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

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Back to normal

Qualitative research review guidelines – RATS

	ASK THIS OF THE MANUSCRIPT	THIS SHOULD BE INCLUDED IN THE MANUSCRIPT
R	**Relevance of study question**	
	Is the research question interesting?	Research question explicitly stated
	Is the research question relevant to clinical practice, public health, or policy?	Research question justified and linked to the existing knowledge base (empirical research, theory, policy)
A	**Appropriateness of qualitative method**	
	Is qualitative methodology the best approach for the study aims? *Interviews:* experience, perceptions, behaviour, practice, process *Focus groups:* group dynamics, convenience, non-sensitive topics *Ethnography:* culture, organizational behaviour, interaction *Textual analysis:* documents, art, representations, conversations	Study design described and justified e.g., why was a particular method (i.e., interviews) chosen?
T	**Transparency of procedures**	
	Sampling	
	Are the participants selected the most appropriate to provide access to type of knowledge sought by the study? Is the sampling strategy appropriate?	Criteria for selecting the study sample justified and explained *theoretical:* based on pre conceived or emergent theory *purposive:* diversity of opinion *volunteer:* feasibility, hard-to-reach groups
	Recruitment	
	Was recruitment conducted using appropriate methods? Is the sampling strategy appropriate?	Details of how recruitment was conducted and by whom
	Could there be selection bias?	Details of who chose not to participate and why
	Data collection	
	Was collection of data systematic and comprehensive?	Method (s) outlined and examples given (e.g., interview questions)
	Are characteristics of the study group and setting clear?	Study group and setting clearly described
	Why and when was data collection stopped, and is this reasonable?	End of data collection justified and described
	Role of researchers	
	Is the researcher (s) appropriate? How might they bias (good and bad) the conduct of the study and results?	Do the researchers occupy dual roles (clinician and researcher)? Are the ethics of this discussed?Do the researcher(s) critically examine their own

	influence on the formulation of the research question, data collection, and interpretation?
Ethics	
Was informed consent sought and granted?	Informed consent process explicitly and clearly detailed ✓
Were participants' anonymity and confidentiality ensured?	Anonymity and confidentiality discussed ✓
Was approval from an appropriate ethics committee received?	Ethics approval cited ✓
S Soundness of interpretive approach	
Analysis	
Is the type of analysis appropriate for the type of study? *thematic:* exploratory, descriptive, hypothesis generating *framework:* e.g., policy *constant comparison/grounded theory:* theory generating, analytical	Analytic approach described in depth and justified ✓
Are the interpretations clearly presented and adequately supported by the evidence?	*Indicators of quality:* Description of how themes were derived from the data (inductive or deductive) ✓
Are quotes used and are these appropriate and effective?	Evidence of alternative explanations being sought ✓ Analysis and presentation of negative or deviant cases ✓ Description of the basis on which quotes were chosen ✓ Semi-quantification when appropriate ✓ Illumination of context and/or meaning, richly detailed
Was trustworthiness/reliability of the data and interpretations checked?	Method of reliability check described and justified ✓ e.g., was an audit trail, triangulation, or member checking employed? Did an independent analyst review data and contest themes? How were disagreements resolved?
Discussion and presentation	
Are findings sufficiently grounded in a theoretical or conceptual framework?	Findings presented with reference to existing theoretical and empirical literature, and how they contribute ✓
Is adequate account taken of previous knowledge and how the findings add?	
Are the limitations thoughtfully considered?	Strengths and limitations explicitly described and discussed ✓
Is the manuscript well written and accessible?	Evidence of following guidelines (format, word count) ✓ Detail of methods or additional quotes contained in appendix ✓ Written for a health sciences audience
Are red flags present? these are common features of ill conceived or poorly executed qualitative studies, are a cause for concern, and must be viewed critically. They might be	*Grounded theory:* not a simple content analysis but a complex, sociological, theory generating approachJargon: descriptions that are trite, pat,

fatal flaws, or they may result from lack of detail or clarity.	or jargon filled should be viewed sceptically *Over interpretation:* interpretation must be grounded in "accounts" and semi-quantified if possible or appropriate *Seems anecdotal, self evident:* may be a superficial analysis, not rooted in conceptual framework or linked to previous knowledge, and lacking depth *Consent process thinly discussed:* may not have met ethics requirements *Doctor-researcher:* consider the ethical implications for patients and the bias in data collection and interpretation

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

ABSTRACT

Objectives:

-To observe the overall work environment including infection prevention and control (IP&C) practices on the target surgical unit;

-To analyze the policies and procedures in the hospital and unit environments;

-To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and

-To collect monthly specific IP&C related anonymized data.

Design:

In this qualitative case study analysis, a socio-ecological approach on health systems informed the research design and provided a framework to better understand the complexity of implementing effective IP&C.

Setting:

The study was conducted on a surgical unit at a Netherlands' hospital that reported successful reductions in the prevalence of targeted multidrug-resistant organisms (MDRO).

Methods:

Research methods included 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.

Results:

The findings indicate some conditions and processes present that may influence the low prevalence 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.

Conclusions:

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.

Further data is available by contacting the primary author directly.

SUMMARY

Article focus:

-To observe the overall work environment including IP&C practices on the target surgical unit;

-To analyze the policies and procedures aimed at the prevention and minimization of MDRO in the hospital and unit environments;

-To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and

-To collect monthly specific IP&C related anonymized data.

Key messages:

The findings indicate some conditions and processes present that may influence the low prevalence 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.

Strengths and limitations:

-Multiple methods of data collection and a broad socio-ecological system approach to study IP&C on the unit strengthen this research.

-It is possible that staff may have altered their behavior from normal practices during unit observations.

-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.

-The focus of this study was on a specific clinical unit of the hospital.

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.[1-3] 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,[4] 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".[5, p.236] Some European countries such as the Netherlands have been recognized as world leaders at minimizing MDRO infection rates, in particular MRSA.[6] Yet, strong evidence on the most effective approaches for 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.[7] 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 prevalence of targeted MDRO and another case study between September and December 2008 on a surgical unit at a Canadian hospital which reported higher rates of targeted MDRO. In this paper, we discuss the key findings of the

Netherlands hospital case study and offer recommendations for policy, practice and future research.

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 prevalence rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI).

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.[7-12] One promising theoretical line of inquiry is supported by Struelens'[8] 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,[9] Gloubeman,[10] Macdonald,[11] and Waldvogel,[12] 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",[13, p.45] enabling us to more accurately interpret and manage whole systems change.[14,15] In socio-ecological terms, the term whole systems may be conceptualized as nested cycles of system development, degradation, or restoration.[14,16-18]

A whole systems' perspective on IP&C is compatible with the participatory methods of citizen science that engage communities in collectively studying and assessing the socio-ecological conditions of their environments in order to collaboratively design and implement useful, sustainable repairs.[14,18,19] 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.[16,19-21] This research approach draws on related work in the fields of ecosystems management and research,[22] economics,[23] restoration management,[24-27] and health systems.[18,19] 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.[14,18,21,28]

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,[8,12,15,18] and used to inform the research design and conduct of the study (Appendix 1). The framework informed but did not constrain the collection and analysis of the data.

Setting

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.[29] 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.

Data Collection and Analysis

Data were collected and analyzed from multiple sources to gain an in-depth understanding of the case [30,31] from a socio-ecological perspective on health systems. The photographic research methods used, which were adapted from previous work in ecological restoration [27] and health systems research [19,32] consisted of practitioner-led audio-taped photo walkabouts with photo narration and communal photo elicitation forums. Participant guided ecological tours of the 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).

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.

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 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. Each theme is illustrated with select findings below.

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 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. Overall, the environmental design of the unit provides challenges to proper IP&C practices thus leading to many workarounds.

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 [33] 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.

An example of a 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).

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 [33] discuss.

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. [34] 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.

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.

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.[34] During my observations, 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).

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.[34]

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 [24-27] and in health systems research, [19,32] 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 2 Green storage box for patient (MGMT-41)):

> 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).

This is an example of a simple yet vital HIP initiative to support IP&C practices.

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.[16,18,22,25,27,35] 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 3 Poster (HIP group) (NURS-19)). 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).

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

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 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 a prevalence rate 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.).

An 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).

Also, a yearly report of the antibiotic usage by specialty is provided by pharmacy. 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 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 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, 2007). Patients are automatically placed on isolation precautions until the test results are available.

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 Table 1.

Table 1: Hospital- and Community-Acquired MRSA, VRE, CDI and ESBL Prevalence Rates (per 1,000 patient days) (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA	5.01	3.25	1.69	1.66	1.77	1.66	1.74	1.94	3.60	0	6.69	1.67
VRE	5.0	0	0	0	0	0	0	0	0	1.7	0	0
CDI	5.0	8.13	3.37	3.32	5.31	3.32	0	1.94	5.40	5.12	1.67	8.33
ESBL	25	9.76	16.9	18.2	21.2	16.6	22.6	32.9	23.4	42.7	28.4	33.3

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 [36-38] 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% [29] 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 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.[39] Also, another study by Borg [40] found a significant correlation between the bed occupancy rate and the MRSA infection rates. Similarly, Borg and colleagues [41] 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,[42] 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”.[43, 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 prevalence 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. 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 (2007), "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.

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.[44] As Amalberti and colleagues [33] 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.[45,46] 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.[47-49]

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 [50] 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.

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, 2007). 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.[51]

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.

DATA SHARING

Supplementary data is available by contacting the primary author.

COMPETING INTERESTS

None.

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CONTRIBUTORSHIP

All of the authors made substantial contributions to the conception and design of the study and the analysis and interpretation of the data. Chantal Backman drafted the article; all of the authors revised the manuscript critically for important intellectual content and approved the final version submitted for publication. Chantal Backman had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Appendix 1: Core elements of a proposed socio-ecological framework for studying IP&C
(Table reprinted from Backman et al. [52])

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.[14,18,19]. 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.[16,19-21]
Place ethic	According to Lawrence Buell [53] and Higgs,[26,27] 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.[18,24-27] 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.[16,18,22,25,27,35] 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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Barriers and Bridges to Infection Prevention and Control: Results of a Qualitative Case Study of a Netherlands' Surgical Unit

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Qualitative research review guidelines – RATS

	ASK THIS OF THE MANUSCRIPT	THIS SHOULD BE INCLUDED IN THE MANUSCRIPT
R	**Relevance of study question**	
	Is the research question interesting?	Research question explicitly stated
	Is the research question relevant to clinical practice, public health, or policy?	Research question justified and linked to the existing knowledge base (empirical research, theory, policy)
A	**Appropriateness of qualitative method**	
	Is qualitative methodology the best approach for the study aims? *Interviews:* experience, perceptions, behaviour, practice, process *Focus groups:* group dynamics, convenience, non-sensitive topics *Ethnography:* culture, organizational behaviour, interaction *Textual analysis:* documents, art, representations, conversations	Study design described and justified e.g., why was a particular method (i.e., interviews) chosen?
T	**Transparency of procedures**	
	Sampling	
	Are the participants selected the most appropriate to provide access to type of knowledge sought by the study? Is the sampling strategy appropriate?	Criteria for selecting the study sample justified and explained *theoretical:* based on pre conceived or emergent theory *purposive:* diversity of opinion *volunteer:* feasibility, hard-to-reach groups
	Recruitment	
	Was recruitment conducted using appropriate methods? Is the sampling strategy appropriate?	Details of how recruitment was conducted and by whom
	Could there be selection bias?	Details of who chose not to participate and why
	Data collection	
	Was collection of data systematic and comprehensive?	Method (s) outlined and examples given (e.g., interview questions)
	Are characteristics of the study group and setting clear?	Study group and setting clearly described
	Why and when was data collection stopped, and is this reasonable?	End of data collection justified and described
	Role of researchers	
	Is the researcher (s) appropriate? How might they bias (good and bad) the conduct of the study and results?	Do the researchers occupy dual roles (clinician and researcher)? Are the ethics of this discussed?Do the researcher(s) critically examine their own

	influence on the formulation of the research question, data collection, and interpretation?
Ethics	
Was informed consent sought and granted?	Informed consent process explicitly and clearly detailed ✓
Were participants' anonymity and confidentiality ensured?	Anonymity and confidentiality discussed ✓
Was approval from an appropriate ethics committee received?	Ethics approval cited ✓
S Soundness of interpretive approach	
Analysis	
Is the type of analysis appropriate for the type of study? *thematic:* exploratory, descriptive, hypothesis generating *framework:* e.g., policy *constant comparison/grounded theory:* theory generating, analytical	Analytic approach described in depth and justified ✓
Are the interpretations clearly presented and adequately supported by the evidence?	*Indicators of quality:* Description of how themes were derived from the data (inductive or deductive) ✓
Are quotes used and are these appropriate and effective?	Evidence of alternative explanations being sought ✓ Analysis and presentation of negative or deviant cases ✓ Description of the basis on which quotes were chosen ✓ Semi-quantification when appropriate ✓ Illumination of context and/or meaning, richly detailed
Was trustworthiness/reliability of the data and interpretations checked?	Method of reliability check described and justified ✓ e.g., was an audit trail, triangulation, or member checking employed? Did an independent analyst review data and contest themes? How were disagreements resolved?
Discussion and presentation	
Are findings sufficiently grounded in a theoretical or conceptual framework?	Findings presented with reference to existing theoretical and empirical literature, and how they contribute ✓
Is adequate account taken of previous knowledge and how the findings add?	
Are the limitations thoughtfully considered?	Strengths and limitations explicitly described and discussed ✓
Is the manuscript well written and accessible?	Evidence of following guidelines (format, word count) ✓ Detail of methods or additional quotes contained in appendix ✓ Written for a health sciences audience
Are red flags present? these are common features of ill conceived or poorly executed qualitative studies, are a cause for concern, and must be viewed critically. They might be	*Grounded theory:* not a simple content analysis but a complex, sociological, theory generating approachJargon: descriptions that are trite, pat,

fatal flaws, or they may result from lack of detail or clarity.	or jargon filled should be viewed sceptically *Over interpretation:* interpretation must be grounded in "accounts" and semi-quantified if possible or appropriate *Seems anecdotal, self evident:* may be a superficial analysis, not rooted in conceptual framework or linked to previous knowledge, and lacking depth *Consent process thinly discussed:* may not have met ethics requirements *Doctor-researcher:* consider the ethical implications for patients and the bias in data collection and interpretation

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

ABSTRACT

Objectives:

-To observe the overall work environment including infection prevention and control (IP&C) practices on the target surgical unit;

-To analyze the policies and procedures in the hospital and unit environments;

-To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and

-To collect monthly specific IP&C related anonymized data.

Design:

In this qualitative case study analysis, a socio-ecological approach on health systems informed the research design and provided a framework to better understand the complexity of implementing effective IP&C.

Setting:

The study was conducted on a surgical unit at a Netherlands' hospital that reported successful reductions in the prevalence of targeted multidrug-resistant organisms (MDRO).

Methods:

Research methods included 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.

Results:

The findings indicate some conditions and processes present that may influence the low prevalence 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.

Conclusions:

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.

Further data is available by contacting the primary author directly.

SUMMARY

Article focus:

-To observe the overall work environment including IP&C practices on the target surgical unit;

-To analyze the policies and procedures aimed at the prevention and minimization of MDRO in the hospital and unit environments;

-To analyze the barriers and bridges to IP&C that practitioners identify in visual narratives of their unit environment; and

-To collect monthly specific IP&C related anonymized data.

Key messages:

The findings indicate some conditions and processes present that may influence the low prevalence 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.

Strengths and limitations:

-Multiple methods of data collection and a broad socio-ecological system approach to study IP&C on the unit strengthen this research.

-It is possible that staff may have altered their behavior from normal practices during unit observations.

-The prevalence counts of MRSA, VRE, CDI and ESBL, the rates of hand hygiene product usage

limiting the ability to assess the rigor of data collection.

-The focus of this study was on a specific clinical unit of the hospital.

INTRODUCTION

Infection prevention and control (IP&C) 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.[1-3] However, although the importance of IP&C 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,[4] and 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".[5, p.236] Some European countries such as the Netherlands have been recognized as world leaders at minimizing MDRO infection rates, in particular MRSA.[6] Yet, strong evidence on the most effective approaches for 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.[7] 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 prevalence of targeted MDRO. In this paper, we discuss the key findings of the Netherlands hospital case study and offer recommendations for policy, practice

The objectives of the research were:

1. To observe the overall work environment including IP&C practices on the target surgical unit;
2. To critically review 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 prevalence rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI).

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.[7-12] One promising theoretical line of inquiry is supported by Struelens'[8] 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,[9] Gloubeman,[10] Macdonald,[11] and Waldvogel,[12] 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",[13, p.45] enabling us to more accurately interpret and manage whole systems change.[14,15] In socio-ecological terms, the term whole systems may be conceptualized as nested cycles of system development, degradation, or restoration.[14,16-18]

A whole systems' perspective on IP&C is compatible with the participatory methods of citizen science that engage communities in collectively studying and assessing the socio-ecological conditions of their environments in order to collaboratively design and implement useful, sustainable repairs.[14,18,19] 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.[16,19-21] This research approach draws on related work in the fields of ecosystems management and research,[22] economics,[23] restoration management,[24-27] and health systems.[18,19] 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.[14,18,21,28]

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,[8,12,15,18] and used to inform the research design and conduct of the study (Appendix 1). The framework informed but did not constrain the collection and analysis of the data.

Setting

The hospital is a 1042-bed tertiary care major teaching and referral center in The Netherlands 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.[29] 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 study 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 [30,31] from a socio-ecological perspective on health systems. The photographic research methods used, which were adapted from previous work in ecological restoration [27] and health systems research [19,32] consisted of practitioner-led audio-taped photo walkabouts with photo narration and communal photo elicitation forums. Participant guided ecological tours of the 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. Nursing, medical, housekeeping and other hospital personnel on the unit were informed that the study was taking place and that the observations collected would be shared with them, and with the hospital in aggregate form only. The first author made it clear that the specific findings would not be linked to any individuals. 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).

Five practitioner-led photo walkabouts and photo narrations (n=7 participants) of their perceived concerns and strengths on their unit in relation to IP&C 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.

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 was coded into thematic categories. These categories were compared and contrasted in relation to the patterns identified that relate to IP&C. As coding, comparing, and contrasting within the qualitative data progressed in iterative cycles of data collection and data analysis, potential links between various groupings of coded visual and

textual data, related emerging theory and research literature were identified and discussed within the research team. Our analysis was sensitive to the policies and procedures, prevalence rates, and other hospital documents that helped contextualize these specific findings.

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 IP&C 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. Each theme is illustrated with select findings below.

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

The environmental design consists of both workplace and work design. 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 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. Overall, the environmental design of the unit provides challenges to proper IP&C practices thus leading to many workarounds.

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 [33] 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

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.

An example of a 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 the photo 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).

During the photo walkabout with the ICP, 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 [33] discuss.

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. [34] 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. For example, during the photo walkabout with a participating physician and ICP, 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 interview, 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 that supports effective IP & C within the group. Another shared practice with potential positive impact on IP&C that was observed is the unit team's regular engagement in shared breaks and evening meals in a staff lounge located on the unit (Observations, P1, 18). During the photo 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 IP&C as it limits staff leaving the unit.

> 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.[34] During

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 IP&C 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.[34]

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 [24-27] and in health systems research, [19,32] 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 ICP, oversees and implements several activities to promote the use of good hygiene precautions in the hospital. During a follow-up discussion, key informants noted that:

> The HIP group is an initiative of the surgical units and the ICP. The ICP 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 ICP (key informant #2).

An example of a HIP initiative is the patient-specific storage box for wound care products (Figure 2 Green storage box for patient (MGMT-41)):

> 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).

This is an example of a simple yet vital HIP initiative to support IP&C practices.

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.[16,18,22,25,27,35] 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 3 Poster (HIP group) (NURS-19)). 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).

Training and education on hand hygiene is provided to units upon request by the unit manager or the IP&C 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. These comments brought forward by staff themselves are important to the development of sustainable solutions.

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 study finding in a variety of ways. At the Netherlands hospital, the IP&C 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 Control Committee who advises the Board of Directors on the IP&C policies. This committee meets every two months and discusses all IP&C-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 a prevalence rate 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 and details such as any outbreaks that have occurred, etc.).

An 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).

Also, a yearly report of the antibiotic usage by specialty is provided by pharmacy. 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 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 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, 2007). Patients are automatically placed on isolation precautions until the test results are available.

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 Table 1.

Table 1: Hospital- and Community-Acquired MRSA, VRE, CDI and ESBL Prevalence Rates (per 1,000 patient days) (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA	5.01	3.25	1.69	1.66	1.77	1.66	1.74	1.94	3.60	0	6.69	1.67
VRE	5.0	0	0	0	0	0	0	0	0	1.7	0	0
CDI	5.0	8.13	3.37	3.32	5.31	3.32	0	1.94	5.40	5.12	1.67	8.33
ESBL	25	9.76	16.9	18.2	21.2	16.6	22.6	32.9	23.4	42.7	28.4	33.3

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. 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 [36-38] 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% [29] published in the literature. The control measures in the search and destroy strategy included preemptive isolation of patients, repeated screening of staff for MRSA,

environmental cleaning. The monthly VRE prevalence rate in 2008 ranged from 0-0.5%. The CDI prevalence rate ranged from 0-0.8% and 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 IP&C 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.[39] Also, another study by Borg [40] found a significant correlation between the bed occupancy rate and the MRSA infection rates. Similarly, Borg and colleagues [41] 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,[42] 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".[43, 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 prevalence 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 IP&C issues on a unit can significantly improve MDRO rates. 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.

Another support for IP&C in the study site that bears further scrutiny 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 (2007), "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 would be worthwhile to study the costs and benefits of this practice at the study site and in other contexts in further detail.

Despite the number of recommended practices in place, some barriers to sound IP&C practices were also evident. For instance, specific environmental design challenges promoted problematic workarounds, which are often developed by staff to adapt to the limitations of their care environments.[44] As Amalberti and colleagues [33] argue, practitioners naturally migrate to the boundaries of and even violate acceptable practices as they attempt to adapt to conflicting work demands in complex health care systems. For example, practitioners, are less likely to clean their hands if they do not have proper access to soap and water or an ABHR, [45,46] and it is recommended that dispensers should be placed in many convenient and accessible locations

for staff.[47-49] Furthermore, 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. However, on the study unit, the ABHR dispensers were only located outside the patient rooms.

Other environmental design issues that pose barriers to IP&C were also observable, such as garbage bins that require handling to open. It is likely that similar design issues abound in most acute care hospitals. Rathert and colleagues [50] 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.

Another deficit at the study site was the calculation of unit-based consumption of ABHR to monitor adherence to hand hygiene practices. 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, 2007). 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.[51]

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. These limitations were addressed 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 hospitals in a variety of countries would be a valuable way to better understand what IP&C programs are most effective in which contexts, and for what reasons. Furthermore, findings from this research can inform current and future efforts to provide infection prevention and control programs and strategies that are socio-ecologically sound. The

findings also support that current initiatives underway to promote system-wide improvements in infection prevention and control should engage local practitioners in designing and implementing interventions that can be adapted to their specific clinical environment. Finally, this research suggests that qualitative research can reveal embedded and taken-for-granted daily and ritualized social practices that contribute to infection prevention and control.

Appendix 1: Core elements of a proposed socio-ecological framework for studying IP&C
(Table reprinted from Backman et al. [52])

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.[14,18,19]. 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.[16,19-21]
Place ethic	According to Lawrence Buell [53] and Higgs,[26,27] 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.[18,24-27] 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.[16,18,22,25,27,35] 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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Barriers and Bridges to Infection Prevention and Control: Results of a Qualitative Case Study of a Netherlands' Surgical Unit

INTRODUCTION

Infection prevention and control (IP&C) 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.[1-3] However, although the importance of **IP&C** 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,[4] and 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".[5, p.236] Some European countries such as the Netherlands have been recognized as world leaders at minimizing MDRO infection rates, in particular MRSA.[6] Yet, strong evidence on the most effective approaches for 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.[7] 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 prevalence of targeted MDRO. In this paper, we discuss the key findings of the Netherlands hospital case study and offer recommendations for policy, practice and future research.

The objectives of the research were:

1. To observe the overall work environment including IP&C practices on the target surgical unit;
2. To **critically review** 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 prevalence rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *enterococci* (VRE), extended spectrum beta-lactamases (ESBLs) and *Clostridium difficile* infections (CDI).

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.[7-12] One promising theoretical line of inquiry is supported by Struelens'[8] 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,[9] Gloubeman,[10] Macdonald,[11] and Waldvogel,[12] 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",[13, p.45] enabling us to more accurately interpret and manage whole systems change.[14,15] In socio-ecological terms, the term whole systems may be conceptualized as nested cycles of system development, degradation, or restoration.[14,16-18]

A whole systems' perspective on IP&C is compatible with the participatory methods of citizen science that engage communities in collectively studying and assessing the socio-ecological conditions of their environments in order to collaboratively design and implement useful, sustainable repairs.[14,18,19] 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.[16,19-21] This research approach draws on related work in the fields of ecosystems management and research,[22] economics,[23] restoration management,[24-27] and health systems.[18,19] 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.[14,18,21,28]

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,[8,12,15,18] and used to inform the research design and conduct of the study (Appendix 1). The framework informed but did not constrain the collection and analysis of the data.

Setting

The hospital is a 1042-bed tertiary care major teaching and referral center in The Netherlands 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.[29] 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 study 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 [30,31] from a socio-ecological perspective on health systems. The photographic research methods used, which were adapted from previous work in ecological restoration [27] and health systems research [19,32] consisted of practitioner-led audio-taped photo walkabouts with photo narration and communal photo elicitation forums. Participant guided ecological tours of the 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. **Nursing, medical, housekeeping and other hospital personnel on the unit were informed that the study was taking place and that the observations collected would be shared with them, and with the hospital in aggregate form only. The first author made it clear that the specific findings would not be linked to any individuals.** 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).

Five practitioner-led photo walkabouts and photo narrations (n=7 participants) of their perceived concerns and strengths on their unit in relation to **IP&C** 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.

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 was coded into thematic categories. These categories were compared and contrasted in relation to the patterns identified that relate to IP&C. As coding, comparing, and contrasting within the qualitative data progressed in iterative cycles of data collection and data analysis, potential links between various**

groupings of coded visual and textual data, related emerging theory and research literature were identified and discussed within the research team. Our analysis was sensitive to the policies and procedures, prevalence rates, and other hospital documents that helped contextualize these specific findings.

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 **IP&C** 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. Each theme is illustrated with select findings below.

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

The environmental design consists of both workplace and work design. 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 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. Overall, the environmental design of the unit provides challenges to proper IP&C practices thus leading to many workarounds.

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 [33] 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.

An example of a 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 the photo 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).

During the photo walkabout with the ICP, 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 [33] discuss.

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. [34] 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. For example, during the photo walkabout with a participating physician and ICP, 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 interview, 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 that supports effective IP & C within the group. Another shared practice with potential positive impact on **IP&C** that was observed is the unit team's regular engagement in shared breaks and evening meals in a staff lounge located on the unit (Observations, P1, 18). During the photo 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 **IP&C** as it limits staff leaving the unit.

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.[34] During observations, a visible clear communication strategy that was identified was 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 IP&C 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.[34]

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 [24-27] and in health systems research, [19,32] 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 ICP, oversees and implements several activities to promote the use of good hygiene precautions in the hospital. During a follow-up discussion, key informants noted that:

> The HIP group is an initiative of the surgical units and the ICP. The ICP 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 ICP (key informant #2).

An example of a HIP initiative is the patient-specific storage box for wound care products (Figure 2 Green storage box for patient (MGMT-41)):

> 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).

This is an example of a simple yet vital HIP initiative to support IP&C practices.

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.[16,18,22,25,27,35] 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 3 Poster (HIP group) (NURS-19)). 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).

Training and education on hand hygiene is provided to units upon request by the unit manager or the IP&C 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. These comments brought forward by staff themselves are important to the development of sustainable solutions.

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 study finding in a variety of ways. At the Netherlands hospital, the IP&C 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 Control Committee who advises the Board of Directors on the IP&C policies. This committee meets every two months and discusses all IP&C-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 a prevalence rate 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 and details such as any outbreaks that have occurred, etc.).

An 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).

Also, a yearly report of the antibiotic usage by specialty is provided by pharmacy. 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 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 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, 2007). Patients are automatically placed on isolation precautions until the test results are available.

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 Table 1.

Table 1: Hospital- and Community-Acquired MRSA, VRE, CDI and ESBL Prevalence Rates (per 1,000 patient days) (colonized and infected cases) (Jan-Dec 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MRSA	5.01	3.25	1.69	1.66	1.77	1.66	1.74	1.94	3.60	0	6.69	1.67
VRE	5.0	0	0	0	0	0	0	0	0	1.7	0	0
CDI	5.0	8.13	3.37	3.32	5.31	3.32	0	1.94	5.40	5.12	1.67	8.33
ESBL	25	9.76	16.9	18.2	21.2	16.6	22.6	32.9	23.4	42.7	28.4	33.3

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. 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 [36-38] 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% [29] 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. The monthly VRE prevalence rate in 2008 ranged from 0-0.5%. The CDI prevalence rate ranged from 0-0.8% and 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 **IP&C** 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.[39] Also, another study by Borg [40] found a significant correlation between the bed occupancy rate and the MRSA infection rates. Similarly, Borg and colleagues [41] 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,[42] 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".[43, 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 prevalence 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 **IP&C** issues on a unit can significantly improve MDRO rates. 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.

Another support for IP&C in the study site that bears further scrutiny 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 (2007), "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 would be worthwhile to study the costs and benefits of this practice at the study site and in other contexts in further detail.

Despite the number of recommended practices in place, some barriers to sound IP&C practices were also evident. For instance, specific environmental design challenges promoted problematic workarounds, which are often developed by staff to adapt to the limitations of their care environments.[44] As Amalberti and colleagues [33] argue, practitioners naturally migrate to the boundaries of and even violate acceptable practices as they attempt to adapt to conflicting work demands in complex health care systems. For example, practitioners, are less likely to clean their hands if they do not have proper access to soap and water or an ABHR, [45,46] and it is recommended that dispensers should be placed in many convenient and accessible locations

for staff.[47-49] Furthermore, 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. However, on the study unit, the ABHR dispensers were only located outside the patient rooms.

Other environmental design issues that pose barriers to IP&C were also observable, such as garbage bins that require handling to open. It is likely that similar design issues abound in most acute care hospitals. Rathert and colleagues [50] 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.

Another deficit at the study site was the calculation of unit-based consumption of ABHR to monitor adherence to hand hygiene practices. 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, 2007). 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.[51]

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. These limitations were addressed 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 hospitals in a variety of countries would be a valuable way to better understand what IP&C programs are most effective in which contexts, and for what reasons. **Furthermore, findings from this research can inform current and future efforts to provide infection prevention and control programs and strategies that are socio-ecologically sound.**

The findings also support that current initiatives underway to promote system-wide improvements in infection prevention and control should engage local practitioners in designing and implementing interventions that can be adapted to their specific clinical environment. Finally, this research suggests that qualitative research can reveal embedded and taken-for-granted daily and ritualized social practices that contribute to infection prevention and control.

Appendix 1: Core elements of a proposed socio-ecological framework for studying IP&C
(Table reprinted from Backman et al. [52])

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.[14,18,19]. 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.[16,19-21]
Place ethic	According to Lawrence Buell [53] and Higgs,[26,27] 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.[18,24-27] 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.[16,18,22,25,27,35] 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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