netherlands hospital and 98.5% in the Canadian hospital. Occupancy rates were often near or above 100% at the Canadian hospital. Once bed capacity is reached, patients are admitted in the hallways or common areas and are at higher risk of infections due to “overworked staff who try to care for these patients in an environment that makes it difficult to follow best practices” (Gardam et al., 2010, p. 20). This supports the idea that bed occupancy rates may provide a useful indicator of a hospital's ability to control or eradicate MDRO infections. At the health system level, one of the possible causes of overcapacity at the Canadian hospital study site may be the unusually low number of acute care beds available for the population served. Other contributors may include inadequate access to timely public health, primary health care, and home care services and inadequate access to appropriate assisted living and long term care facilities.

The staffing ratios on the surgical unit at the Netherlands and the Canadian hospitals are compared in Table 6-3 (p. 226). The Netherlands hospital has a slightly higher nurse: patient ratio than the Canadian hospital during the day shift. However, the Canadian hospital has a significantly greater nurse: patient ratio on night shifts. In 1999, Vicca found that the incidence of new cases of MRSA correlated with periods of increased nursing workload and times of reduced nurse-to-patient ratios within an intensive care unit in a large tertiary referral centre in the UK. Furthermore, in their systematic review of 38 studies, Stone et al. (2008) found a statistically significant association between nurse staffing variables and HAI rates in over 80% of the studies. However, due to the limitations of the study designs, a nursing staffing level benchmark associated with a decreased risk of HAI was unable to be determined.

It is also important to recognize that patients on isolation require more nursing time, including the extra time staff need to correctly don, wear, and dispose of personal protective equipment (Dancer et al., 2008; Diekema et al., 2007). Furthermore, while the Netherlands hospital surgical unit has 8-hour shifts and the Canadian hospital unit has 12-hour shifts, the impact of these shift policies is unknown. According to Geiger-Brown (2010), studies have shown that 12-hour shifts affect performance and safety. A study by Rogers et al. (2004) showed that over three times more errors occurred among nurses working over

12.5 hour shifts than nurses working up to 8.5 hours. Conversely, another recent study by Stone et al. (2006) of 12- and 8-hour shifts in 13 New York City hospitals found no differences in patient outcomes related to medication events, patient falls, and decubitus ulcer prevalence. Furthermore, they found that nurses on 12-hour schedules were 58% less likely to be absent from work, and units using 12-hour schedules had less vacancies.

The findings also suggest that we need a better understanding of which kinds of environmental cleaning are most important for IP&C in what contexts. Current evidence indicates that equipment should be cleaned and disinfected between each patient to avoid cross-contamination (Siegel et al., 2007). Enhanced environmental cleaning has shown to decrease environmental contamination of MDRO (Goodman et al., 2008) and decrease the likelihood of patients acquiring HAI (Hayen et al., 2006; Hota, 2004; Boyce, 2007; Dancer et al., 2009). However, the centralized bed cleaning system at the Netherlands hospital is a process not common in North America. Further research on the effectiveness of this method in limiting MDRO transmission is needed. The different approaches (centralized versus manual) to bed cleaning practices warrant further investigation in regards to the effectiveness of these techniques at reducing hospital infections.

Unique to the Netherlands hospital case study is the Hygiene in Practice (HIP) group, a grass roots community of practice that oversees, implements and promotes evidenced-informed IP&C practices in the hospital. Healthcare workers who take ownership of the infection control issues on their unit can significantly improve MDRO rates (Plexus Institute, 2009). While we are well aware of the benefits of the support from IP&C experts, it is worth exploring which kinds of community of practice (e.g. unit-based practitioner-led or IP&C-led) have the most positive influence on IP&C practices in which contexts.

The research findings also reveal a lack of comparable findings between the two cases on the aspects of hand hygiene audit protocols (observations versus product measurement), surveillance and control strategies (high risk versus universal screening), reporting of acquisition rates (prevalence versus incidence rates), and the nature and extent of high risk populations for community-acquired methicillin-resistant *Staphylococcus aureus* (e.g. people in contact with pigs, veal calves or other livestock versus drug users, homeless people and prisoners) in the two hospitals' catchment areas. The World Health Organization (WHO) recommends that adherence to hand hygiene be monitored through observations in healthcare settings to inform local decisions on how to improve compliance. However, adherence rates between the two hospitals are not comparable. The method used to monitor adherence to hand hygiene practices at the Netherlands hospital is measuring the unit-based consumption of alcohol-based hand rub (ABHR). The accuracy of this method is poor, as (1) there could be some unused bottles left on the unit or (2) the alcohol could be used by patients and families and (3) the reference value may not be appropriate. However, in the Dutch guideline of hand hygiene for staff (2007), there are no recommendations on how to monitor compliance of hand hygiene in Dutch hospitals. The Canadian hospital uses direct observations. According to the WHO, direct observation is the recommended method to monitor hand hygiene compliance. Monitoring product consumption does not determine if proper hand hygiene is performed. Furthermore, the amount of product consumed may not be accurate, as it could also include the quantity of product used by visitors and patients (WHO, 2009).

Many IP&C guidelines recommend either universal (all patients) or targeted (high risk patients) MRSA and VRE screening on admission (Muto et al., 2003; Coia et al., 2006; Siegel et al., 2006; Dutch Working Party Infection Prevention, 2007). The significant differences in screening strategies for MRSA and VRE between the Netherlands hospital, which conducts high risk screening only, and the Canadian hospital, which conducts universal screening of all patients on admission, can have an impact on the differences in reported rates. At the Canadian hospital, we would expect to detect more cases because all patients are screened (universal screening), whereas in the Netherlands only the high-risk population is screened.

Another challenge is the difference in reporting of MRSA, VRE, CDI and ESBL rates between the two hospitals. At the Netherlands hospital, only prevalence rates of MRSA, VRE, CDI and ESBL are reported, whereas at the Canadian hospital, incidence rates of these pathogens are reported. In order to allow for some comparison between the two hospitals, prevalence rates were obtained from the Canadian hospital. It is not possible, however, to distinguish between hospital-acquired and community-acquired MRSA cases. The high risk groups for community-acquired MRSA differ between these two countries. In the Netherlands, the high risk group is people in contact with pigs, veal calves or other livestock (Dutch Working Party on Infection Prevention, 2007) whereas in Canada, the high risk group includes: injection drug users, homeless people, the incarcerated, and native aboriginals (First Nations people) (Simor et al., 2010). In the Netherlands case study, the monthly MRSA prevalence rate for 2008 ranged from 0 and 0.67% which is consistent with the rate of less than 1% (Muto et al., 2003) published in the literature. In the Canadian case study, the monthly MRSA prevalence rate was greater, ranging from 3.87 and 7.11%. The monthly VRE prevalence rate in the Netherlands case study ranged from 0-0.5% compared to 0-1.1% in the Canadian case study. Also, the CDI prevalence rate was lower, ranging from 0 and 0.8% in the Netherlands case study compared to 2.03-4.64% in the Canadian case study. However, the monthly ESBL prevalence rate was higher, 0.98%-4.27%.in the Netherlands case study compared to 0.18-0.81% in the Canadian case study. Although MRSA, VRE and CDI rates may be below 1% in the Netherlands case study, other pathogens such as ESBL does not appear to be as controlled. This increase is seen in all European countries, and it has been suggested that colonization of the food-producing animals (especially poultry), facilitated through antibiotic use, leads to the contamination of meat. It is unknown yet, if food contamination is the source of this high prevalence in European hospitals (Leverstein - van Hall et al., in press).

There were several limitations to the study. It is possible that staff on the study units may have altered their behavior during unit observations. The use of multiple methods of data collection is intended to minimize these potential sources of bias. It was difficult to compare some key empirical elements between the two cases because of the different IP&C data collection and reporting methods carried out by each hospital. As previously indicated, for instance, hand hygiene observations were performed in the Canadian study site and the consumption of the ABHR was calculated in the Netherlands site. Because the case study hospitals used different antibiotic resistant measures (total prevalence count of isolates for one case and nosocomial incidence rates for the other), all data were converted to prevalence rates to allow for comparison. This data collected by others, however, limited the possibility of determining the proportion of MDRO that were hospital-acquired versus imported or community-acquired. Organizations should aim at adopting best practices at the national and international level (i.e. World Health Organization, Organisation for Economic Co-operation and Development (OECD), etc.) in order to facilitate better comparison of data. Collaborative or standardized data that are comparable would provide better information to drive health policy changes. Furthermore, only one clinical unit at each hospital was studied in this research, which means that the findings, while qualitatively rich and analyzed with a whole systems perspective, need to be interpreted cautiously. It is possible that hospital-wide, regional, or even country wide factors could account for some of the differences in rates.

Conclusion

There is ongoing urgency in the field of infection control to respond to outbreaks without strong levels of evidence. This clinical reality cannot be dismissed, but there are several common findings across both cases that merit further study in our ongoing efforts to develop and translate evidenced-informed

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IP&C programs into policy and practice. These findings include the perceived importance of engaged leadership across the system, the presence of environmental design issues, a lack of antibiotic prescribing restrictions, and the frequent use of workarounds that may be problematic for IP&C. It is equally important in future research to further investigate the significance of health system and organizational practices where there were disparate findings between cases, such as the differences found between the Netherlands and Canadian study sites in ratios of hospital beds per capita, bed occupancy rates, staffing practices, equipment cleaning processes, and bed cleaning systems (centralized versus manual), as well as the presence or absence of unit-based IP&C communities of practice. For example, it is not possible to ascertain from the current study findings alone, but further research may bear out that hospital beds per capita and bed occupancy rates have the most impact on the rates of MDRO in hospitals. As all of these factors are better understood, we can achieve stronger integration between the development and study of effective IP&C interventions and their translation into sustainable, evidenced-informed decision-making, programs, and practices.

As future studies are designed, the findings and methodological challenges identified in this study suggest that case selection in future comparative IP&C case studies should be based on an expanded list of criteria. These criteria should include comparable audit, surveillance and reporting practices and comparable demographic and other relevant data, such as data on the agricultural practices within and demographic attributes of vulnerable populations within the hospital catchment areas.

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CHAPTER 7: General Discussion and Conclusions

In this last chapter, I highlight the contributions of this research to nursing and other health professionals, provide suggestions for the design of future whole system comparative case studies, and offer recommendations for practice, policy, research, and education.

Contributions to Nursing and Other Health Professionals

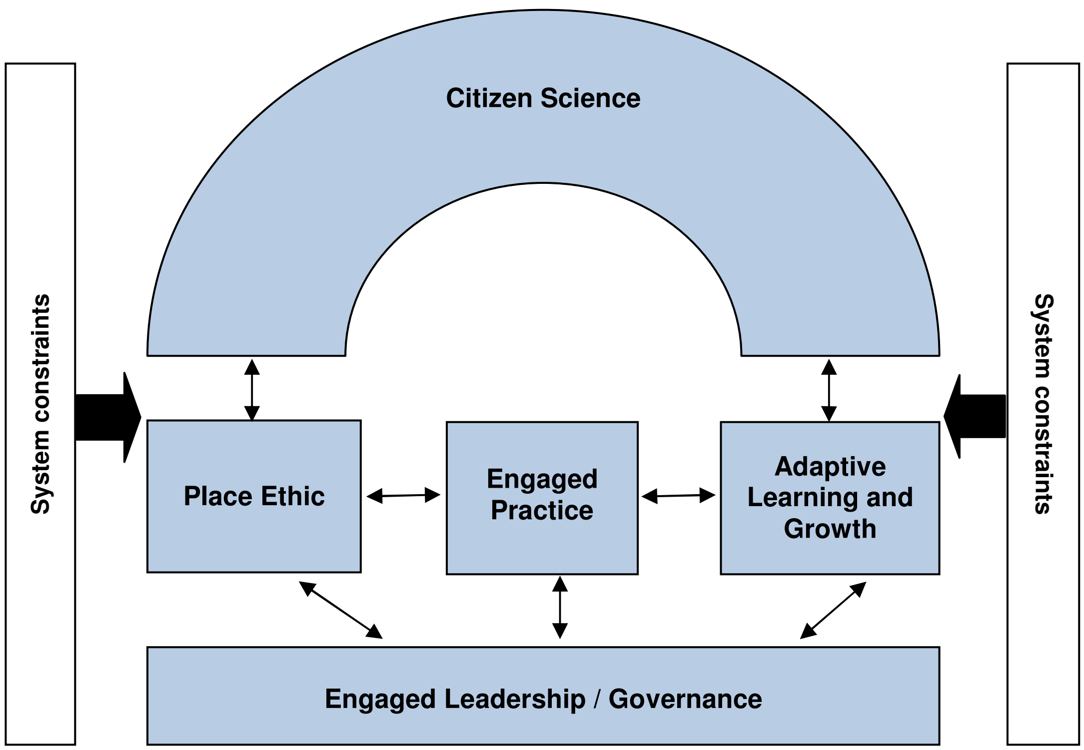
Nurses, other health professionals, leaders and managers, and support staff play a significant role in providing a safe and healthy environment for patients. The results of my doctoral work support the value of using an integrated socio-ecological approach to collaboratively study infection prevention and control (IP&C) in the acute care setting with researchers, practitioners, and managers. This perspective enables scientists and collaborators to critically examine a range of relevant structures, influences, and practices from a whole systems perspective. The socio-ecological framework for studying IP&C (adapted from Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006a) that I described in Chapter 3 (Table 7-1, below) provided me with this whole systems lens as I worked with my committee and my clinical research partners to define the research questions and design the study.

Table 7-1: Original elements of a proposed socio-ecological framework for studying IP&C

Core Elements	Definitions
Citizen science	The notion of citizen science refers to individuals working collaboratively with communities, governing bodies and others to conduct research and generate evidence (Marck et al., 2006a; Marck et al., 2006b; Edwards et al., 2007). This includes using a participatory and collaborative approach to the design, conduct and analysis of IP&C research, involving members of the community in data collection, data analysis and knowledge translation wherever feasible and appropriate and seeking multiple sources of data (including sources of indigenous or local knowledge) and using a variety of methods to develop integrative knowledge about local places as well as the larger system (Irwin, 1995; Gunderson et al., 2002; Rhemtulla et al., 2002; Marck et al., 2006b).
Place ethic	According to Lawrence Buell (1995) and Higgs (1999, 2003), a place ethic is shown in the ways that individuals treat and support each other and the places they share. Place ethic refers to the importance of fostering a deep understanding of and respect for the history, culture, knowledge and rituals of communities. In this research, thinking about place ethic includes inquiring about what people see as important in the care of each other and their environment, how they reinforce and support each other to value IP&C, and whether respect for historical knowledge informs how a place functions over time.
Engaged practice	The concept of engaged practice refers to the creation, implementation and evaluation of sound practices that are evidence-informed (Higgs, 1991, 1997, 1999, 2003; Marck et al., 2006a). This includes self monitoring and adjustment of daily IP&C practices (e.g.: audits, equipment checks), using local feedback processes to continually improve workflow, work design, and processes at the individual, team and healthcare community levels.
Adaptive learning and growth	The idea of adaptive learning and growth refers to the development and use of knowledge translation strategies that disseminate learnings across individuals, teams, organizations and system levels to drive sustainable changes (Gunderson et al., 2002; Gunderson et al., 1995; Higgs, 1997; Higgs, 2003; Marck et al., 2006a; Walker et al., 2002). This includes evidenced-informed management of multidrug-resistant organisms (MDRO), screening policies, resource allocation decisions about patient care staffing, housekeeping, availability of equipment and supplies, staff and public education policies and funding.

The research findings in this study provided some validation of the initial framework, but also required me to expand this framework in order to highlight the importance of strong support, commitment and engagement from management for IP&C policies and practices. The study findings also identified significant issues of system constraints (i.e. occupancy rates), environmental design, and various workarounds adapted by healthcare providers in order to do their work (refer to Figure 7-1).

Figure 7-1: An Expanded Socio-Ecological Framework for Studying IP&C Within Organizations and Across Health Systems



A key finding of this research is the emergence of the theme of engaged leadership, which was not an element within the original framework that informed the design of the study. Recent research suggests that engaged leadership and board involvement is associated with improved patient outcomes (Vaughn et al., 2006; Jiang et al., 2008; Ramsay et al., 2010). Specifically, building on earlier research by Eeckol et al. (2004) on hospital governance, Ramsay et al. (2010) assert that organizational governance, defined as "the systems, processes, behaviours and cultures by which an organization leads and controls its functions to achieve its objectives" (p.1), has an important influence on IP&C. Other organizations and experts have also examined board engagement related to quality (Baker et al., 2010; Rose et al., 2006; Slessor et al., 2008; Institute for Healthcare Improvement, 2008). In addition to these studies and reports, healthcare safety experts argue that senior leaders and boards need to engage with their healthcare organizations in ways that enable them to gain a better understanding of the quality issues that characterize their environments (Baker et al., 2010; Donaldson, 2001; Conway, 2008). This engagement includes working with practitioners and other stakeholders to help develop more effective means of monitoring and addressing the "ability to deliver safe, effective, high quality care within organizations with the right cultures, the best systems and the most highly skilled and motivated workforces" (Donaldson, 2001, p. 8).

Both study hospitals have reporting structures that provide IP&C related information to the Board of Directors, and both organizations demonstrated active leadership through their interest in taking part in this research. In addition, participants at both study sites noted the importance of responsive active leadership to ensuring sound IP&C. Based on my findings, and drawing on socio-ecological thinking about systems change in health care (Edwards et al., 2008; Marck et al., 2006a) and in ecosystems management (Bohensky & Lynam, 2005; Gunderson & Holling, 2002; Gunderson, Holling & Light, 1995), I propose an initial definition of engaged leadership as follows: the interactive, ongoing provision of responsive monitoring, feedback, decision-making, and support across clinical, managerial, executive, and political levels of the health system to generate adaptive learning and evidence-based policy and practice. However, it is not clear from this initial study alone how a responsive, interactive conceptualization of leadership throughout all levels of a health system inter-relates with the other proposed concepts within the framework of citizen science, engaged practice, place ethic, and system constraints.

What is also not clear and warrants further study is, as Ramsay et al. (2010) suggest, the precise nature of the inter-relationships between internal governance, external governance, and the incidence of healthcare-associated infections (HAI) in each of these health systems. As well, the differing degrees of clinical leadership for IP&C between the two study sites suggests that we need to understand more about the impact of various levels of internal governance and leadership on HAI incidence. For example, it is not feasible to determine from the present work whether or not the Netherlands Hygiene in Practice group contributes significantly to their lower rates of most multidrug-resistant organisms (MDRO), but the possibility merits exploration in future research. Further theoretical and empirical work is therefore needed to explore the dynamics between all of the framework elements and their implications for IP&C.

Addressing workarounds and environmental design could be arguably considered as part of adaptive learning and growth to the extent that organizations have autonomy and resources to do so. However, many system constraints, such as government funding policies and priority setting, pertinent legislation and regulation, catchment area demographics, national or regional IP&C initiatives, agricultural policies, and other related factors all profoundly shape how the elements interact. Yet, these kinds of whole system factors operate well outside the boundaries of specific units, programs, and organizations. I therefore propose that these extra-organizational system factors are not an additional element to the expanded framework, but rather form the whole systems context within which the elements interact and co-evolve.

The research experience has also generated several insights about methods for future work. Specifically, the participatory research approach facilitated the engagement of health professionals, managers, and clinical support staff in the collection and analysis of the data and translation of findings into practice. As participants indicated to me, the research provided them with opportunities to critically reflect on and gain a deeper communal understanding and respect for their units, the places they share. Given participants' reported experiences of the research and the ongoing collaboration of several clinical partners to disseminate the work and implement practice changes, I would argue that this form of citizen science can offer meaningful contributions to health systems research and to the fields of quality improvement and knowledge translation.

It was also clear as the research progressed that multiple methods from various viewpoints were essential in obtaining a comprehensive analysis of IP&C practices in these two case studies. By using diverse qualitative and quantitative data collection methods, it was possible to get a more comprehensive representation of the state of IP&C in each hospital that would not have been possible using only one of the methods alone. The field observations exposed me to the overall practices and the workflow of each unit. The photo walkabouts drew out participants' stories and perspectives and generated rich dialogue between participants and the researcher about the strengths and weaknesses of their clinical unit in relation to infection control. The photo elicitation focus groups facilitated critical reflection on the images and narratives that were gathered during the walkabouts, fostering more open disclosure about the observations. It was also useful to obtain more details on IP&C issues through the participants' written comments during the focus groups. The other qualitative documented data and quantitative IP&C related data provided a better understanding of the overall existing practices, policies, procedures and infection rates in each environment.

Based on this research experience and the resulting findings, I propose that the expanded socio-ecological framework provides a sound basis for future IP&C practice, research, policy, and education in various contexts with a range of partners. There is a real potential for nurse researchers and other scientists to further develop this participatory approach and work collaboratively with fellow clinicians, managers, policy makers, communities, and students to advance practice, research, policy, and education in this area.

Recommendations for Future Practice, Research, Policy and Education

In light of my study findings, the following recommendations for practice, research, policy, and education are discussed.

Implications for Practice

In healthcare, we are quick to adapt to one-size-fits-all quality improvement strategies without sufficient adaptation to specific real world contexts. Many wonder why multidrug-resistant organisms are still on the rise despite substantial efforts. Inquiring into why current approaches are not successful draws attention to studying inter-relationships and interactions within the whole system. Better integration between effective IP&C interventions and knowledge of what drives individuals, organizations and systems towards evidence-informed and sustainable IP&C practices is needed.

The participatory methods employed in this research created the potential for communities to become more engaged in governing change and improving their clinical environment. Notably, this research has already generated some direct, practical outcomes in the Canadian study site. This includes the development of a policy for equipment cleaning, clearly describing the responsibilities of each member of the team at the Canadian hospital. Also, it includes addressing an issue with the design of the sinks and gooseneck faucets (i.e. splashing) discovered during the photo walkabout with the infection control professional on the study unit. This finding has led to further investigations on the problematic design of the handwashing stations. In light of these research-related practice changes, it seems reasonable to recommend the potential use of participatory photo walkabouts and other visual methods when working with healthcare teams to improve practice in order to assess and facilitate their readiness to implement evidence-informed practice changes as well as foster successful implementation and evaluation of practice changes.

Another predominant finding across both case studies was the environmental design of both hospitals, which lead nurses and other health professionals to develop and adopt a variety of workarounds (Amalberti et al., 2006). This raises the concern about the implications of these workarounds for IP&C and the safe delivery of care. Rathert and colleagues (2009) recommend that organizations examine how the implementation of policies and procedures influence the work and work environment of nurses in order to avoid unfavourable workarounds. In order to reduce the use of problematic workarounds, practitioners must be engaged in health system and organizational decision making processes that affect their workload, workflow and daily practices on the unit.

Shared stories by the participants on barriers and bridges to IP&C relevant to their unit are a powerful tool to encourage knowledge exchange. My research findings validate what others have proposed about effective strategies for the uptake of evidence into practice. For example, Kitson et al. (1998), discuss a framework to demonstrate how research findings can be successfully implemented into practice. My research approach attended to all three of the framework's main elements: the level of the evidence, the context, and the facilitation method. Also, Hagedorn and colleagues (2006) discuss several "lessons learned" during the conduct of the Veterans' Health Administration's Quality Enhancement Research Initiative (QUERI) which are relevant to my research experience and findings. Specifically, at least three of the principles of quality improvement identified as crucial to success by the QUERI project team, which was focused on translating evidence into the daily provision of patient care, relate to my findings and recommendations for practice as follows:

1. QUERI Lesson: Customize the Intervention to Local Conditions – My participants' feedback on the benefits of studying their unit with the participatory visual methods confirms the importance of understanding and accounting for local context and conditions when trying to understand and foster practice improvements.
2. QUERI Lesson: Develop Clear Benchmarks for Performance that are Clinically Meaningful and Locally Acceptable – My participants' reactions to and meaningful discussion of the photos that were collected suggest that the potential to use practitioner-led collection of images in quality improvement programs for benchmarking needs to be explored. It is very possible that conducting regular practitioner-led photo walkabouts, posting clear images of desired practices, and other uses of photo data could provide clear, clinically meaningful and locally relevant supports for benchmarking good practice and providing timely, useful practice audit and feedback. The actions of the Netherlands Hygiene in Practice group seem to support this argument, as they already use images to illustrate many of their evidence-informed educational materials on the unit.
3. QUERI Lesson: Know Your Audience: Identify and Utilize Local Leaders and Involve Relevant Stakeholders – This QUERI recommendation is also borne out by my research experience, where the involvement of managers, staff, and infection control experts has enabled one of the sites to use the research findings to move forward with some practice changes even before dissemination efforts are completed.

Implications for Research

This research provided an opportunity to expand the application of the restoration science principles in healthcare in order to better understand IP&C in two hospital units from a whole systems view. The findings and methodological challenges identified in this study suggest that future studies should continue to use a variety of theoretically driven research approaches to investigate the interactions among and between the range of variables that influence the outcome of MDRO. At the same time, when considering the use of comparative case study research approaches, my research experience offers some important lessons for future work. Specifically, while my two study hospitals initially appeared to be similar in many important respects (e.g. publicly funded, size, university affiliated, patient populations), it became apparent in the course of the research that they also had some critical differences, such as the differences in screening strategies, which made them difficult to compare. This suggests that case selection in future comparative IP&C case studies should be based on an expanded list of criteria. These criteria should include comparable audits, surveillance and reporting practices and comparable demographic and other relevant data, such as data on the agricultural practices within and demographic attributes of vulnerable populations within the hospital catchment areas. In addition, further research on the knowledge translation attributes of the participatory visual methods would further our knowledge on how communities collaboratively work together to study and assess their practice environments to then design and implement meaningful, sustainable changes.

Furthermore, given the growing consensus that engaged leadership is needed to improve the quality of healthcare (Vaughn et al., 2006; Jiang et al., 2008; Ramsay et al., 2010), a better understanding of what organizations are currently doing to fully engage leaders in safety and quality governance, as well as what does and does not work to secure and sustain their engagement, is necessary. Research with organizational leaders, board members, and practitioners using a participatory visual approach could help us learn how they presently do or do not actively engage in assessing the quality of their healthcare environments with their practice communities and possibly produce knowledge on how their engagement can be most effectively initiated and maintained. There is no reason why such a research approach could not be used across a variety of settings that are not limited to acute care hospitals. Furthermore, given the Canadian Institutes of Health Research (CIHR)'s new strategic initiative to support patient-oriented research (2010), it also seems timely to involve patients to collaborate on or co-lead such research efforts in some healthcare settings.

In addition, based on our knowledge to date about the relationship between nurse staffing and patient outcomes, the disparate staffing practices between my two study sites also warrant further investigation in future research. In a study by Sales et al. (2008) of nurse staffing for non ICU patients in 123 Veterans Administration hospitals, "increased RN staffing was significantly associated with decreased mortality risk (OR, 0.91; 95% CI, 0.86 – 0.96)" (p. 938). Given that a recent review of research on nurse staffing and healthcare-associated infections (HAI) by Stone et al. (2008) supports the importance of closely monitoring the links between nurse staffing practices and the incidence of HAI, the finding that the Netherlands' unit skeletal night staffing is currently associated with the lower incidence of HAI is perplexing. This finding demonstrates the complexity of determining what kinds of staffing practices are needed in which contexts for what reasons in order to minimize the acquisition of HAI, and confirms the need for further research to guide policy makers and managers. Similarly, the disparate infection control professional (ICP) staffing between the two study sites confirms the contention of Stone and colleagues (2009) that additional research is needed to understand what kind of ICP staffing and programs are best suited to which kinds of hospitals.

Finally, this research did not attempt to explore any form of costing estimates or cost-benefit analyses of interventions on the burden of MDRO. In a systematic review of 70 studies by Stone and colleagues (2005), a wide range of cost estimates of HAI were found. The authors concluded that the broad range was likely not due to actual differences in costs, but to the differences in methods used for conducting the economic analyses. Nonetheless, the costs of HAI are on the rise with the increase of MDRO infections (Stone, 2009). Thus, there is a strong need to incorporate cost-effectiveness analyses for IP&C practices and policies when doing future comparative work.

Implications for Policy

Findings from this research can inform current and future efforts to provide IP&C programs and strategies that are socio-ecologically sound. For example, current IP&C initiatives underway include the Institute for Healthcare

Improvement (IHI)'s 5 Million Lives campaign in the United States (i.e. Reduce methicillin-resistant *Staphylococcus aureus* (MRSA) infection) and the Canadian Patient Safety Institute (CPSI)'s *SaferHealthcareNow!* Interventions (i.e. New Approach to Controlling Superbugs, and Canada's Hand Hygiene Campaign) in Canada. These efforts are aimed at promoting system-wide improvements in IP&C and patient safety. Initiatives like these should engage local practitioners in designing and implementing interventions that can be adapted to their specific clinical environment.

Furthermore, the findings of this study indicate a lack of strict antibiotic restriction processes in place. In 2001, the World Health Organization launched its first global strategy for combating the serious issues caused by the emergence and spread of antimicrobial resistance. In the Netherlands, the SWAB (Working Party on Antibiotic Policy) has developed guidelines and educational programs as well as a surveillance program of antibiotic use and resistance to help contain antimicrobial resistance. In Canada, a new initiative called Ontario Antimicrobial Stewardship Project by the Institute for Safe Medication Practices Canada (ISMP Canada) is underway to establish antimicrobial programs in Ontario hospitals. In view of the global nature of this issue, efforts to contain antimicrobial resistance must be tackled worldwide.

While policy development on antibiotic prescribing and other critical IP&C strategies must proceed, it is equally important to recognize, however, that the number and range of issues with work design, workarounds, overcapacity, and other system issues uncovered in this research provide a cautionary tale about implementing additional IP&C policies and regulations without ensuring that they are accompanied by other necessary cultural and environmental changes. Recent work by de Saint Maurice et al. (2010) on quality improvement in anaesthesia, for instance, suggests that compliance with new safety rules can be very difficult to achieve and sustain in already over-burdened health systems. In the end, the most cost-effective policies may rest with making evidence-based modifications to practitioners' staffing, work environment, workflow, and work design that free them up to more consistently perform simple safety interventions that we already know are beneficial, such as proper hand washing and timely, consistent cleaning of equipment and the care environment. In other words, as de Saint Maurice and colleagues would advise (2010), if we want better outcomes, we need to give equal attention to reforming system violations (in the case of IP&C, such system issues as unmanageable workloads, chronic overcrowding, and ergonomically degraded workplaces) as we currently focus on improving practitioner and public compliance with guidelines and regulations.

Implications for Education

The active engagement of practitioners in the visual methods holds implications for undergraduate and continuing health professional education about safety and quality, including but not limited to IP&C concerns. This kind of clinically based, participatory visual research program has been previously demonstrated as contributing to effective student learning (Marck et al., 2007) and fits well with the kinds of undergraduate nursing program research apprentice models outlined by other nurse authors (Reutter et al., 2010; de Cordova et al., 2008). There is no reason to believe that increased use of participatory visual methods and the data collected in such projects would not be equally as useful in ongoing IP&C education programs for health professionals, managers, and potentially the public. For example, if photo elicitation can evoke rich discussions and communal learning in research focus groups, there is every reason to explore the merits of similar visual elicitation strategies in educational venues for students and professionals. It is also possible that photos collected during this kind of research could be useful in the development of the kinds of educational materials and "how to" guides that Sharp et al. (2004) have suggested for healthcare teams who are charged with implementing evidence-informed interventions.

Concluding Thoughts

This dissertation provided me with an opportunity to study the whole system for IP&C on two surgical units in different countries. Despite the challenges associated with conducting this type of research, the in-depth comparative case study approach helped me better understand the interrelationships between different components of the system for IP&C.

Multiple knowledge exchange strategies will be used to share and disseminate the results of this research. The participatory study approach, the photographs, and their accompanying stories have inherent knowledge exchange prospects, facilitating dialogue with a variety of stakeholders throughout and after completion of the study. I will share my experiences and knowledge gained through academic publications and presentations. In addition, I will present the findings to leaders and staff within each participating organizations to give them the opportunity to engage and share their overall learning experience. In addition to presenting to the study participants, I will also disseminate the knowledge gained more broadly within each organization by writing an article summarizing the results for the hospital newsletter. At the Ontario hospital site, I will present at the Nursing research grand rounds in early 2011. Also, I will offer to present my findings at a meeting of each of the two organizations that have provided tremendous support for this project: the Canadian Patient Safety Institute (CPSI) and the Community and Hospital Infection Control Association – Canada (CHICA – Canada). I also hope to engage in future opportunities to collaborate in research, policy making and education with nurses, other healthcare providers, physicians and senior leaders to further our knowledge on the socio-ecological conditions for IP&C practices in order to better understand the system as a whole.

Significance

The research study is an innovative approach to IP&C that generated ongoing knowledge exchange throughout and after the study. The results of this research study provided insight not only into how nurses and other staff do engage in assessing the quality of their healthcare environment pertaining to IP&C, but how these methods helped participants understand that engagement. The research also contributed valuable understanding of the factors which need to be taken into account when comparing two health systems. It is my intention to ensure that the findings of this research and related future work influence the quality of care, support the development of feasible policy and practice, and contribute to ongoing education.

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APPENDIX A: Consent Form (The Netherlands Hospital)

Information Letter and Consent Form

INFORMATION SHEET

Title of Research Study: Barriers and Bridges to Infection Prevention and Control in the Netherlands and Canada: Two Comparative Case Studies

Principal Investigator: Dr. Patricia Marck, University of Alberta
Co-Principal Investigator: Ms. Chantal Backman, University of Alberta

Background: We are interested in looking at infection prevention and control practices in the hospital to better understand the issues. We hope that this survey will help practitioners assess the infection prevention and control practices on their unit. This research has been reviewed and approved by the Health Research Ethics Board of the University of Alberta, the Ethics Board in the Netherlands and The Research Ethics Board in Canada.

Purpose: You are being asked to participate in a research study to assess infection prevention and control practices on your unit.

Procedures: If you participate in this study, you will be asked to:

a) Participate in one focus group which will last approximately 1 to 1 ½ hours.

b) Look at a variety of digital photographs of your unit.

c) Give any verbal or written comments about the digital photographs.

Possible Benefits: The possible benefits to you for participating in this study are that may help you to identify and discuss infection control issues on your unit. This research project may help you to quickly visually assess the infection control issues on your unit. We will report the results of this research to all the unit staff and in future publications and presentations for other audiences.

Possible Risks: It is not expected that you will suffer any risks from participating in this study. Employment will not be jeopardized by withdrawal or non-participation in this study.

Confidentiality: All documents and information relating to this study will be kept confidential. The group session will be tape recorded to assist with this research. Any research data collected about you during this study will not identify you by name, only by your initials and a coded number. Your name will not be disclosed outside the research study. Any report published as a result of this study will not identify you by name. While we will do everything possible to protect the confidentiality of what you have said, we cannot guarantee that others in the

Title of Research Study: Infection prevention and control research study

group will do so. As part of our ongoing research, we will keep all audio tapes, group notes and completed scoring tools in our secure archives, which are only accessible to the research team, for a period of 7 years. We may wish to use the research findings in later studies; any use of these research findings in further studies will only occur after review and approval by the Health Research Ethics Board of the University of Alberta and any other relevant parties.

Voluntary Participation: Your attendance is voluntary. You will not be penalized in any way if you choose not to take part in the research study. If you are participating during non-scheduled work time, you will receive $100 to compensate you for the time spent participating in this study. If at any time during your involvement with the focus group you wish to withdraw, you are free to do so without any penalty. We will reimburse you for your time spent in the session (if you are participating during non-scheduled work time).

Contact Names and Telephone Numbers:

If you have concerns about your rights as a study participant, you may contact the Chairperson of the Ethics Board at xxx-xxx-xxxx.

Please contact any of the individuals identified below if you have any questions or concerns about the study:

Dr. Patricia Marck Principal Investigator	xxx-xxx-xxxx
Chantal Backman Co-Investigator	xxx-xxx-xxxx

CONSENT FORM

Title of Project: Barriers and Bridges to Infection Prevention and Control in the Netherlands and Canada: Two Comparative Case Studies

Principal Investigator: Dr. Patricia Marck **Phone Number:** xxx-xxx-xxxx
Co-Investigator: Chantal Backman **Phone Number:** xxx-xxx-xxxx

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Part 2 (to be completed by the research subject):

	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read and received a copy of the attached Information Sheet?	☐	☐
Do you understand the benefits & risks involved in taking part in this study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to withdraw from the study at any time, without having to give a reason and without affecting your work?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you understand who will have access to your records?	☐	☐
Can any of the information you provide be used in further studies?	☐	☐

Who explained this study to you? ____

I agree to take part in this study: YES ☐ NO ☐

Signature of Research Subject ____
(Printed Name) ____
Date: ______________________

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator or Designee ______________________ Date __________

THE INFORMATION SHEET MUST BE ATTACHED TO THIS CONSENT FORM AND A COPY GIVEN TO THE RESEARCH SUBJECT

APPENDIX B: Consent Form (Canadian Hospital)

Information Letter and Consent Form

INFORMATION SHEET

Title of Research Study: Barriers and Bridges to Infection Prevention and Control in the Netherlands and Canada: Two Comparative Case Studies

Principal Investigator: Dr. Patricia Marck, University of Alberta
Co-Principal Investigator: Chantal Backman, University of Alberta

Background: We are interested in looking at infection prevention and control practices in the hospital to better understand the issues. We hope that this survey will help practitioners assess the infection prevention and control practices on their unit. This research has been reviewed and approved by the Health Research Ethics Board of the University of Alberta, the Ethics Board of the Netherlands hospital and the Research Ethics Board of the Canadian hospital.

Purpose: You are being asked to participate in a research study to assess infection prevention and control practices in the hospital.

Procedures: If you participate in this study, you will be asked to:

a) Participate in one focus group which will last approximately 1 to 1 ½ hours.

b) Look at a variety of digital photographs of your unit.

c) Give any verbal or written comments about the digital photographs.

Possible Benefits: The possible benefits to you for participating in this study are that may help you to identify and discuss infection control issues on your unit. This research project may help you to quickly visually assess the infection control issues on your unit. We will report the results of this research to all the unit staff and in future publications and presentations for other audiences.

Possible Risks: It is not expected that you will suffer any risks from participating in this study. Employment will not be jeopardized by withdrawal or non-participation in this study.

Confidentiality: All documents and information relating to this study will be kept confidential unless release is required by law. The group session will be tape recorded to assist with this research. Any research data collected about you during this study will not identify you by name, only by a coded number. Your name will not be disclosed outside the research study. Any report published as a result of this study will not identify you. While we will do everything possible to protect the confidentiality of what you have said, we cannot guarantee that others in the group will do so. As part of our ongoing research, we will keep all audio tapes, group notes and completed scoring tools in our secure archives, which are only

Title of Research Study: Infection prevention and control research study

accessible to the research team, for a period of 15 years. The Research Ethics Board, the Health Research Ethics Board of the University of Alberta, and the Ethics Board of the Netherlands hospital may review your relevant study records for audit purposes. We may wish to use the research findings in later studies; any use of these research findings in further studies will only occur after review and approval by the Health Research Ethics Board of the University of Alberta and any other relevant parties.

Voluntary Participation: Your attendance is voluntary. You will not be penalized in any way if you choose not to take part in the research study. If you are participating during non-scheduled work time, you will receive $100 to compensate you for the time spent participating in this study. If at any time during your involvement with the focus group you wish to withdraw, you are free to do so without any penalty. We will reimburse you for your time spent in the session (if you are participating during non-scheduled work time).

Income earned as a result of your participation in this study that is not for reimbursement of study expenses, will be considered taxable income by Revenue Canada. In order to receive payment for your participation in this study, it will be necessary to provide the investigator or their delegate with your Social Insurance Number. The hospital will then issue a T4A for any amount over $500.00 by the end of February of the following year.

Contact Names and Telephone Numbers:

If you have concerns about your rights as a study participant, you may contact the Chairperson of the hospital's Research Ethics Board at xxx-xxx-xxxx.

Please contact any of the individuals identified below if you have any questions or concerns about the study:

Dr. Patricia Marck Principal Investigator	xxx-xxx-xxxx
Chantal Backman Co-Principal Investigator	xxx-xxx-xxxx

CONSENT FORM

Title of Project: Barriers and Bridges to Infection Prevention and Control in the Netherlands and Canada: Two Comparative Case Studies

Principal Investigator: Dr. Patricia Marck **Phone Number:** xxx-xxx-xxxx
Co-Principal Investigator: Chantal Backman **Phone Number:** xxx-xxx-xxxx

Part 2 (to be completed by the research subject):	Yes	No
Do you understand that you have been asked to be in a research study?	☐	☐
Have you read this 3-page consent form and will receive a copy of the attached Information Sheet?	☐	☐
Do you understand the benefits & risks involved in taking part in this study?	☐	☐
Have you had an opportunity to ask questions and discuss this study?	☐	☐
Do you understand that you are free to withdraw from the study at any time, without having to give a reason and without affecting your work?	☐	☐
Has the issue of confidentiality been explained to you?	☐	☐
Do you understand who will have access to your records?	☐	☐
Can any of the information you provide be used in further studies?	☐	☐

Who explained this study to you? ____

I agree to take part in this study.

Signature of Research Subject ____
Printed Name ____
Date: ______________________________

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator/Delegate ____
Printed Name of Investigator/Delegate ____

Date: ______________________________

THE INFORMATION SHEET MUST BE ATTACHED TO THIS CONSENT FORM AND A COPY GIVEN TO THE RESEARCH SUBJECT

APPENDIX C: Digital Voice Recorder Protocol for Collecting Photo Narrations of Unit Infection Prevention and Control Practices

(Adapted from Capital Health and Royal Alexandra Hospital Grant (P Marck, PI). Assessing the Safety and Quality of Medication Delivery: A Proposal to Evaluate a Unit Dose Medication Delivery System D Swanson, K Haluska, B Kwan, T Kubasek, B Ring, D Ryan, D Segall, L Thomas, K Woo)

(Implemented as planned)

Equipment

- Digital Voice Recorder
- Supply of Photography consent forms
- List of photographs to be taken
- Hand Sanitizer

Before leaving the Office:
Preparation:

1. Check Digital Voice Recorder (DVR) equipment to make sure batteries are charged and that equipment is working.
2. Set date if batteries had been taken out of DVR
    i. Use arrows to adjust hour,
    ii. Press play to set hour and move on to minutes.
    iii. Use arrows to adjust minutes
    iv. Press play set minutes and move on to year.
    v. Continue this process until all date and time information is set
    vi. When information is correct press play a final time- main menu should appear.
3. Put DVR case with remaining equipment in back pouch of camera case.

At the picture taking site:

1. Wash hands

    *****Note: Due to infection control concerns, if one handles any of the equipment they cannot touch anything in the room until hands have been sanitized, likewise no equipment can touch any surface while on the unit. Furthermore if one touches a surface on the unit, hands must be sanitized before handling any of the equipment again. ****

2. Set up the DVR

a) Push FOLDER/REPEAT button to find appropriate folder. Folders are:

1. Case study 1
2. Case study 2

b) Make sure that the DVR is set on Dictation: DICT button is on back right of DVR. Press RECORD

c) Test DVR before process begins, to ensure it is working properly, turn it on and have the participant speak, stop the recording and play it back to ensure the recording can be heard clearly.

d) Verbally record date, time, patient care unit, attendees and any other notables deemed important.

e) Give DVR to accompanying hospital personnel to hang around his/her neck

*** Remind team that the DVR will be recording the entire process so they will need to speak at a reasonable volume and use a clear speaking voice***

3. Record the accompanying hospital personnel's commentary about the scene

a) Photographer verbally confirms picture number.

b) Allow accompanying hospital personnel to comment on picture and answer questions. Prompt with further questions if necessary.

c) When accompanying hospital personnel has finished answering questions- confirm subject and title

d) Photographer takes picture

e) Photographer checks photograph and verbally confirms whether the quality is acceptable

f) Accompanying hospital personnel checks photograph and verbally confirms whether the subject is acceptable. If the photograph is not acceptable have accompanying hospital personnel explain what is wrong and repeat steps e-g

g) If there is a staff member in the picture, fill in a staff picture information form and have the staff member sign a consent form.

At Office:

1. Download DVR material into software and transcribe into word document.

2. Remove batteries from DVR and place equipment in locked cabinet.

APPENDIX D: Photography Protocol for Collecting Visual Data of Unit Infection Prevention and Control Practices with Accompanying Hospital Personnel

(Adapted from Capital Health and Royal Alexandra Hospital Grant (P Marck, PI). Assessing the Safety and Quality of Medication Delivery: A Proposal to Evaluate a Unit Dose Medication Delivery System D Swanson, K Haluska, B Kwan, T Kubasek, B Ring, D Ryan, D Segall, L Thomas, K Woo)
(Implemented as planned)

Equipment:

- Camera
- Lens
- White balance card
- Memory card
- Spare batteries for camera
- Hand Sanitizer

Before leaving the Office check all equipment to make sure batteries are charged, that equipment is working and memory card has been cleared of all previous pictures.

At the picture taking site:

I. Brief accompanying hospital personnel:

1. Review with the accompanying hospital personnel the:
    a. Background of the project and purpose for taking pictures.
    b. list of photos to be taken (including the researcher's ideas)
    c. Researcher will ask accompanying hospital personnel to answer questions about each scene

2. Explain to the accompanying hospital personnel that s/he will be asked to direct the framing of the scene as necessary and to review the scene in the viewfinder to ensure that the photograph being taken accurately captures the subject.

II Set up photographic equipment:

*****Note: Due to infection control concerns, the camera must not be put down on any surface in the Unit. During photography the camera should be either in the case or held by the photographer. The photographer MUST NOT touch anything on the unit. Anyone who wants to touch the camera must first wash his/her hands*****

1. Wash hands

2. Put camera strap around neck

3. Remove lens cap from camera and store in lid pocket of case.

4. Turn camera on

III. <u>Take photograph(s)</u>

1. Listen to commentary from the accompanying hospital personnel describing what is important about the scene.

2. Compose photograph to capture details described by the accompanying hospital personnel. Orient yourself next to permanent landmarks so as to facilitate taking repeat photographs. If by a window, try to arrange scene to eliminate distracting reflections.

3. Confirm picture number verbally.

4. Take picture.

5. Check photograph for glare/ reflections/ shadows/ subject/ focus. If there are technical flaws with photograph state so for the verbal record and retake photograph.

6. Have the accompanying hospital personnel check photograph for appropriate composition. If not satisfied with picture readjust camera and repeat steps 2-5 until an appropriate picture is obtained. Have the hospital personal verbally explain why picture isn't acceptable. Be sure to confirm new picture number and what has changed in the picture.

7. Consult with hospital personnel to determine if any other aspects of the scene should be photographed separately. * Researcher will confirm subject title and any further information with accompanying hospital personnel.*

8. Repeat steps 1-10 until list of pictures for this site has been completely photographed.

9. When finished photographing unit, turn off camera and store in camera case.

At Office:

IV. <u>Download pictures from camera to computer:</u>

1. Plug USB cable into camera and into computer.

2. Create new folder to store photographs in the respective directory

3. Download photos from camera to new folder.

4. Set camera battery to charge. When finished, put camera equipment away in locked cabinet.

APPENDIX E: Photograph Database Tracking Tool (Implemented as planned)

Photograph Database Tracking

Location: **Hospital Personnel:** **Camera Body/Lens:**
Date: **Other Equipment:**

Unique #	Photograph File Name	Title	Height of Camera (inches)	Camera Angle	Type of Lighting	Notes	Modified Y/N	Shooting date/time	Shooting mode	Shutter Speed	Aperture	ISO Speed	Focal Length	Image Size	Image Quality	Flash	File Size

APPENDIX F: Selection Criteria for Focus Group Photographs (Implemented as planned)

1. Compare the multiple photographs to determine which ones are the best/most representative/highest quality pictures:
    a. Eliminate photographs which have distracting elements, elements that obscure the scene, or which are technically flawed and unlikely to be able to be salvaged with digital editing (see # 5).
    b. Try and retain the picture which depicts the most information about the scene or which is a more accurate depiction of the real scene.
    c. When choosing between two "less than ideal" pictures, consider if the flaw is a fatal flaw or if the viewer can still extract the important information about the scene.

2. Select photographs that reflect some common infection control issues raised in one or more of the photo walkabouts (e.g. potential for cross contamination, lack of hand hygiene stations, etc)

3. Select photographs that reflect some common infection control strategies raised in one or more of the photo walkabouts (e.g. infection control posters, green pails, green patient-specific wound dressing containers, etc.)

4. In addition, select photographs where possible that reflect various socio-ecological aspects of infection prevention and control, for example:
    - Place ethic
        - Photographs, if any, that depict how individuals treat each other and the unit they share (e.g. photographs that (1) depict teamwork or tasks that they need to work, (2) are seen as important in the care of their environment, (3) reinforce and support each other to value infection prevention and control, (4) respect the historical knowledge of how a place has functioned over time) (i.e. nurse server, dirty utility room)
    - Citizen science
        - Photographs, if any, that depict opportunities to take part in infection control research (e.g. using a participatory and collaborative approach to the design, conduct and analysis of infection prevention and control research, involving members of the community in data collection, data analysis and knowledge translation wherever feasible and appropriate, seeking multiple sources of data (including sources of indigenous knowledge) and using a variety of methods to develop integrative knowledge about local places as well as the larger systems those places are part of)
    - Engaged practice
        - Photographs that depict opportunities for self monitoring, feedback and adjustment of daily infection prevention and

control practices (e.g.: audits, equipment checks, reminder posters, checklists, cleaning checklist behind isolation signage, etc), using local feedback processes to continually improve workflow, work design, and processes at the individual and team levels (e.g. unit conditions - system and workflow: pictures that talk about a system process such as the cleaning process of patient side table – the clean patient side tables are placed on one side of unit when they are dirty and then once cleaned, they are placed on the other site of the unit, etc.), physical environment: pictures that discuss the work environment and workarounds (e.g. garbage with lid, tap design, etc.)

- Adaptive learning and growth
    - Photographs that depict opportunities for influencing evidenced-informed management of MDRO, screening policies, resource allocation decisions about patient care staffing, housekeeping, availability of equipment and supplies and staff and public education policies and funding (i.e. patient pamphlets)

5. Determine if a picture requires digital editing

Digital editing should be kept to a minimum to reduce the influence of bias and subjectivity. However, in certain instances technical difficulties with shooting the scene or resulting from user error may require digital intervention in order to retain a picture for analysis.

- Editing options include:
    a. Cropping
    b. Straightening
    c. Changing Brightness/contrast
    d. Changing color balance

APPENDIX G: Focus Group Moderator's Guide (Implemented as planned)

A. INTRODUCTION

1. Introduce myself and welcome participants to the focus group.

2. Provide a brief description of the study

3. The purpose of the focus group is to gather your insights and opinions of infection prevention and control practices.

4. The discussion will last approximately 60-90 minutes.

5. The session is being audio-taped for analysis purposes, in case I need to double-check the proceedings against my notes. We work on a first name basis during the group, and in analyzing the tapes, I will not attribute comments to specific people.

6. Describe how a focus group functions. Focus groups are designed to have open and honest discussions. My role as a moderator is to guide the discussion and encourage everyone to participate. Another function of the moderator is to ensure that the discussion stays on topic. Your role is a little more difficult – you have to answer questions and voice your opinions. Everyone's opinion is important and should be respected.

7. Answer any questions and obtain informed consent from participants

8. Discuss group rules which will be written by moderator and placed on a wall in the room

    - Explain that complete confidentiality is not possible in focus groups
    - Explain that any comments made within the group should not be discussed outside of group
    - Explain that there is no right or wrong answers
    - Speak one at a time and as clearly as possible
    - Ask group for suggestions on other ground rules
    - Group rules

9. Ask each participant to tell the group their first name only

B. DISCUSSION

10. Using the original problem list, the photos and the walkabout commentary to stimulate discussion, ask the group to provide the strengths and limits of

their infection prevention and control programs on their units and in their hospitals.

11. Ask the participants provide written comments on the basis of their assessment of the safety of the scene displayed.

12. Ask the group to discuss each picture as a whole and record the discussion points on a flip chart for reflection back to the group.

13. Then, ask the group to offer their ideas about (a) what is working well, and (b) what could be improved in terms of infection prevention and control in their hospital and on their unit.

C. CONCLUSION

14. Summarize participants' perceptions

15. Explain to participants that the focus group is drawing to an end

16. Explain that there is an opportunity for participants to now share any thoughts or ideas that they have regarding the topic that were not addressed or to discuss something they learned as a result of the focus group

17. Thank participants for volunteering their time and sharing their thoughts

APPENDIX H: Modified Digital Photograph Scoring Tool

(Adapted from EFF Support for the Advancement of Scholarship Small Faculties Research Grant # A021904 (P Marck PI). Using restoration science to develop a digital photography assessment tool (DPAT). E Vieira, CIHR EQUIPP Scholar & T Whelehan, Honors Undergraduate Research Student & K Hagedorn, Safer Systems Research Program Coordinator ($3,000.00), 2006 – 2007.)

Thank you for taking part in my study. Before we begin the focus group, please review the Information & Consent Letter provided to you. Please ask the researcher any questions that you have about the study. If you do not have your Information & Consent Letter with you, the researcher can provide you with one.

After you have reviewed the Information & Consent letter, if you wish to take part in the focus group, please:

- Review **Part 1: Instructions for Assessment Ward Photographs**
- Complete **Part 2: Scores for Ward Photographs**
- Complete **Part 3: Other Comments**
- Return your completed **Digital Photography Assessment Tool** to Chantal Backman at the end of the session.

Please do not write your name on any of the forms.

Thank you for your participation.

PART 1: Instructions for Assessment of Ward Photographs

We are looking for your opinions of the safety of the space presented in pictures of the ward environment.

The researcher will display each ward photograph on a Power Point slide for participants to view. As you view each photograph, we will ask you to:

1. make an overall assessment of the safety of the area photographed in terms of infection prevention and control;
2. CIRCLE the number between 1 (very unsafe) and 10 (very safe) that most closely matches your assessment of the safety of the environment displayed in the photograph;
3. add any written comments that you wish about each photograph in the space provided on the form for that photograph;

   For example, as applicable for each photograph, you may want to comment on:
   - the cleanliness and hygiene of the photographed area (for example, the absence of dirt, moisture, or other sources of contamination; access to proper hand washing and drying);
   - the organization (degree of clutter, space, orderliness) of the photographed area; and/or
   - any other aspect of infection prevention and control that you believe is relevant to the photographed area.

4. After we have viewed all the photographs you will have an opportunity to share any comments that you wish to share with the rest of the group

Once you have rated all of the photographs and we have completed our discussion of your ratings, please add in this section any additional comments about infection prevention and control that you wish to as a result of viewing the photographs.

PART 2: Infection Prevention and Control Scores for Ward Photographs

1. Photo # 1:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

2. Photo # 2:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

3. Photo # 3:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

4. Photo # 4:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

5. Photo # 5:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

6. Photo # 6:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

7. Photo # 7:

Very Unsafe									**Very Safe**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments

8. Photo # 8:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

9. Photo # 9:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

10. Photo # 10:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

11. Photo # 11:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

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12. Photo # 12:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

---

13. Photo # 13:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

---

14. Photo # 14:

Very
Unsafe **Very Safe**
1 2 3 4 5 6 7 8 9 10

Comments

PART 3: Other Comments

1. If I could do anything to improve any of these areas in relation to infection prevention and control, I would:

2. I have other concerns about infection prevention and control that are not covered by these photographs (please elaborate):

3. What other photos would you take to track infection prevention and control issues in your area? Why these photos?

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APPENDIX I: Code List

Netherlands Hospital	Canadian Hospital
Communication Community of practice Individual practices Local feedback Management initiatives Shared practices Shared values Staff resources Team building activities Teamwork Training and education Unit or hospital-wide practices Work design Workarounds Workplace design	Communication Individual practices Information for patients Interruptions Local feedback Management initiatives Shared practices Shared values Staff resources Team building activities Teamwork Training and education Unit or hospital-wide practices Work design Workarounds Workplace design

APPENDIX J: Example of the Data Matrix for Case Study #1 (Initial Draft)

THEME: HUMAN FACTORS

Primary Codes THEMES (T) and codes (C)	**Exemplars from the Research Data**			**Emerging Theory & Relevant Literature**
	Observations	**Photo Walkabouts**	**Group Discussions / Written Comments**	
HUMAN FACTORS (T)	The theme *Human factors* is based on the codes from the observations such as: environment (location of hand hygiene products, accessories), workflow	The theme *Human factors* is based on codes from the photo walkabouts such as: environment (location of hand hygiene products, type of hand hygiene products, accessories) and workflow	Data from the group discussions and written comments help to confirm and expand the codes that were previously developed in the observation s and photo walkabouts.	*Human factors* has been identified as an important theme to add to the proposed socio-ecological framework for infection prevention and control (Adapted from Stokols 1996, Waldvogel 2004, Struelens 1998, Marck et al. 2006b) Pat Croskerry Robert Wears Richard Cook Rene Amalberti Eric Hoefnagel CPSI competency work Suresh et al. 2007 – tool to assess the user-friendliness of hospitals for practicing hand hygiene. Based on previous work done by Suresh and Cahill (2007) and the Human Factors Group, UHN, the following products must be analyzed when conducting an

Primary Codes THEMES (T) and codes (C)	**Exemplars from the Research Data**			**Emerging Theory & Relevant Literature**
	Observations	**Photo Walkabouts**	**Group Discussions / Written Comments**	
				environmental assessment: • Alcohol based hand rubs • Soaps • Lotions • Gloves • Sinks • Waste baskets • Hand drying technology
Environment (C) **1- Location of hand hygiene products**	At the entrance of each room, there is a sink for staff use which is stocked with a wall mounted soap dispenser, paper towels, a garbage container with lid, a wall mounted alcohol sanitizer dispenser, and gloves in various sizes: small, medium and large. **A dirty utility room**: a narrow room where items used by patients can be cleaned and / or disinfected, with two urinal	"Like here it's to disinfect your hands. If you have been in the room or something or you cleaned and you want to wash your hands, and the, where you disinfection" … "It's all the same…in the same rooms yes. There's always soap and alcohol." "And every room has its own…sink and...an alcohol sanitizer"...	"There are gloves, hand alcohol, possibility to wash your hands."	Q: Is housekeeping responsible to replenish the soap, alcohol sanitizer, paper towels and gloves? How often is this done? -Processes for hand hygiene product replacement/refilling , cleaning, and maintenance (Johnson et al, 2005, Kohan et al. 2002, Gould et al. 2002, Larson 2003) **Alcohol-based hand rub** -Positive effect of alcohol-based hand rubs on compliance (Gordin et al. 2005, Muto et al. 2000, Muto et al. 2007, Weber et al. 2003, Whitaker et al. 2007, -Alcohol-based hand rubs should be

Primary Codes THEMES (T) and codes (C)	Exemplars from the Research Data			Emerging Theory & Relevant Literature
	Observations	**Photo Walkabouts**	**Group Discussions / Written Comments**	
	and bed pan cleaning machines at each end, a long counter with sink equipped with a wall mounted soap dispenser, paper towels, a garbage container with lid, a wall mounted alcohol sanitizer dispenser, and gloves in various sizes: small, medium and large. …the alcohol sanitizer dispensers can only be found mounted on the wall near the sinks in the patient rooms or the sink in the dirty utility room and the medication room. There are no additional alcohol sanitizer dispensers in the hallways,	"We always [*have*] gloves everywhere. We have it here but we have also inside the bathroom so it's, when you wash a patient or you use the toilets, clean the patient I always use hand gloves so I think it's very important that they are everywhere."		placed in convenient and redundant locations (Creedon, 2005, Suresh et al. 2007, Harbarth et al, 2002) **Sinks** -Hand operated tap faucets can contaminate healthcare workers' hands when taps on turned off (Cochrane, 2003, Merrer et al. 2005) -Use of elbow, sensor or foot operated taps are more likely to prevent hand contamination (Cochrane 2003) -Another study found that sensor faucets are more likely to harbor bacteria and contaminate hands than manual faucets due to their low flow water saving function (Merrer et al. 2005) **Waste baskets** -Hands can become contaminated when opening or closing

Primary Codes THEMES (T) and codes (C)	Exemplars from the Research Data			Emerging Theory & Relevant Literature
	Observations	**Photo Walkabouts**	**Group Discussions / Written Comments**	
	near the elevators, in the staff lounge, or at the nursing station.			waste baskets. Thus, it is recommended to provide waste baskets that are foot operated (Cochrane, 2003, Ward, 2000)

APPENDIX K: Procedure Protocol for the Analysis of the Visual and Written Text (Original – see Appendix L for revised version)

(Adapted from EFF Support for the Advancement of Scholarship Small Faculties Research Grant # A021904 (P Marck PI). Using restoration science to develop a digital photography assessment tool (DPAT). E Vieira, CIHR EQUIPP Scholar & T Whelehan, Honors Undergraduate Research Student & K Hagedorn, Safer Systems Research Program Coordinator ($3,000.00), 2006 – 2007.)

1) I will review the focus group data and photographs and read through:
    a. all of the comments about each photograph collected from the modified DPST survey comments;
    b. all of the overall comments collected from the DPST survey comments; and
    c. all of the transcriptions and Flip Chart notes from the focus groups in relation to each photograph.

2) I will then re-reading all of the DPST survey comments on each photograph and overall. On this second reading, I will highlight any comments that seem significant to me based on the core elements of the restorative framework. I will make notes in the margins of the text on my rationale for highlighting particular comments.

3) Next, I will focus on the flip chart notes. I will re-read all of the comments on each photograph from the Flip Chart notes of the focus groups. On this second reading, I will highlight any comments that seem significant to me based on the core elements of the restorative framework. I will make notes in the margins of the text on my rationale for highlighting particular comments.

4) Using a numbering system from #1 onwards, I will group together any comments that I view as related to similar themes or ideas by assigning the text the same #. In a table, I will note which themes correspond to which number in my numbering system.

5) If a comment speaks to more than one important theme, I will assign it more than one number, noting my rationale in the margin beside the text.

6) As a last step, I will look for themes which are common across several photographs. For example, if crowding is a theme in three photos, I will put my Code # for crowding in one column and list the photos that theme appears in across from that column like this:

Code	Theme	Pictures
Code #1	crowding	Photos 1, 4, 6

7) The final themes will then be developed in relation to specific photographs and also the set of photographs based on the review and discussion of the data and preliminary themes.

APPENDIX L: Procedure Protocol for the Analysis of the Visual and Written Text (Revised October 16, 2009)

For each case study and then across the two case studies, I will conduct an iterative data analysis of the unit observations, photo walkabouts, focus groups, written comments, and photographs, using atlas.ti to support the management and analysis of the written and visual data. After creating one "*hermeneutic unit (HU)*" in atlas.ti for each case study, I will carry out my data analysis as follows:

<table>
<tr><th>Analytical Step</th><th>Methodological Rationale</th></tr>
<tr><td>1. Beginning with the first case, I will sequentially review for accuracy, completeness, and initial impressions all of the written and visual text in the following order:
a. Field notes of unit observations
b. Transcripts and field notes of the photo walkabouts
c. Photographs from the walkabouts
d. Transcripts of the photo walkabouts in relation to each of the photographs
e. Transcripts and field notes of the focus groups
f. Transcripts of the focus groups with the photographs
g. Comments on the Digital Photograph Scoring Tool

All these documents will be assigned as "primary documents (PD)" to the HU in atlas.ti.</td><td>• To initially go through the various documents to obtain my initial impressions of the data as a whole</td></tr>
<tr><td>2. In the second read through, I will re-examine select photographs and related transcripts a second time, underlining any text that seemed significant to me for whatever reason with no particular coding. I will write comments in the margin to identify my rationale for highlighting particular comments and my thoughts of the linkages with previous data.</td><td>• To start analyzing the data by reviewing each transcript and the photographs in order to compare and contrast with my initial interpretation.
• To establish links and relationships in the data not looking only at individual parts but the data as a whole</td></tr>
<tr><td>3. On the third reading, I will begin to assign preliminary "codes" in atlas.ti to categorize the</td><td>• To review the data again and group together</td></tr>
</table>

Analytical Step	**Methodological Rationale**
comments that appear to relate to similar themes or ideas. If a comment speaks to more than one important theme, I will assign it to more than one code. At this point in time, I will also start to cross-reference in atlas.ti selected visual images and portions of images with the preliminary codes and relevant written text using the "*hyperlink*" function.	similar ideas or emerging themes – repeating this several times (iterative process) to develop themes not only looking at the individual parts but the data as a whole • Repeating this process several times enhances the rigor by facilitating a substantive iterative process of coding
4. On the fourth read of the visual data and related written texts, using the *"query tool"*, I will create preliminary "*super codes*" (themes) to combine many of the preliminary "codes" (exemplars) identified in step 3. "*Super codes*" are at a more theoretical level of abstraction. At this point in time, I will also look to see the links (if any) between the preliminary "*super codes"* I have derived and: a. various socio-ecological frameworks (for example, Stokols, 1996; Waldvogel, 2004; Struelens, 1998; Marck et al., 2006c) b. any other relevant literature (for example, infection control research) c. my field observation notes, and d. the policies, procedures, infection rate reports, and any other institutional documents. Based on this stage of analysis, I will develop *"theoretical memos"* in atlas.ti of my "working hunches" about the potential links between various groupings of data, the codes I have assigned, and emerging theory (socio-ecological or otherwise) about infection prevention and control. I will use the "*families*" tool in atlas.ti to organize all the codes and memos and the "*networks*" function in atlas.ti to illustrate and explain potential links and relationships between codes, memos, quotations, and images.	• To link the codes (exemplars) to super codes (themes) to help tighten and articulate the central themes • To compare if the emerging themes found in the data relate to previous theory, frameworks and the literature. • To use the memo function to track method and theory development (i.e. visual interpretation, emerging patterns and missing pieces)

Analytical Step	Methodological Rationale
5. As data from Case 2 becomes available, I will repeat Steps 1 – 4 above with the Case 2 data. I will create separate "*families*" of codes for both case studies which will be compared and contrasted for similarities and differences between them. The data will also be examined across cases for linkages with the evolving framework.	• To compare and critique the data in order to develop the theoretical perspective • To analyze the links between the codes and themes across the two cases
6. As I proceed with my preliminary super coding, cross-referencing, theoretical memoing and subsequent comparative case analyses, I will regularly confer with my supervisor, committee members, and external experts as indicated by the emerging analysis to obtain critiques of my preliminary analysis. As I complete these steps, I will check back with each institution as necessary to ensure I have the accurate and complete data that I need to proceed with my analysis.	• To increase rigor by obtaining ongoing critique of the analysis

APPENDIX M: Preliminary Themes and Codes for Case Study #1

Theme 1. There are considerable challenges to and inherent complexity to environmental design in the acute care setting as it relates to infection prevention and control

This theme refers to human factors which is "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." (International Ergonomic Association) This theme is based on codes from the research data such as: workplace design, work design and workarounds. The definitions and some examples for each code are described below.

1.1 Workplace design

This code refers to the physical environment or the physical space and its features that either encourages or discourages infection prevention and control (i.e. unit layout, location of hand hygiene products, technology, equipment, hospital or unit design, etc).

- At the entrance of each room, there is a sink for staff use which is stocked with a wall mounted soap dispenser, paper towels, a garbage container with lid, a wall mounted alcohol sanitizer dispenser, and gloves in various sizes: small, medium and large. The alcohol sanitizer dispensers can only be found mounted on the wall near the sinks in the patient rooms or the sink in the dirty utility room and the medication room. There are no additional alcohol sanitizer dispensers in the hallways, near the elevators, in the staff lounge, or at the nursing station. (Observations)
- During the group discussion for the management group, one of the participants spoke about his concerns with the garbage can lids. *"Here, you have washed your hands and you throw away the paper towel and you have to touch the lid of the dirty waste box again and in fact you have dirty hands again. Afterwards, you should use the alcohol. You don't have to touch anything. It's going to be a problem if not used properly."*
- During the same group discussion, another participant raised another issue: *"to open the tap you cannot come with your elbow to the…you have to use your hands instead of using your elbow as it should be, so it's too short... I think that the handles should be longer and you can move it easy. Yeah it's too short and it's in all the patient rooms. So these taps will be used in a wrong way…"*

Photograph: MGMT-2

1.2 Work design

This code refers to the routines or the workflows that encourage or discourage infection prevention and control.

- During the photo walkabout with the nurse, she explained that *"...when we use this one [the patient table], we have this side, it's the clean one and the other side are the dirty ones. So you never make a mistake to put a dirty one in the room…this side of the hallway is the clean one…it's the clean one. When you put it inside or just on the other side, they are dirty ones so you never make a mistake like you put a dirty one to a new patient so that's…" (PW nurse)*

Photograph: NURS-12

- During the photo walkabout with the nurse, she commented on the linen carts that hold both clean and dirty linens: *"the 'clean' towels, and the* *dirty one touch each other so sometimes that's, that's difficult but she do it well, she don't put too many things inside."* (PW nurse)

Photograph: IC-50

- During the photo walkabout with the nurse, the participant explained that *"we also use this cart. We put it outside the rooms and most of the time we have one cart for three, four rooms but we put it, we never take it inside the room because when you do it, it's, it can be full of bacteria, inside the bag." (PW nurse) "Essentially what the nurse explained to me is that they actually, once they take the dressing packages from the cart, and they bring in the patient room, they don't put it back on the cart." (FG support staff) "It's mobile. It's everything in one place. You go to the room and you get everything; it's faster." (FG health professionals)*

Photograph: MGMT-47

1.3 Workarounds

This code refers to the "adaptation of procedures by workers to deal with the demands of the work". (Amalberti et al., 2006) These procedures are often adapted to bypass or avoid a problematic feature of the system.

- The equipment is stored in the hallway. During my observations, a nurse was setting up an IV pump in the hallway. Another nurse was plugging the blood pressure machine into the wall in the hallway after taking a patient's vital signs.
- The ventilation system for the isolation rooms is a central system within the hospital and cannot be turned off when there is a patient admitted in the isolation room who is not on isolation, therefore, according to the engineering department, the door should remain closed even if the patient is not on strict isolation otherwise it will affect the climate control of the unit. During the study, there was conflicting information being provided. During the walkabout with the physician, the participant explained that *"they [staff] can look through the window. Only when it is airborne infection they have to close both doors. But with this contact isolation one door closed is enough 'cause you do not need a sluice for this type of isolation." (PW physician)* During the group discussion with the support staff, one of the participant indicated that *"there's one door at the back that's closed, but the door of the hallway is still open...that's one of the points I'm fighting for, with all the nursing people that, they are blaming us that the climate control is not all right. You have to close the doors, you have to, and then the nurse, they're coming up and they write, a refreshment of the whole area. That's how it builds, how it is built and if you use it like this, you never make it… there is the potential of…; there is a high pressure in the room, there is a low-pressure in the 'sluice' in between and there is a higher pressure in the hallway." (FG support staff)*

Photograph: PHYS-12

- During my walkabout with the physician, the participant talked about the issue of hand hygiene compliance with non-single patient rooms: *"the only problem they'll be that they have to wash their hands every, every time they care for a patient and then go to another. That maybe... there's a risk having more patients in a room. If you have one patient in a room then you go out and you wash your hands. If you have four patients in a room, you go to one patient then to the other…" (PW physician)*
- During my walkabout with the ICP, the participant explained the workflow of the staff when they enter a single patient room as follows: *"it should be in fact because you have to wash here; put off your gloves, put on alcohol but there's no alcohol here [chuckles]; go out to the sluice; take off the other things and disinfect your hands again with alcohol. So in fact there should be alcohol at this place…"*
- During my walkabout with the unit manager, the participant explained that *"bottles of water, something to clean the wound, yogurt, dirty gloves and some dirty water and soap and I don't know what this is…food, food, dirty, dirty, dirty, wound… this makes me a bit sad." (PW unit manager) "And also when you wash your patient and it's finished then you move the basins and then you do the wound. Not do two things at once because I see a lot of hand cloths and also wound." (FG health professionals)*

Photograph: MGMT-38

By this photograph, it is evident that nurses need more space to work (workplace design). It can be difficult for nurses to do their work because there is very little space to set up the necessary supplies.

Theme 2. A variety of management practices are seen by participants as having an important impact on infection prevention and control

In order to support the mission, vision, values and key success factors of the organization, management decisions are required to clarify roles and responsibilities and to ensure consistent and safe delivery of care across departments and services. This theme is based on codes from the research data such as: staff resources and management initiatives for infection prevention and control. The definitions and some examples for each code are described below.

2.1 Staff resources

This code refers to the management decisions relating to staff resource allocation.

- The night shift staffing is comprised of 2 registered nurses on the unit. According to a key informant, *"if there are many patients on isolation or patients with a high workload, than an extra assistant is called in to work on the ward, or an extra medical student (MST-s)."* It is common knowledge that "isolated patients need more nursing time, in that they are not so easily visible, they might require constant nursing presence, and the isolation status demands barrier methods of protection for everyone entering the room" (Dancer et al. 2008; Diekema et al. 2007).
- According to a key informant, *"there is vacancy for nurses, but the rate is unknown for the overall hospital (because of the division structure with human resource management). Intensive care nurses and operating room nurses are [the most] difficult to find because of bed closures or cancelled operations."*

2.2 Management initiatives

This code refers to the management decisions relating to initiatives for infection prevention and control.

- During my unit observations, I noticed that the nursing, transport and housekeeping staff wear the same uniform. A key informant mentioned that *"each nurse is provided with a total of six uniforms. They are each identified with a tag with personal information. The hospital takes the responsibility of washing them and placing them back in the nurse's locker. There are designated places around the hospital where nurses can drop off their uniform for cleaning"*. The physician explained that*"…they have to put their dirty suit down, the basement of the hospital there are special delivery rooms where they can put their suit in it and they have a name in it so when it's washed, it would be put back into their own lockers so they can get it back. Every nurse has a special number of suits which is enough to do the whole week of work. And you can change your clothes everyday that's what they're supposed to do." (PW physician)*
- During the photo walkabout, the participant explained that *"except for the strict isolation then they have to use disposable gowns and then they change it every time and for contact isolation, contact box isolation they can use the cotton gowns and they change it every shift so three times a day" (PW ICP).* In follow-up with a key informant, there has not been any issue from an infection control perspective, to reuse cotton gowns during a shift. **"***In contact isolation, reusable gowns [are used] during one shift, [however] they [are]change[d] earlier when dirty. It works well and [it] is cost effective since disposable gowns are very expensive."*

Photograph: IC-11

Theme 3. The development and use of infection control knowledge supports adaptive learning and growth.

This theme illustrates the development and use of knowledge that translates into learnings across individuals, teams, organizations and system levels to drive sustainable changes (Gunderson et al. 2002, Gunderson et al. 1995, Higgs 1997, Higgs 2003, Marck et al., 2006a, Walker et al. 2002). This theme is based on codes from the research data such as: training and education and local feedback. The definitions and some examples for each code are described below.

3.1 Training and education

This code refers to the training or feedback necessary to encourage infection prevention and control amongst the healthcare workers.

- There is a nurse educator which plans the education for the staff. For example, the educator would ask the infection control department to do the education on isolation precaution and hand hygiene. There is also the Hygiene in Practice group (HIP group) which is also involved in the education of nurses. Every surgical ward has a nurse participating in this group (key informant).
- During the group discussion with the support staff, many comments were received on the poster created by the HIP group. Some comments include:
    - *"I will say that it's…it's more clear to show you photograph which is… of good or not good…instead of just written paper." (FG support staff)*
    - *"Clear, practical information and pictures, gives good information, better because of the photographs!" (FG support staff, written comments)*
    - *"It is a good idea to give some idea about hygiene by a picture. Than people have an idea of what is hygiene and good." (FG management, written comments)*

Photograph: NURS-19

3.2 Local feedback

This code refers to the use of local feedback received across individuals and teams.

- During the group discussion with the health professionals, one of the participants explained that *"…the [IV] cart [should have] a cover…and then you can, before you start you can, grab things and lay them on top and you can…you can clean after it's off." (FG health professionals)* Also, one of the written comments was *"the IV cart should be covered to protect against dust." (FG health professionals, written comments)*

Photograph: IC-20

Theme 4. Participants who engage in communal activities tend to strengthen infection prevention and control practices.

This theme refers to the vigilance, attentiveness and awareness of one's practices and each other's practices in order to reinforce and actively use what one learns and knows. (Higgs, 1991, 1997, 1999, 2003, Marck et al., 2006a). This theme is based on codes from the research data such as: community of practice, unit or hospital-wide, individual practices and teamwork. The definitions and some examples for each code are described below.

4.1 Community of Practice

This code refers to initiatives of local experts that work to create, implement and evaluate the sound infection prevention and control practices and support new evidence.

- The Hygiene in Practice (HIP) is a group of eight nurses' representative of every surgical unit. They plan several activities to promote the good use of hygienic precautions. The HIP group meets every month for a day. Additional staff is provided that day to ensure that the appropriate care is administered on the ward. Participating nurses' work on a rotating schedule thus, the same person cannot participate every month because of their schedule.

Some examples of their initiatives include the following:
(1) Storage box for individual wound care products
"*This is a box in use. Personal wound products for the patient and they're stored in here…" (PW management) "So every patient when they need a lot of bandage gets a…green box." (PW management) "I like this very much; material needed for one patient is stored in a closed box. Box can be disinfected. No cart necessary in the room." (FG management, written comments)* According to a key informant, the bottles are usually left inside the box and this works fine.

Photograph: MGMT-41

(2) Poster indicating what cleaning product to use
In the dirty utility room, there are two signs: one with photographs of items that should be disinfected with 80% ethanol (stethoscopes, commodes, basins and blood pressure cuffs); the other with photographs of items to clean with soap and water (patient side table, oxygen mount, IV pole, and IV pumps). (Observations)
"Everything is to make everything so clean as possible. Hygiene is very important. And easy, easy as possible for the users. You know what I mean?" (PW management) *"Look with the posters over here, disinfects with alcohol, washing well the stethoscope, everything which comes in contact with the patient, direct contact... so also the remote control, TV, remote control for the bed. It's disinfected with alcohol 'cause it's in contact with patient." (PW management)*

Photograph: MGMT-29

4.2 Unit or hospital-wide practices
This code illustrates the unit or hospital practices that are formalized in policies. These practices may or may not reduce the risk of infection.

- During my observations, urinals and bed pans used by patients were found to be cleaned and disinfected, using the two cleaning machines available in the dirty utility room. (Observations)

Photograph: IC-40

- *"But the system with soiled equipment…yeah well everything was on it [the counter in the dirty utility room] is soiled and when it's clean it's in the cupboards. Wheelchairs, stretchers, yeah they all clean it here or in the patient room. And they clean it with the disinfecting liquid so alcohol or chloride solution… The nurses have to clean all the equipment…that's used with the patient. Housekeeping staff is only cleaning chairs and tables." (PW infection control professional)*

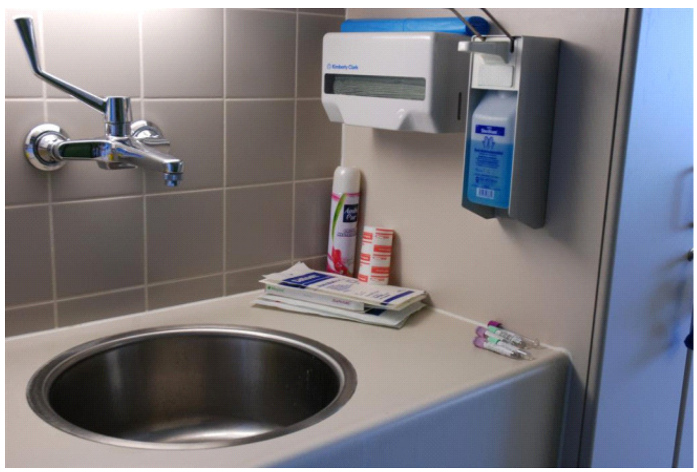
Photograph: IC-43

- During the photo walkabout with a physician, the participant pointed out the following: *"a bed that's going off the unit to be cleaned... It's going to be washed... in this building; it's like a car wash." (PW physician)* Another written comment received by a health professional about the central bed cleaning department was: what a *"good system. Beds are cleaned well at the central bed cleaning department."*

4.3 Individual practices

This code refers to the current individual practices that promote sound evidenced-informed infection prevention and control practices.

- During my unit observations, I noticed that a nurse entered the medication room and used the alcohol sanitizer located near the sink before taking the medication from the patient's medication bin. (Observations)
- During the walkabout with the nurse, the participant said *"I always clean the table with the patient so it's clean to put your material on it, on the side of the desk." (PW nurse)*
- One of the written comments received relating to the photograph MGMT-35 is that *"bandages can become wet because of the tap or alcohol dispenser and therefore are no longer sterile. Also, the unpacked blood collection materials are not very hygienic. (FG health professionals, written comments)*



Photograph: MGMT-35

4.4 Teamwork

This code refers to individuals collaboratively working together towards a common goal.

- During the group discussion, one of the participants said: *"I think it's a good example [the checklist of what needs to be cleaned] how to work as a team." (FG health professionals)* This checklist was developed by the Hygiene in Practice Group (HIP group). According to a key informant, **"***the monitoring is definitely a weak point as it is not performed [consistently]."*

Photograph: NURS-20

Theme 5. Participants view organizational and team cultures as integral to the way they enact infection prevention and control practices

This theme refers to the notion that a culture of patient safety "arises from attitudes, activities and enduring ethical values that are conducive to the safe delivery of patient care. More specifically, it refers to the commitment of healthcare practitioners and their institutions and organizations to minimize patient harm, promote the well-being of patients and healthcare providers, reduce the likelihood of adverse events, and communicate safety concerns while at the same time learning from close calls and other events." (CPSI Safety Competency Framework, 2008) This theme is based on codes from the research data such as: shared practices, shared values, team building activities and communication. The definitions and some examples for each code are described below.

5.1 Shared practices

This code refers to the individuals sharing the same practices or routines within the group.

- During the walkabout with the physician and ICP, the participant explained that *"this is the woman's change room here. They put on, they take off their own clothes and put on their hospital suit before they start working." (PW physician and ICP)*

Photograph: PHYS-22

According to a key informant, *"only a few staff members (<5%) wear their uniform outside the hospital. It's a rare occurrence. Most nurses change uniforms in the hospital. We try to draw attention by education, by cultur[ing] hands and rings, etc."* Most physicians and nurses do not wear their stethoscope around their neck but some still do.

5.2 Shared values

Values are an important concept in the workplace. This code refers to the individuals sharing similar beliefs within the group.

- During my observations on the unit, I noticed that there is a table in the four-patient bed room which allows patients to sit together. (Observations) According to a key informant, there has not been cross-contamination of patients interacting together. This type of activity promotes well-being and provides a sense of community amongst patients and families.

Photograph: IC-24

5.3 Team building activities

This code refers to the relationship building behaviors amongst staff. Team building activities promote staff well-being.

- The nurses have their meals and coffee breaks in the staff lounge located on the unit when everyone is ready. During my observations on the unit, I observed that eight nurses are in the staff room taking their break together. (Observations) During the walkabout with the physician, he explained that *"this is where the nurses…drink their coffee, lounge." (PW physician)*

5.4 Communication

This code refers to the importance of effective communication to obtain optimal patient outcomes. (CPSI Safety Competency Framework, 2008) More specifically, it relates to communicating safety concerns while at the same time learning from close calls and other events.

- During my observations, the list of patient names, color coded by medical specialty, with the respective nursing assignment was found posted on the wall in front of the nursing station. (Observations) Physicians and other health professionals can clearly verify the nursing assignment when they arrive on the unit.
- Another clear communication is the isolation card that is found posted underneath the room number. The card reads "barrière-box" isolation with gloves and gowns symbols. (Observations) During the walkabout with the housekeeping staff, the participant said that *"with the isolation room you have this card so everybody knows who enters the room that this is happening and what you have to wear." (PW housekeeping staff)*

An example of poor communication was discussed by a participant during the management group discussion.

- The participant said that *"there's not enough information to her staff about the control, infection control measures during a transport. They wear gowns and gloves when they're in the room and they don't tell her staff what to do during transport, so they're not informed." (FG Management) "It's too complex; there are too much different kinds of situations, so we always go to the nurse. To the nursing people in the hospital which things we have to do. And they told us, we have to wear gloves, you have to put a mask on, or whatever…" (FG support staff)*

APPENDIX N: Examples of Local Experts' Responses to the Preliminary Themes (Case Study #1)

The following is an overview of the themes that were prevalent in the data analysis of the case study. Each theme encompasses two or more codes; each code refers to clusters of data that reflect various aspects of the theme. Could you review the themes and examples and then respond to the following questions?

Overall, do these themes make sense to you or not? Please comment on any/all of the themes as you wish.

Yes. Some interview material is not good English. Is it possible to summarize what was said instead?

Do the codes and examples under each theme fit with the theme as explained?

Environmental design Do you have a better picture of the wound dressing cart? The photo shows two carts (in front the cleaning cart, in back there is the wound-cart).

Can you think of other examples for any of the themes that would be as relevant – or even more relevant?

Management practices Training/education - The HIP group is an initiative of the surgical units and the ICP. The ICP visits the meetings of the HIP group every month and together they make plans on activities and education. It has great value because of the cooperation! Participation / local activities - Local initiatives are stimulated by the working group. They learn to look at their working procedures through the eyes of an ICP. Once they've experienced that, they can change all kinds of procedures in the same way.

In your mind, is there anything critical that is missing from this interpretation of the qualitative findings?

No

In your mind, is there anything critical that is missing from this synopsis?

Screening: there's also a monthly screening on the prevalence of VRE/ARE, resistant gram negative-strains on all ICU and MCU-wards. Screening at admission is only performed for MRSA (and mrgns) when originating from foreign countries, and for MRSA (when working/living on a veterinary setting (pigs/cattle).

Weekly during the meeting of zhip we analyse the number of micro-organisms (isolates) per ward, in relation to the P75 that we have calculated on earlier data. If there's an increase we'll start further investigation to the source/spread.

Does this synopsis represent an accurate and complete description of the European, national, hospital and unit context at that point in time?

The role of the working group HIP is not mentioned in this part of your article; in the other paper (study results-part 1) you describe their presence and their role. Personally I think this working group has a great influence and attribution to the hygiene and work-procedures on the surgical wards. We've started also groups at the cardiac surgery and internal medicine wards, because of this success.

Is there any other feedback or additional recommendations that you can provide?

N/A

APPENDIX O: Example of the Cross-Case Analysis

Theme: Nurses and other staff employed a wide variety of workarounds to try to adapt to the design of their care environment.

Case Study #1	Case Study #2	Findings		
		Similar	Different	Non-Comparable
Flow of clean versus dirty equipment in the hallway A nurse explained that the equipment in this hallway is clean and the equipment in the other hallway is dirty. Staff are aware of this process and when they need a patient table, for example, they know which side of the hallway to obtain a clean table *(PW nurse, P9, 201).*  *Clean equipment in this hallway (NURS-12)* A checklist was developed at the Netherlands hospital to clearly identify who, when, and how each piece of equipment should be cleaned. This checklist is posted in the dirty utility room of the unit.  *Cleaning checklist (NURS-20)*	**Equipment in hallway (clean versus dirty)** Challenge with knowing if the equipment in the hallway is clean or dirty. A participant explained that there is *"no label to say whether [the equipment is] clean or dirty. And usually you get a bad surprise when you pull up the seat and you see, I guess [this commode] has not been cleaned. It's just the general principles of the clean should be put away somewhere as opposed to just out there [in the hallway]" (FG management, P9, 443).* Housekeeping staff are to put a "clean" label on the equipment and nursing is then to remove it upon use. This process has not been audited to see how well this is followed (key informant). A participant explained that *"it's excellent; the only thing is that it's only as good as, as long as the nurse takes off the sign once it's been used, right. Because housekeeping's not going to go re-clean that until that sign's off. But someone has to, there's a human element; someone has to actually remove the sign to say I've used it. Ideally this should be stored in a clean hold somewhere, because obviously anyone coming by can touch it with soiled hands so that's the only thing" (FG management, P9, 495).*  *Lift in hallway with clean sign (C-MG-52)*		X	

Case Study #1	**Case Study #2**	**Findings**		
		Similar	**Different**	**Non-Comparable**
	The patient lift in the photograph above has a sign indicating that housekeeping has cleaned it. Although the labeling is a clear mechanism in place, it is important that staff always remove the sign once they have used it to ensure that it is not re-used on another patient until it is re-cleaned again.			
Equipment stored in hallway Observations: a nurse setting up an IV pump in the hallway and another nurse plugging in the blood pressure machine into the wall plug located in the hallway after taking a patient's vital signs *(Observations, P2, 22).*  *Equipment in hallway (MGMT-37)*	**Storage of a mix of clean and dirty equipment in the hallway** The equipment includes walkers, wheelchairs, chairs, scales, lifts, blood pressure machines, oxygen tanks, bags of dirty linen, carts with pillows and gowns, isolation carts and linen carts in the hallway *(Observations, P1, 21).* During the walkabout with the physician, the participant explained that *"as I walk down this corridor, one of the first things that strikes [me] is there's an awful lot of stuff stored in the corridor as opposed to in a discreet area. Some of that stuff is bed linen [that] is going to be used for patients and it's sitting here out in the breeze and I don't know if that's significant or not..." (PW physician, P7, 15).* A participant pointed out the following: *"see all this clutter here? This is because of the lack of storage space that they have to put these carts and poles and pumps in the hallway. On a positive side at least it's all on one side" (PW housekeeping manager, P5, 36).*  *Equipment stored in hallway (C- NS-04)*	X		

APPENDIX P: Sample of Scheduled Dates for Review of Data with Supervisor, Committee Members and other PhD students to Ensure Reliability and Validity of the Data

Case Study #1: Netherlands hospital

Date	Data reviewed by whom	Details
September 8, 2008	Supervisor	Elluminate session to review preliminary data analysis
October 15, 2008	Supervisor and case study expert (NK)	Teleconference call re: preliminary data analysis **Feedback received was:** Prior to conducting the 2nd case: • Identify the challenges from the first case • List prompt questions that need to be checked at other case study • Identify the practices that stand out at case study #2 and check back with case study #1 • Where there any surprises that resonate? In terms of my case study methods paper: • What are the most interesting contrasts? • Look at cluster of data
October 15, 2008	Committee	Teleconference call re: preliminary data analysis **Action:** Data analysis progressing well, received the go ahead to conduct the 2nd case study
December 2008	PhD 5 group	Presentation of preliminary analysis to other PhD students **Action:** shared lessons learned and work to date
	Supervisor and hospital expert (MB)	Teleconference to check with original participants to validate analysis to date

		Action: follow-up on any clarifications needed
June 12 2009	Supervisor	Teleconference call to review of the data and obtain feedback
April 26 2009	Supervisor	Visit to Ottawa – meeting to review the data (independent review)
	Supervisor	Teleconference call – review of the data and obtain feedback
June 19, 2009	PhD 5 group	Elluminate session with other PhD students to present status of my work to date
June 26, 2009	Supervisor and one committee member (GT)	Teleconference call to present comparative case study data
	Supervisor and other committee member (AS)	Teleconference call to present comparative case study data
June 26, 2009	Hospital experts	Follow-up questions to hospital experts **Action:** revisions made based on comments received

APPENDIX Q: Examples of Researcher's Journal Entries

The researcher's journal contains examples of my on-going decision-making processes. A few examples are listed below.

(1) April 9, 2008 – Preparation for Unit Observations
Email to Supervisor
As per my research protocol, I plan to observe and document the work and work environment of the staff and housekeeping on the unit in regards to the infection prevention and control practices.

Here are some of the things I anticipate to observe and document:
- observe a sample of nurses and other health professional re: handwashing with soap or using an alcohol sanitizer (provide specific details re: location, practice, etc)
- equipment sharing
- storage area for supplies and equipment
- soiled equipment and laundry
- physician visits or rounds (if possible)
- follow a couple of nurses on the shift to understand the workflow process of the unit
- cleaning of rooms: routine cleaning and at discharge (if possible)
- isolation rooms (if applicable)
- etc…

Response from Supervisor
You are on track - it is just more a state of mind than the specifics. That is, think "systems", "whole systems", the inter-relatedness of things with IC, also looking at the unit culture, communication (e.g. interruptions - both the nature and number of them), etc - in other words, think socio-ecologically about the work environment and work flow as much as you look at specific procedures, and worry later when you analyze the data about what it all may mean or how it may hang together.

And don't be so focused on looking for certain things that you do not notice the whole. And don't alert everyone that you are watching specific things or they will start to perform for you rather than just go about their daily work. Rather, just tell them that you are trying to take in as much as you can to learn about their work and work environment.

Good luck and have some fun. Try to take it in overall as well as specifics. Take regular breaks to think about what you are seeing and make field notes and write in your journal when you need to. It is hard work - you will feel tired after a few hours of it at a time - don't go for too many hours at a time but rather aim to cover different times of day, etc.

Action
-Take a broad thinking (whole system) mindset to infection prevention and control, focus on the whole
-Take notes of all observations
-Select different times of day to conduct the observations

(2) April 15, 2008 – Logistical issue in regards to the focus groups
Email to Supervisor
I am facing some challenges in scheduling the focus groups. Here is what I was able to confirm for April 28 and 29:

Support staff: April 28 - (4-6 people)

- Member of housekeeping staff
- Member of transport staff
- Member of engineering staff
- Member of nutrition staff

I was asked if it would be possible to combine both the management and health professionals' sessions together because of time, availability, etc - would it be okay to do so. We had split the groups in three because of the potential power issues between the support staff and health professionals, etc… To avoid this, I am conducting a separate session for the support staff. However, do you see any concerns with combining the health professionals and management group together? The second option I have would be to conduct two 45-minute sessions back-to-back (instead of a 90 min session) - but I am concerned that it might be too short of a time to go in much depth. Please advise. Below is how the combined group would look like:

Management/Health Professionals: April 29 (12 people)

- senior nurse
- physician
- medical resident
- physiotherapist
- nurse educator (TBC)
- team leader
- unit manager
- infection control manager
- engineering manager
- housekeeping manager
- transport manager (TBC)
- nutrition manager (TBC)

Feedback from Supervisor
My preference would be that you split them into two 45 minute groups as follows:

Group 1 - senior nurse, physician, medical resident, physiotherapy, clinical nurse educator, team leader
Group 2 - all the managers

For several reasons:

- you will get likely get better discussion in smaller groups - 12 is a really large focus group
- you will be adhering to your ethics application and proposal re: power relations and getting at that local knowledge
- 45 min may not be ideal but you will get more than you think and hopefully more chance of getting all voices heard

Follow-up
It seems that 45 minutes provided enough time to review all the photographs and receive responses from all the participants.

APPENDIX R: Permission to Include a Version of my Published Article

Chantal Backman

From: AJIC [ajic@columbia.edu]
Sent: October-25-10 1:35 PM
To: Chantal Backman
Subject: Re: Permission to include version of my published article in my unpublished PhD dissertation

Yes. You may include the below-mentioned article in your dissertation.

Chantal Backman wrote:
Dear Dr. Larson,

Would it be possible to obtain written permission to include the following article in my dissertation:

AJIC-D-10-00188 - An Integrative Review of Infection Prevention and Control Programs for Multidrug-Resistant Organisms in Acute Care Hospitals: A Socio-Ecological Perspective

The paper will be referenced as having been accepted for publication in the American Journal of Infection Control.

Warm regards,
Chantal