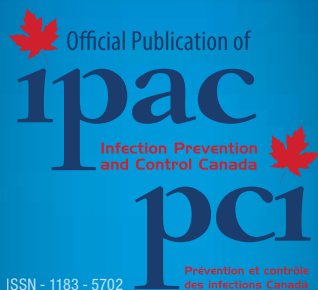


# CJIC

The Canadian Journal of Infection Control  
Revue canadienne de prévention des infections



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# Ready-to-use vs. dilutables

## Discover the more cost-effective option

The price tag of dilutable disinfectants may seem appealing. But ready-to-use formats save users from incurring hidden costs arising from cross-contamination, quality control issues and low compliance that have all been associated with dilutables.<sup>1</sup>

### The toll of improper use

When it comes to dilutables, non-compliance and cross-contamination in particular are thought to contribute to hospital-acquired infections (HAIs).<sup>2</sup>

More than 200,000 patients get infections every year while receiving healthcare in Canada, and more than 8,000 die as a result.<sup>3,4</sup> Not surprisingly, treatment is more costly than prevention, totaling an estimated \$129 million in 2010 alone.<sup>4</sup>

Swapping out dilutable products for ready-to-use disinfectants may help hospitals achieve consistent, compliant use for terminal disinfection.

### Ready-to-use advantages

#### No risk of cross-contamination

Ready-to-use products like Clorox Healthcare® Hydrogen Peroxide Cleaner Disinfectant Wipes are disposed of after each use, eliminating the risk for cross-contamination.

By comparison, reusable cotton and microfibre towels, which are often used with dilutables, have been shown to harbour microorganisms even after laundering, contributing to cross-contamination.<sup>5</sup>

#### Better compliance

A study comparing formats found significantly higher compliance with ready-to-use products and compliance issues with dilutables, including improper dilution, rag reuse, rag double dipping and inadequate rag saturation.<sup>1</sup>

#### Time saved

The same study also found that employees took, on average, 21% less time per patient room when disinfecting with ready-to-use products, translating to a cost savings of \$38.58 per employee per day.<sup>1</sup>

#### Improved quality control

Ready-to-use wipes ensure the proper saturation and concentration of disinfectant in every wipe, every time.

Achieving consistent dilution and towel saturation leaves room for human error that can lead to quality control issues.<sup>1</sup> Dilution systems should also be maintained and tested regularly, as environmental factors can hurt their performance.<sup>6</sup>

#### Built-in compatibility

All Clorox Healthcare® disinfecting wipes are designed for better compliance and built-in compatibility.

Alternatively, using cotton cloths with dilutable disinfectants may result in inadequate transfer of solution to surfaces.<sup>7</sup> Even microfibre (the preferred vehicle for applying dilutable disinfectants) has variable performance after repeated washes.<sup>8</sup>

#### The environmental factor

Almost all Clorox Healthcare® products are available in containers that can be recycled. Our pre-moistened wipe containers can be retained and refilled conveniently with wipe refill bags, which means less water and energy are used without the need for constant laundering. Savings for your facility. Better for our planet.

Plus, our facilities have strict protocols to reduce waste, conserve water and reduce greenhouse gases. In fact, our Canadian sites have achieved zero waste to landfill status, recycling at least 90% of its waste and sending the remainder to a waste-to-energy facility.<sup>9</sup>

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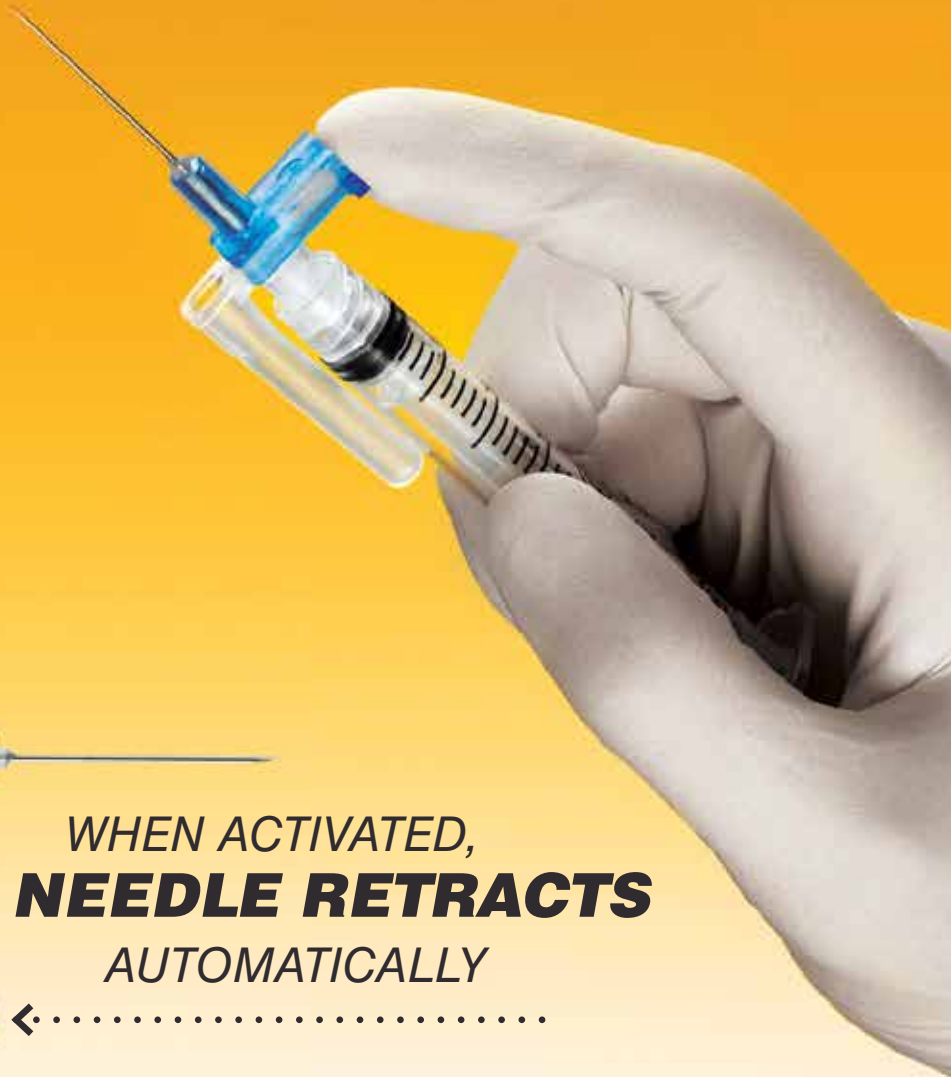
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<sup>1</sup> Sixt N, Dalle F, Lafon L, Aho S, Couillaud G, Valot S, et al. Reduced fungal contamination of the indoor environment with the PLASMAIR™ system (Airspace). J Hosp Infect 2007; 65:156-162.

<sup>2</sup> Fernandez-Gerlinger MP, Jannot AS, Rigau deau S, Lambert J, Eloy O, Mignon F, Farhat H, Castaigne S, Merrer J, Rousselot P.

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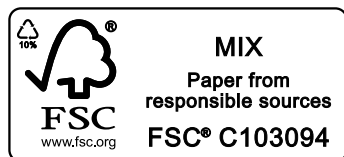
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# Welcome to new Editor and Associate Editor

It is with regret that the Board of Directors of IPAC Canada has accepted the resignation of Chingiz Amirov, Editor of the *Canadian Journal of Infection Control*. IPAC Canada thanks Chingiz for his extraordinary service to the association through increasing the journal's international profile and preparing the journal for PubMed Index. Chingiz is to be commended for increasing the number of published manuscripts, decreasing the time between review and publication, generating national and international contacts for prospective manuscripts, and generating increased revenue for the journal. We wish Chingiz well in all his future endeavours.

The Board of Directors is pleased to announce that Victoria Williams, MPH, CIC has been appointed Interim Editor of the *Canadian Journal of Infection Control*.

“The Board of Directors is pleased to announce that Victoria Williams, MPH, CIC has been appointed Interim Editor of the *Canadian Journal of Infection Control*... The Board also announces that Devon Metcalf, MSc, PhD, CIC has been appointed Associate Editor.”

Victoria has been a member of the journal's Editorial Board for several years and is a prominent author of several of its publications. The Board looks forward to continued progress of the journal through Victoria's oversight.

The Board also announces that Devon Metcalf, MSc, PhD, CIC has been appointed Associate Editor. The role of this new position is to provide assistance to the Editor through direct liaison with authors during the manuscript review process.

We also acknowledge the ongoing support of Craig Kelman & Associates, publisher of the *Canadian Journal of Infection Control*. Through the support of our publisher, the journal has made significant advances as an internationally recognized expert journal. ✨



“We wish Chingiz well in all his future endeavours.”



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# POSITION PAPER: Hepatitis B practice recommendations

This position statement was developed by IPAC Canada's Dialysis Interest Group:

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Hemodialysis patients are at high risk for acquiring blood-borne infections. The dialysis treatment requires large volumes of blood to be processed outside of the body. Contact either directly or indirectly with the contaminated environment, equipment, or hands of healthcare workers (HCWs) may result in the transmission of blood-borne pathogens [1].

Hepatitis B virus (HBV) is spread by percutaneous or permucosal exposure to blood or body fluids that contain HBV. HBV is relatively stable in the environment and can remain viable for at least seven days on environmental surfaces [1, 5]. Hemodialysis programs should institute a comprehensive HBV prevention plan [1, 4], including the recommendations provided below, and audits [6]. These recommendations address the prevention and management of HBV infection in hemodialysis patients. Other blood-borne pathogens (such as hepatitis C or HIV) do not require isolation. These patients are effectively managed through the implementation of routine practices [1-4].

## INFECTION PREVENTION AND CONTROL PRACTICE RECOMMENDATIONS FOR PREVENTION OF TRANSMISSION OF HEPATITIS B AMONG HEMODIALYSIS PATIENTS

1. Single-use injectable medications should be dedicated for use on a single patient and be entered one time only. Multi-dose vials should be avoided [7]. All parental medications should be prepared in a clean area separate from potentially contaminated items and surfaces [6].
2. Immunization  
The risk of transmission of HBV is reduced by immunization [2].
  - **Patients:** Hepatitis B vaccination is recommended early in the course of kidney disease for all susceptible patients. Beyond hemodialysis, this includes pre-dialysis and peritoneal dialysis patients. Kidney failure interferes with the body's natural immunity and chronic dialysis patients who become infected may become chronic carriers of the disease. Hemodialysis programs should have policies and procedures in place regarding revaccination and follow-up of immune status [1, 2, 4].

- **Staff:** HBV immunization of HCWs began in Canada in 1982 and is recommended for those persons at increased risk of occupational infection (i.e., those exposed to blood, blood products, and bodily fluids that may contain the virus) [2, 4, 5]. Hemodialysis programs should have a policy and procedures to monitor HCWs' HBV immunization.
- Test all who have been vaccinated for antibody to hepatitis B surface antigen (anti-HBs) one to two months after the last primary vaccine dose in order to determine their response to the vaccine (adequate response is defined as > 10 mIU/mL) [2, 4, 5]. Patients and staff members who do not respond to the primary vaccine series should be revaccinated with three additional doses and retested for response. No additional doses of the vaccine are warranted for those who do not respond to the second series [2, 4]. In this case, follow recommendations for patients considered susceptible.

3. Containment and management  
Contact transmission is the most important route by which pathogens are transmitted in healthcare settings [3].
  - Consistently use routine practices for the care of all hemodialysis patients [3].
  - Hand hygiene reduces the number of microorganisms on the hands and is the most important practice to prevent the spread of infection to patients and staff [2, 3, 5].
  - Personal protective equipment (PPE) – single use [2, 3, 5]:
    - Gloves for direct patient care or when touching the patient's equipment. Perform hand hygiene prior to donning and after doffing gloves.
    - Mask and eye protection or face shield to protect the mucous membranes of the eyes, nose, and mouth when performing procedures that may generate splashes or sprays of blood or body fluids.
    - Gown to prevent soiling of clothing or unprotected skin.
  - Standard facility-based environmental cleaning policies should be in place to reduce opportunities for transmission of infectious agents [2, 3, 5].

The following additional infection prevention and control practices should be taken with hepatitis B surface antigen-positive (HBsAg) patients:

- Dialyze HBsAg patients in a separate room with dedicated machine, equipment, medications, and supplies [1, 2, 4].
  - If a separate room is not available, a separate area may be used in order to geographically separate HBV-positive patients from HBV-susceptible patients [1, 2, 4].
  - HCWs should not care for HBV-positive patients at the same time as HBV-susceptible patients [1, 4].
  - HBV-immune patients may act as a geographical buffer between positive and susceptible patients [1, 4].
  - Staff members can be assigned to care for both HBV-positive and HBV-immune patients on the same shift. There must be current serology to confirm the patient's HBV immunity prior to assigning the two groups together. Protection against HBV is not maintained if the patient's anti-HBs drop below protective levels of 10 mIU/ml [1, 4].
4. Cleaning and disinfection
- The internal surface (previously, "pathways") of the dialysis machine used on an HBV-positive patient must be disinfected with a high-level disinfectant prior to use on another patient [1, 4].
  - The external surface of the dialysis machine must be cleaned and disinfected with a facility-approved low-level disinfectant prior to use on another patient [1, 4].
  - Following dialysis treatment, clean and disinfect all surfaces in the dialysis station with a facility-approved disinfectant, including the bed/chair, table, doorknobs, and television remote [1, 4].
  - For centres with dialyzer reprocessing programs, dialyzers should not be reused on HBsAg-positive patients [1].
5. Screening
- Serologic testing of all chronic kidney disease patients should occur prior to admission to the program or at the first dialysis treatment (hemodialysis or peritoneal dialysis). This should include testing for HBsAg, anti-HBs, and hepatitis B core antibody [4].
  - If the patient's HBV status is unknown at the time of first treatment, the dialysis machine must not be used on another patient until the internal and external surfaces have been cleaned and disinfected [4].
  - A method should be developed to monitor, review, evaluate, and communicate all serological testing for HBV [1, 4].
  - Annual testing of all hemodialysis patients is required to determine immunity, susceptibility, and/or conversion. Susceptible patients should be tested more frequently until immunity has been established by vaccination. The frequency of testing (Q monthly, Q two months, or Q six months) will depend on the patient population and risk [1, 4].

- Programs should have a policy for follow-up and testing of susceptible patients who have received hemodialysis at other facilities (e.g., while travelling).

#### 6. Education

- The hemodialysis program should have an educational plan for patients, their families, and advocates.
- This can be supported via education regarding the patient's role in infection prevention and control, including hand hygiene, access and wound cleaning, respiratory etiquette, and understanding/reporting signs and symptoms of infection [8].
- Ensure the patient has received appropriate education on the steps to prevent spreading the virus to others.
- Families and advocates should be educated by hemodialysis staff regarding what infection prevention measures they should expect to see taken by their dialysis team [8].
- The program should also provide educational opportunities for HCWs to gain knowledge and familiarity in [1-3, 5]:
  - Transmission of blood-borne viruses.
  - Interpretation of HBV serology.
  - Routine practices, including hand hygiene and the donning and doffing of PPE.
  - Additional transmission-based precautions (airborne, droplet, contact).
  - Consultation with the institution's Infection Prevention and Control department for additional education regarding the appropriate management and prevention of HBV infection.

#### GLOSSARY/DEFINITIONS

As per the Canadian Standard Association:

"SHALL" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard;

"SHOULD" is used to express a recommendation or that which is advised but not required; and

"MAY" is used to express an option or that which is permissible within the limits of the standard, an advisory or optional statement.

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# Designing an innovative professional development experience to build infection control professionals' educational expertise

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## ABSTRACT

**Background:** Advances in networked learning technologies have impacted our understanding and organization of teaching and learning. In the modern context of a learning society, conventional classroom-style education and transfer of knowledge is being challenged. Infection prevention and control (IPAC) educational practice must respond to the changes that technology brings to teaching and learning. While education is an important component of IPAC professional practice, few Infection Control Professionals (ICPs) have formal pedagogical training. ICPs need support in shifting from teaching-as-telling approaches to becoming designers of contemporary active and engaged teaching and learning environments.

**Methods:** To build ICP pedagogical expertise and practice within the Alberta Health Services (AHS) IPAC program, a Design-Based Research methodology was used to systematically engineer an intentionally disruptive professional development experience (PDE) for ICPs that aligned with contemporary teaching and learning strategies. The PDE was situated in the context of a Community of Learning (CoL) located within the ICPs' workplace practice. Learning in the CoL was mediated through participation in collaborative design, teaching, and learning activities over a period of one year.

**Results:** The PDE framework that emerged in this study facilitated changes in the AHS ICP CoL participants' understanding of teaching and learning, their sense of identity as educators, and their educational practices. The core of the framework focused on designing for a flexible, responsive collaborative learning environment supported by four strategies: a) creating an awareness of ICP educational practice, b) building pedagogical knowledge, c) experiencing different teaching and learning strategies, and d) building ICPs' identity as educators.

**Discussion:** Creating conceptual change and new designs for teaching practice is not easy, as it involves significant transformation that can be uncomfortable and complex and often requires new ways of learning. This paper discusses the guiding principles used in the design of this intentionally disruptive yet positive and responsive learning experience to build the participating ICPs' pedagogical expertise and practice.

## KEYWORDS

Infection prevention and control; education; teaching and learning; professional development; instructional design

## INTRODUCTION

This paper, the last in a series of four, describes the design, development, and implementation of an innovative professional development experience (PDE) for Infection Control Professionals (ICPs) within the Alberta Health Services (AHS) Infection Prevention and Control (IPAC) Program. The PDE sought to facilitate a paradigm shift in how ICPs think about and practice education in response to a call for action described

in the first paper in this series [1]. The PDE was informed by and designed to respond to ICPs' requests for opportunities to build their educational expertise and address their challenges, as described in the third paper in this series [2]. In response to many influences such as learning technologies, major changes are taking place regarding contemporary teaching and learning processes and it is important that ICPs build the necessary

**Acknowledgements:** This research would not have been possible without the ongoing support of the Alberta Health Services Infection Prevention and Control Program and the participation of the Infection Control Professionals in that program.

**Conflicts of interest:** None.

**Funding:** There was no formal funding for this research. Alberta Health Services provided Group Learning Initiatives Funding. Funds from competitive Alberta Health Services Learning and Professional Development Awards in 2012, 2013, and 2014 addressed some of the costs associated with this research.

**Ethics approval:** This research was conducted as part of a larger doctoral research study that received ethical approval from the University of Calgary's Conjoint Health Research Ethics Board.

pedagogical expertise they need to respond to these changes.

Advances in technology, including the growing prevalence of networked mobile devices, have impacted our understanding and organization of teaching, including the place, space, and pace of where and how learning occurs [3-5]. One result is a greater focus on the concept of a learning ecology with increased attention to instructional design and what it means to learn [6, 7]. The workplace is increasingly becoming a place of learning, much of which occurs through informal learning processes [8]. Healthcare delivery is also becoming more complex, requiring learning that enables healthcare workers (HCWs) to adapt to ever-changing work environments and generate new knowledge to continuously improve their practice [9]. In the context of a modern learning society, and with the need for lifelong learning, conventional classroom-style education based on knowledge transfer is being challenged, particularly in workplace settings [10].

Learning in the twenty-first century requires a shift away from educational delivery informed by behaviourist philosophies that have objectivist roots. Such approaches treat knowledge as objective, independent, and external to an individual. From this perspective, education is an organized, pre-planned activity with specifically defined outcomes that take place within an individual [11]. Important shifts regarding contemporary educational approaches have emerged in recent decades. These shifts have been informed by constructivist theoretical frameworks such as Lev Vygotsky’s Zone of Proximal Development, Yrjö Engeström’s Activity Theory, and Jean Lave and Étienne Wenger’s Situated Learning [12-14]. Such constructivist learning theories hold that learning not only takes place within an individual, but is also embedded in the context

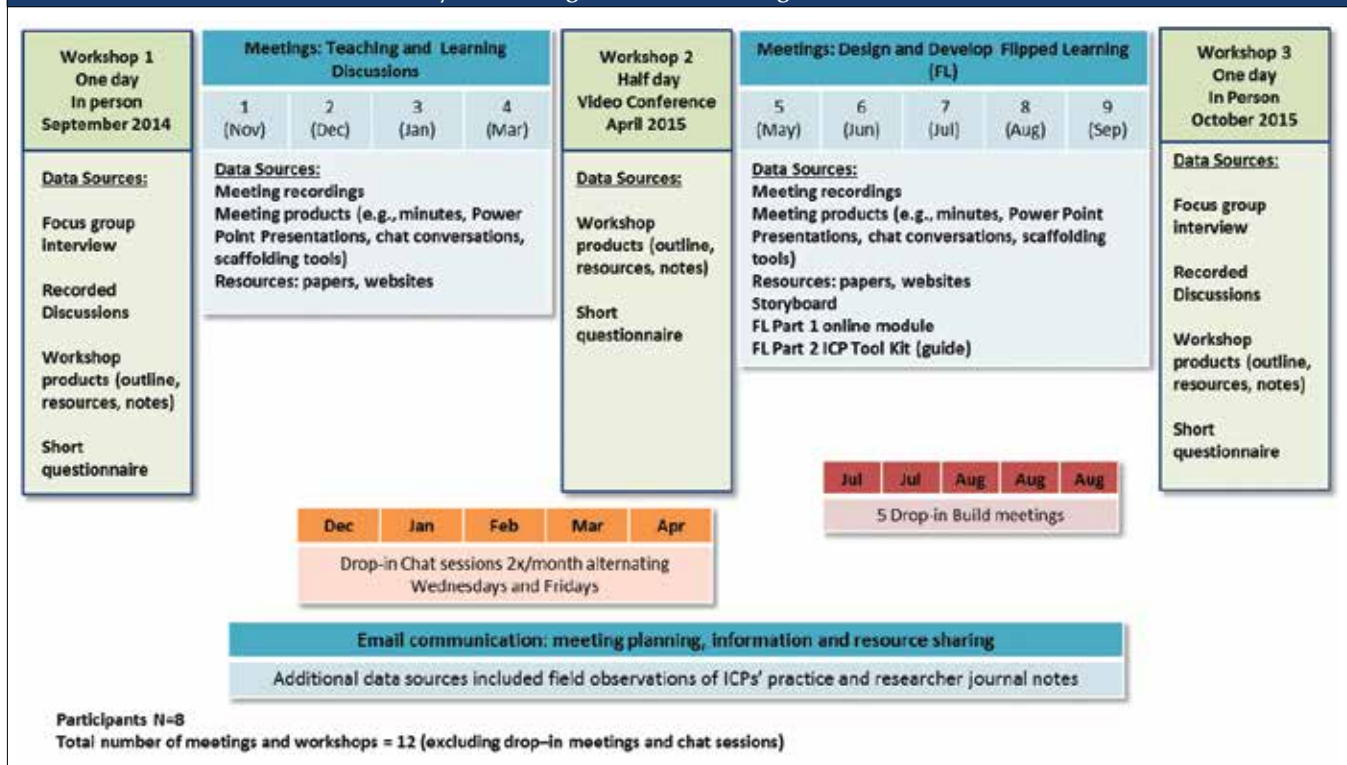
and culture in which learning occurs and is mediated by activity within such systems [13-15]. Socially situated collaborative approaches to learning expand the idea of knowledge transfer to the individual to include the idea of socially distributed knowledge building between and among groups [16-18].

Education is an important component of IPAC professional practice and a core competency for ICPs [19]. ICPs spend a significant amount of time providing repeated education and training to HCWs on core IPAC principles [20]. However, few ICPs have formal pedagogical training. ICPs rely primarily on conventional teacher-centric information-giving modes of teaching but find the design, delivery, and evaluation of such educational approaches both challenging and troublesome [2]. Effective education calls for active, interest-based learning by HCWs situated in the constantly changing environments and social contexts in which they work. ICPs need support in making these shifts in their teaching and learning practices because the changes involved require modifying how ICPs work with disciplinary knowledge, embrace educational technologies, and design educational environments for learning.

**METHODS**

The main objective of this research was to build ICP pedagogical knowledge, expertise, and practice within the AHS IPAC program with a view to facilitating a conceptual shift from commonly held conventional and passive approaches of education as information transfer to more active and engaged teaching and learning environments. To achieve this, a Design-Based Research (DBR) methodology was used to systematically engineer an intentionally disruptive PDE that aligned with constructivist teaching and

**FIGURE 1: Overview of the Community of Learning’s structure and organization.**



learning approaches. DBR is an innovative, complex, change-oriented research methodology that emerged from the field of the Learning Sciences [21]. In DBR, the research is embedded in both theory and practice, which are used together throughout the research process to inform the design, development, and implementation of an intervention to address an identified problem. This theoretical and practical grounding of the research necessitates collaborative researcher-practitioner partnerships that incorporate expert advice based on the experience and practice wisdom of the participants, which help shape the research and the many decisions taken throughout the research process. As the research progresses, the intervention is modified through a series

of iterative cycles. Emerging data is analyzed and reflected upon and new designs are created and implemented. In this way, not only is the intervention refined in context, but the theory upon which the intervention is based is extended, facilitating a better understanding of how and why the intervention does or does not work to address the identified problem. A DBR approach balances rigor with relevance, allowing for flexibility and responsiveness to emerging issues while maintaining a research focus as the study evolves. A detailed explanation of the DBR methodology is provided in the second paper in this series [22].

Participants for the PDE were recruited via email between June and August 2014 from a convenience sample of 87 full-time

**TABLE 1: Educational content and activities of the Community of Learning.**

Domain Content	Examples of Content Topics
Teaching and Learning Concepts	<ul style="list-style-type: none"> <li>• Behaviourism, Constructivism, and Cognitivism</li> <li>• Learning theories and models</li> <li>• Instructional Design</li> <li>• Collaborative and situated learning</li> <li>• Communities of Inquiry (CoI) and Communities of Practice (CoP)</li> <li>• Learning in virtual environments</li> </ul>
Teaching Strategies	<ul style="list-style-type: none"> <li>• Scaffolding</li> <li>• Facilitating discussion techniques: Think, pair, share; what, so what, now what (the 3Ws)</li> <li>• Anchored instruction</li> <li>• Flipped Learning (FL)</li> </ul>
Elements of Instructional Design	<ul style="list-style-type: none"> <li>• ADDIE model (Analyze, Design, Develop, Implement, Evaluate)</li> <li>• Domains of learning: cognitive, affective, and psychomotor</li> <li>• Benjamin Bloom's Taxonomy</li> <li>• Writing effective learning objectives</li> <li>• Design principles for developing multimedia learning environments</li> <li>• Robert Gagné's nine events for e-learning</li> <li>• Storyboarding</li> <li>• Learning Management Systems and Sharable Content Object Reference Model</li> </ul>
Constructivist Activities	Examples of Content Topics
Discussing concepts in workshops and meetings	<ul style="list-style-type: none"> <li>• ICPs engaged in small and large group discussions on a variety of topics to explore their understanding and applicability to IPAC teaching.</li> <li>• Researcher modelled different approaches to facilitating discussion.</li> <li>• ICPs reflected on their own educational practices and experiences, including their experiences with Ebola teaching and training.</li> </ul>
Playing the online public health game <i>Outbreak at Watersedge</i> <sup>1</sup>	<ul style="list-style-type: none"> <li>• During the first workshop, to experience learning using technology, ICPs explored learning in a virtual environment by playing an online game in pairs and then discussed their experiences as a larger group in the context of learning concepts.</li> </ul>
Experiencing Flipped Learning	<ul style="list-style-type: none"> <li>• Prior to being asked to create an FL experience, the ICPs experienced FL for themselves. An FL strategy was used to teach them about Instructional Design concepts for teaching and learning in multimedia environments: <ul style="list-style-type: none"> <li>• Asynchronously, on their own time, the ICPs replayed the game <i>Outbreak at Watersedge</i>, paying attention to instructional design elements used in the game, and compared the experience with the first time they played the game in Workshop 1. They then discussed their findings and experiences synchronously as a group.</li> <li>• The ICPs were then asked to reflect on and discuss their FL experience from an educator's perspective.</li> </ul> </li> </ul>
Collaboratively designing a learning experience for ICPs to teach HCWs	<ul style="list-style-type: none"> <li>• After experiencing FL as learners, together the ICPs then designed, developed, implemented, and evaluated an FL experience they and other AHS ICPs could use to teach HCWs. This collaborative activity was the core interventionist experience of the CoI professional development experience.</li> </ul>

<sup>1</sup> *Outbreak at Watersedge* is an interactive online public health discovery game created in 2004 by the University of Minnesota. The learner helps discover and stop the source of an outbreak that has hit the small virtual community of Watersedge. See <http://www.mclph.umn.edu/watersedge>.

ICPs employed by the AHS IPAC program. Eight self-selected ICPs volunteered to participate with permission from their directors, which ensured formal support and time for the ICPs to participate in the PDE during working hours.

The resulting PDE, which took place over 13 months between September 2014 and October 2015, was situated in the context of a Community of Learning (CoL) located in the ICPs' workplace practice. Figure 1 illustrates the final organizational structure of the CoL that evolved from a series of iterative modifications during the study. The CoL involved three workshops, held at the beginning, the middle, and the end of the PDE, and nine online meetings. The first and last workshops were day-long face-

to-face events. Workshop 2 was a half-day video conference. There were nine scheduled online meetings and several informal online drop-in meetings and chat sessions throughout the PDE. Additional communication occurred via email to plan and share information and resources.

To build their educational knowledge, the ICPs engaged in several collaborative teaching and learning activities. The educational concepts explored and activities used in the CoL are summarized in Table 1.

The core activity was to invite the ICPs to create and implement an FL experience that all AHS ICPs could use for teaching HCWs. FL is a pedagogical strategy that blends online

**TABLE 2: Design strategies used in the Community of Learning experience.**

<b>Design Strategies</b>	<b>Explanation of the Design Strategy</b>
Design-Based Research [22]	<ul style="list-style-type: none"> <li>• The ICPs' practice wisdom and experience informed decision-making regarding the design of the CoL.</li> <li>• Theory and practice woven together to intentionally and iteratively inform the CoL's ongoing design.</li> <li>• Collaborative partnership between researcher and the ICP participants facilitated responsive design solutions to identified problems and emerging local issues.</li> </ul>
Blended Learning [23]	<ul style="list-style-type: none"> <li>• Learning experience integrated face-to-face and online interaction, taking advantage of affordances offered by both instructional approaches.</li> <li>• Use of Blended Learning (BL) responded to ICPs' requests for PDEs regarding the use of technology for teaching.</li> <li>• Embedding the CoL in the ICPs' workplace practice facilitated their ability to situate and model learning using familiar technologies (e.g., Microsoft Lync®, videoconference, and the Internet).</li> <li>• BL supported both synchronous and asynchronous interactions and a flexible learning environment.</li> </ul>
Collaborative Learning [24, 25]	<ul style="list-style-type: none"> <li>• ICPs worked together as a group to discuss and solve problems with supporting learning-by-doing that was socially situated to facilitate distributed knowledge building across the group.</li> </ul>
Cognitive Apprenticeship [26]	<p>Approaches used to enable ICPs learning to acquire, develop, and use cognitive tools through activity:</p> <ul style="list-style-type: none"> <li>• Pedagogical content: ICPs were provided with foundational knowledge with which to build their understanding of teaching and learning and a vocabulary to enable reflection on and discussion about their teaching and learning experiences.</li> <li>• Scaffolding: ICPs were provided with structures to facilitate completion of tasks, including objectives, timelines, resources, and exemplar documents to guide practice and activities.</li> <li>• Role modelling: Researcher made teaching concepts and approaches visible by verbalizing her thinking while performing tasks so ICPs could visualize and observe the tasks and processes involved.</li> <li>• Sequencing: Learning activities were ordered with increasing complexity and diversity over time to assist ICPs' knowledge building and skill development.</li> </ul>
Community of Inquiry [23]	<p>In collaborative learning environments, the higher-order thinking needed for transformative learning is facilitated by the interrelationship of:</p> <ul style="list-style-type: none"> <li>• Social presence, which builds group cohesion and trust through open, respectful communication and discourse.</li> <li>• Cognitive presence, which cultivates and facilitates deep, meaningful learning through information sharing, connecting, applying, and questioning ideas.</li> <li>• Teaching presence, which involves the creation of a learning environment in which the teaching function can be taken on by any member of the group. This was facilitated in the group by shaping the constructive exchange of information and fostering an environment of critical thinking and problem-solving. The researcher planned and led most of the teaching activities in the CoL. The ICPs took on teaching functions during these activities by sharing their educational experience and practice wisdom from their IPAC professional practice and their attempts to implement what they were learning in the CoL in their practice outside the CoL.</li> </ul>



and face-to-face learning by rearranging how time is spent both in and out of a classroom-type setting [5]. Prior to being asked to create an FL experience, the CoL ICPs participated in an FL strategy designed and delivered by the researcher. This FL strategy was used to teach the ICPs about instructional design in online multiuser environments, and also to model the use of FL and have the ICPs experience learning within this type of teaching method.

Several design strategies – such as blended learning, collaborative learning, cognitive apprenticeship principles; the CoL principles of social, cognitive, and teaching presence; and the DBR approach itself – were used to shape the CoL experience. A summary explanation of how each of these design elements was used is provided in Table 2.

As DBR embraces the concept of triangulation, multiple data collection methods were used over the course of the CoL to cross-check results for consistency, to inform subsequent activities, and to enhance the confidence of the research findings. These data sources are summarized in Figure 1.

The use of focus group interviews conducted by the researcher at the beginning and end of the CoL enabled the collection of before-and-after data to assess processes and changes in educational understanding and practice through participation in the CoL. The focus group interviews were also useful for bringing the participants together to explore shared experiences, generate new ideas within a social context, and facilitate team learning through self-disclosure and interaction in focused discussions [27-29]. The specific intent of the first focus group interview was to collect qualitative data to gain a deeper understanding of the ICPs' educational experiences, expertise, beliefs, attitudes, and understanding regarding their educational practices. The specific intent of the second focus group interview at the end of the CoL was to have the participants reflect on their learning and experience in the CoL as well as to evaluate the CoL by outlining challenges they encountered and to make suggestions for improvement. Question guides, with a series of open-ended questions, were used to conduct the focus group interviews.

In addition to the focus group interviews, participants were asked to complete a short paper-based questionnaire at the end of each of the three workshops. The questionnaire comprised two open-ended questions: the first asked ICPs to identify and comment on three key learnings, while the second asked them to identify and comment on any challenges they were experiencing. Responses helped to identify the participants' learning progress as well as to inform the next steps in the design and development of the PDE.

Data collected from focus group interviews and short questionnaires was based on self-report, and thus was subject to the risk of under- or over-reporting of issues by participants. To study actual behaviour and ideas or concepts made explicit in the self-reported data, field observations of a subset of the CoL ICPs' educational practices were conducted by the researcher. These observations were carried out while the ICPs provided education to HCWs in their various home sites outside of the context of the CoL. The researcher took the role of non-participant observer and used a paper-based tool to record these observations. The observation tool, informed by the concept of a learning ecology,

facilitated the documentation of relationships amongst the instructor, learners, content, teaching strategies, technologies used, and the learning environment.

In DBR, a deeper understanding of the phenomena under investigation can develop while the research is in progress. Consequently, it is important to systematically and comprehensively document and record the data and the design progress [7]. Where possible, all conversations occurring during focus group interviews and various CoL activities and meetings were recorded and transcribed for analysis. These recordings, as well as meeting documents, emails, teaching plans, and other resources produced in the CoL, provided rich sources of data.

Researcher journals kept throughout the study also proved to be valuable data sources. At the outset of the study, a set of criteria was created to guide the journaling process. Transparency was facilitated by methodically documenting communications, procedures, processes, and problems identified during the research, including how such problems were responded to and accounted for. This documentation was important given that the intimate involvement of the researcher in the DBR process is recognized as a potential challenge for the researcher [30, 31]. The collaborative researcher-participant relationship resulted in the researcher needing to manage the roles of researcher, educator, and colleague in the CoL. The data from the journals helped clarify these roles, track the complex sequence of events, and understand how and why the multiple design decisions that occurred in the study contributed to the credibility and trustworthiness of the research.

In addition to the use of multiple data sources to make connections between intended and unintended outcomes, member checking, external audits, and expert opinion were employed to further ensure trustworthiness and credibility of the research. Member checking involved regularly asking participants for their feedback on data interpretation and findings to assess their representativeness, completeness, and fairness throughout the study. Regular discussions with fellow researchers regarding decisions, next steps, and emerging findings provided objective feedback that also enhanced the credibility and trustworthiness of the research. External audits of data and activities were conducted by a research assistant. The research assistant took notes and observed individual (including the researcher) and group interactions during all workshop activities. These notes and observations were reviewed after each workshop and were also treated as data sources.

As data were collected, they were cleaned and entered into Microsoft Excel© and QSR NVivo 10© for analysis. A systematic process, informed by the principles of grounded theory, was used for coding and to identify emerging themes [32, 33]. Four analysis cycles occurred during the study. The first cycle was a preliminary data analysis that occurred after each CoL activity was completed to iteratively inform the next steps in the design of the CoL. The second cycle was a sequential, time-based approach that analyzed the data in the order that it was collected after all data collection was completed. This facilitated collation and synthesis of data and resulted in the identification of several broad, overarching categories. The third analysis cycle involved

a thematic approach. All data sources were re-examined and recoded under the categories identified in the second cycle to further synthesize and integrate data. This facilitated the development of explanatory relationships between themes. The fourth cycle of analysis occurred while writing about the themes. During this phase, identified relationships were refined into visual diagrams and models.

## RESULTS

### Description of CoL participants

The eight CoL ICP participants worked in all five AHS zones across the province, which included both urban and rural settings as well as acute, continuing, and community healthcare sectors.

The participants' years of experience in IPAC varied and they came to IPAC with training in a variety of professional backgrounds, including microbiology, epidemiology, and nursing. Some of the participants had experience teaching in nursing programs and colleges, and most had engaged with clinical nurse educators in the various portfolios they covered. While three reported some education training as a part of their degrees, the ICPs indicated that most of their training as teachers was experiential based on practice, trial and error, observing others, and obtaining feedback from learners. The key reasons ICPs identified for participating in the CoL were because there was "no formal training for educating in IPAC" and "the desire to be part of a group to share experiences and learning," as "ICPs often educate in isolation."

### Impact of the CoL: What ICPs learned

The ICPs reported several learning outcomes from participation in the CoL, which aligned with three themes: a) developing awareness, b) learning about learning, and c) learning in community. They reported developing a greater awareness of their own and AHS IPAC program teaching processes and where they were in relation to those processes. The ICPs reported that the IPAC Program relied primarily on the use of PowerPoint "as the unspoken but expected approach" for teaching: "This is how our department does things and sends messages out." One ICP indicated that learning about pedagogical concepts created awareness by making her implicit practices explicit: "I often used elements of adult principles and didn't know that they were a thing!" The ICPs reported becoming aware of different teaching strategies, beyond those they had been using, which provided them with resources and ways to change their practice: "I think that coming to IPAC it felt like I needed to use PowerPoint but now I know it is okay to use other methods and it works." The ICPs also reported becoming more aware of the importance of their role as educator, noting that "one of the main things is that we're all kind of in the same boat so it's nice to know that you're not alone" and that "There are others who yearn to become better educators." Developing increased awareness of diverse practices enabled the ICPs to understand and reflect on their present educational practices in order to make changes.

In addition to increasing their awareness of educational practices, the ICPs indicated they "learned about learning." ICPs reported learning new terms such as "transformative

learning," that there were "different teaching strategies to facilitate learning, and these approaches could be used for different reasons," and that "designing for teaching was important to facilitate learning, rather than just focusing on content." They also reported that it was "easy to be complacent and focus on content, forgetting the value in knowing how to do our teaching." They valued learning that "research[-]validated approaches to more effective teaching" existed. Exposure to research literature both affirmed and validated their frustrations regarding surface approaches to education.

Learning about learning in community resonated strongly with the ICPs. They identified the value and importance of being able to share, support, and learn from each other in the context of community: "We are stronger and better together" and "We're all experiencing a lot of the same challenges." They valued discussion that was "open, free[-]flowing, comfortable and honest." The ICPs talked about group cohesion in terms of "camaraderie" and having "an appreciation for each other." They talked about wanting to "continue to grow, learn and work together."

Diversity of voice in the context of community was also important to ICPs and they valued "being able to hear different perspectives." The benefits of shared experience included being able to strategize together and being supported by their connectedness. Emotionally, ICPs felt sustained by each other: "It's quite energizing, to hear all the different voices and sort of hear echoes of what I was thinking." The ICPs talked about connecting ideas by "obtaining insights I had not considered" and remarked that group discussions often provided "closure to ideas." Over the course of the CoL, the ICPs formed a group identity, which speaks to the value and importance of collaborative learning. They also appreciated being able to "put their learning into practice through activity." The ICPs noted that by working collaboratively, they shared the workload. Working as a group was easier than working individually. The shared workload helped support them in attending to their other work responsibilities while working to achieve CoL deadlines. The collaborative design offered flexibility, and the core FL project could keep moving forward while individual ICPs could come and go, getting caught up and learning from the group upon their return.

### Impact of the CoL: What changed

In addition to growing awareness, learning about learning, and experiencing new teaching and learning concepts, the ICPs also identified that their perception of themselves as teachers and their teaching practices had changed. At the end of the CoL, the ICPs talked about being more comfortable with seeing themselves as educators. As one ICP noted, "I believe, at the beginning, most of us wouldn't talk about ourselves as teachers." While exploring their identity as educators, the ICPs found being called an educator either "intimidating" or "empowering" or both. Being empowered was viewed as positive, being able to influence others, and having good resources and tools to be more effective at facilitating learning and engaging learners. Being intimidated, on the other hand, was linked to an "imposter syndrome, kind of

almost like you're pretending." ICPs felt like they were educating but did not feel qualified: "Anyone can educate, but not everyone is an educator." They noted that being an educator is an expected core competency in the IPAC profession, but they did not feel they possessed that competency. While they taught as part of their role, they felt the formal role of educator goes unrecognized because it is embedded in their consultative practice.

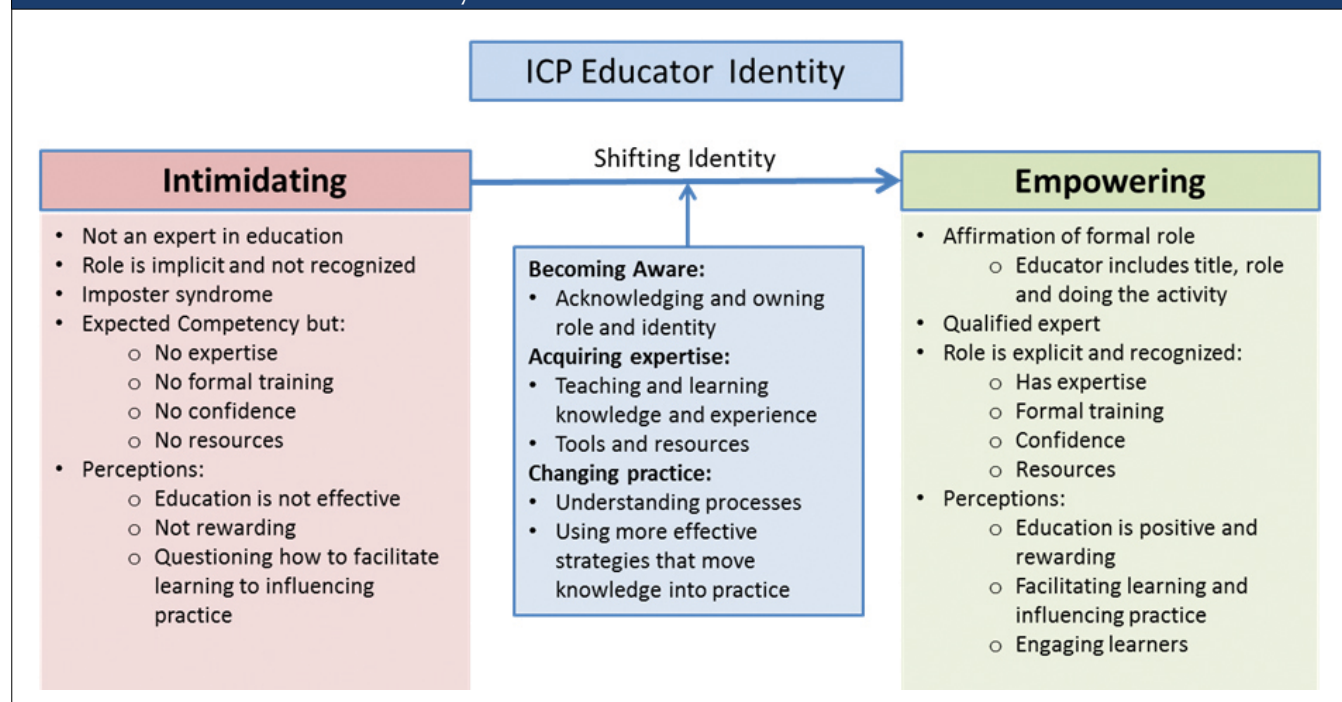
To shift from intimidation to empowerment in their educator role, ICPs reported needing to develop awareness and ownership of their educator role, to make their implicit educational role explicit, and to acquire teaching and learning knowledge and experience. Their identity as educator was linked to feeling competent and having expertise. As one ICP noted, "I feel like I have some authority behind my opinions. It's not just opinion[;] now it's backed by a bit of research and theory [...and] I can kind of spew out some of those key words and talk about them." Research-informed practice led to a sense of validation in the ICPs' educator roles. The ICPs valued acquiring resources because these provided a context and language for understanding their teaching and learning practices. These resources were practical tools that would support continued growth and ability to implement new teaching strategies. The ICPs also discovered resources in each other, drawing on each other's knowledge and experiences. Figure 2 summarizes the issues regarding ICPs' identity as educators and how they shifted from feeling intimidated to empowered in that role.

The ICPs reported that the shift in their identity as teachers and their thinking about teaching and learning also changed their teaching practices. Gaining insight into their role and teaching practices, greater understanding of pedagogical concepts, and a language to understand their practices helped the ICPs to begin to modify their practices. Modifications

included shifting from relying on PowerPoint to incorporating more interactive components in their teaching.

Initial field observations of ICP educational practice conducted prior to or near the beginning of the CoL supported the findings from the self-reported data that ICPs tend to use a teacher-centric approach to their education. ICPs' teaching focused on providing information using PowerPoint. When case scenarios were embedded in their presentations, the ICPs used a traditional question-and-answer style of interaction with the learners, resulting in limited learner engagement. The types of incremental practice changes reported by the CoL ICPs were corroborated by the later field observations. Two of the CoL ICPs' practices were observed after the completion of the CoL. Both of the observations were of formal in-service education sessions. While both of the ICPs still employed an overall teacher-centric information-giving approach, both had modified their approaches to include interactive activities interspersed throughout the sessions. The nature and application of learner activities suggested more attention was being given to designs for learning rather than information-giving. While both ICPs still used PowerPoint, the content in slides did not focus on a series of facts or information. One ICP used the PowerPoint technology to design a learning activity in which learners took control of the technology and used a drag-and-drop feature to document the other learners' responses to an IPAC scenario. The other ICP incorporated a video on vaccination to promote discussion and invited learners to work together in small groups to discuss issues they had each observed in the video. The small groups were then asked to share highlights of their discussion with the larger group. Both ICPs achieved greater HCW engagement in their education sessions by moving away from reliance on information-giving via PowerPoint and conventional

FIGURE 2: Issues related to ICPs' identity as educators.



question-and-answer approaches and toward learning activities designed to engage learners in discussions and debates with each other.

ICPs moved from designing content to designing more for learning. As one ICP shared, "I loved the comment, 'If you can't change the content, change the method of delivery.' A lot of what we need to teach them can be dry, but the way we teach doesn't have to be." Another ICP noted, "I didn't give much thought before to lesson planning. And now I give more thought to learning style and just sort of thinking more about the learning than just thinking about the tasks, the outcomes." The ICPs also reframed how they perceived learners. For example, one ICP stated, "I guess I don't see learners in the same way, throwing information at them as empty vessels. I now see them as having more responsibility for their learning. Maybe now thinking about them being invested enough in the information that they actually feel sort of empowered by it."

Although ICPs indicated they had more confidence in planning education, they noted that this was different than having confidence in actually applying and practicing it: "So I guess I have more confidence in the planning and presentation of myself as an educator, not in doing education." The ICPs identified that these newer approaches take more time and are more demanding of them but felt they would result in greater satisfaction from achieving better outcomes. They reported that change was challenging, and there was an element of discomfort in moving out of practices with which they were comfortable. Their response was to take smaller steps by integrating more interactive activities in their education sessions and relying less on PowerPoint, using it more as a guide instead. The ICPs reported moving toward more open, participatory education. As they did so, they found the experiences more rewarding.

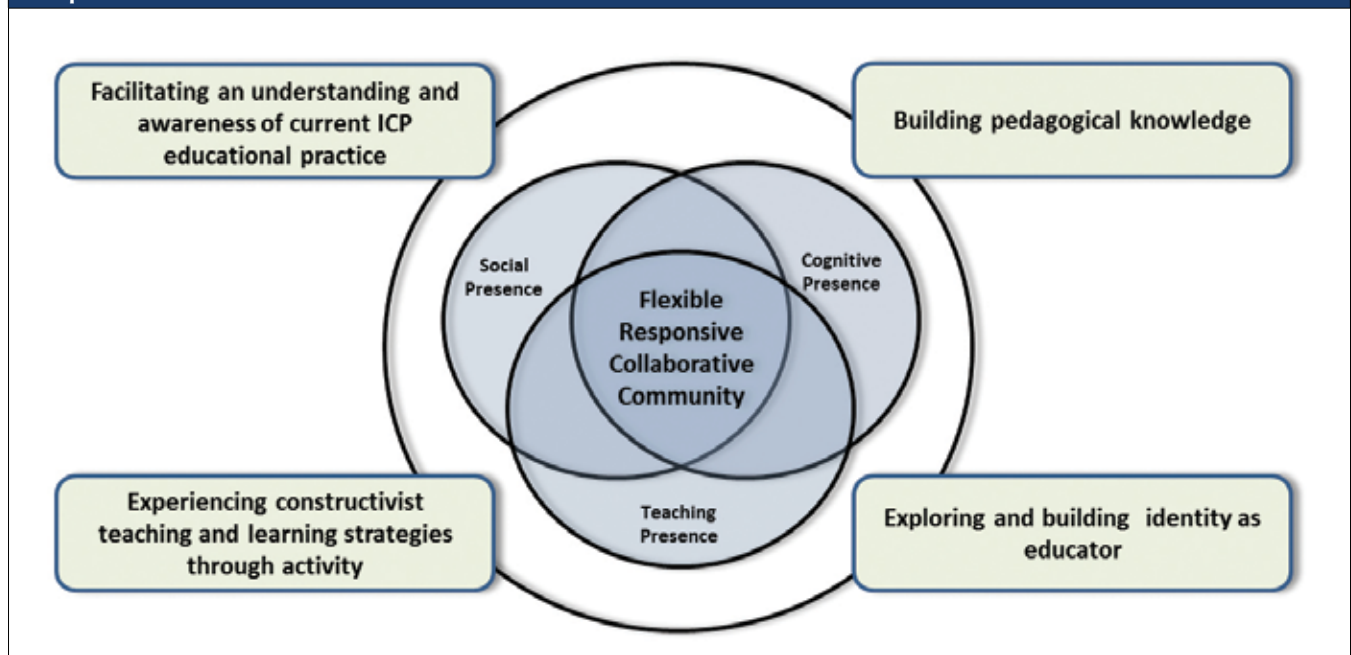
### The process of learning and change in the CoL

The ICPs described the CoL learning experience as positive and rich despite the fact that it was more involved than they had expected. They indicated participating in the CoL was "not like attending a conference, workshop, or course where your role is to be a student." The ICPs indicated learning was achieved through disruption of their thinking, by experiencing a different style of learning, applying that different style, and challenging their perceptions of themselves. The constructivist experience was not always easy. The ICPs noted that it could be "challenging, difficult, and sometimes confusing," reporting that they "had to learn new learning processes themselves." Figure 3 summarizes the interventionist pedagogical design framework that emerged from the CoL PDE that facilitated a shift in the ICPs' thinking and understanding of learning and changes to their teaching practices.

Community was at the core of the framework. To create a positive, responsive, and collaborative learning community, the CoL design attended to fostering the concepts of social, cognitive, and teaching presence (see Table 2 for descriptions of social, cognitive, and teaching presence). This facilitated emotional support and a sense of belonging through the social relationships that were built based on open, honest communication and sharing and a sense of collective responsibility and accountability in the group. This also supported flexibility in responding to the ICPs' IPAC practice needs. This was particularly important because the CoL was situated in the context of the ICPs' workplace, with all the entailing demands and upheaval.

Within the CoL framework, four main strategies informed the building of the ICPs' pedagogical expertise: 1) creating an awareness of ICP educational practice, 2) building ICP pedagogical knowledge, 3) experiencing different teaching and learning strategies, and 4) building identity as educators.

**FIGURE 3: An interventionist professional development framework to facilitate change in ICP educational understanding and practice.**



Facilitating the ICPs' awareness of their educational practice and making their underlying assumptions about that practice explicit was achieved through reflection and discussion. This enabled the ICPs to identify key teaching and learning challenges and to understand the reason for and nature of those challenges in order to have intentional and informed dialogue regarding possible solutions to address those challenges.

To have informed dialogue, the ICPs needed pedagogical knowledge, a vocabulary, and a conceptual framework with which to discuss and reflect on their problems and possible solutions. This was accomplished by providing the ICPs with pedagogical content, scaffolding their learning experiences, and sequencing learning activities and role modelling to make those pedagogical concepts and experiences more explicit.

To achieve deeper learning, the ICPs needed to apply their knowledge. The ICPs were therefore engaged as learners to collaboratively use different teaching and learning strategies so they could better understand the strategies through lived experience. ICPs also experienced the value of distributed knowledge building through involvement in and reflection on experiences in the CoL.

Lastly, in order to be open to new approaches and perspectives for teaching and learning, the ICPs needed to embrace their identity as educators. This required opportunities to make their implicit educator role explicit and recognize they were not alone or isolated in their educator role or practices. Opportunities to build their identity as educators through the acquisition of knowledge, resources, experience, and pedagogical language led to ICPs feeling more validated and empowered in modifying and making changes to their practice.

### Limitations

Due to this study's small sample size, the findings may be reflective of this particular study group's educational training and experience and may differ if repeated elsewhere. Also, the unique nature of the AHS organization must be considered, as healthcare is a provincial responsibility. Organizational policies and procedures vary between provinces and territories and the IPAC programs within them, potentially impacting IPAC educational culture and teaching practices. The findings and design framework that emerged from this study are based on the first macro cycle of the DBR methodology contributing primarily to local practice and theory. DBR is a long-term research process requiring a series of macro cycles to upscale local theory to achieve more generalizable, higher-level theory for the broader ICP population and for ICP educational practices in general. For these reasons, additional cycles will need to be conducted to refine the emerging theory and educational professional development framework. Further testing of the design framework in the context of other IPAC programs will be important.

### DISCUSSION

The notion of conceptual change embodies the idea that learners must build new ideas in the context of old ones, emphasizing change rather than the acquisition of knowledge [34]. Significant learning, such as that involved in conceptual change, is not

easy [15]. Transformative learning requires the disruption of belief systems, attitudes, and behaviours. Incorporating new ideas and concepts can be uncomfortable and disconcerting. The PDE framework described in this paper outlines a set of guiding principles to facilitate the creation of an intentionally disruptive yet positive and responsive learning experience to promote change in ICPs' educational practice.

To accommodate the demands of the workplace in which the PDE was situated, it was necessary to design for responsiveness and flexibility. Flexibility is a key instructional design consideration in collaborative learning communities so that the learning environment can be responsive to the complex nature of the teaching and learning process. The designer of the learning environment also needs the flexibility to adjust the learning design within the teaching and learning goals to negotiate emerging and unexpected events [23, 35].

Because the PDE was focused on situated learning in community, consideration was given to the learning environment in which the learners interacted and the concepts and resources provided [36]. The CoL framework, comprising social, cognitive, and teaching presence, provided a useful conceptual structure to support the design of the learning environment [23]. CoL concepts align naturally with the ICPs' workplace practice. ICPs regularly work collaboratively in teams with various stakeholders to solve problems such as those encountered during outbreaks (social presence). ICPs draw on scientific evidence and best practice to make decisions (cognitive presence) and they often engage in coaching and mentoring each other (teaching presence) as they cross-cover each other's areas of specialty. It is not surprising, therefore, that using the various CoL presences worked well in designing the CoL environment.

Designing for sociality in the learning environment is important to consider in future CoL experiences, especially given the importance the ICPs gave to this aspect of the CoL and because the social dynamics will likely vary with different groups of ICPs. It has been reported that the nature of social, cognitive, and teaching presence may change with different learner profiles [37]. The ICPs identified that the activities in the CoL did not just disrupt their thinking, but also required that they learn different ways of learning. Accordingly, individual learner attributes and abilities, in particular the ICPs' approach to learning and need for sociality, need to be considered in designing future iterations of the CoL.

The CoL instructional design focused on developing learning by the community as opposed to by the individual. Knowledge building at the community level focuses on the idea of knowledge creation and advancement through idea improvement and developing knowledge that is deeper and richer, akin to understanding the "how and why" of something, not just the "what" [18]. To facilitate such collaborative knowledge building, it was important to focus on meaning-making (i.e., making sense of constructivist teaching and learning processes situated as ICP educators) through joint activity [13, 38]. This necessitated designing activities that involved creation and evaluation, which require higher-order thinking, as described in Bloom's revised taxonomy [39].

Acquiring knowledge of learning concepts and teaching strategies provided the ICPs with a pedagogical vocabulary with which to dialogue about their educational practice. This articulation was helpful for learning, as it made reflection and metacognition about the process for teaching and learning possible, giving ICPs the ability to reframe their educational challenges and to identify potential solutions [21]. Discussion in the CoL supported learning through argumentation as the ICPs debated and questioned their ideas and experiences, working together to make sense of the ideas they were encountering in relation to their educator role and practice. Argumentation has been identified as an effective method for learning as it not only facilitates making knowledge explicit, but can also facilitate conceptual change and co-elaboration of new knowledge [40]. Such discussions, grounded in an understanding of the ICPs' current educational practice, provided a foundation on which to build pedagogical knowledge. Grounding the learning in the ICPs' prior knowledge and experience made the new information more relatable and relevant, a key principle of adult learning [41].

The need to build the ICPs' identity as educators emerged during the DBR iterative process and became an important design principle. Because learning transforms who we are and what we do, it is an experience of empowering identity [42]. The process of "becoming" is not simply a matter of the acquisition of knowledge and skills; it is a process of transforming knowledge within a context. Therefore, the development and affirmation of the ICPs' identity as educators was supported by engaging in situated learning activities to develop ICP educational expertise as part of a community.

Participation in the CoL PDE resulted in changes in the ICPs' understanding of teaching and learning, their sense of identity as educators, and changes in their teaching practices. Upon completion of the PDE, several of the ICPs who participated in the CoL participated in the creation of an AHS ICP education CoP to continue developing their educational expertise and practice along with other ICPs in the AHS IPAC program. The findings and local changes resulting from this research, while positive and successful, constitute an important first step toward the greater goal of building ICP educational expertise and practice in the profession generally. The IPAC profession would benefit from developing partnerships with educational experts from the Learning Sciences to further our educational understanding and research. By building such expertise, our understanding of the value, relevance, and effectiveness of IPAC educational practices can be re-evaluated and IPAC educational research can be opened to new discoveries and advances in teaching and learning to improve our ability to effect behavioural change among HCWs.

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# Incidence of surgical site infections after caesarean sections in a community hospital

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## ABSTRACT

**Background:** Rates of performed caesarean sections have increased globally [1]. Surgical site infections (SSIs) following a caesarean section pose a threat to the safety of the patient. This study intended to determine the current SSI rate after caesarean sections at one community hospital. The rate of incidence of these infections was compared to benchmark rates from various studies, including a report from the American National Healthcare Safety Network (NHSN). This comparative study provides objective evidence of performance in relation to SSIs.

**Method:** The primary data collection method included a form completed by the obstetrician-gynecologists of the individual patients at the six-week post-partum follow-up visit. Demographic data was collected retrospectively through analysis of medical records. Patients who underwent a caesarean section in the seven-month data collection period (between November 2015 and May 2016) were asked to participate, and consent was obtained.

**Results:** A total of 118 caesarean sections were reviewed and seven SSIs diagnosed. A crude SSI rate was calculated at 5.9%. For further insight, NHSN risk-adjusted SSI rates were calculated. The NHSN risk-adjusted SSI rate was determined at 6.1% for those patients presenting with a risk index level of 0 and at 5.9% for those with a risk index level of 1. Both NHSN risk index levels of 2 and 3 were identified to have an adjusted SSI rate of 0.0%.

**Conclusion:** This study, while limited in scope, does add to the collective literature on SSI rates following caesarean sections. Most significantly, it provides a methodology for other centres interested in determining their own infection rates and could lead to improved practices and better patient outcomes.

## KEYWORDS

Surgical site infection rate; caesarean section; community hospital

## INTRODUCTION

Healthcare infections can contribute largely to the morbidity and mortality of hospitalized patients. This study examined post-caesarean section surgical site infection (SSI) rates at a community hospital and compared these rates to other reported benchmarks. Globally, the rate of caesarean sections performed has increased [1]. In Canada, the 2016-2017 rate of caesarean sections performed was 28.2% of births, an increase from the previous 26.7% of births in 2007-2008 [2]. Following a caesarean section, it has been reported that 3% to 15% of patients develop an SSI [1, 3].

Many studies have examined and reported benchmark post-caesarean section SSI rates, with differing results. For

example, the National Healthcare Safety Network (NHSN) conducts a multitude of studies on SSIs using a risk index classification system. The NHSN risk index is defined as either a score of 0, 1, 2, or 3, with benchmark rates for post-caesarean section SSIs presenting at 1.46%; 2.43% for level 0 and 1, respectively; and 3.82% for 2 and 3 combined [4]. Additionally, in a study conducted in 14 National Health Service (NHS) hospitals in England, a crude post-caesarean section SSI rate of 9.6% was reported [5]. These two published studies demonstrate some of the research done on post-caesarean section SSI rates and represent the low and high ends of reported benchmark SSI rates.

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Obstetric infections pose a threat to post-caesarean section patients, as they account for approximately 12% of maternal deaths [6]. Thus, it is important to monitor the rate of infections within a hospital and to compare the rates of incidence with other benchmarks. Additionally, there was a perceived increase of SSIs in post-partum patients at the community hospital, which provided impetus for this study. This study provides another SSI benchmark that can inform the ongoing understanding of surgical infection rates after caesarean sections.

## METHODS

The purpose of this study was to generate a post-caesarean SSI rate for the community hospital and to compare it to other reported SSI rates. The study population was derived from one community hospital and patients were recruited during a seven-month time period. Data was collected from patients who were over the age of 18, who consented to participate in the study, and who underwent a caesarean section between November 2015 and May 2016 at the community hospital.

The research setting was a community hospital that serves a large rural area but is situated in a city of approximately 30,000 residents. The hospital is part of an alliance with three other, smaller community hospitals and provides comprehensive services with 118 beds [7]. The community hospital performs on average 250 caesarean sections annually.

There were two main data collection points. The first consisted of a qualitative survey distributed to the patients' obstetrician-gynecologists (OB-GYNs) for completion at the six-week post-operative follow-up appointment. The second collection period involved a retrospective chart review related to patient demographics and risk factors. Both data sets were collated and quantified for analysis. Demographic data and risk factors gathered in the second collecting period were then used to assign each patient a NHSN risk index factor. A crude SSI rate and NHSN SSI rates, separated by NHSN risk index scores, were calculated. A comparison of the community hospital's post-caesarean section SSI rates with other reported post-caesarean section SSI rates was conducted using statistical evaluations.

The survey distributed to OB-GYNs at the six-week follow-up appointment requested the following information: patient's hospital identification number, surgeon's name, date of the follow-up appointment, and whether the appointment was scheduled or an emergency visit. OB-GYNs also reported if the patient had an SSI and, if so, whether the SSI was classified as either a superficial incisional SSI, a deep incisional SSI, an organ/space SSI, endometritis, no infected complications, or other. Attached to the survey form was a table published by the Centers for Disease Control and Prevention that classifies superficial incisional SSIs, deep incisional SSIs, and organ/space SSIs [8].

Patients' demographic data was retrospectively collected through an analysis of patient medical charts. Factors were identified as important data collection points following a review of related literature and so that NHSN risk indexes could be generated [9-13]. The following factors were recorded: age of patient, gestational age at time of operation, nature of

caesarean section (emergency or elective), American Society of Anesthesiologists (ASA) score, wound class, if prophylactic antibiotics were used, if the patient experienced premature rupture of membranes (PROM) or had a predisposing illness, and length of procedure from cut to close.

Following analysis of both the surveys and the medical records, each patient's risk factor was determined using the NHSN classification method. One point was assigned for each of the following indicators: an ASA score between 3 and 5, a wound classification of dirty or contaminated, and/or an operation that lasted longer than the recommended average length for the procedure [14]. A target length of 56 minutes for the caesarean section was chosen, as this is the duration recommended in the NHSN report [4]. In accordance with the NHSN process, each of these categories were allocated a rating of 1, and patients were then ranked with a composite risk score [4].

Once data was collated, the crude SSI rate and the NHSN risk-adjusted SSI rates were calculated. The crude SSI rate was calculated using the following formula:  $[\text{total number of infections} / \text{total number of caesarean sections performed}] \times 100$ . The NHSN risk indexes that were assigned to each patient were used to calculate the NHSN risk-adjusted SSI rate. Each risk-adjusted SSI rate was calculated using the following formula:  $[\text{number of infections in each risk index} / \text{number of caesarean sections performed in each risk index}] \times 100$  [15]. In order to compare the community hospital's SSI rate with other benchmarks, various other studies were selected from the literature. Statistical analysis of compared benchmark rates were calculated using MedCalc and the "N-1" chi-squared test, as recommended by Campbell (2007) [16] and Richardson (2011) [17]. The confidence interval was calculated according to the recommended method given by Altman et al. (2000) [18].

Standard of care following the caesarean section was not altered for patients participating in this study, as a six-week post-operative follow-up appointment is the recommended practice. If a patient developed a complication before the follow-up visit, they were advised to contact the surgeon's office. If the patients were seen at the Emergency department or family physician's office, physicians were advised to contact the patients' surgeons so that data could be accurately recorded. The study protocol was approved by the University of Western Ontario and Huron Perth Healthcare Alliance ethics review boards.

## RESULTS

The study population was derived from one community hospital and patients were recruited during a seven-month time period. A total of 123 patients consented at the outset to participate in the study; however, survey data was not received for five patients. Therefore, the results of this study represent the 118 patients who underwent caesarean sections in the time period and for whom surveys were collected. The patients ranged in age from 20 to 45 years old. The majority (87.3%) delivered at the gestational age of between 35 and 39 weeks. 75 of the 118 procedures were noted as emergency procedures (63.6%).

In addition to demographic information, a review of predisposing illnesses and risk factors was conducted. The highest reported risk factor in the study population was gestational diabetes, wherein 8.5%, or ten patients, had this diagnosis. Three patients were reported to have had gestational hypertension and one patient was reported to have had diabetes. Body mass index (BMI) was only recorded for patients with a BMI above 40, and those patients with scores between 40 and 50 represented 2.5% of the overall study population, or three patients. One patient had a recorded BMI above 50.

Table 1 depicts data that was used to calculate the NHSN risk index scores for the cohort patient population [4, 14].

Table 2 reports the crude SSI rate and a risk-adjusted SSI rate for each risk index level [4].

The following observations can be made related to specific demographic and operational data of the seven patients who developed SSIs. Of particular note is the fact that the majority of the patients, or five patients in the cohort of those infected, had developed an SSI following an emergency caesarean section. Additionally, although there are four cases of predisposing illnesses, including gestational diabetes, PROM, an elevated BMI, and/or diabetes, some patients had more than one predisposing illness. This information will not be broken out in order to maintain patient confidentiality.

## DISCUSSION

The purpose of this study was to critically examine the crude and risk-adjusted SSI rates after caesarean sections at a community hospital and to compare these rates with other benchmarks. Studies from Nova Scotia, Saskatchewan, England, and Texas were chosen as basis for crude rate comparison. Statistical analysis was conducted to compare each of the chosen four benchmarks with the community hospital's SSI rate.

The Nova Scotia study consisted of 25,123 patients over a 16-year period and reported a crude SSI rate of 2.7% [19]. Statistical analysis of this study compared to the community hospital's SSI rate shows a difference of 3.2%, a 95% confidence interval (CI) of 0.1747 to 9.0023, a chi-squared value of 4.555, degrees of freedom (DF) of 1, and a significance level of  $p = 0.0328$  [20]. Saskatchewan performed an evaluation of eight regional authorities with a combined cohort of 3,437 patients over a one-year period with a reported crude SSI rate of 3.5% [15]. Statistical analysis showed a difference of 2.4%, a 95% CI of -0.6915 to 8.2266, a chi-squared value of 1.903, DF of 1, and a significance level of  $p = 0.1677$  [20]. A third study from England collated a study cohort of 4,107 patients from 14 NHS hospitals over a six-month period and demonstrated a crude SSI rate of 9.6% [5]. Statistical analysis of this study compared to the community hospital showed

**TABLE 1: Data used to calculate the NHSN risk index.**

Characteristic	Number of Patients		Percentage of Patients	
	SSI developed		SSI developed	
	No (111 patients)	Yes (7 patients)	No (111 patients)	Yes (7 patients)
<b>Wound class</b>				
Clean	31	2	27.9%	28.6%
Clean-contaminated	78	5	70.3%	71.4%
Contaminated	0	0	0.0%	0.0%
Dirty	0	0	0.0%	0.0%
Not reported	2	0	1.8%	0.0%
<b>ASA score</b>				
ASA 1	40	2	36.0%	28.6%
ASA 2	39	3	35.2%	42.8%
ASA 3	31	2	27.9%	28.6%
ASA 4	1	0	0.9%	0.0%
ASA 5	0	0	0.0%	0.0%
ASA 6	0	0	0.0%	0.0%
<b>Length of procedure</b>				
< 56 minutes	106	7	95.5%	100.0%
≥ 56 minutes	5	0	4.5%	0.0%

**TABLE 2: Crude SSI rate vs NHSN risk index-adjusted SSI rate.**

Parameter	Number of Procedures	Number of Infections	Surgical Site Infection Rate
<b>Crude SSI calculations</b>	118	7	5.9%
<b>NHSN risk-adjusted SSI calculations</b>			
Risk index 0	82	5	6.1%
Risk index 1	34	2	5.9%
Risk index 2	2	0	0.0%
Risk index 3	0	0	0.0%

a difference of 3.7%, a 95% CI of -2.1631 to 6.8611, a chi-squared value of 1.827, DF of 1, and a significance level of  $p = 0.1765$  [20]. The last study used for comparison was from Texas. It comprised a review of 19 hospitals, representing 57,182 patients over a three-year period, and reported a crude SSI rate of 6.5% [21]. Statistical analysis for comparison shows a difference of 0.6%, a 95% CI of -5.2026 to 3.6253, a chi-squared value of 0.070, DF of 1, and a significance level of  $p = 0.7917$  [20]. The community hospital's crude benchmark SSI rate of 5.9% lands in the middle of the range of other benchmark SSI ratings.

Studies were selected from both Saskatchewan and the NHSN as they offer benchmarks using the risk-adjusted SSI rates. As noted in Results, the community hospital reports an SSI rate for risk index 0 as 6.1% (82 procedures), for risk index 1 as 5.9% (34 procedures), and for risk index 2 and 3 as 0.0% (two procedures). The NHSN study found risk level 0 had an SSI rate of 1.46% (20,743 procedures) [4]. Statistically, this compared to the community hospital's findings with a difference value of 4.64%, a 95% CI of 1.1696 to 12.0368, a chi-squared value of 12.073, DF of 1, and a significance level of  $p = 0.0005$  [20]. NHSN risk level 1 had an SSI rate of 2.43% (8,995 procedures); statistical values were calculated with a difference value of 3.47%, a 95% CI of -0.8075 to 16.6910, a chi-squared of 1.711, DF of 1, and a significance level of  $p = 0.1909$  [4, 19]. Risk indexes 2 and 3 from the NHSN were reported with a combined SSI rate of 3.82% (1,256 procedures) [4]. Comparative statistical analysis could not be completed, as the null hypothesis was not comparable. In the same Saskatchewan study mentioned above, patients were categorized into NHSN risk indexes and SSI rates were calculated for each NHSN risk index. For risk index 0, an SSI rate of 2.8% was reported (2,496 procedures) [15]. Statistical analysis comparing to the community hospital's results show a difference of 3.3%, a 95% CI of -0.2408 to 10.7178, a chi-squared value of 3.064, DF of 1, and a significance level of  $p = 0.0800$  [20]. Risk index 1 reported an SSI rate of 5.1% (692 procedures), with a comparative statistical analysis of difference of 0.8%, a 95% CI of -3.8686 to 14.0921, a chi-squared value of 0.042, DF of 1, and a significance value of  $p = 0.8367$  [15, 19]. The Saskatchewan study reported an SSI rate for risk index 2 and 3 of 14.0% (50 procedures) [15]. No statistical analysis was calculated, as null hypothesis is not comparable. Not included in the Saskatchewan study NHSN risk index breakdown are 162 procedures with unknown risk indexes with a 4.3% calculated SSI rate [15].

Both of these study findings demonstrate increasing SSI rates as risk indexes increase. The studies' findings would support the supposition that increased risk indexes would contribute to an increased likelihood of the development of an SSI post-caesarean section [4]. This result differs from the findings of the present study, where a higher SSI incidence rate was found in those patients identified with the lowest risk level. These differences could be attributed to the limited number of patients (118) in the study cohort and, even more significantly, to the small number of patients (seven) presenting with an SSI.

It is expected that results could differ if this study duration was extended and therefore would be able to access a larger cohort of participants.

Nonetheless, a noteworthy finding is the prevalence of emergency caesarean sections for patients in this study. At 63.6% (75 procedures), most of the caesarean sections were performed as emergency procedures. Multiple studies have concluded that the performance of an emergency caesarean section increases the risk of the development of an SSI, and this could have contributed to the elevated rate of SSIs for those who appeared to have low risk factors [22, 23]. In this study, five of the seven patients (71.4%) presenting with an SSI had undergone emergency caesarean sections.

This study faced limitations, first and foremost related to the size of the study cohort. With only seven reported SSIs, the study was limited in its ability to generalize findings. Additionally, given that part of this study was premised upon predominantly qualitative information provided through surveys completed by numerous OB-GYNs, there could also be questions about the reliability and validity of the data, as well as limitations reflected in the physicians' willingness to complete the surveys. Recall that five surveys from consenting participants were not received for analysis. Also, patients who presented to other physicians with normal wound swelling and inflammation could have been misdiagnosed with an SSI. Therefore, there is the possibility that some data could represent false positives. And, finally, there were limitations in the data collection processes in that information about some risk factors, such as obesity, were not comprehensively collected. Specifically, while a BMI above 35 is identified as obese, the surveys only collated data for those patients with levels above 40. Studies would identify obesity as a predictive risk factor and a fulsome collection of this information for this study could have provided another lens through which to examine the results [6, 24].

Despite the limitations of the cohort size and data collection mechanisms, this study adds value by contributing to the literature on SSI rates and provides opportunities for next steps. The methodology is replicable and could serve as a means for this or other community hospitals to develop quality control indicators. Moreover, there are advantages that resulted from our methodology. These include improved classification of SSIs through physician diagnosis and reporting of these infections. Furthermore, by advising all physicians to refer patients with suspected SSIs to OB-GYNs, both patient records and SSI information were collated into the centralized hospital database.

Additionally, this study could support the development of a provincial SSI surveillance program with established benchmark targets similar to those established in Nova Scotia and Saskatchewan [15, 20]. A provincial SSI benchmark would enable hospitals to have evidence-informed comparatives, which could then be monitored and addressed. An increased understanding of the SSI rates for caesarean sections across the province could inform decisions about how to best minimize patient risks and decrease complications related to this increasingly prevalent procedure.

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# Urine collection practices in a small rural hospital: Evaluation of alignment with antimicrobial stewardship guidelines

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## ABSTRACT

**Background:** The diagnosis of a symptomatic urinary tract infection (UTI) can be challenging among elderly patients, resulting in an increased risk for specimen collection and treatment of asymptomatic patients. The Vancouver Coastal Health Authority's Antimicrobial Stewardship Guidelines provide a systematic approach to support clinicians in the assessment and treatment of UTIs. The purpose of this quality review was to evaluate if urine collection practices were in alignment with the guidelines.

**Methods:** The review involved a retrospective examination of all urine specimens collected from medical and surgical patients of a small rural hospital from September 1, 2015 to August 31, 2016. A survey of staff was also conducted to evaluate the interdisciplinary team's knowledge of urine collection and interpretation and to assess concordance with the guidelines.

**Results:** 318 urine cultures were reviewed, of which only 78 (24.5%) met microbiologic criteria and were considered to be positive cultures. A large proportion of samples resulted in mixed organisms. There was a highly statistically significant relationship between urinalysis and a positive culture (Fisher's exact test  $p < 0.0001$ ). A positive urine culture ( $> 100$  million CFU/L) was statistically significantly more likely to be observed when there was a positive urinalysis.

**Conclusions:** Older adults represent a large and growing population of hospitalized patients. Diagnosis of a symptomatic UTI in the elderly can pose challenges. Urine cultures are frequently obtained and a high proportion sent for culturing with missing or negative urinalysis. Urinalysis results are pertinent in the diagnosis of a UTI as there is correlation between a positive urinalysis and a positive urine culture. Adoption of a systematic approach in the management of UTIs would result in consistent and appropriate assessment and treatment of UTIs for elderly patients.

## KEYWORDS

Elderly; urinary tract infections; urinalysis; antimicrobial stewardship; systematic approach

## INTRODUCTION

Urinary tract infections (UTIs) have been identified as the single most common healthcare-acquired infection, accounting for 40% of all hospital-acquired infections and resulting in a substantial burden for patients and the healthcare system [1-3]. UTIs impact patient morbidity and mortality, which can lead to delirium, falls, and an increased length of stay in hospital [4, 5].

Older adults are at a greater risk for UTIs due to increased post-void residual volume, prostatic hypertrophy, age-associated changes in immune function, and a growing number of comorbidities [4, 6-8]. Hospitalized older adults generally have more functional impairments, higher cognitive deficits, and a greater number of medical comorbidities. Medical

comorbidities, such as a stroke and dementia, may predispose individuals to bowel and bladder incontinence, which has been associated with symptomatic UTIs and persistent asymptomatic bacteriuria [6]. However, the most significant risk factor associated with UTIs in hospitalized patients is the presence of a urinary catheter. Approximately 80% of healthcare-acquired UTIs are catheter-associated [1, 4, 8].

The diagnosis of a symptomatic UTI requires both the presence of genitourinary symptoms in addition to a positive urine culture [2, 6]. Elderly patients who suffer from significant cognitive deficits that impair their ability to communicate and chronic genitourinary symptoms (e.g., incontinence, urgency, and frequency) make the diagnosis of symptomatic UTIs

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**FIGURE 1: The ASPIRES Urinary Tract Infections Management Algorithm.**



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**Innovation, Research, Education, and Safety**  
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**VCH Management of Urinary Tract Infections (UTI) in Non-pregnant Adults**

**KEY POINTS:**

1. Malodorous/cloudy urine alone is **NOT** a sign/symptom of UTI and is **NOT** an indication to obtain urine cultures <sup>(1)</sup>
2. Changes in cognitive function and activities of daily living **REQUIRE** clinical assessment; never assume these are due to UTI
3. Urine should **ALWAYS** be collected midstream, by in/out catheterization, or through a new catheter (unless contraindicated) <sup>(2)</sup>
4. Positive urine cultures in asymptomatic patients should **NOT** be treated except in pregnancy or prior to urologic/gynecologic surgery

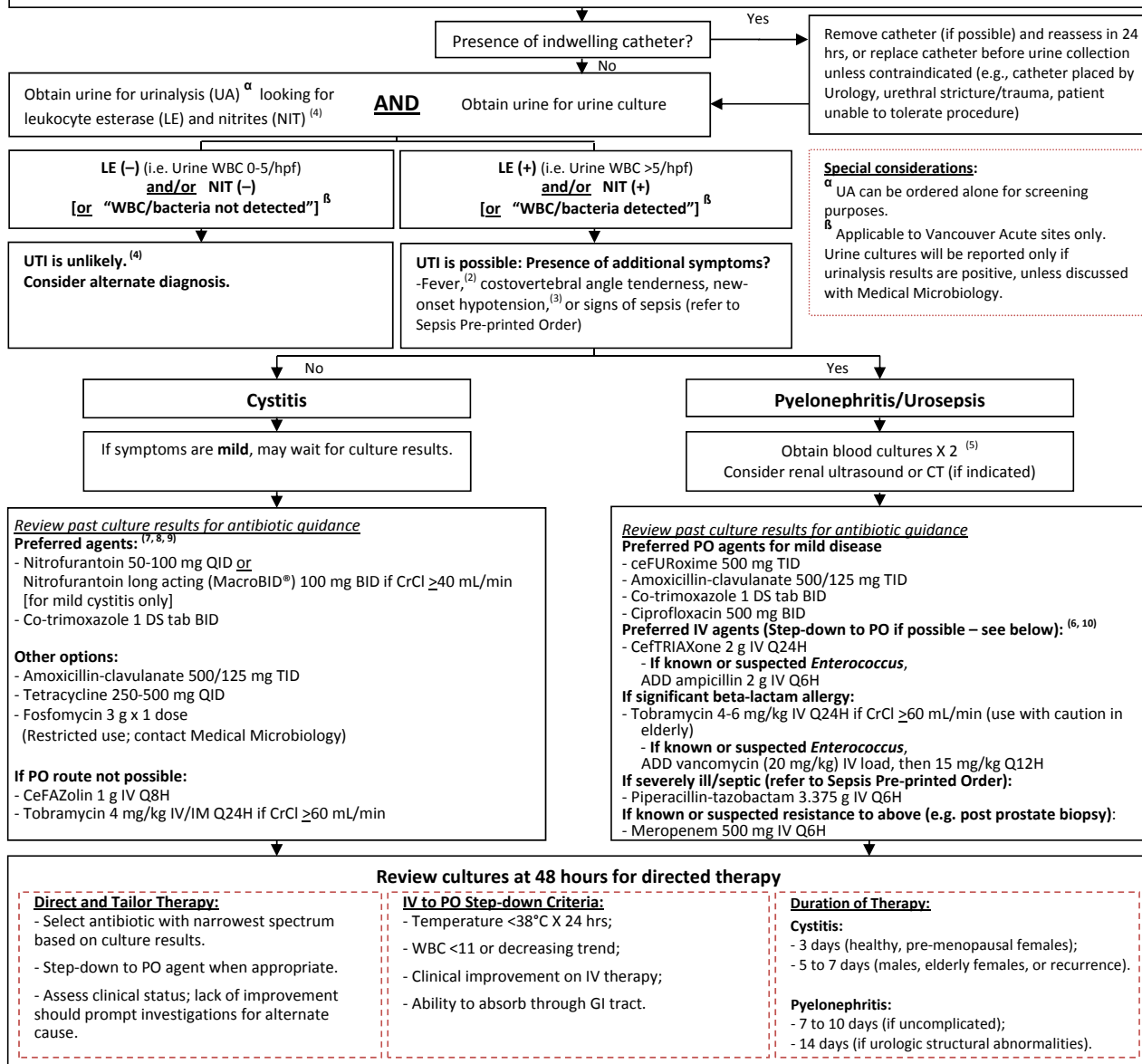
**Signs and Symptoms of Suspected UTI <sup>(3)</sup>**

-One of the following in febrile patients (oral temperature >37.8 °C [or 1°C above baseline in Spinal Cord Injury]) or **two** of the following in afebrile patients:

- |  |  |
|--|--|
| i. Acute dysuria                               | vi. Suprapubic pain  |
| ii. New or marked increase in incontinence     | vii. Gross hematuria   |
| iii. New or marked increase in urgency         | viii. Swelling, or tenderness of the testes, epididymis, or prostate |
| iv. New or marked increase in frequency        | ix. New-onset of acute costovertebral angle pain or tenderness       |
| v. New or marked increase in urinary retention | x. Episode of autonomic dysreflexia (with no other apparent cause)   |

**NOTE:** Only after clinical assessment and ruling-out of other possible causes should changes in mental status and functional decline, and sudden fever, rigors or new-onset hypotension suggest UTI in patients; use clinical judgment. <sup>(3)</sup>

**For Geriatric and Spinal Cord Injury (including conus/cauda equina):** UTI may present atypically; use clinical assessment to guide decision for urine culture & urinalysis.



VCH UTI Algorithm

ASPIRES

Revised: August 8, 2017

challenging [6]. Based on these challenges, there is an increased risk for specimen collection and treatment of asymptomatic patients.

The Antimicrobial Stewardship Programme: Innovation, Research, Education and Safety (ASPIRES) has been part of the Vancouver Coastal Health Authority's (VCH) Quality and Patient Safety department since 2012. One of the many contributions made by the ASPIRES team was the development of the Urinary Tract Infections Management Algorithm, which provides a systematic approach in the assessment and treatment of UTIs in non-pregnant adults, as seen in Figure 1.

As urine testing often drives prescribing, a key component of antibiotic stewardship around UTIs must be in the ordering and interpretation of urine tests. In the absence of a standardized approach, there is an increased risk of over-collection of samples and treatment of asymptomatic patients. Interpretation of the significance of the bacterial culture results requires evaluation of a number of factors, including clinical signs and symptoms, urinalysis results, specimen collection and storage, and antibiotic treatment [7, 9].

Urinalysis specimens provide critical information for interpretation of results and should be collected in coordination with urine for culturing [4, 8, 10]. According to recent studies, the minimum laboratory evaluation for a suspected UTI should include urinalysis for determination of leukocyte esterase (LE) and nitrate (NIT) levels by use of dipstick and microscopic evaluation for white blood cells. If the urinalysis is negative for LEs and NIT, a positive culture is very unlikely [6, 10, 11].

To prevent contamination, urine specimens should be collected using a clean-catch midstream technique or by intermittent catheter. The clean-catch midstream approach is influenced by the patient's physical ability to perform the task and adhere to the instructions provided by the healthcare worker. Specimens should not be collected while using a bedpan, as they are not sterile and there is risk for urine to contact the surrounding perineum, resulting in contamination. Indwelling catheters must be replaced prior to obtaining specimens, as the inner and outer surfaces of the lumen develop a biofilm within days of insertion. Once a biofilm has been established, it protects the uropathogens from antimicrobial treatment and provides an environment that supports bacterial growth [8].

With respect to storage, urine specimens should be kept refrigerated and transported to the microbiology lab without delay. A delay in processing can lead to inaccurate results due to bacterial growth [10]. This is particularly pertinent to Powell River General Hospital (PRGH), as the Microbiology department was recently closed. Since June 2014, all urine specimens for culturing have been sent to the microbiology laboratory in Vancouver General Hospital (VGH) for processing. Urinalysis specimens continue to be processed at PRGH.

Although the ASPIRES algorithm outlines a systematic approach for the assessment and treatment of UTIs from the evaluation of clinical signs and symptoms, specimen collection, and treatment, the primary objective of this quality review was to assess the use of urinalysis in the diagnostic assessment of patients for UTIs.

## METHODS

The quality review was undertaken in PRGH, a small community hospital located on the northern Sunshine Coast of British Columbia. PRGH is a 33-bed facility that supports a regional district with an estimated population size of 20,000. The annual number of admissions for 2015-2016 was 1,599, with an average length of stay of 6.89 patient days. Older adults ( $\geq 65$  years) accounted for 819 (51%) of the admissions, with an average length of stay of 8.7 patient days.

### Design

The review involved two separate components: a staff educational survey and a retrospective analysis of electronic microbiology data.

Ethical review was not required for this quality assurance project as it involved evaluation of expected knowledge and practice.

### Staff survey

The objective of the staff survey was to evaluate the interdisciplinary team's knowledge of urine specimen collection and interpretation of results, which would identify opportunities for improvement. The survey was distributed during the week of March 13 to March 17, 2017 to 19 staff members working day shifts on the medical/surgical unit. 17 of the 19 staff were nurses (LPN/RN), one staff member was an occupational therapist, and one was a physiotherapist. Completed surveys were returned and results were entered into an Excel spreadsheet.

The survey consisted of 16 items based on the VCH Professional Practice guidelines *Indwelling urinary catheter: Guideline to prevent catheter associated urinary tract infections (CAUTI) – Adult* and the ASPIRES algorithm *VCH Management of Urinary Tract Infections in Non-pregnant Adults*. Survey items 1 to 7 evaluated sample collection; items 8 to 16 evaluated the interpretation of urine specimen results.

### Electronic data review

Microbiology data, including the date and time of urine culture specimen results, was extracted for all patients admitted to the medical/surgical unit over a one-year period (September 1, 2015 to August 31, 2016). Corresponding urinalysis data was retrieved manually from the local electronic patient care information system.

Data was imported into Statistical Package for Social Sciences (SPSS, version 18) and reviewed for data quality prior to conducting the descriptive and statistical analyses.

### Definitions

For the purpose of analysis, the following case definitions were used.

#### Urinalysis

"Urinalysis test" was defined as a physical, chemical, or microscopic analysis or examination of urine. It determines the levels of LEs and NITs by use of a dipstick and a microscopic examination for white blood cells.

“Positive urinalysis” was defined as a urine specimen resulting in LEs and/or NITs of any value, whereas a “negative urinalysis” was defined as a urine specimen resulting in the absence of LEs (-) and NITs (-).

#### Urine cultures

“Positive urine culture with significance” was defined as a single urine specimen with the isolation of one predominate bacterial strain with a count of > 100 million CFU/L [4, 8]. “Negative urine cultures” included those with no growth, an insignificant quantity of growth, or mixed growth due to probable contaminants.

## RESULTS

### Education survey

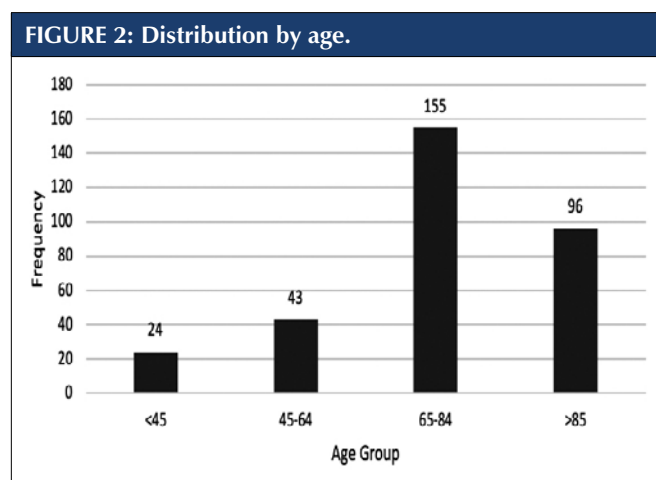
All 19 surveys distributed were returned for a response rate of 100%. No survey items were left blank. There was a general consensus overall: staff scored higher on Section B (interpretation of results) at 80.7% than on Section A (specimen collection) at 69.2%, as summarized in Table 1. The difference was statistically significant (Fisher’s exact test,  $p = 0.02$ ). Four questions were answered with less than 54% accuracy and were distributed between both sections. The question that received the lowest number of correct answers was A7 (16%), which measured knowledge on urine collection methods for the catheterized patient.

### Microbiology data

#### Sample characteristics

318 urine specimens were collected from September 1, 2015 to August 31, 2016 and submitted to the VGH microbiology laboratory for culturing, as noted in Figure 2. 148 (46.5%) specimens were collected from males and 170 (53.5%) specimens were collected from females. The mean age was 73.6 years, with a median of 77 years and a range of 18 to 101 years. Statistical analysis using a non-parametric median test showed that the difference in the median age for males (78.5) vs females (77.0) was not statistically significant ( $p = 0.742$ ).

As noted in Table 2, 62 (19.5%) of the 318 specimens did not have a corresponding urinalysis. Of the 256 urinalysis specimens processed, 136 (53.1%) were negative for both LEs and NITs,



and 120 (46.9%) were positive by definition. 78 (24.5%) of the 318 urine cultures met microbiologic criteria for significant growth of organisms and were considered to be positive urine cultures; of these, 50 (64.1%) corresponded to a positive urinalysis, in comparison to nine (11.5%) corresponding to negative urinalysis. The remaining 19 (24.5%) positive cultures were associated with an absent or missing urinalysis.

184 (57.9%) of the 318 specimens resulted in no growth, of which 45 (24.4%) were associated with a positive urinalysis and 105 (57.1%) were associated with a negative urinalysis. The remaining 34 (18.5%) specimens, which had no growth, were associated with a missing urinalysis. 56 (17.6%) of the 318 cultures submitted did not grow organisms with numbers greater than 100 million CFU/L and were not considered to be positive based on our case definition.

There was a highly statistically significant relationship between urinalysis and clinical significance (Fisher’s exact test  $p < 0.0001$ ). Specifically, a positive urine culture (> 100 million CFU/L) was statistically significantly more likely to be observed when there was a positive urinalysis, and a negative culture (< 100 million CFU/L and No growth) was statistically significantly more likely with a negative urinalysis.

**TABLE 1: Educational survey.**

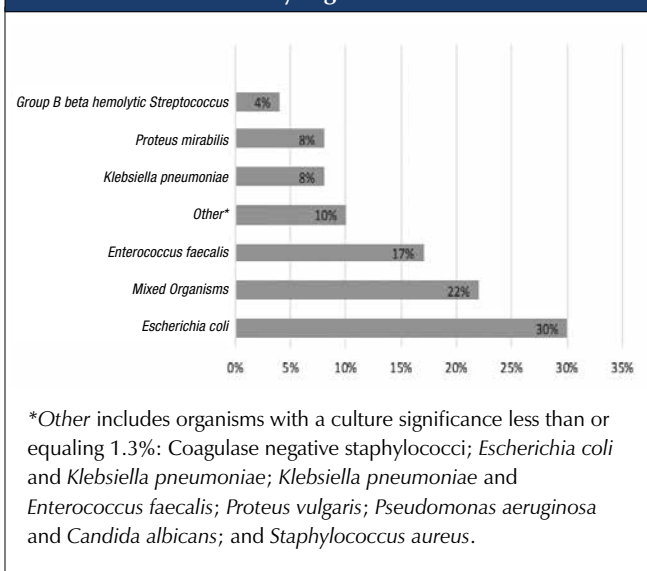
Question	Correct	Percentage
A1 Elderly population and risk factors for developing a UTI.	17	89%
A2 Change in cognitive function – indication of a UTI.	18	95%
A3 Malodorous/cloudy urine – indication of a UTI.	9	47%
A4 Signs and symptoms of a UTI.	17	89%
A5 Collection of a urinalysis specimen.	14	74%
A6 Ideal urine specimen for culture.	14	74%
A7 Urine specimen from a catheterized patient.	3	16%
<b>Section A subtotal</b>		<b>69.1%</b>
B8 Urinalysis results and interpretation.	18	95%
B9 UTI vs asymptomatic bacteriuria.	15	79%
B10 Definition of a positive urine culture.	10	53%
B11 Prevalence of bacteriuria in elderly patients.	17	89%
B12 Treatment of a positive culture in asymptomatic patients.	15	79%
B13 Asymptomatic bacteriuria vs a UTI.	16	84%
B14 Treatment of asymptomatic bacteriuria.	18	95%
B15 Location of urinalysis results.	19	100%
B16 Location of urine cultures results.	10	53%
<b>Section B subtotal</b>		<b>80.8%</b>



**TABLE 2: Culture significance vs urinalysis.**

Urinalysis		Culture Significance			Total
		Greater than 100 million CFU/L	Less than 100 million CFU/L	No growth	
Not collected	Count	19	9	34	62
	Column %	24.4%	16.1%	18.5%	
(-) Leukocyte and (-) Nitrate	Count	9	22	105	136
	Column %	11.5%	39.3%	57.1%	
(+) Leukocyte and/or (+) Nitrate	Count	50	25	45	120
	Column %	64.1%	44.6%	24.4%	
Total	Count	78	56	184	318

The organisms isolated in urine cultures with significance greater than 100 million CFU/L are summarized in Figure 3. The predominant individual organisms identified were *Escherichia coli* (n = 23; 29.5%), and *Enterococcus faecalis* (n = 13; 16.7%). Mixed organisms contributed the second-highest percentage (21.8%).

**FIGURE 3: Distribution by organism.**

## DISCUSSION

The ASPIRES algorithm provides a systematic approach in the assessment, diagnosis, and treatment of UTIs. Findings from this quality assurance review reinforce the importance of adherence to evidence-driven best practices to ensure consistently high-quality care for our patients. Results revealed areas where concordance with the guidelines needs to be improved.

Firstly, the practical and effective use of a urinalysis specimen in combination with a urine culture in the assessment and diagnosis of a UTI needs to be recognized. Evidence shows that specimens resulting in a negative urinalysis are unlikely to be associated with a positive culture (less than 20%) [7, 10, 11].

In this review, 62 (19.5%) of the 318 cultures did not have a corresponding urinalysis. Of the 256 urinalysis specimens collected, 136 (53.1%) resulted in a negative urinalysis and of

those, 105 (77.2%) were associated with no growth. These results correspond to what is reported in the literature and support the intent of the ASPIRES algorithm to reduce unnecessary testing and treatment of urine cultures, which can lead to significant side effects and expense and can drive antibiotic resistance [2, 6, 10].

As with many rural hospitals affected by the centralization of services, the local microbiology laboratory has been closed, impacting the processing of urine specimens. In response, two separate workflows have evolved to manage urine specimens. All urine for culture and sensitivity is sent to the regional laboratory irrespective of an absent or negative urinalysis. This workflow limits the ability of front-line staff to be compliant with the algorithm and results in an increased number of urine specimens sent for culturing.

Secondly, opportunities for improvement in staff knowledge and practice specific to specimen collection became apparent with the high proportion of cultures that resulted in mixed organisms, which is suggestive of contamination. In this review, mixed organisms accounted for 22% of all organisms with a culture of significance. This was second to *E. coli*, which was the most predominate organism. "Mixed growth" is defined as the presence of more than one bacterium in the urine sample [8, 9]. Cultures that contain more than one organism are usually considered contaminated. Contamination occurs when samples are not collected properly or when there is a substantial delay in processing. Mixed organisms do not meet the clinical definition of a positive culture and therefore impede diagnosis, resulting in a delay of treatment and/or inappropriate antimicrobial use [8, 9, 12].

The challenges of midstream urine collections without contamination are greatly underestimated. Fecal and urinary incontinence have an impact on specimen collection and may play a significant role in contamination. Further investigation is required to assess urine specimen collection techniques, as it is unclear if staff were able to provide adequate instructions to patients in the correct methods of proper cleansing prior to obtaining a specimen.

The results of the staff survey provided insight into the nurses' knowledge of sample collection in the presence of an indwelling catheter. Only 16% of the staff surveyed recognized the need to replace the catheter prior to obtaining urine for culturing. This may have contributed to the large proportion of specimens that resulted in mixed organisms.

Another contributing factor that may influence contamination is the extended period of time between collection of the specimen on the unit and the processing of the urine culture in the regional laboratory.

Lastly, the diagnosis of symptomatic UTIs in older adults is challenging, as most accepted definitions require the presence of localized genitourinary symptoms. However, underlying medical comorbidities such as dementia and stroke may impair peoples' ability to communicate symptoms. As a result, clinicians rely on nonspecific symptoms such as a change in behaviour and laboratory data for diagnosis [2, 6, 13, 14].

A disproportionate number of urine cultures ( $n = 251$ ; 78.9%) were collected from adults ( $\geq 65$  years), suggesting that older adults were more likely to be investigated for possible UTIs. This may be attributed to both the increased risk of UTI for older adults as well as the challenges associated with diagnosis [2, 14-16]. As a chart review was not completed as part of the review, it is unclear if urine specimen collection was influenced by a change in patient behaviour or based on signs and symptoms. The survey suggests opportunity for education in the clinical assessment of a UTI, as only 47% of the participants answered the question pertaining to malodorous and cloudy urine correctly.

This quality review had limitations. Firstly, chart reviews were not conducted to verify the signs and symptoms associated with the urine specimen collection, nor did the review investigate the appropriateness of antimicrobial therapy. Urine specimens obtained from catheterized patients were not distinguished from non-catheterized patients, as this is not reliably documented in the electronic patient care information system.

In summary, older adults represent a large and growing population of hospitalized patients who are at high risk of complications during their stay. UTIs have been identified as the single most common healthcare-acquired infection [1, 2, 16, 17]. Studies have shown that the diagnosis of a symptomatic UTI is challenging due to chronic genitourinary symptoms and cognitive deficits among elderly patients. Urinalysis specimens can provide critical information for interpretation of results in conjunction with urine for culturing.

In the absence of a standardized approach, there is an increased risk of over-collection of samples and treatment of asymptomatic patients, which may lead to a variety of negative consequences, including the development of multidrug-resistant organisms [2].

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# Healthcare workers' attitudes toward hand hygiene practices: Results of a multicentre qualitative study in Quebec

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## ABSTRACT

**Background:** Hand hygiene (HH) is one of the most effective practices to reduce healthcare-associated infection (HAI) transmission, though compliance remains inadequate among hospital personnel. The aim of this study was to explore perceived barriers and enablers of HH compliance in hospital care and healthcare workers' (HCW) HAI risk and severity perceptions.

**Methods:** Qualitative study using semi-structured interviews and observations. Interview recordings were transcribed verbatim and supplemented with transcribed observations and field notes. Data was aggregated and coded thematically using a qualitative data analysis software.

**Results:** 65 interviews and 18 observations with HCWs were conducted in nine hospital centres in Quebec, Canada. Data analysis revealed several factors that may influence HCWs' compliance with HH recommendations. These included clinical environment factors (e.g., lack of sinks), organizational factors (e.g., inadequate staffing, demanding workloads), and communication factors (e.g., dissemination of infection prevention and control [IPAC] information, feedback, and interpersonal professional relationships). At the individual level, knowledge of IPAC and HAI risk perceptions were associated with the adoption of HH.

**Conclusion:** Understanding the determinants of HH adoption is crucial for improving current practices and reducing HAI rates in hospital care. Our findings suggest that environmental strategies (e.g., additional sinks and HH stations) and organizational and communication strategies (e.g., continuing education and training sessions, support from hospital management, positive feedback) could help raise HCWs' awareness of HAI prevention and adoption of HH guidelines.

## KEYWORDS

Hand hygiene; infection control practice; healthcare provider; perception; belief; behaviours

## INTRODUCTION

Healthcare-associated infections (HAI) continue to threaten patient safety in healthcare facilities. Approximately 80,000 to 90,000 patients suffer from a HAI in Quebec, Canada annually [1-3]. *Clostridium difficile* infections (CDI) and antibiotic-resistant infections such as methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci are among the most common. These HAIs significantly increase economic costs for healthcare systems as well as patient mortality and morbidity rates [4, 5].

Hand hygiene (HH) is one of the most effective infection prevention and control (IPAC) practices for preventing HAI transmission [6-8]. The importance of adhering to HH guidelines has been studied extensively, yet compliance remains low among healthcare workers (HCWs) [7, 8]. A study by Kingston et al. (2017) surveyed nurses' HH attitudes and practices between 2007 and 2015 [9]. The authors found that self-reported alcohol-based hand rub (ABHR) was suboptimal, as fewer nurses reported

compliance with ABHR in 2015 compared to 2007 (42% and 55%, respectively) [9]. The World Health Organization estimates that on average, HCWs wash their hands less than half the time they should [10].

Many quantitative research studies have examined the barriers to HH compliance, but few have resulted in the implementation of effective interventions [11-13]. Several qualitative studies have also been conducted on this topic. Smiddy et al. (2015) conducted a systematic review of 11 qualitative studies on HCWs' compliance with HH [14]. The authors' thematic analysis identified two broad categories of factors that influenced adherence to HH guidelines: motivational factors (i.e., social influences, acuity of patient care, self-protection, and use of cues) and perceptions of the work environment (i.e., resources, knowledge, information, and organizational culture). Chatfield et al. (2017) also reviewed 36 qualitative studies on HH among HCWs worldwide in a meta summary using the GRADE-

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CERQual process of quality assessment [15]. Findings from the study showed that although adequate HH training was available, content and reach could be improved. Furthermore, though management support evidenced through provision of human and hygiene resources was deemed necessary, it was often lacking. The authors also identified that HCWs' subjective risk assessment also influenced HH behaviours.

Both reviews highlight the strengths of qualitative research. Understanding the factors that influence HCWs' compliance with HH guidelines involves exploring their complex social behaviours within context-specific conditions [11]. Conditions that influence adherence to HH guidelines need to be assessed at a local level to inform the development of interventions that are appropriate to the setting, context, and subgroups of a given working environment [16]. Qualitative research can provide an in-depth understanding of HCWs' perceptions and practices within their local context and help fill existing knowledge gaps in a comprehensive way.

The purpose of this qualitative study was to explore HCWs' knowledge, attitudes, and practices toward HH [9, 17]. More specifically, our study examined the perceived barriers and enablers influencing HH adoption and explored HCWs' HAI risk perceptions. Previous qualitative studies on HH adherence have been conducted in Canada [7, 18-22]; however, most of these involved individual or group interviews or were conducted over five years ago. Furthermore, few have been conducted in the province of Quebec.

## METHODS

This multicentre qualitative study employed an exploratory descriptive research design. Individual semi-structured interviews and observations were conducted over a period of two years, from May 2015 to May 2017, in nine hospitals in Quebec, Canada. The study was part of a larger research project with co-investigators from select hospital centres involved in the clinical development of a diagnostic test. The aims of the larger project were to develop, evaluate, and above all deliver to the healthcare system of Quebec novel rapid molecular diagnostic tests for the prevention, control, and treatment of CDIs and bacterial multidrug-resistant infections. One of the project's objectives was to evaluate the acceptability of the technology among end users and the usefulness of the results for real-time surveillance. Interviews on HH were conducted in this context [23].

### Participants

Of the nine participating hospitals, four were in Montreal and five were in Quebec City. All were university-affiliated centres. Seven centres were francophone and two were anglophone. The number of admissions ranged from 12,948 to 36,730 per year. Bed capacity ranged from 256 to 1,053. HH observance rates, measured through regular audits [24, 25], were under 60% for the year 2015-2016 for all participating centres. Informants were contacted by email and invited to participate in this study. The snowballing technique was used to identify other participants. The sampling was done purposively to include HCWs of varying levels of experience and with different professional backgrounds, including infection control professionals. All participants were employees at one of the nine

participating sites. Participants included front-line nurses, nurse managers, physicians specializing in infectious diseases, infection prevention and control nurses (IPCN), and IPCN managers.

### Data collection

This study was conducted on a voluntary basis. No incentives were given for participation. Individual in-person interviews were scheduled according to participants' availability and convenience and took place on-site in a private room. To conduct interviews and observations with front-line nurses, we first asked their clinical managers for their authorization. The interview guide included questions on HH, IPAC, HAIs, and risk perceptions and was tailored to participants' professions and adjusted throughout the data collection process as new themes emerged. Open-ended questions and dialogue were prioritized during interviews; however, conversations remained centred on the main topics and follow-up questions were asked when necessary. Interviews were conducted in either French or English by a senior researcher trained in social and cultural anthropology and a junior research assistant training in qualitative methods and public health. Interviews lasted approximately 30 to 45 minutes. All interviews were audio recorded and supplemented with field notes describing non-verbal responses, the interview context, and information given off the record. Participants were recruited until data saturation was achieved. During data collection, weekly team meetings were held to discuss preliminary findings and hypotheses and to review the interview guide.

To complement data collected during interviews, observations were conducted at each of the sites by both the senior researcher and junior research assistant. The observations consisted of following either a participating nurse, physician, or an IPCN for a period of four to eight hours. Observations were scheduled during weekdays according to participants' availability. HCWs' daily work routines were observed, including HAI and cohort management, nurse-patient interactions, sample collecting methods, environmental challenges, and workflow. Observations also took place at IPCN meetings and IPAC training sessions. The observations were conducted in order to provide a more contextual and detailed understanding of the participants' environments, workflow, and settings. Handwritten field notes were taken during observations, then transcribed. To avoid disrupting participants' work routines during observations, the research team interacted with participants only when certain situations or exchanges needed to be clarified.

All collected data was kept anonymous and was stored in a secure database to ensure participant confidentiality.

### Data analysis

Data collection, interview transcriptions, and analysis occurred concurrently to monitor the progress of themes emerging from individual interviews. Using an inductive approach, transcripts and observational data were reviewed several times by members of the research team to identify emerging themes and subthemes [26]. Data was aggregated and coded thematically using NVivo 10 qualitative analysis software. A two-phased approach of ethnographic analysis was used: analysis and interpretation [27].

Data was coded using a constant-comparative and concept-development approach of emerging themes [26, 28]. Data analysis was performed for each individual hospital site to allow a better comparison between the different work environments. This involved data coding, in which the qualitative data was organized into patterns, categories, and basic descriptive units. Data interpretation was performed by the senior researcher in collaboration with the research team and involved attributing meaning and significance to the collected data by explaining patterns and identifying relationships among descriptive dimensions. Data obtained from all participants and sites were compared to generate and test interpretations of existing relationships between HCWs' work environments, their risk perceptions of HAIs, and their HH practices. The research team identified key verbatim quotations and observations that were most representative of the research findings and best illustrated the prevalence of the final themes and sub-themes. Quotations were edited for clarity and brevity and were labelled with participants' professions.

### Ethical considerations

This study was approved by each site's research ethics board. Written informed consent was obtained from all study participants. Prior to data collection, participants were reminded that the contents of their interviews and observations would remain confidential and that no identifying information would be shared with their peers or senior management teams.

### RESULTS

65 interviews and 18 observations were completed for this study. Participants' average years of work experience was 7.60 years (range: 0.6 to 30 years) with a median of five years. Participants' characteristics are provided in Table 1.

Data analysis revealed several factors that may influence HCWs' adherence to HH recommendations in hospital care, with several shared perceptions across all sites. No significant differences were found between Montreal and Quebec City participants, nor between French- and English-speaking participants. Observations helped supplement findings from the individual interviews. No major discrepancies between participants' discourses (interviews) and practices (observations) were identified. Barriers as well as intervention and implementation strategies to enhance HH adoption are presented in Tables 2 and 3.

### Barriers

#### *HCWs' attitudes and perceptions of HH*

The importance of proper HH was acknowledged and accepted by all, though participants across all sites reported that HH was not consistently prioritized in practice. Nurses described physicians as non-compliant with HH recommendations. Conversely, IPCNs and other nurse participants claimed that HH resistance was not exclusive to physicians, as they described non-compliance to be present among hospital personnel, visitors, and patients. They also reported concerns regarding night teams and float nurses. These groups were harder to reach, which hindered IPAC communication, and were generally less compliant with guidelines

and difficult to supervise. Similarly, IPAC nurses described being more vigilant with staff returning from vacation, as they tended to be less compliant with HH.

At the individual level, lack of HH and IPAC knowledge and low HAI risk perceptions were identified as barriers to HH adoption. Interviewed IPAC nurses, nurse managers, and physicians reported that the invisibility of infectious agents did not favour HH among hospital staff, nor did it reinforce the legitimacy of certain IPAC practices. HCWs' lack of knowledge and awareness of HAI severity also discredited the importance of certain HH practices. Some nurses believed that gloves replaced proper handwashing. Others perceived patients to be at higher risk of contracting HAIs than themselves. They also reported feeling confident in their abilities to properly apply IPAC measures, though very few expressed the need to protect their own health and safety during patient care.

#### *Contextual and organizational barriers*

Generally, each participating centre's infection control team reported implementing IPAC measures adapted to their own clinical setting, with a strong emphasis on HH. HH was described as a key practice that HCWs needed to implement to successfully achieve an "IPAC culture" change within their hospital. Nurses and nurse managers reported that hospital management's support and commitment to IPAC helped reinforce the legitimacy of IPAC practices, including HH.

However, HH performance was perceived as an additional task that hindered workflow for many HCWs. Contextual barriers to HH included heavy workloads and inadequate staffing. Nurses

**TABLE 1: Sample characteristics (N = 65).**

Participant Characteristics	N (%)
<b>Gender</b>	
Male	13 (20)
Female	52 (80)
<b>Profession</b>	
Nurse <sup>a, b</sup>	53 (82)
Physicians <sup>c</sup>	12 (18)
<b>Role in hospital</b>	
Front-line care providers (nurses and physicians)	28 (43)
Nurse managers	13 (20)
Infection prevention and control staff and managers	24 (37)
<b>Experience (years)</b>	
0 to 5	34 (52)
6 to 10	17 (26)
10 or more	14 (22)
<b>Language</b>	
French	52 (80)
English	13 (20)
<b>City</b>	
Quebec City	44 (68)
Montreal	21 (32)
<b>Legend</b>	
<sup>a</sup> Includes nurse educators and nurse manager assistants.	
<sup>b</sup> Includes nurse managers and directors.	
<sup>c</sup> Includes only infection control specialists.	

**TABLE 2: Barriers to hand hygiene adoption.**

HCWs' attitudes and perceptions of HH	Verbatim <sup>1</sup> /Observation
Differences across health professions	NM: "[...] there are more doctors who have been observed compared to the rest of the team, so it lowers our [hand hygiene audit] results, because they [doctors] don't do it all the time."
Lack of knowledge of and education on HH	IN: "We discovered last year that some nurses, to go faster, were washing their gloves in between patients instead of changing them. And they saw no problem with that."
Invisibility of pathogens leading to lack of legitimacy of some IPAC practices	IN: "We can't see the bugs. It's an invisible contamination. It's like an imaginary problem [...]. It [hand hygiene] is not integrated in the culture. It's not automatic."
Low risk perceptions: wearing gloves	NM: "Even if you have a pair of gloves on, you are not completely protected. There is always something that will remain afterwards."
Self-protection not prioritized during patient care	NM: "Employees need to understand that handwashing is to protect patients, but it's also to protect themselves. You wash your hands to protect yourself."
<b>Contextual and organizational barriers</b>	
Heavy workload	IM: "When you increase the workload of staff, you have non-compliance with everything really, from environmental cleaning to handwashing."
Inadequate staffing and high patient-nurse ratio	IN: "[...] when we didn't have enough resources, like nurses working and caring for many patients at the same time. Well hand hygiene showed lower audit results. Like it went down from 70% to 50%."
Budgetary restrictions and lack of time	N: "Putting on your protective equipment, reserving your material, disinfecting all your tools when you exit a patient's room. It all requires a lot of time. And time, well nurses don't have a lot of that."
Supply issues	N: "[...] it's management, they're the ones who oversee the change. I think it's because the new gloves cost less. So, we're not the ones to decide [...] like gloves, care material and gloves, they never ask us our opinion, it just happens."
<b>Environmental barriers</b>	
Limited space on hospital floors	OB: There is insufficient space on the floor to install more sinks. HCWs do not have close access to sinks to wash their hands.
Lack of sinks and/or bad positioning of sinks on hospital units	MD: "[...] we absolutely have to wash hands with water and use soap like in the good old days. Hospitals are not equipped with sinks. So often, the sink is 15 to 20 feet away. The health provider has to go all the way there, wash their hands, come back, so there is a big loss of time and it's not efficient."
<b>Communication barriers</b>	
Hierarchical working relationships and HCW resistance	IM: "One of the problems we've had, is that yes, we'll be quick to criticize a porter or a nurse who didn't wash their hands. But when it's a doctor or something, well we won't say anything because we don't want them to answer us rudely."
Youth, maturity, and relational proximity	NM: "[...] our teams are young and all around the same age [...] when I need to say something to someone about hand hygiene, I'll do it within the hour if I see them and it'll be professional. But what taints everything is that they talk amongst themselves. They're family, they're friends."
Negative perceptions of infection control team	OB: Some nurses ignored the IPAC nurse when she reminded them to wash their hands. They pretended that she wasn't there and did not answer her when she spoke to them.
<sup>1</sup> Legend IN: IPCN nurse; IM: IPCN manager; MD: physician; N: nurse; NM: nurse manager; OB: observation	

reported frequently working overtime to compensate for the shortage of staff, which in turn may compromise the quality of care and lead to professional burnout.

#### *Environmental barriers*

Environmental barriers included features of hospitals' physical layout and structure that challenged or restricted participants' HH performance. Frequently reported barriers included limited space, the absence of single-patient rooms, and the lack of sinks and HH stations. Furthermore, the lack of single-patient rooms was reported to be problematic, as restricted space on care units and inadequate isolation facilities compromised the application of IPAC measures. However, sites equipped with numerous single-patient rooms reported having frequent HAI outbreaks, which could be explained by staff's poor compliance with HH in between patients.

#### *Communication barriers*

Communication posed a major challenge for IPAC teams. The increased number of HCWs in hospitals and high employee turnover rates made the dissemination of IPAC and HH recommendations more challenging. Other communication barriers included hierarchical working relationships (i.e., between physicians and nurses), which impeded communication relating to IPAC; silo mentality, where IPAC information was segregated among HCWs belonging to the same care unit or profession; and concerns about critical feedback, where HCWs who had developed friendships with some of their peers were uncomfortable reminding colleagues to comply with HH guidelines. Communication and adherence to IPAC measures were also hindered by HCWs' negative perceptions of IPAC teams, as some perceived them to be the "police."

**TABLE 3: Intervention and implementation strategies for hand hygiene adoption.**

<b>Organizational strategies</b>	<b>Verbatim<sup>1</sup>/Observation</b>
Dissemination of IPAC and HH guidelines using existing roles	N: "The infection control team will address the nurses directly, but [...] I, myself, or the nurse managers will act as sort of the intermediary to spread the word to all the staff."
Implementation of a new role: infection control agents, with the goal of promoting IPAC and HH guidelines	IM: "We have infection control agents on each unit. They have a day of infection control and prevention training [...] those working on units refer to those agents. It's infection prevention promotion, it's our transmission belt for communicating."
Implementing HH games on hospital units	MD: "That [certification program] will help develop infection control and prevention culture."
<b>Communication strategies</b>	
Implementing positive deviance (feedback, positive leaders)	IM: "Positive deviance is a lot of things [...] when you see someone doing something well, it's important to point them out to their peers because others will want that positive reinforcement as well."
Posting posters, handouts, reminders	IN: "Campaigning, we have posters. Each unit has them to motivate their team and remind the staff to wash their hands." OB: Posters are placed in strategic locations to be visible to all. Locations included elevators, cafeteria, walls of care units, IPAC offices, and even bathrooms.
Audits and publicizing HH audit results	IM: "So now our hand hygiene compliance results will become public [...] so everybody is going to be accountable." OB: Hand hygiene audit results are clearly displayed at entrance of care unit. They are visible to visitors, patients, and cleaning staff.
Implementing online training sessions and e-learning	IM: "There are also videos, e-learning videos is what we call them, online sessions where they can learn [...] for instance on hand hygiene."
Support from hospital management to increase nurses' adherence to IPAC practices	IM: "Implementing these measures has significantly decreased the pressure put on the infection control team. It's supported by management so there's nothing better than that."
Positive working relationship with infection control team	N: "It's not long before the infection control team is advised. They are always advised as soon as something happens."
<b>Environmental strategies</b>	
Increased access to single-patient rooms	IN: "[...] it's a government recommendation that all new rooms created in the healthcare system be private to prevent infection transmission."
Installation of additional sinks, soap dispensers, and HH stations	N: "We replaced the hand sanitizers so that they were more accessible, more visually present, to remind the staff that: 'OK, you need to wash your hands.' OB: Extra sinks are installed outside patient rooms. Visible "Stop" signs are placed near soap dispensers to remind visitors and staff to wash their hands.
<sup>1</sup> Legend IN: IPCN nurse; IM: IPCN manager; MD: physician; N: nurse; NM: nurse manager; OB: observation	

### Intervention and implementation strategies to enhance HH adherence

Findings from this study have shown that IPAC teams have implemented different strategies to efficiently disseminate IPAC information in hospitals and change HCWs' practices. As shown in Figure 1, the interventions and strategies that have been implemented in participating hospital centres were in direct response to the barriers that have been identified.

#### Organizational strategies

At the organizational level, IPAC teams benefited from the support of nurse managers, assistant nurse managers, or nurse educators to facilitate the implementation of HH guidelines. In some participating centres, nurses who wished to promote IPAC practices on their respective units could volunteer to receive additional training to become "IPAC agents." Finally, interviewed IPAC nurses and physicians reported that support from hospital

management was crucial to promote staff's adherence to HH and reinforce the legitimacy of IPAC.

Nevertheless, HCWs' negative perceptions of infection control teams in some hospitals could have negatively impacted these efforts. Some nurses described IPAC nurses as the bearers of bad news and criticism, whereas some IPAC nurse participants reported feeling unwelcome and misunderstood by hospital personnel. HCWs' acceptance of IPCNs is important, as it may strengthen their commitment to IPAC.

#### Communication strategies

Communication strategies included distributing handouts and reminders year-round, especially during the week of the Canadian Patient Safety Institute's National Hand Hygiene Day in May. Other strategies included publicizing HH audit results in care units, implementing online IPAC training sessions (e-learning), having frequent information sessions for hospital

**FIGURE 1: Barriers and strategies to enhance HH adherence.**

Context & organization	Environment	Communication
<p><b>Barriers:</b></p> <ul style="list-style-type: none"> <li>- Heavy workload</li> <li>- Inadequate staffing</li> </ul>	<p><b>Barriers:</b></p> <ul style="list-style-type: none"> <li>- Limited space</li> <li>- Lack of single patient rooms</li> <li>- Lack of sinks and HH stations</li> </ul>	<p><b>Barriers:</b></p> <ul style="list-style-type: none"> <li>- Increased number of HCWs</li> <li>- Employee turnover rates</li> <li>- Hierarchical working relationship</li> <li>- Silo mentality</li> <li>- Concerns about critical feedback</li> <li>- Negative perceptions of IPC teams</li> </ul>
<p><b>Strategies:</b></p> <ul style="list-style-type: none"> <li>- Managerial support</li> <li>- Hospital management support</li> <li>- Training IPC agents</li> </ul>	<p><b>Strategies:</b></p> <ul style="list-style-type: none"> <li>- Additional sinks &amp; HH stations</li> <li>- More single-patient rooms</li> <li>- Floor space reorganization</li> </ul>	<p><b>Strategies:</b></p> <ul style="list-style-type: none"> <li>- Handouts &amp; reminders</li> <li>- HH audit reports publication</li> <li>- Training sessions</li> <li>- Frequent &amp; short meetings</li> <li>- Positive feedback</li> <li>- Use of UV light</li> </ul>

personnel, and handwashing under ultraviolet lights<sup>1</sup> to reveal bacteria and enhance HAI awareness. One strategy relied on HCWs to act as role models and “IPAC educators” by disseminating IPAC information, increasing HAI awareness, and promoting the adoption of IPAC measures. Lastly, some respondents mentioned using a “positive deviance” approach [6, 18], where positive feedback was given to those who adhered to HH guidelines, viewing them as “positive leaders,” as opposed to giving critical feedback to non-compliant HCWs. However, issues in providing critical feedback to non-compliant colleagues were also reported by participants.

#### *Environmental strategies*

Finally, in newer hospitals, environmental strategies included the installation of additional sinks and HH stations and an increased number of single-patient rooms. In older hospital centres, participants described reorganizing floor space and modifying certain IPAC measures to better fit their actual clinical environment and maximize space.

## DISCUSSION

Though HH is a priori a simple task to perform and incorporate into clinical practice, adherence to HH guidelines among HCWs remains low. Some qualitative studies have explored HCWs’ perceptions of HH and HAIs in Quebec hospital care [29], though few have been multicentre studies [30, 31]. Previous quantitative studies conducted in Quebec have shown that HCW adherence to IPAC practices is sub-optimal but have often failed to identify reasons why [32-34].

Though most nurses recognized the importance of proper HH in preventing HAI transmission [16, 19, 35], patients’ needs and fast-paced environments made it difficult for nurses to strictly adhere to HH guidelines and prioritize them

in practice. Previous research has noted the importance of organizational-level support and leadership to facilitate the implementation of HAI prevention initiatives and encourage an IPAC cultural change within health establishments. Furthermore, adequate nurse staffing levels have been associated with lower rates of patient mortality and morbidity and lower rates of HAIs [36, 37]. Similar to previous studies, environmental barriers consisted of poor physical structure and lack of resources, such as poor placement or absence of sinks and handwashing stations [18, 36, 38, 39]. While single-patient rooms may facilitate patient management [40], our findings and other studies indicate that on their own they are unable to reduce HAI transmission [41-43].

In this study as in others, HCWs’ “lack of knowledge and education” of HH guidelines was reported to be a significant barrier at the individual level [35, 36]. As HCWs’ poor levels of hospital hygiene knowledge were a reoccurring theme across sites, this could indicate that current educational initiatives are not conducive to learning. IPAC training tailored to HCWs’ respective professions may help address this issue. However, according to one study, low HH compliance is not necessarily linked to HAI knowledge, but rather to HCWs not incorporating this knowledge into their daily practice, which could be due to low motivation and HAI awareness, heavy workloads, and facilities’ physical structures [38]. Though IPAC education remains an important component of improving HH adherence, training aimed at improving HCWs’ preventive beliefs and HAI risk perceptions should also be considered [8].

Nurses interviewed in this study claimed that physicians did not comply with HH recommendations, which has been cited in previous research [14, 15]. However, our findings indicate that low adherence to HH was not solely a physicians’ problem, as it was reported to also be present among various

<sup>1</sup> The ultraviolet light is used to test HCWs’ handwashing technique and enhance their awareness of infection transmission. Though bacteria are invisible to the naked eye, the “glow” of the ultraviolet light reveals any bacteria left on the hands following handwashing.



groups of HCWs and visitors. As described by Shah et al. (2015), encouraging adherence to IPAC practices can be challenging in multidisciplinary teams where perceptions of clinical practice may vary and where HCWs are more likely to adhere to the norms of their respective professions [16].

In this context, IPAC teams relied on different strategies to enhance HCWs' adherence to HH. Our findings have highlighted that organizational climate or "pro-IPAC culture," HCWs' commitment to IPAC through different communication strategies, IPAC leadership initiatives, as well as knowledge and self-efficacy appeared to be highly influential success factors. Our findings also showed that barriers to HH adherence were complex and context-specific, and successful IPAC interventions were tailored to HCWs' context.

Though there is no "one size fits all" IPAC strategy, findings from our study suggest that continuous education, HCW cohesion and communication, organizational IPAC support, accessibility of materials, and improving facilities' physical layouts may help improve HH compliance in hospital care. Prioritizing HCW communication at all levels may improve cohesion and promote a workplace where feedback is welcomed and encouraged, which has previously been linked to higher HH compliance rates [11]. A systematic review of HH clinical trials conducted by Kingston et al. (2016) also concluded that multimodal approaches to HH intervention strategies can improve HH adherence among HCWs [6].

Our study had some limitations. Participation was voluntary and HCWs who were unavailable or declined to participate may therefore have characteristics and opinions that differ from those recruited. Furthermore, there was an under-representation of men and front-line nurses in our final sample. Recruiting front-line nurses was challenging, as they often had heavy workloads and needed the authorization of their clinical managers in order to participate in our study. Though data saturation was achieved, our findings could not adequately represent the views of all front-line nurses. Moreover, participants may have enhanced their responses to interview questions to provide socially desirable answers. We tried to control this by conducting observations and interviews with multiple participants from the same health facility, which allowed us to observe HCWs' behaviours and helped us identify any missing information from participant interviews. In addition, we used different methodological techniques that were intended to enrich validity: purposeful sampling using diversification criteria, grounded theory, and double coding [28]. Finally, only primary results have been developed in this manuscript to respect the journal's guidelines regarding article length.

To conclude, understanding the determinants of HH adoption is crucial in developing and implementing sustainable HH guidelines in hospitals. Strategies that consider HCWs' local contexts and opinions may increase IPAC awareness, improve cohesion among professions, and promote a safer working environment. Our findings provide valuable insight into the factors that may influence HCWs' compliance with HH in Quebec hospital care. We have identified key barriers at the organizational, environmental, and individual levels,

which include inadequate staffing, demanding workloads, lack of sinks and HH stations, lack of knowledge, and reduced HAI risk perceptions. Our findings also indicate that communication strategies are often prioritized in hospitals to overcome these barriers. Further research is needed to verify whether the representations identified in this study are present among all HCWs working within Quebec hospital centres and elsewhere in Canada.

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## OUTBREAK MANAGEMENT

# Person-to-person transmission of microbes in a nursing home serving patients in a persistent vegetative state

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## ABSTRACT

**Background:** A probable outbreak of respiratory disease in a nursing home serving exclusively patients in a persistent vegetative state (PVS) resulted in hospitalization of eight patients.

**Methods:** Microbes from all PVS patients' respiratory tracks and environments were surveyed by microbiological methods. Major pathogenic microbes were analyzed by pulsed-field gel electrophoresis (PFGE).

**Results:** 24 PVS patients were investigated. Half were colonized with at least four different pathogenic microbes in their respiratory tracts. The most prevalent microbes were *Pseudomonas aeruginosa* in 15 patients (62.5%), *Serratia marcescens* in 14 (58.3%), *Citrobacter koseri* in nine (37.5%), *Streptococcus pneumoniae* in six (25%), and *Proteus mirabilis* in five (20.8%). By PFGE analysis, one major pulsotype each was identified for *S. marcescens* (92.9%, 13/14) and *S. pneumoniae* (100%, 6/6), whereas diverse pulsotypes were identified for *P. aeruginosa*, *C. koseri*, and *P. mirabilis*. Both major pulsotypes for *S. marcescens* and *S. pneumoniae* were also found in strains from patients outside the nursing home. No environmental reservoir was found for prevalent microbes.

**Conclusions:** Clonal transmission of *S. marcescens* and *S. pneumoniae* among PVS patients in the nursing home was evident, indicating a need to enforce control measures to reduce threats to this type of facility.

## KEYWORDS

Microbial surveillance; microbial transmission; persistent vegetative state; *Serratia marcescens*; *Streptococcus pneumoniae*

## INTRODUCTION

Episodes of infectious disease are important issues in nursing homes, where respiratory infections are most common [1, 2]. Infections can cause high morbidity and mortality among residents [3] since conditions there are ideal for the dissemination of infectious agents. Such conditions are susceptible residents, common exposure sources, people flow, and long-term residence [4]. Development of nosocomial or healthcare-associated infections are associated with two key pathophysiological factors, colonization of pathogenic organisms and impaired host immune defense [5].

Nursing homes that serve patients in a persistent vegetative state (PVS) possess additional distinctions that predispose residents to infections. PVS patients require comprehensive daily care and hygienic practice that is fulfilled solely by nursing home staff. Most PVS patients use intruding devices, well-known risk factors associated with infectious reservoirs [5]. Surveillance studies showed that prevalence of pneumonia in nursing homes for PVS patients was 14.2% [6] and that pathogenic colonization and being susceptible to aspiration pneumonia and systemic infections were associated with tube-fed institutionalized elderly patients [7-9].

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A probable outbreak of respiratory disease involving hospitalization of eight PVS patients in a nursing home alerted the health authority to prompt this study. The purpose was to survey microbe prevalence in respiratory tracts of all PVS patients to determine any person-to-person transmission of microbes. We also surveyed surrounding environments to find reservoirs for suitable control measures.

## METHODS

### Background and setting

Through the national surveillance system for healthcare institutions, a cluster of respiratory infection was reported to the Taiwan Centers for Disease Control in February 2009. It took place in a 45-bed nursing home in northern Taiwan serving PVS patients from low- and middle-income families by a social welfare foundation. When the outbreak occurred, a total of 25 PVS patients resided in three separate wards and received physical therapy of steam inhalation and sputum suction daily.

### Microbial surveillance

Sputum was collected from 24 PVS patients. Environmental samples were taken by using swabs from all possible reservoirs, including tubes, bed railings, spraying humidifiers, faucets, shower heads, mops, water buckets, outlets of reverse osmosis (RO) water, sinks, aprons, CD carts, and telephones. Sputum samples, pretreated with sterile glass beads by vortexing, and environmental swabs were inoculated on blood, chocolate, and MacConkey agar plates. Suspected colonies were selected for identification. Bacteria species and antimicrobial susceptibility were determined by biochemical reaction agar-tubes and the Phoenix Automated Microbiology System (BD, Sparks, MD, U.S.A.) using PMIC/ID-14 and NMIC/ID-4 panels. Serotype of *Streptococcus pneumoniae* was determined by capsule swelling test with pneumococcal antisera (SSI, Copenhagen, Denmark). *Pneumocystis carinii* was detected with polymerase chain reaction [10].

### Bacterial genotyping

Genotyping was performed using pulsed-field gel electrophoresis (PFGE) analysis with the CHEF-DRIII apparatus (Bio-Rad, Hercules, CA, U.S.A.). Ramp and running time were five to 50 seconds and 21 hours with *SpeI* digestion, or five to 15 seconds and eight hours followed by 15 to 45 seconds and 12 hours with *XbaI* digestion for *Serratia marcescens*; five to 30 seconds and 24 hours with *SpeI* digestion for *Pseudomonas aeruginosa* and *Citrobacter koseri*; five to 40 seconds and 23 hours with *SfiI* digestion for *Proteus mirabilis*; and two to 20 seconds and 21 hours with *SmaI* digestion for *S. pneumoniae*. BioNumerics 4.0 software (Applied Maths, Austin, TX, U.S.A.) was used to determine clonal similarity. Greater than 80% similarity in genetic relatedness was defined as strains with the same pulsotype.

### Statistics

Categorical variables were analyzed using  $\chi^2$  statistic or Fisher exact test. In all data analysis, a *p* value of < 0.05 was considered significant.

## RESULTS

### History and patient characteristics

The average age of all 25 PVS patients was 43.8 years (range: 15 to 87 years), with an average residence of 4.7 years (Table 1). In late January 2009, a 26-year-old male, the index case, was hospitalized due to fever, tachypnea, and pneumonia patches in lungs. Within ten days, seven more PVS patients were hospitalized due to respiratory symptoms (32.0% attack rate). They, including six males, came from all three wards, with an average age of 51.6 years (range: 23 to 67 years). Seven hospitalized PVS patients recovered within one week, and the index case had a longer hospital stay.

**TABLE 1: Characteristics of all 25 PVS patients in the nursing home.**

Characteristic	No. of patients (%) (n = 25)
Male	16 (64.0)
Female	9 (36.0)
Respiratory disease	8 (32.0)
Fever ( $\geq 38^\circ\text{C}$ )	8 (32.0)
Cough	7 (28.0)
Tachypnea	4 (16.0)
Tracheostomy	16 (64.0)
Hospitalized in the past year	8 (32.0)
Duration of residence	
More than three years	20 (80.0)
More than five years	9 (36.0)

None of the 15 healthcare workers developed respiratory symptoms two weeks before and after the outbreak. Neither did visitors who visited the nursing home one week before. When performing caring duties, healthcare workers wore masks and gloves according to the standard operation protocols. All PVS patients and healthcare workers received seasonal influenza vaccine prior to the outbreak.

*S. marcescens* was isolated from the index case's sputum three days after disease onset in the hospital. Nonetheless, no viral or bacterial cause was concluded. Both clinical characteristics and remedy of antibiotic treatment were not specific for *S. marcescens* infection. However, the outbreak was terminated in a short period due to implementation of control measures, including enhanced hand hygiene, strengthened environment cleanliness and equipment disinfection, and suspending visiting for two weeks.

### Microbial surveillance

Immediately following the episode, a microbial surveillance of the respiratory tract was conducted for 24 PVS patients, excluding the index case patient, who was then still hospitalized (Table 2). As for Gram-negative bacteria (GNB), 15 PVS patients (62.5%) were colonized with *P. aeruginosa*; 14 patients (58.3%) were colonized with *S. marcescens*, including five of the seven hospitalized and recovered patients (71.4%); and nine and

**TABLE 2: Microbial surveillance from respiratory tracts of 24 PVS patients in the nursing home.**

Microbe(s)	No. of patients (%) (n = 24) <sup>†</sup>
Gram-negative bacteria	
<i>Pseudomonas aeruginosa</i>	15 (62.5)
<i>Serratia marcescens</i>	14 (58.3)
<i>Citrobacter koseri</i>	9 (37.5)
<i>Proteus mirabilis</i>	5 (20.8)
<i>Stenotrophomonas maltophilia</i>	3 (12.5)
<i>Klebsiella pneumoniae</i>	1 (4.2)
Gram-positive bacteria	
<i>Streptococcus pneumoniae</i>	6 (25)
<i>Staphylococcus aureus</i>	2 (8.3)
<i>Corynebacterium spp.</i>	16 (66.7)
<i>Streptococcus spp.</i>	12 (50)
Fungus	
<i>Pneumocystis carinii</i>	4 (16.7)
Any one of the above	0 (0)
Any two of the above	3 (12.5)
Any three of the above	9 (37.5)
Any four of the above	7 (29.2)
≥ five of the above	5 (20.8)

<sup>†</sup>One PVS patient was not included in the surveillance due to his hospitalization. However, *S. marcescens* was isolated from his sputum in the hospital.

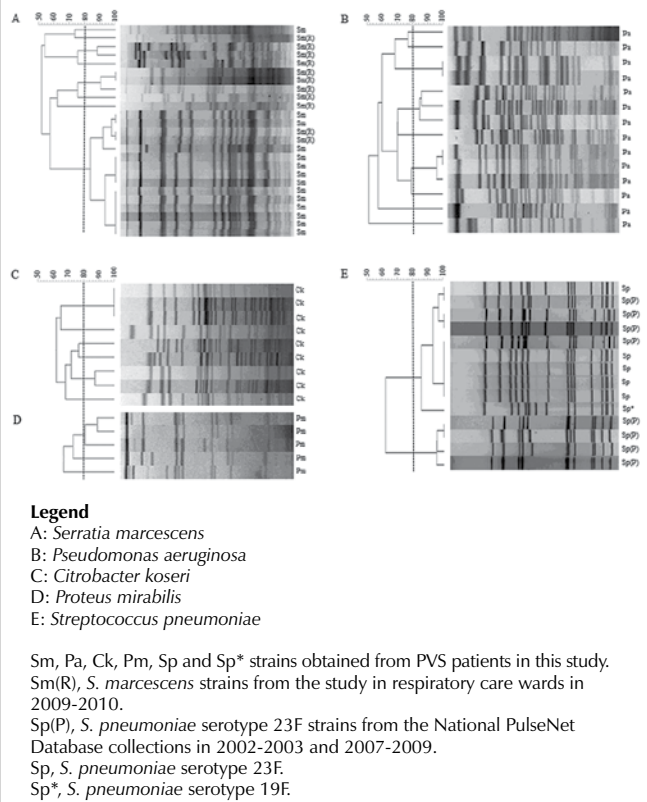
five patients were colonized with *C. koseri* and *P. mirabilis*, respectively. As for Gram-positive bacteria, six patients were colonized with *S. pneumoniae* (25%). Polymicrobial colonization was common. 50% of PVS patients were colonized with at least four different microbes.

None of the variables analyzed – including age group, hospitalization in the past year, with tracheostomy, albumin level, length of residence, and *P. aeruginosa* colonization – was significantly associated with *S. marcescens* colonization.

Environmental reservoirs were not found for prevalent microbes. Only *Bacillus cereus*, *Enterobacter cloacae*, and *Stenotrophomonas maltophilia* were identified from the outlets of RO water, mops, and sinks in the nursing station. One of the 15 *P. aeruginosa* strains was resistant to imipenem (6.7%) and none of the *S. marcescens* strains was an extended-spectrum beta-lactamases producer. Both *S. aureus* strains were methicillin-resistant.

### Bacterial genotyping

To clarify possible transmission in the nursing home, all 49 strains of the five major microbes were analyzed by PFGE genotyping (Figure 1). For *S. marcescens*, one major pulsotype was identified for 13 of the 14 strains (92.9%), including all five strains from the seven hospitalized and recovered patients (Figure 1A, *SpeI* digestion). Restriction digestion with *XbaI* gave the same result (data not shown). For *P. aeruginosa*, nine pulsotypes were identified for 14 of the 15 strains (Figure 1B).

**FIGURE 1: PFGE profiles for microbes.**

One *P. aeruginosa* strain could not be digested by *SpeI*. For *C. koseri* and *P. mirabilis*, six and three pulsotypes were identified, respectively (Figures 1C and 1D). For *S. pneumoniae*, one pulsotype was identified for all six strains (100%).

PFGE genotyping was applied to 11 *S. marcescens* strains collected from a microbial surveillance of patients in general respiratory care wards (RCWs) as well (see “Discussion”). Seven pulsotypes were identified, including the major pulsotype in this study, which was observed for two strains from the same hospital in southern Taiwan (Figure 1A). Meanwhile, PFGE genotypes of *S. pneumoniae* strains in this study were submitted to the National PulseNet Database of *S. pneumoniae* in Taiwan. The database included PFGE genotypes of *S. pneumoniae* strains isolated from patients with invasive infections throughout Taiwan during 2002-2003 and 2007-2009 (unpublished data). In the database, a total of 199 *S. pneumoniae* serotype 23F strains were classified into nine pulsotypes, including two major pulsotypes consisting of 90 (45.2%) and 87 (43.7%) strains, respectively. All six *S. pneumoniae* strains in this study shared the same pulsotype as the 90 strains from the database (Figure 1E).

### DISCUSSION

In this study, we found that polymicrobial colonization was common, GNB colonization was prevalent, and person-to-person transmission of *S. marcescens* and *S. pneumoniae* was evident among PVS patients.

A microbial surveillance for patients residing in RCWs conducted in 2009-2010 revealed that 45.9% and 14.9% of patients were colonized with *P. aeruginosa* and *S. marcescens* in their respiratory tracts, respectively (our unpublished data). The *S. marcescens* colonization rate was significantly lower than that in PVS patients ( $p < 0.001$ ), while the *P. aeruginosa* colonization rate was not ( $p = 0.16$ ).

*P. aeruginosa* constituted a high proportion of pathogenic GNB from respiratory tracts of tube-fed elderly patients (31% and 34% in two studies) [7, 11]. *P. aeruginosa* (23.4%) and *S. marcescens* (10.8%) were major microbes in a bacterial surveillance for respiratory aspirates from patients in RCWs [12]. *P. aeruginosa* was well-known for its colonizing tendency for respiratory equipment and thriving in oropharynx. *S. marcescens* emerged as an opportunistic pathogen to cause outbreaks, likely attributable to its rapid spreading and innumerable heterogeneous clones, its potential reservoirs in infected or colonized carriers and inanimate objects, and its correlation with use of intruding tubes [13-19]. A previous study reported that 89% of PVS patients in Taiwan used a nasogastric tube (NGT) for feeding [6]. Most PVS patients in our study also used an NGT for feeding.

In our study, one pulsotype each was dominant for *S. marcescens* and *S. pneumoniae*. In contrast, diverse pulsotypes were identified for *P. aeruginosa*, *C. koseri*, and *P. mirabilis* in our study as well as for *S. marcescens* from RCW patients and for *S. pneumoniae* from the National PulseNet Database. These results clearly suggest that *S. marcescens* and *S. pneumoniae* were transmitted among PVS patients in the nursing home. Furthermore, the dominant pulsotype for either *S. marcescens* or *S. pneumoniae* in the nursing home was not unique, since it was also found in *S. marcescens* strains from RCW patients and in *S. pneumoniae* strains from the National PulseNet Database. This result indicates that both dominant pulsotypes for the *S. marcescens* and *S. pneumoniae* strains were circulating in the community as well. Since at least 37.5% of all nosocomial infections were due to cross-transmission [20], microorganisms from outside environments constituted a great public health concern.

There were limitations to our study. First, it was carried out in one single nursing home with a small patient number. However, the entire PVS population was included, except the index case patient, and the findings represented the real situation in this facility. Second, no risk factor was found in association with *S. marcescens* colonization, suggesting that further studies are required. Third, the exact mode of microbial cross-transmission was not identified. The outbreak occurred during a one-week holiday; infectious reservoirs were likely eliminated during environmental disinfection. Nonetheless, clonal transmission among PVS patients was supported by bacterial genotyping results.

In conclusion, we report the cross-transmission of *S. marcescens* and *S. pneumoniae* in a nursing home serving PVS patients, highlighting the threat to this type of healthcare facility and the importance of comprehensive control measures.

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## CONCISE REPORT

# Effective prevention bundle to eliminate catheter-related bloodstream infections in ambulatory hemodialysis patients

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## ABSTRACT

**Background:** Hamad General Hospital (HGH) is the principal provider of dialysis in the state of Qatar, comprising a total of four facilities in different cities. Infection rates in dialysis patients are increasingly used as a surrogate marker for measuring patient safety and quality of healthcare. These infections are associated with substantial morbidity, mortality, and excess healthcare costs. We observed an elevated rate of hemodialysis catheter-related bloodstream infections (HD-CRBSI) in our outpatient dialysis facilities (1.4/1,000 Central Venous Catheter [CVC] days) in 2011. Our goal was to reduce our HD-CRBSI rate by 80% within a period of four years in HGH ambulatory dialysis facilities.

**Methods:** HD-CRBSIs are defined as the presence of positive blood cultures in a febrile catheter-dependent patient in the absence of alternative sources of infection upon clinical evaluation. The project was led by the HGH quality improvement program director in coordination with a multidisciplinary team (nephrologists, nurses, vascular coordinators, a patient educator, and an infection control team) after implementation of a bundle of infection prevention measures.

**Results:** The rate of HD-CRBSI was reduced from 1.4/1,000 CVC days in 2011 to 0.014 in 2017, achieving a 99% reduction rate ( $p < 0.001$ ).

**Conclusions:** Strict implementation of our new infection prevention measures bundle is sufficient to significantly reduce HD-CRBSIs.

## KEYWORDS

Prevention; hemodialysis catheter; bloodstream; infection

## INTRODUCTION

Minimization of line-related bloodstream infections and establishing dialysis access are often challenging tasks in hemodialysis facilities for patients requiring renal replacement therapy. A number of factors, including patient reluctance, anatomic host factors, and prolonged maturation time, have contributed to a preponderance of dialysis catheter use.

Many scientific societies and the U.S. Centers for Disease Control and Prevention have suggested different measures to prevent catheter-related bloodstream infections (CRBSIs) [1]. Many promising articles targeting the prevention of CRBSIs have been published since the publication of these guidelines in 2011.

One of the measures for prevention is to encourage fistula creation and usage. National quality improvement programs, which included the breakthrough Fistula First Initiative, have been shown to be ineffective and, in many instances, have

contributed to many patients on hemodialysis (HD) initiating renal replacement therapy with a catheter.

Up to 80% of patients undergoing maintenance HD in the United States initiate treatment via a central venous catheter (CVC) with significantly more infections than arteriovenous fistulae or grafts [2].

CRBSIs were not well defined until 2009, when the Infectious Diseases Society of America recognized the unique characteristics of HD catheters. The definition relied on obtaining a blood specimen from the dialysis catheter and an additional specimen from a peripheral vein [3]. The existence of a similar colony count, differential, and time-to-sensitivity at both sites are the criteria for diagnosis of a CRBSI in the absence of alternative sources of infection upon clinical evaluation.

It should be noted that indwelling vascular catheters are colonized by microorganisms within 24 hours after their insertion. Bacteria are introduced into the lumen through

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**Funding:** None.



**TABLE 1: Project design/strategy for change.**

Current practice reviewed	New management practice developed	New practice implemented and evaluated
<ul style="list-style-type: none"> <li>• Previous outcome studied</li> <li>• Barriers identified:               <ul style="list-style-type: none"> <li>• Patient level</li> <li>• Staff level</li> <li>• Management level</li> </ul> </li> <li>• Vascular access</li> </ul>	<ul style="list-style-type: none"> <li>• Vascular access management quality improvement project initiated</li> <li>• Vascular access management protocol developed</li> <li>• Data collection tracking system created</li> <li>• Vascular access educational care program initiated</li> </ul>	<p>The new practices were implemented based on:</p> <ul style="list-style-type: none"> <li>• Multidisciplinary team care evaluation</li> <li>• Vascular access management protocol reviewed and updated as needed</li> <li>• Monitoring staff adherence to protocol</li> <li>• Clinical practices measurements</li> <li>• Tracking outcome data</li> </ul>

the flora of the overlying skin or the hands of healthcare personnel during catheter manipulation via either connection or disconnection [4, 5].

In the state of Qatar, Hamad General Hospital (HGH) is the principal provider of dialysis, comprising a total of four facilities located in different cities. In 2011, we observed an elevated rate of hemodialysis catheter-related bloodstream infections (HD-CRBSIs) in our outpatient dialysis facilities (1.4/1,000 CVC days).

### Aim

Infection rates in dialysis patients are increasingly used as a surrogate marker for measuring patient safety and quality of healthcare and are associated with substantial morbidity, mortality, and excess healthcare costs [6, 7]. We targeted to reduce our HD-CRBSI rate by 80% within a period of five years in HGH ambulatory dialysis facilities.

### METHODS

We planned to achieve our objective by applying a bundle of infection prevention measures. The project was implemented by the HGH quality improvement program director in coordination with a multidisciplinary team that included nephrologists, nurses, vascular coordinators, a patient educator, and an infection control team.

### Project design/strategy for change

We started our project by reviewing our current practice, identifying instances where previous outcomes had been studied, and identifying barriers at all levels, including patient, staff, and management. Particular attention was given to reviewing vascular access management protocols.

While reviewing our current protocols, we also developed our new catheter management practice. Our vascular access quality improvement project, initiated in 2012, consisted of a new vascular access management protocol, a data collection system, a patient tracking system, and a vascular access educational care program.

Lastly, we conducted evaluation of the new practice, which consisted of multidisciplinary team care evaluation, assessment of the vascular access management protocol, monitoring of staff adherence to the new protocol, clinical practices measurements with real-time data, and outcome tracking.

### Changes made (the five tracks model)

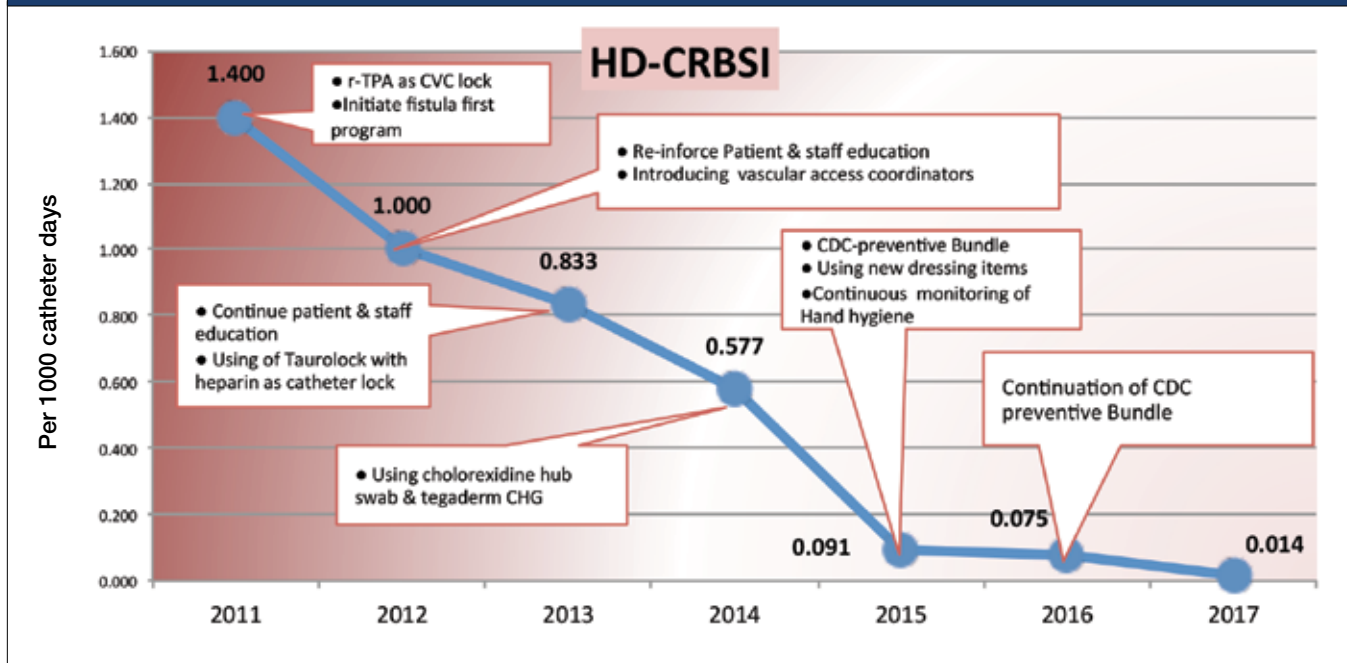
The following five tracks of changes have been implemented simultaneously:

1. Patient and family education efforts focused on general hand hygiene awareness and on early recognition of signs and symptoms of catheter infection. Patients and family members were advised to use a waterproof pocket to protect the catheter during swimming and showering. Educational materials were developed to improve their awareness of the importance of catheter access point care.
2. Nursing education: all of our dialysis facility nurses revalidated their competency for CVC care through mandatory infection control courses. Furthermore, change of catheter dressing was limited only to the qualified dialysis staff. As part of the project, dialysis staff initiated ongoing surveillance of catheter infection with the infectious disease team.
3. Reduction of permanent catheter insertion: reducing the number of permanent catheter insertions was achieved via adoption of the Fistula First program, with emphasis on maintaining patency of arteriovenous fistula (AVF)/arteriovenous graft by early intervention and close monitoring.
4. Management of catheter malfunction: we implemented the use of innovative catheter lock solutions such as taurolidine and recombinant tissue plasminogen activator locks.
5. Technique improvement: we implemented several changes to improve our techniques of access point management, including the introduction of chlorhexidine 2% to replace betadine and iodine on the catheter hub and exit site, respectively. We also introduced a chlorhexidine-impregnated Tegaderm™ dressing for seven-day use on the exit site. As well, a single sterile kit replaced a set of separate sterile items used at the start and termination of each dialysis session.

### RESULTS

Our study included 99 patients dialyzed via permanent catheters, including 59 males and 40 females with a mean age of  $55 \pm 14.8$  years. The study lasted for seven years, from 2011 to 2017. Of the 99 patients, 89 patients had

FIGURE 1: Hemodialysis catheter-related bloodstream infection rate in Hamad General Hospital dialysis units.



their catheters exchanged, six received antibiotic therapies and continued to use their catheters, two had their catheters removed and AVF created, and two more patients were lost to follow-up due to international travel. The most common organism found in our study population was *Enterobacter cloacae*, which constituted 15% of infections.

Figure 1 shows that after implementing the new infection prevention bundle, the rate of HD-CRBSI decreased from 1.4/1,000 CVC days in 2011 to 0.014/1,000 CVC days in 2017, an overall reduction of 99%.

## DISCUSSION

CRBSIs are one of the most common bacterial infections in patients receiving hemodialysis treatments [8]. In our study, we successfully reduced the rate through an intervention bundle that proved to be effective against CRBSIs.

The success of the bundled intervention is largely attributable to a multidisciplinary team approach, which included participation from nephrologists, nurses, vascular coordinators, a patient educator, and infection control practitioners. Education of patients, families, and nursing staff has been previously reported to improve the outcome [9].

We have successfully overcome the problem of catheter malfunction with the use of new catheter lock solutions like taurolidine and recombinant tissue plasminogen activator locks. Olthof et al. (2014) appreciated the value of using taurolidine lock in their home parenteral nutrition group of patients, where it significantly reduced the rate of CRBSI and occlusion [10].

Our project has since transitioned into sustainability mode, placing greater emphasis on the evaluation of patient clinical outcomes such as hospitalization, mortality rates, and cost.

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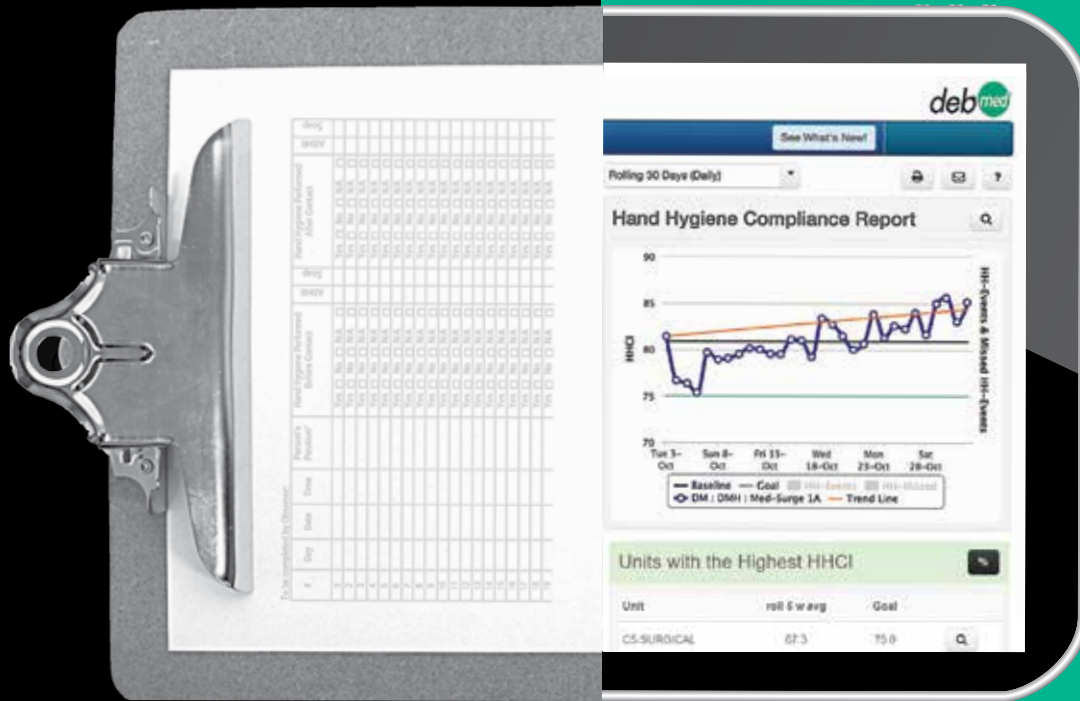
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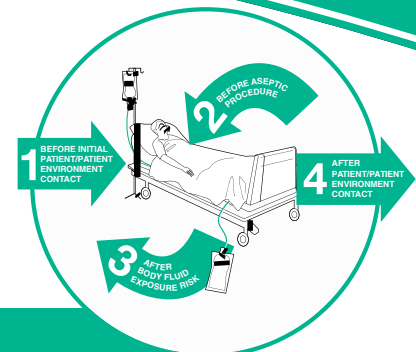


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**EMPOWERING CLINICIANS TO ADDRESS A CAUSE OF CLABSI FOR BETTER PATIENT OUTCOMES.** In the fast-paced world of healthcare, clinicians strive tirelessly for better patient outcomes. However, studies have shown that lack of compliance with scrubbing the needle-free connector hub can lead to infections, such as central line-associated bloodstream infection (CLABSI). The BD PureHub™ disinfecting cap provides a 99.99% reduction in bacteria most commonly linked to CLABSI within 1 minute of application by disinfecting with a sterilized 70% IPA solution. Designed for compatibility with leading needle-free connectors, it also maintains a physical barrier to contamination for up to 7 days, which can result in reduced risk of CLABSI and improved patient outcomes. Discover how clinicians can be empowered with this standardized approach to disinfection. **Discover the new BD.**

Learn more at [bd.com/PureHub](https://bd.com/PureHub)



\*Demonstrated reduction on *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Candida glabrata* and *Candida albicans*, as tested in a laboratory

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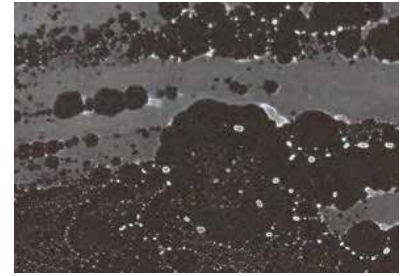


**“Disinfectant Residues Should Be Removed”**

No Residue



Residue



**Neutral pH PCS 250 Oxidizing Disinfectant/Disinfectant Cleaner**

*Use to clean frequently touched surfaces.*

*Apply to surface and wipe dry with microfibre cloth or other clean dry absorbent cloth.*

**Cleaning**

- PCS 250 Oxidizing Disinfectant/Disinfectant Cleaner
- Apply with pre moistened wipe and wipe dry with PCS microfiber cloth.

**Versus**

- 1.4 % Hydrogen Peroxide wipes
- Quaternary disinfecting wipe containing alcohol.
- Cleaning and disinfecting one wipe used to clean and a second wipe applied to disinfect.

**CREM CO Quantitative Carrier Test QCT-3**

**Vegetative Bacteria (S. aureus and S. marcescens)**  
Average CFU per square centimetre

Product	CFU/cm2			Chemical Residue	Average Percent Reduction
	Control	After Wiping	Transfer		
<b>PCS 250</b>	<b>26,900</b>	<b>0.25</b>	<b>0</b>	<b>NO</b>	<b>99.999</b>
<b>1.4% HP</b>	<b>14,000</b>	<b>1.27</b>	<b>0</b>	<b>YES</b>	<b>99.991</b>
<b>QUAT/ALC</b>	<b>34,400</b>	<b>2.54</b>	<b>0</b>	<b>YES</b>	<b>99.993</b>

**C. difficile spores**  
Average CFU per square centimetre

Product	CFU/cm2			Chemical Residue	Average Percent Reduction
	Control	After Wiping	Transfer		
<b>PCS 250</b>	<b>3330</b>	<b>15.15</b>	<b>2.44</b>	<b>NO</b>	<b>99.53</b>
<b>1.4% HP</b>	<b>1150</b>	<b>14.33</b>	<b>15.3</b>	<b>YES</b>	<b>98.75</b>
<b>QUAT/ALC</b>	<b>750</b>	<b>263</b>	<b>161</b>	<b>YES</b>	<b>60.39</b>



# Micrylium

PROFESSIONAL CHOICE

[www.micrylium.com](http://www.micrylium.com)



Micrylium is proud to support WWF-Canada's freshwater conservation efforts. Visit [wwf.ca](http://wwf.ca) © 1986 Panda symbol WWF-World Wide Fund For Nature (also known as World Wildlife Fund) \* WWF is a WWF Registered Trademark



KINDER



SAFER



FASTER

MICRYLIUM IS PROUD TO SUPPORT

**DOCTORS WITHOUT BORDERS  
MEDECINS SANS FRONTIERES**



# STAFF-FRIENDLY ANTIMICROBIAL CURTAINS

*Privacy curtains – two words that make ICPs shudder. Curtains are a challenge - they define the patient's environment providing shelter, privacy and comfort... and they are touched continuously, potentially undermining hand hygiene and your cleaning and disinfection protocols.*

*Our easy to install, antimicrobial curtains have been tested in Canadian and European hospitals.*

- ✓ Reduce staff injury by 80%
- ✓ Preferred by staff
- ✓ 3 log reduction of pathogens such as MRSA

*Contact us and let us show you how we can help you **reduce costs, protect staff and patients.***



## PROTECT YOUR INCISIONS



### The PREVENA™ Incision Management System:

is intended to manage the environment of surgical incisions and surrounding intact skin in patients at risk for developing post-operative complication, such as infection, by maintaining a closed environment via the application of negative pressure wound therapy system to the incision. The PREVENA™ Dressing skin interface layer with silver reduces microbial colonization in the fabric.

### PREVENA™ Therapy can help:

- Hold incision edges together
- Remove fluids and infectious materials
- Act as a barrier to external contamination
- Deliver continuous negative pressure at -125mmHg up to 7 days

For more information, please visit [prevenatherapy.com](http://prevenatherapy.com) or call 1-800-668-5403 to schedule a meeting with your local KCI Representative

NOTE: Specific indications, contraindications, warnings, precautions and safety information exist for PREVENA™ Therapy. Please consult the applicable PREVENA™ System Clinician Guide instructions for use prior to application. This material is intended for healthcare professionals.

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