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

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ABSTRACT

Background
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 (MDRO).

Method
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 conducted on a surgical unit at a Netherlands hospital with very low rates of MDRO and a surgical unit in a Canadian hospital with higher rates of these pathogens. Research methods included a total of six unit observations, nine practitioner-led photo walkabouts of the units (n=13), six focus groups (n=26), and the review of relevant policies and procedures.

Results
When looking at the whole system for infection prevention and control in the context of particular environmental design constraints, and where hospital staff have reinforced norms of vigilance to prevent cross contamination, there were multiple conditions or activities at the Netherlands hospital that differed from the Canadian hospital which may have had an impact on the lower MDRO prevalence rates. These conditions or activities included differences in ratios of hospital beds per capita, bed occupancy rates, equipment cleaning processes in place, bed cleaning systems (centralized versus manual) and the presence of an active grassroots Hygiene in Practice group engaging practitioners in several ongoing activities to promote infection prevention and control.

Conclusion
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 in order to guide health system leaders who need to decide where to allocate finite resources.

INTRODUCTION

Many studies and guidelines have been published in the last 10 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). Although published studies have shown successful reductions or elimination of MDRO, several factors limited 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 (1). Additionally, the studies in questions were largely descriptive or quasi-experimental in nature (2) and had 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 (3-5) and infection control literature (6,7) is beneficial to build theory which more accurately reflects the real world and can possibly, at 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 (8-10) 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 (10-13).

The core elements of the socio-ecological framework that guided this study, adapted from Stokols (14), Waldvogel (15), Struelens (16) and Marck et al. (17) 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 (10,12). The second element, place ethic, refers to the need to understand and respect the history, culture, knowledge and rituals of communities (9,18), 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 (9,10) 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 (8-10,19,20).

The purpose of this research was to conduct a comparative case study analysis of two hospital units. The two case studies were conducted 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% (21). The second case study was conducted on a surgical unit at a Canadian hospital, which reported higher rates of these pathogens (22).

TABLE 1: Summary of Statistical Information

Elements	The Netherlands Hospital	Canadian Hospital
Country Level Organization for Economic Co-operation and Development (OECD)		
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		
Population	294,742	898,150
Total acute care beds (adult)	2,400	1,598
Hospital Level		
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%)

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% (23) 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 (24). 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 were 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 were much greater in the Netherlands. Furthermore, the city in the Netherlands was much closer to agricultural production, while the Canadian city was very urban. In addition, the volume of admissions, emergency department visits, and outpatient visits differed greatly. There were 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 in the Netherlands hospital as in the Canadian hospital. A summary of statistical information on the two case study contexts is available in **Table 1**.

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 by each hospital's Research Ethics Board. The data collection methods conducted by the lead author (CB) included six field observations of the clinical units, the collection of IP&C policies and procedures, nine practitioner-led photo walkabouts (n=13), six focus groups (n=26) to review and obtain further discussion about the narratives and photographs collected during the walkabouts, and the collection of MDRO rates.

Data Analysis

Following successive iterative analyses of the individual case studies, a cross-case synthesis technique [25,26] was used to compare and contrast perspectives and analyze themes found in the two case studies.

FIGURE 1A: The Netherlands hospital – 4-bed patient room (IC-24)

FIGURE 1B: Canadian hospital – 4-bed patient room (C-MG-60)

Results

The two case studies had the following similar themes:

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

Some key findings for each of these themes are compared below.

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

At the Netherlands hospital, the 34-bed unit consisted of six single-bed patient rooms, 10 two-bed patient rooms, and two 4-bed patient rooms, with shared bathrooms in the two-bed and four-bed rooms. Similarly at the Canadian hospital, the 40-bed unit consisted of eight single-bed patient rooms, 12 two-bed patient rooms, and two four-bed patient rooms, also with shared bathrooms for the 2-bed and 4-bed rooms. Photographs of the four-bed patient rooms on the study unit at the Netherlands hospital (**Figure 1 (a)**) and at the Canadian hospital (**Figure 1 (b)**) are presented below.

Although the configurations of these rooms were quite different, both hospi-

FIGURE 2A: The Netherlands hospital - Equipment in hallway (MGMT-37)

FIGURE 2B: The Netherlands hospital - Linen storage closet (IC-66)

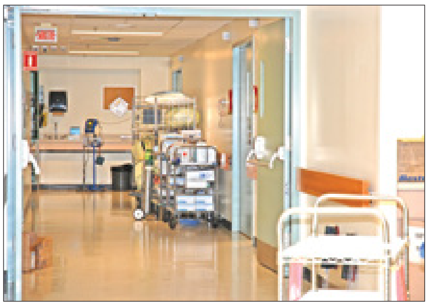


FIGURE 3A: Canadian hospital - Equipment in hallway (C-HK-01)

FIGURE 3B: Canadian hospital - Linen cart in hallway (C-NS-16)

FIGURE 4A: The Netherlands hospital - Dirty utility room (IC-43)

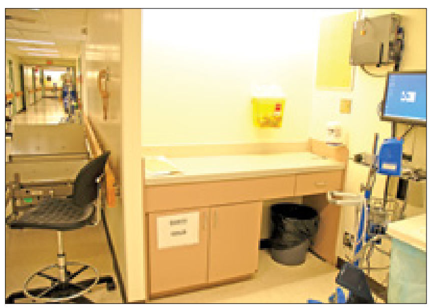


FIGURE 4B: Canadian hospital - Dirty hold (C-NS-08)

tals had four-bed patient rooms. In the Netherlands, the four-bed rooms were located in the corners of the unit, with the beds forming a L shape; in Canada, the four beds were facing 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 (27,28).

Lack of storage space on the units was another environmental challenge for both case study sites. Both hospitals stored equipment in the hallway. At the Netherlands hospital, for example, the photograph in **Figure 2 (a)** 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 in the hallway, though, the Netherlands hospital has many storage areas on the unit. For example, **Figure 2 (b)** displays 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.

In the hallway of the Canadian hospital, **Figure 3 (a)** illustrates that there were several carts (e.g., isolation, linen) and blood pressure machine visible. Contrary to the Netherlands hospital, there were 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 3 (b)**).

At the Netherlands hospital, there was one dirty utility room on the unit (**Figure 4 (a)**). By contrast, at the Canadian hospital, there were no dirty utility rooms on the unit. There was only a very small dirty hold outside of the patient rooms (**Figure 4 (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).

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 was 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 contained many patient belongings. The nurse had set up two basins to bathe the patient (**Figure 5 (a)**).

Similarly, at the Canadian hospital, patient belongings and extra supplies were found on the windowsill and bedside table (**Figure 5 (b)**) thus making it challenging for nurses to set up their supplies in the room. 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.

“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.”

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. An example was 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 (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 (b)**). This checklist was posted in the dirty utility room of the unit.

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. 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 was responsible for cleaning equipment. However, the patient lift below had a sign indicating that housekeeping had cleaned it (**Figure** 7). 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

"The environmental design of both hospitals creates many challenges to IP&C practices and lead staff to develop and adopt a variety of workarounds."

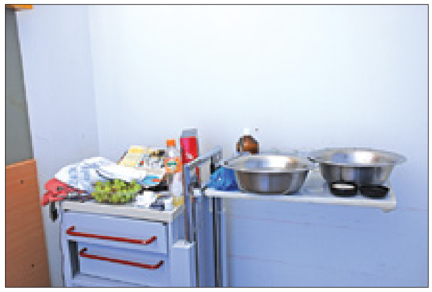


FIGURE 5A: The Netherlands hospital - Patient's bedside table (MGMT-38)

FIGURE 5B: Canadian hospital - Patient table (C-MG-34)

FIGURE 6A: ***(above)*** The Netherlands hospital - Clean equipment in this hallway (NURS-12)

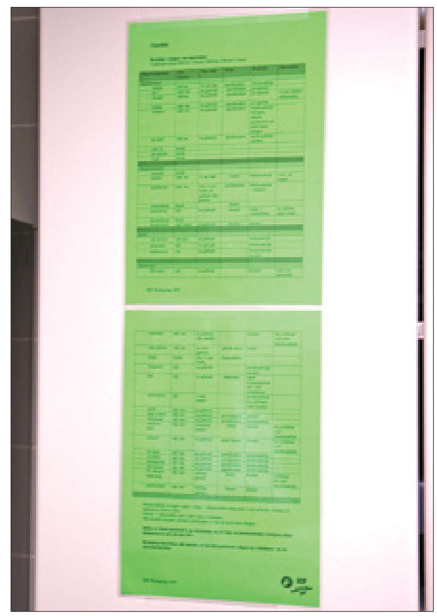
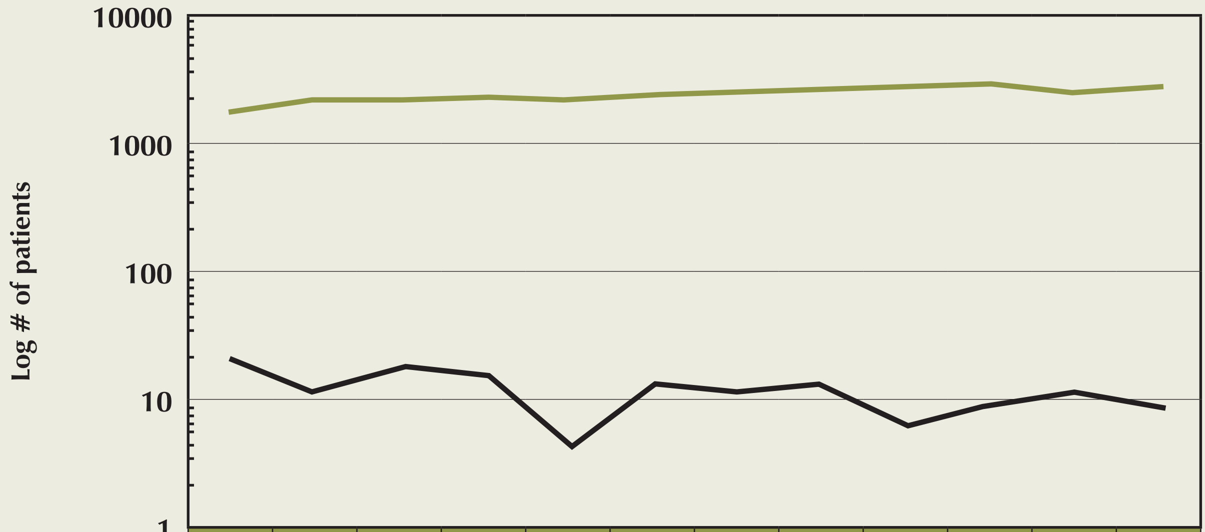


FIGURE 6B: ***(right)*** The Netherlands hospital - Cleaning checklist (NURS-20)

FIGURE 7: ***(below)*** Canadian hospital - Lift in hallway with clean sign (C-MG-52)

FIGURE 8: Cross-Case Comparison of the number of admitted patients screened for MRSA



	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

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 (29). At the Netherlands hospital, a clear communication strategy was the isolation card found posted underneath the room number. The card read "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 discharged, 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).

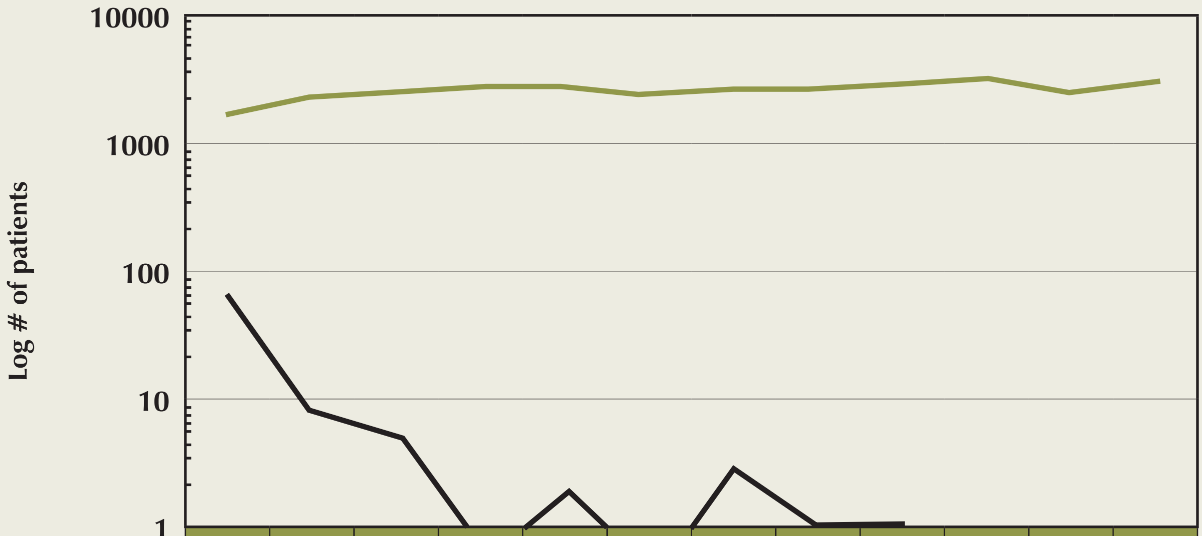
Similarly problematic communication was presented at the Canadian hospital by a participant who explained: "There's a specific code for an isolation patient in the patient tracking system that rarely gets used. I mean if it is used, when the porter picks up the call it says, patient on isolation so he 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 (29).

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

As a critical component of organizational

FIGURE 9: Cross-Case Comparison of the number of admitted patients screened for VRE



	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

governance, engaged leadership was identified in both study sites as important for supporting consistent IP&C practices within an organization. An example which requires engaged leadership and governance both within and external to individual healthcare organizations, was the management of the bed occupancy issues. Overcapacity can be a significant barrier to IP&C in hospitals. The city in the Netherlands had 8.0 acute care beds per 1,000 population; whereas the number of acute care beds was much lower (1.77 beds per 1,000 population) in the Canadian city.

The average bed occupancy rate reported, at the Netherlands hospital, was estimated at approximately 80% whereas at the Canadian hospital, the average rate was 98.5%. Although, these rates differed slightly in their calculations (e.g., the Netherlands hospital did not factor in bed closures); 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 had developed policies and procedures at the Canadian hospital. For example, bed management meetings were held daily. In attendance were the patient flow managers 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 was 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 was published and shared with the department heads. The antimicrobial Defined Daily Dose (DDD) was 62.2 per 100 patient-days. Comprehensive antimicrobial data was collected including the defined daily dose (DDD) but antimicrobial was not prospectively controlled. The Canadian hospital, on the other hand, did not collect DDD data but carried out retrospective reviews of appropriate use of selected drugs (e.g., vancomycin, meropenem, fluconazole). The designated antimicrobial pharmacy specialist reviewed these target antibiotics on a periodic basis and made a determination about the appropriateness of use. The information was presented to the Antimicrobial Subcommittee of the hospital and antibiotic house staff education sessions were provided as needed.

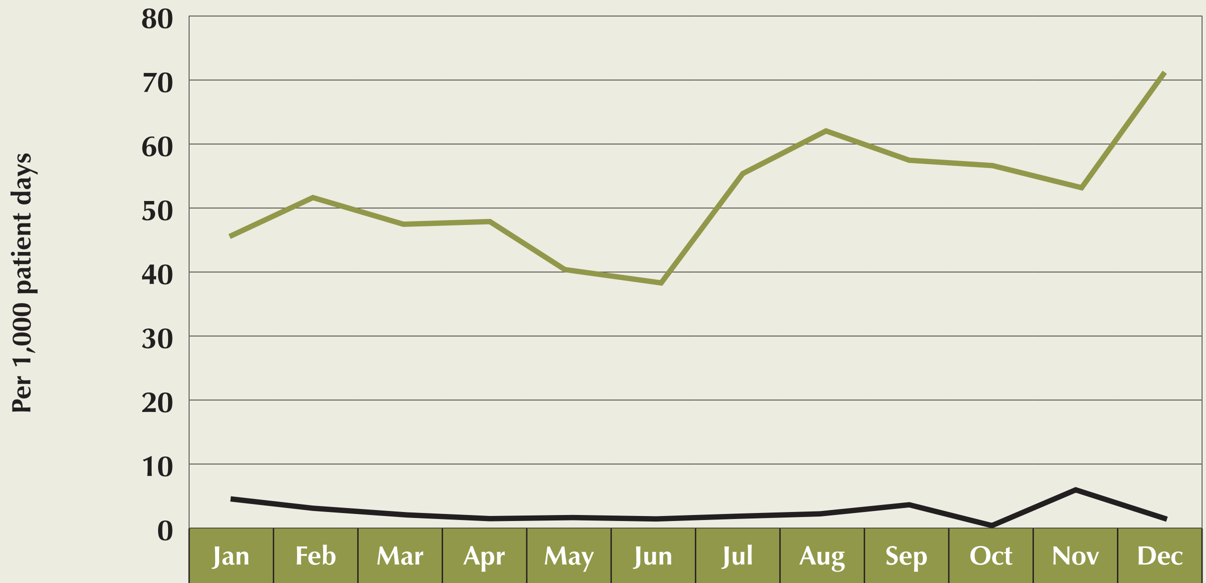
It is also evident that management in both study sites supported a variety of environmental cleaning processes, but with some possibly important differences. At the Netherlands hospital, a centralized hospital-wide bed cleaning system was in place. A physician participant pointed out: "a bed that's going 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 provided consistent cleaning procedure with high temperatures (Dutch Working Party on Infection Prevention, 2007). However, at the Canadian hospital, beds were manually cleaned on the unit by the housekeeping staff when a patient was discharged.

Over 10 years ago, the search-and-destroy strategy for MRSA was implemented at the Netherlands hospital. The strategy consisted of the screening of high-risk patients which included mainly patients admitted from foreign hospitals and individuals who had come into close contact

FIGURE 10: Cross-Case Comparison of MRSA Prevalence Rates



	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

with live pigs or calves. Screening cultures were taken when MRSA was suspected or to rule out MRSA contamination. 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 is presented in **Figure 8** and **Figure 9**.

The prevalence rates for MRSA, VRE, CDI and extended spectrum beta-lactamases (ESBL) were compared in **Figures 10** to **13**. During the study, only high-risk patients at the Netherlands hospital were screened whereas at the Canadian hospital, all patients were screened on admission.

Furthermore, despite the overall common themes between the two individual case studies presented above, the following themes differed between the two cases:

1. Participants who engaged in communal practice activities tended to monitor and support the use of recommended IP&C practices (Case Study 1 only) (21).
2. The use of knowledge about IP&C supported adaptive learning and growth (Case Study 1 only [21]).
3. Common practices posed barriers to sound IP&C (Case Study 2 only) (22).

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 provided a forum for engaged practice where groups of professionals worked 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 grassroots HIP group built on the current staff knowledge and experience and was geared to address gaps in practice. This kind of coordinated educational initiative provided a strong example of adaptive learning and growth. At the Canadian hospital, there was not a consistent or standardized approach to IP&C education across the organization. IP&C education was provided at a program level to staff by their respective clinical educators. While there was no question that useful learning may be occurring with these non-standardized approaches, it was not possible to accurately assess what standardized learning was 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.

Overall, it was difficult to confidently speculate why the themes discussed above were only present in one case study and not the other. Potential

FIGURE 11: Cross-Case Comparison of VRE Prevalence Rates

	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

explanations may include the differences between the two sites in grassroots involvement in IP&C, in approaches to IP&C education, and in the methods in place to ensure sound IP&C practices.

Discussion

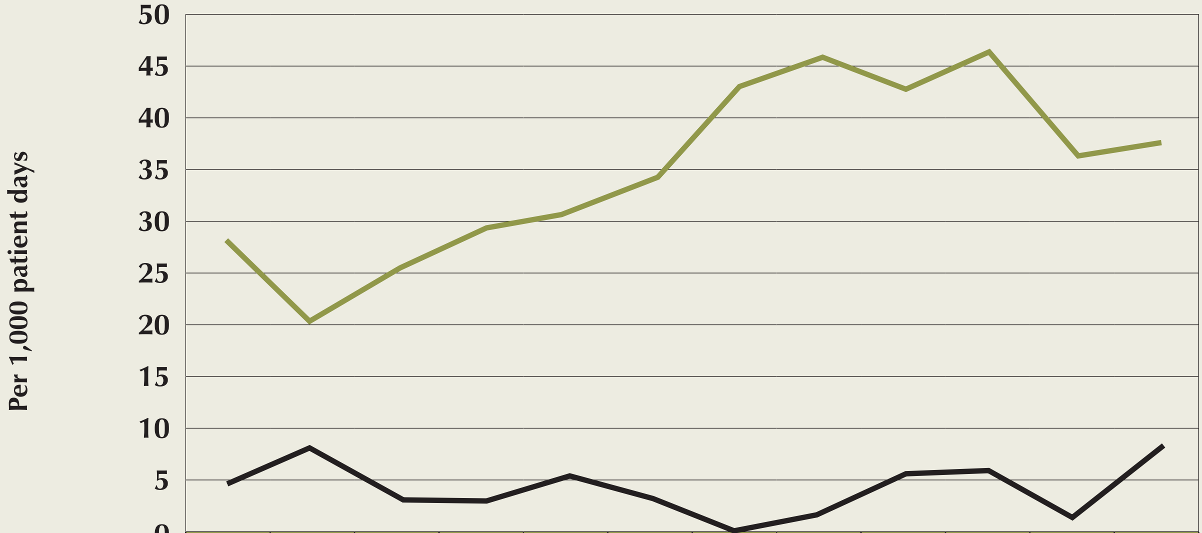
The key findings provided a starting point to better understanding the system for IP&C through the practitioners' experiences in these two organizations and demonstrated that there were several similar and different practices in place for IP&C in both hospitals, as well as a lack of comparable data between the two cases.

Common findings across both cases included 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 (30-32). Other experts (33-35) and organizations such as the Institute for Healthcare Improvement have also examined board engagement related to quality. 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 (33,36,37). 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" (36) (p. 8). Both hospitals had 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. (32) suggest, 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) was critical in reducing the emergence of antimicrobial-resistant organisms. Although the Netherlands hospital produced an antibiotic usage report on a yearly basis, and the Canadian hospital carried out retrospective reviews of the appropriate use of selected antibiotics, neither hospital had 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 (38).

Another common finding across both cases was the environmental design issues which often lead healthcare providers to use workarounds. According to Amalberti and colleagues (39), 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). Overall, the design of the unit can also have a strong influence on the risk of MDRO contamination. Joseph (27) and Ulrich (28) recommended single patient-bed rooms each with private washrooms as well as appropriate storage on the unit for all new construction. In addition, adequate access to ABHR or soap and water at point of care is necessary in order to reduce cross contamination in multiple patient rooms. According to the World Health Organization (40), the ABHR dispensers should be located at point of care. In addition, Creedon (41), Suresh et al. (42) and Harbarth et al.(43) supported the notion that ABHR

FIGURE 12: Cross-Case Comparison of CDI Prevalence Rates



	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	25.32	29.02	31.32	34.21	43.62	46.05	43.46	46.36	36.33	37.83

dispensers should be located in many convenient locations around the unit.

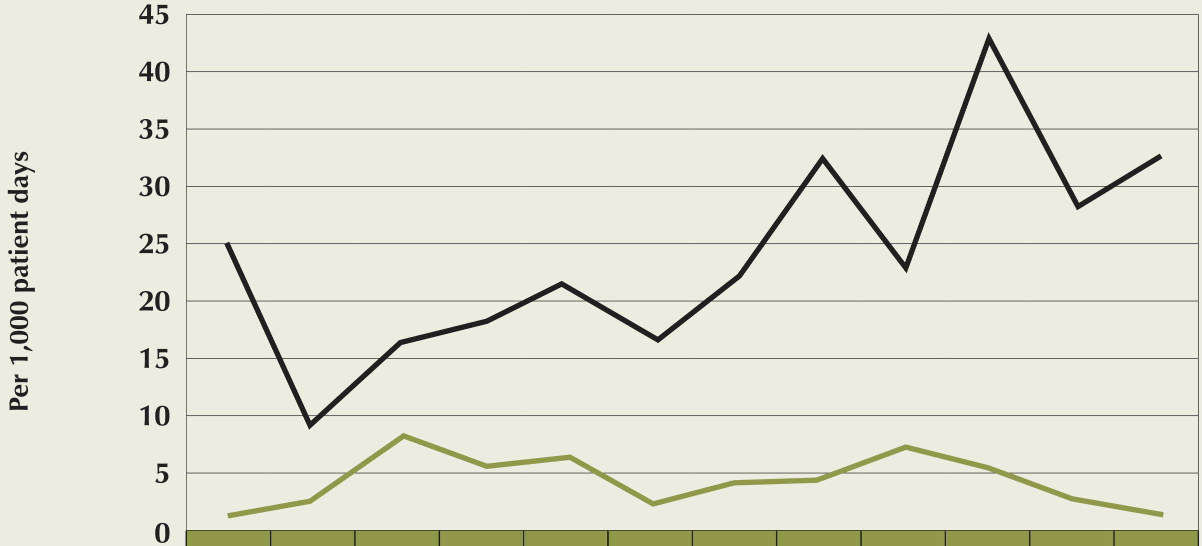
When looking at the whole system for IP&C in the context of particular environmental design constraints, and where hospital staff have reinforced norms of vigilance to prevent cross contamination, there were multiple conditions or activities at the Netherlands hospital that differed from the Canadian hospital which may have had an impact on the lower MDRO prevalence rates. These conditions or activities included differences in ratios of hospital beds per capita, bed occupancy rates, equipment cleaning processes in place, bed cleaning systems (centralized versus manual) and the presence of an active grassroots 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 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 (44-47). Studies have shown that occupancy rates higher than 90% have higher MRSA infection rates than those with rates below 85% [48,49]. 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 was reached, patients were admitted in the hallways or common areas and were 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" (50) (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 healthcare, and home care services and inadequate access to appropriate assisted living and long term care facilities.

The findings also suggested that we need a better understanding of which kinds of environmental cleaning are most important for IP&C and in what contexts. Current evidence indicates that equipment should be cleaned and disinfected between each patient to avoid cross-contamination (51). Enhanced environmental cleaning has shown to decrease environmental contamination of MDRO (52) and decrease the likelihood of patients acquiring HAI (53-56). 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 grassroots community of practice that oversaw, implemented and promoted 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, unpublished report, 2009). While we are well aware of the benefits of the support from IP&C experts, it is worth exploring which kinds of

FIGURE 13: Cross-Case Comparison of ESBL Prevalence Rates



	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

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 revealed 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. Hand hygiene adherence rates between the two hospitals were not comparable. The method used to monitor adherence to hand hygiene practices at the Netherlands hospital was measuring the unit-based consumption of alcohol-based hand rub (ABHR). In contrast, the Canadian hospital used direct observations. According to the World Health Organization, direct observation is the recommended method to monitor hand hygiene compliance. Monitoring product consumption does not determine if proper hand hygiene was 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 (40).

Many IP&C guidelines recommend either universal (all patients) or targeted (high risk patients) MRSA and VRE screening on admission (21,57,58). The significant differences in screening strategies for MRSA and VRE between the Netherlands hospital, which conducted high risk screening only, and the Canadian hospital, which conducted 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 were screened (universal screening), whereas in the Netherlands only the high-risk population was screened.

Another challenge was 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 were reported, whereas at the Canadian hospital, incidence rates of these pathogens were 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 differed between these two countries. In the Netherlands, the high risk group was people in contact with pigs, veal calves or other livestock (Dutch Working Party on Infection Prevention, 2007) whereas in Canada, the high risk group included: injection drug users, homeless people, the incarcerated, and native aboriginals (First Nations people) (24).

In the Netherlands case study, the monthly MRSA prevalence rate ranged from 0 and 0.67% which was consistent with the rate of less than 1% (23) 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%.

"There were several limitations to the study. It was possible that staff on the study units may have altered their behavior during unit observations."

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 did not appear to be as controlled. This increase was seen in all European countries, and it had been suggested that colonization of the food-producing animals (especially poultry), facilitated through antibiotic use, lead to the contamination of meat. It is unknown yet, if food contamination was the source of this high prevalence in European hospitals (59).

There were several limitations to the study. It was possible that staff on the study units may have altered their behavior during unit observations. The use of multiple methods of data collection was 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 standardized 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. Comparable data 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 IP&C programs into policy and practice. 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.

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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