



INFECTION PREVENTION AND CONTROL IN HEALTH CARE FACILITY DESIGN

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EXECUTIVE SUMMARY

In 2011, in response to safety and cost concerns raised by governments, health care professionals, and the public, the Canadian Standards Association created the standard *Z8000 Canadian Health Care Facilities*.

The development of the Z8000 was driven by a range of factors, including:

- Planned increases in Canadian capital spending on health care facilities (HCFs)
- Disappearance of dated provincial guidelines;
- The lack of a commonly-accepted national standard;
- A shortage of HCF planning and design experts in some areas of the country; and
- Public awareness of safety issues around health care-associated infections (HAIs), and pandemic preparedness.

The standard included several features designed to help improve patient and staff outcomes at HCFs, but for the purposes of this study, we specifically examined three features and whether HCFs with these features have seen a decrease in HAI rates. The features examined include: the requirement for single patient rooms (and separate washrooms in the exceptional cases where a room is shared); dedicated provisions for human waste disposal; and the requirement for deeper and better designed hand hygiene sinks.

At the time that Z8000 was published, there was resistance to including these features in hospital design for a variety of reasons, including capital costs, product availability, and uncertainty about their impact.

Enough time has now passed that we have seen examples of several HCFs adopting the basic principles of Z8000, offering us an opportunity to see whether this standard is helping reduce HAI rates.

The report discusses:

- Our objectives and the parameters employed to conduct the study;
- The methodology used, including the planning/development of the study questionnaire, the selection of qualified participants, and an explanation of the limitations of the study;
- The existing literature related to this topic, with an overview of the conclusions drawn;
- An overview of the existing patient safety surveillance programs in Canada that include HAI and hand hygiene rates within their mandates;
- A look at Z8000 requirements that were considered in this study;
- The results of our study, which includes tables and analysis; and
- Our conclusions, which suggest that following the requirements in this standard, in conjunction with other measures, can contribute substantially to reducing infection rates in health care facilities.



2 INTRODUCTION

Each year, about 220,000 Canadians are struck by health care-acquired infections (HAIs) and 8,000 will die from these infections, according to the Public Health Agency of Canada (PHAC, 2013). In addition to the terrible human cost, there is the ongoing financial burden on the Canadian health care system. In Canada, it is estimated that the annual cost associated with *Clostridium difficile* infections (CDI) alone is \$46.1 million, and nearly as high (\$36.3 million) for methicillin-resistant *Staphylococcus aureus* (MRSA) infections (PHAC, 2015 and CIHI, 2008).

This research project was initiated to investigate the effects of specific aspects of health care facility (HCF) design on infection prevention and control. The first edition of Z8000 was published in 2011, at a time when hospitals were coming under fire and garnering negative media attention because of concerns over infections. Given the rising costs of capital spending on HCFs and the disappearance of dated provincial guidelines, it was clear that a national standard was needed to help improve patient safety and outcomes as well as the safety and well-being of HCF staff.

The Standard introduced a common national approach to the planning, design, and construction of HCFs in Canada. It was based on the best available knowledge and evidence at the time, gathered from multiple sources, and further refined following an accredited standards development process.¹

The first edition of Z8000 included requirements that challenged some of the accepted design practices at the time. Three notable examples were:

- The requirement for single patient rooms (and separate washrooms in the exceptional cases where a room is shared);
- Dedicated provisions for human waste disposal; and
- The requirement for deeper and better designed hand hygiene sinks.

Each of these three requirements encountered resistance because of the increased capital cost of single patient rooms and the fact that, at the time, there were no commercially available sinks meeting the requirements set out in the standard. Since then, manufacturers have developed hand hygiene

¹ CSA Group is accredited as a standards development organization by the Standards Council of Canada, a federal Crown corporation. This accreditation is based on established standard development principles that promote social development and trade.

sinks meeting Z8000 requirements and recommendations. In regards to patient bedrooms and the provisions for human waste disposal, there have been some advances but there has not yet been 100 percent acceptance of these requirements across the country.

Although Z8000 was not available when the projects in this study were being designed, the research team looked at HCFs that were early adopters of the design features outlines in CSA Z8000 to gauge their effect on hand hygiene compliance and infection rates.

3 RESEARCH OBJECTIVE AND STUDY PARAMETERS

The purpose of this research project was to investigate the effect of specific hospital design requirements on preventing exposure to infectious diseases acquired within the health care setting.

The hospital design elements considered in this study were:

- Patient separation (i.e., single patient rooms vs. multi-bed rooms);
- Ratio of patient rooms to patient washrooms;
- Hand hygiene sink design and distribution; and
- Human waste disposal (equipment/technology and location).

The infection prevention indicators used in this study were:

- Health care-associated infection (HAI) quarterly rates (# cases/1,000 patient days) for:
 - Methicillin-resistant *Staphylococcus aureus* (MRSA); and
 - *Clostridium difficile* infection (CDI); and
- Hand hygiene compliance – "before" moment (i.e., hand hygiene taking place immediately before initial patient contact or initial contact with the patient's environment).

Further information on MRSA is available [here](#),² and information on CDI is provided [here](#).³

4 RESEARCH METHODOLOGY

4.1 Planning and development

The study began with a review of existing literature to determine whether the design elements under study had been examined in the past, and if so, what had been learned regarding their effect on health care-associated infection rates. See [Section 5](#) for a complete discussion of the relevant articles identified through this review.

Next was an examination of surveillance and reporting systems in Canada – both for hand hygiene compliance, and for the incidence of HAIs in health care facilities. The results of this research are summarized in [Section 8](#) of this report.

The research on design provisions and their possible effects on HAI rates took place in three phases:

- In the initial phase, a beta tested questionnaire was sent to HCFs. At this stage, participants were recruited from a list of HCFs across the country that had recently undergone new builds or major renovations.
- Following completion of the questionnaire and engagement of the participants, phase two (data collection) was launched. Participating HCFs were sent the questionnaire (which asked for statistics on HAIs and hand hygiene rates, as measured both before and after a hospital renovation or a move to a newly constructed building) along with the necessary information and support to facilitate their responses. The questionnaire results were reviewed with each respondent to ensure that the instructions had been correctly understood and that the data had been collected as consistently as possible.
- The final phase involved reviewing and analyzing the data from the questionnaires, including a review of the reported HAI and hand hygiene rates.

A total of nine health care facilities participated in our study. The majority (seven) were newly constructed facilities. With only two completed questionnaires for renovation projects,

² Public Health Agency of Canada (2008). Fact Sheet - Methicillin-resistant *Staphylococcus aureus*. Available at: <http://www.phac-aspc.gc.ca/id-mi/mrsa-eng.php>

³ Government of Canada (2014). Pathogen Safety Data Sheets: Infectious Substances – *Clostridium difficile*. Available at: <https://www.canada.ca/en/public-health/services/laboratory-biosafety-biosecurity/pathogen-safety-data-sheets-risk-assessment/clostridium-difficile-pathogen-safety-data-sheet.html>



“

There has been a sustained focus on infection prevention and control to ensure our health care system is safer for patients, workers, and visitors to HCFs.

”

the data obtained from these 2 projects was not sufficient to find significant relationships or identify representative trends. Due to the unequal sample sizes, the renovation data was excluded as it was not easily comparable to the data obtained from new construction projects. Therefore, this report will only be presenting data for newly constructed facilities.

4.2 Limitations

Infection prevention and control is complex, both in the application of infection prevention measures, and in the measurement of their efficacy. It is difficult to measure the impact of a single variable when there are so many factors that can affect HAI rates. For example, a patient's immune status, comorbidities, exposure to potential transmission routes (air, water, medical devices, skin contact, etc.), and environmental considerations such as relative humidity, air exchanges, and filtration can all influence whether or not they develop an HAI. This study did not attempt to consider the impact of all such factors, but rather was an effort to review the correlation between key design parameters and related patient safety metrics, using a "before" and "after" comparison (i.e., moving from an older HCF to a new HCF while implementing more current hospital design features).

It is important to note that there are many moving parts in a new build that need to be considered when examining HAI rates. As a result, the correlation between each specific design element and a rate change is difficult to pinpoint given the multiple factors that are changing. To address this challenge, we considered the design elements together as a bundle for the purposes of this study.

Because case definitions for MRSA and CDI are not uniform across all HCFs, variation may have existed depending on what definitions the participating HCFs had used.

In collecting comparison data, many of the facilities had difficulty collecting "before" data as participants did not have easy access to information for the older, "before" HCF. There was also greater variability in how the data might have been collected in the past. Therefore, the information collected was not always complete.

The first edition of Z8000 was published in 2011, and therefore was not available at the time of design and planning for the new HCFs participating in this study. As a result, study participants could not specifically indicate "compliance" with this standard. However, given that many of the requirements found in Z8000 were incorporated in the design of the new HCFs, there is a legitimate basis for comparison.

5 LITERATURE REVIEW

Infection prevention and control has long been a major focus in health care. In 2013, the Chief Public Health Officer's Report on the State of Public Health in Canada found that every year, more than 200,000 patients develop an HAI and more than 8,000 of these patients die as a result (PHAC, 2013). To address this, there has been a sustained focus on infection prevention and control (IPAC) to ensure our health care system is safer for patients, workers, and visitors to HCFs. These efforts are reflected in the extensive literature that exists on this topic. For example, a PubMed database search using search term "health care-associated infections" resulted in 102,504 articles found, with the earliest dating back to 1912.

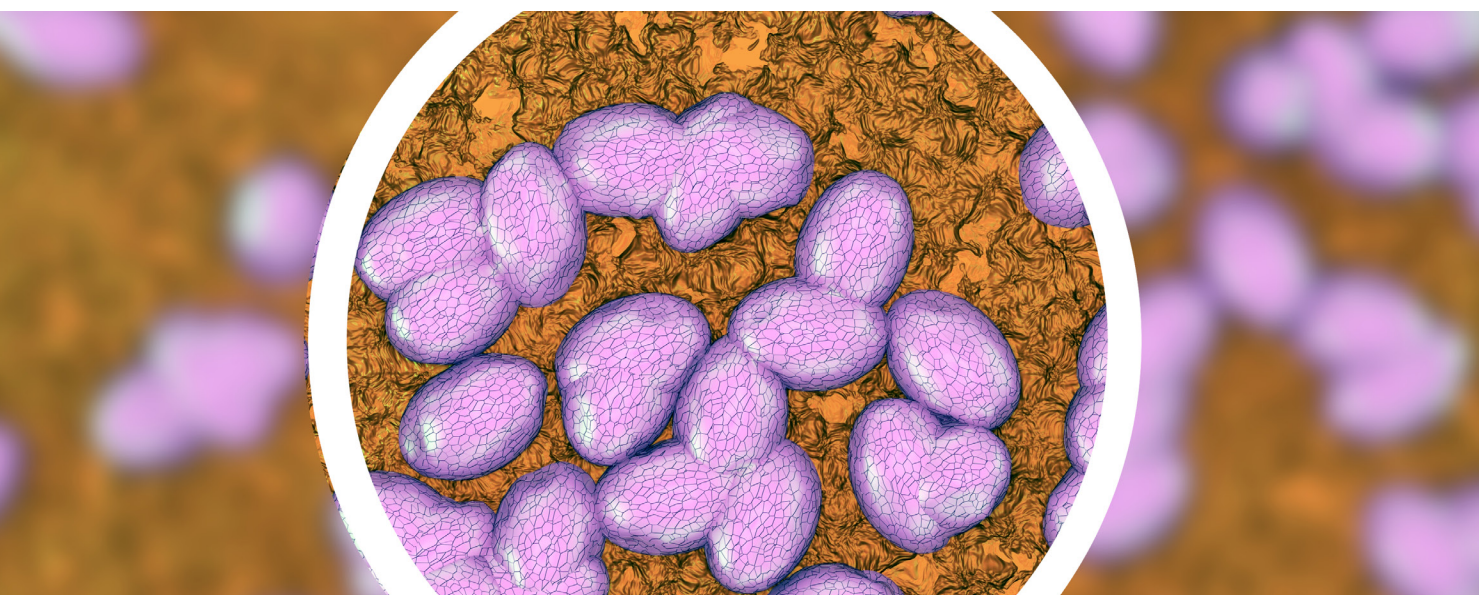
One of the key focuses of this study was looking at HAI rates and patient separation (e.g., increased use of single-patient rooms in new HCFs to prevent exposure to and spread of infectious diseases/agents), so this is where we focused our literature review.

5.1 Survey of available studies

The literature suggested there were improvements when these design elements were present in the HCF. The majority of studies reported positive results. A summary of each research article reviewed is provided below in further detail.

It is worth noting that a similar review of literature, examining hospital design and improvements to patient safety and well-being, was written in 2004. *The Role of the Physical Environment in the Hospital of the 21st century: A Once-in-a-Lifetime Opportunity*⁴, found six studies giving limited

⁴ Ulrich R., Quan X., Zimring, C., Anjali, J., & Choudhary, R. (2004). The role of the physical environment in the hospital of the 21st century: A once-in-a-lifetime opportunity. Report to The Center for Health Design for the Designing the 21st Century Hospital Project. Retrieved from https://www.healthdesign.org/sites/default/files/Role%20Physical%20Environ%20in%20the%2021st%20Century%20Hospital_L0.pdf



support to improved compliance when hand hygiene sinks and alcohol-rub dispensers were conveniently located. Three studies supported single-patient rooms with conveniently located sinks to reduce HAIs in Intensive Care Units (ICUs), Neonatal Intensive Care Units (NICUs), and burn units versus multi-bedded rooms with fewer sinks. The review uncovered 16 studies related to single-patient versus multi-bedded rooms and collectively provided evidence to support lower infection rates in single-bed rooms.

Among studies done since, several suggested a significant connection between hospital design/hygiene practices and HAI rates. For instance, *Relationship between Hospital Ward Design and Healthcare-Associated Infection Rates: a Systematic Review and Meta-Analysis*⁵ concluded that single-patient rooms and easily accessible hand rub dispensers near the patient's bed are beneficial for infection control and useful parts of a multifaceted strategy for reducing HAI colonizations

and infections. (A letter to the editor submitted by Wilson, J. *et al.*⁶ argued that the review's conclusion was not substantiated by the evidence which was largely drawn from uncontrolled before and after studies in the absence of a transparent assessment of the risk of bias.)

Another study that supported this connection, *Hospitalization in Double-Occupancy Rooms and the Risk of Hospital-Acquired Influenza: a Prospective Cohort Study*⁷, found an incidence rate almost three times higher in double-occupancy rooms compared to single-occupancy.

In 2010, *Exposure to Hospital Roommates as a Risk Factor for Health Care-Associated Infection*⁸, concluded that the number of roommate exposures per day was significantly associated with MRSA and CDI. Finally, a 2016 case study, *Do Cost Savings from Reductions in Nosocomial Infections Justify Additional Costs of Single-Bed Rooms in Intensive Care Units? A Simulation*

⁵ Stiller A., Salm F., Bischoff, P., & Gastmeier, P. (2016). Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. *Antimicrob Resist Infect Control*, 5(61). Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5129243/>

⁶ Wilson, J., Dunnet, A., & Loveday, H. (2017). Response to Relationship between hospital ward design and healthcare-associated infection rates: a systematic review and meta-analysis. *Antimicrob Resist Infect Control*, 6(71).

⁷ Munier-Marion, E., Bénet, T., Régis, C., Lina, B., Morfin, F., & Vanhems, P. (2016). Hospitalization in double-occupancy rooms and the risk of hospital-acquired influenza: a prospective cohort study. *Clin Microbiol Infect.*, 22(5), 461. Retrieved from <https://www.ncbi.nlm.nih.gov/pubmed/26806256>

⁸ Hamel, M., Zoutman, D., & O'Callaghan, C. (2010). Exposure to hospital roommates as a risk factor for health care-associated infection. *Am J Infect Control*. 38(3),173-81.

Case Study⁹, concluded that although more costly to build, single-bed rooms can result in substantial savings compared with open-bay rooms by avoiding costs associated with nosocomial infections.

Other studies offered slightly less convincing arguments. For instance, *ICU Ward Design and Nosocomial Infection Rates: a Cross-Sectional Study in Germany*¹⁰ found only minor associations between design factors and ICU infection rates. In *Hospital Ward Design and Prevention of Hospital-Acquired Infections: A Prospective Clinical Trial*¹¹, a restricted analysis of medical patients demonstrated a moderate difference in rates from the new design ward (1.89/1,000 patient days) versus historic design wards (3.47/1,000 patient days), warranting further study. Similarly, *Private Rooms: A Choice between Infection and Profit*¹² generally supported single-patient rooms.

Sequential Introduction of *Single Room Isolation and Hand Hygiene Campaign in the Control of Methicillin-Resistant Staphylococcus Aureus in Intensive Care Unit*¹³ concluded that provision of single room isolation facilities and promotion of hand hygiene practices are important. Finally, *Single Rooms May Help to Prevent Nosocomial Bloodstream Infection and Cross-Transmission of Methicillin-Resistant Staphylococcus Aureus in Intensive Care Units*¹⁴ suggested that in an institution in which MRSA is not hyperendemic, infection control measures may be more effective to prevent cross-transmission of microorganisms in patients housed in single rooms.

A handful of studies reviewed offered neutral conclusions, including *Is Single Room Hospital Accommodation Associated*

with Differences in Healthcare-Associated Infection, Falls, Pressure Ulcers or Medication Errors? *A Natural Experiment With Non-Equivalent Controls*¹⁵, the results of which provided no long-term evidence of either benefit or harm from all single-room accommodation in terms of safety-related outcomes.

*Prevention of Transmission of Multidrug-Resistant Bacteria*¹⁶ concluded that the guidelines and recommendations for dealing with colonized and infected patients are of low evidential value and often difficult to implement in the clinical practice. While hand disinfection is the single most important measure to avoid transmission, the relevance of single room isolation and contact precautions is unclear, it surmised. Another study¹⁷ on the topic did not draw any conclusions and rather focused on related topics such as the involvement of stakeholders.

Finally, one article, *Analysis of Contemporary Hospital Infrastructure Pertaining to Infection Prevention in Germany*¹⁸, did not offer conclusions, per se, but based on its analysis it offered recommendations, including increasing the number of dispensers to improve hand hygiene, and consideration for more single-patient rooms.

The findings demonstrate that while some evidence may exist, there still appears to be a strong need for more well-designed studies to determine the impact of HCF design on patient safety, particularly in a Canadian context.

There are many factors influencing whether or not a patient will acquire an infection in a HCF, ranging from patient

⁹ Sadatsafavi, H., Niknejad, B., Zadeh, R., & Sadatsafavi, M. (2016) Do cost savings from reductions in nosocomial infections justify additional costs of single-bed rooms in intensive care units? A simulation case study. *J Crit Care*, 31(1), 194-200.

¹⁰ Stiller, A., Schröder, C., Gropmann, A., Schwab, F., Behnke, M., Geffers, C., Sunder, W., Holzhausen, J., & Gastmeier, P. (2017). ICU ward design and nosocomial infection rates: a cross-sectional study in Germany. *The Journal of Hospital Infection*, 95(1), 71-75.

¹¹ Ellison, J., Southern, D., Holton, D., Henderson, E., Wallace, J., Faris, P., Ghali, W.A., & Conly, J. (2014). Hospital ward design and prevention of hospital-acquired infections: A prospective clinical trial. *Can J Infect Dis Med Microbiol*, 25(5), 265-70.

¹² Stall, N. (2012). Private rooms: A choice between infection and profit. *CMAJ*, 184(1), 24-25.

¹³ Cheng, V., Tai, J.W., Chan, W.M., Lau, E.H., Chan, J.F., To, K.K., Li, I.W., Ho, P.L., & Yuen, K.Y. Sequential introduction of single room isolation and hand hygiene campaign in the control of methicillin-resistant *Staphylococcus aureus* in intensive care unit. *BMC Infect Dis*, 10, 263.

¹⁴ Bracco, D., Dubois, M.J., & Eqqimann, P. (2007). Single rooms may help to prevent nosocomial bloodstream infection and cross-transmission of methicillin-resistant *Staphylococcus aureus* in intensive care units. *Intensive Care Med*, 33(5), 836-40.

¹⁵ Simon, M., Maben, J., Murrells, T., & Griffiths, P. (2016). Is single room hospital accommodation associated with differences in healthcare-associated infection, falls, pressure ulcers or medication errors? A natural experiment with non-equivalent controls. *J Health Serv Res Policy*, 21(3): 147-155.

¹⁶ Fussen, R., & Lemmen, S. Prevention of transmission of multidrug-resistant bacteria. *Internist (Berl)*, 56(11), 1246-54.

¹⁷ Bartly, J., & Streifel, A.J., (2010). Design of the environment of care for safety of patients and personnel: does form follow function or vice versa in the intensive care unit? *Crit Care Med*, 38(8 Suppl), S388-98.

¹⁸ Stiller, A., Schröder, C., Gropmann, A., Schwab, F., Behnke, M., Geffers, C., Sunder, W., Holzhausen, J., & Gastmeier, P. (2016). Analysis of contemporary hospital infrastructure pertaining to infection prevention in Germany. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz (Federal Gazette of Research Health)*, 59(8), 986-991.

characteristics (e.g., immunosuppressed individuals or those with multiple comorbidities being more susceptible) to hospital practices (e.g., hand hygiene, cleaning/disinfection protocols, patient screening, and isolation measures). HCF design plays an important role in the direct transmission of infectious microorganisms, as well as the effect on staff compliance with institutional infection prevention and control (IPAC) practices. For example, along with training and increased awareness, the availability of more hand-washing sinks should help to increase hand-washing compliance.

Surveillance of related metrics is required to determine if these collective measures are improving patient safety. As a result, Canada has active federal and provincial monitoring programs, which include examining HAI and hand hygiene rates, although there are regional variances in what is collected, how the information is collected, and the availability of data.

5.2 Patient safety surveillance (HAI and hand hygiene rates)

HAI infection rates are monitored at a national level under the Canadian Nosocomial Infection Surveillance Program (CNISP) which falls under the umbrella of the Public Health Agency of Canada in collaboration with the Canadian Hospital Epidemiology Committee. The program has been collecting data since 1995 and includes participation from 62 hospitals in 10 provinces. While this is a small proportion of the estimated [1,400 hospitals in Canada](#), approximately 78 per cent of Canadians live within 100 km of at least one of the participating hospitals¹⁹ thereby this sample size provides a good approximation for the country as a whole. Its surveillance includes HAI rates for MRSA and CDI, the two infections this study focuses on.

A CNISP surveillance report on MRSA infection rates (PHAC, 2014) reviewing data from January 2008 to December 2012 found that the mortality rate for patients with a clinical (non-blood) MRSA infection was 9 per cent, while 25 per cent of patients with a MRSA bloodstream infection died 30 days after the date of positive culture. Overall, MRSA infection rates have been decreasing since 2009 with the most dramatic reduction seen

in HAI rates. Similar trends are also seen in other developed countries.

While it is encouraging to see a decline in rates, MRSA infections are still reported as the leading cause of HAIs worldwide. Meanwhile, HAI in 2016, CDI rates in Canada continued to decline. (PHAC, 2017).

In more recent years, provinces also began requiring hospitals to report HAI and hand hygiene data to monitor patient safety for health care facilities within their jurisdiction. However, the surveillance varies based on what data is collected, the reporting timeframes, and how to access the data. The most readily available data was found in British Columbia and Ontario.

British Columbia's surveillance program is called Provincial Infection Control Network of British Columbia (PICNet). In its 2016 – 2017 surveillance report of acute care facilities, it noted a general decrease in the incidence of CDI since 2009, although there was a spike in 2015-16. From 2010 to 2016, the number of new MRSA cases associated with a current hospital admission has decreased, suggesting that current provincial HAI infection prevention and control strategies implemented in these facilities have worked well to reduce MRSA infection rates. The target for hand hygiene compliance was set at 80 per cent, and since monitoring began, acute care facilities have steadily improved, rising from 69.7 per cent in 2011-12 to 83.2 per cent in 2015-16 and plateaued to 82.5 per cent in 2016-17 (PICNet, 2016, PICNet, 2017).

In Ontario, patient safety indicator results are reported by all hospitals and made publicly available by Health Quality Ontario (HQP). Standardized data elements, case definitions and reporting requirements have been established, and include monitoring CDI, MRSA, and hand hygiene compliance. In 2008, Ontario's Ministry of Health and Long-Term Care (MOHLTC) also initiated the "Just Clean Your Hands" (JCYH) program to improve compliance to best practices in hand hygiene. Since then, rates of MRSA (January 2009 to March 2014) and CDI HAIs (October 2008 to March 2015) both have shown an overall decrease (MOHLTC website, 2017).

¹⁹ Statista (2018). Number of hospital establishments in Canada as of 2015, by province. Available at: <https://www.statista.com/statistics/440923/total-number-of-hospital-establishments-in-canada-by-province/>



6 Z8000 – HEALTH CARE FACILITY DESIGN

Z8000 sets out requirements for the design of HCFs in Canada. The following design elements were considered for this study:

- **Patient separation** – Single inpatient bedrooms, unless otherwise specified in the functional program with supporting justification;
- **Inpatient bathroom and human waste disposal** – One washroom with a sink and toilet per patient unless in services in which a patient will not use a toilet. In those cases, there would be provisions with disposal; and
- The design and location of hand hygiene sinks, and location of alcohol-based hand rub (ABHR) stations.

7 HCF OUTREACH (STUDY QUESTIONNAIRE)

A list of HCFs to invite as study participants was compiled. The list included HCFs across Canada that had either undergone recent renovation projects related to a design parameter of interest, or construction of a new facility, both of which would provide "before" and "after" data for comparison. All the

information was collected confidentially, therefore the HCF sites will not be disclosed in this study. As mentioned earlier, the number of participating HCFs for new renovation projects was very limited, therefore data for new builds is discussed in this report.

The study questionnaire was used to collect the relevant information. Information was collected for intensive care (ICUs), and medical/surgical units to focus on in-patient rooms. The study questionnaire was structured as follows:

- **Section A. General hospital information** – This section collected information about the number of hospital beds, private rooms vs. multi-bed rooms, airborne isolation rooms (AIRs), and AIR anterooms. The ratio of washrooms to patients was also collected.
- **Section B. Hand hygiene sinks and waterless hygiene stations/ABHR (alcohol-based hand rubs)** – This section gathered information on how hand hygiene audits are collected, hand hygiene rates, sink type/dimensions, quantity and distribution of sinks/stations, and other observations made in relation to hand hygiene that the participant considered relevant (e.g., any change in policy/practice). Participants were asked to provide data from at least three years prior to the move and all data available after the move.

- **Section C. Human waste management** – This section collected descriptions of the type and location of equipment used to manage human waste (e.g., washer disinfectors, macerators).
- **Section D. Health care-associated infections (HAIs)** – This section polled the HCFs about the collection of HAI rates for CDI and MRSA. Participants were also asked to describe any other changes that may have had an impact on HAI rates during the timeframe under review. HCFs were requested to provide data from at least five years prior to the move and all data available after the move.
- **Section E. General questions** – This section asked participants to identify any other major changes (before/after) that may have had an impact on HAI rates at their HCF.

8 RESULTS

A total of seven newly constructed HCFs participated in this study. Results are reported in Tables 1 to 5 where "n/a" indicates the data from the HCF was insufficient or unavailable and averages for all sites include only HCFs that provided both before and after data to allow for proper comparison.

8.1 Hospital design features

Key design features considered in the study are summarized in Tables 1 and 2. Overall, the survey results show an increase in compliance to Z8000 requirements relating to single patient rooms and design/availability of hand hygiene sink and ABHR stations.

8.2 Hand hygiene rates

Most participants noted that record-keeping improved when provincial requirements to report hand hygiene rates were set out. Given issues such as staff turnover or a transition from paper to electronic recording of data, some HCFs had difficulty obtaining data. Also, the reported hand hygiene compliance rates were incomplete for some of the old HCFs (i.e., the "before" comparison). Table 3, on page 15, includes more specific details.

The variability in measurement methods and insufficient data points made it difficult to calculate statistical significance for this indicator. This also limits the ability to compare between facilities. However, the hand hygiene rates showed an overall increase in compliance with the average rate for the participating sites increasing from 83 per cent to 88 per cent after hospital design changes were implemented. Interestingly in many facilities, there is no direct relationship between hand hygiene sinks and ABHR availability, nor is there a positive correlation between

TABLE 1: PERCENTAGE OF SINGLE PATIENT ROOMS BEFORE AND AFTER CHANGE IN HOSPITAL DESIGN

	ICU		MEDICAL/SURGICAL UNITS		HOSPITAL	
	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)
HCF-A	50	100	14	91	12	91
HCF-B	100	100	19	80	24	80
HCF-C	No ICU		0	35	0	48
HCF-D	100	100	7	67	8	70
HCF-E	0	100	32	83	22	87
HCF-F	n/a	100	n/a	57	n/a	61
HCF-G	32	100	16	28	22	49
All sites (average)	56	100	15	64	15	71

TABLE 2: SUMMARY COMPLIANCE TO Z8000 HAND HYGIENE SINKS AND ALCOHOL BASED HAND RUB (ABHR) STATION REQUIREMENTS, BEFORE AND AFTER CHANGE IN HOSPITAL DESIGN

	ICU				MEDICAL/SURGICAL UNITS			
	SINK		ABHR		SINK		ABHR	
	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)
HCF-A	23	100	100	100	23	100	100	100
HCF-B	18	89	27	89	0	64	n/a	91
HCF-C	No ICU		No ICU		50	64	22	83
HCF-D	67	89	78	78	18	82	82	82
HCF-E	25	89	25	100	67	92	83	83
HCF-F	25	100	100	100	n/a	77	n/a	100
HCF-G	25	73	11	45	82	100	44	64
All sites (average)	31	90	57	85	40	84	66	82

TABLE 3: HAND HYGIENE COMPLIANCE RATES BEFORE AND AFTER CHANGE IN HOSPITAL DESIGN

	ICU		MEDICAL/SURGICAL UNITS		HOSPITAL	
	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)	BEFORE (%)	AFTER (%)
HCF-A	90	90	87	89	88	92
HCF-B	90	94	90	91	92	94
HCF-C	No ICU		83	89	80	87
HCF-D	62	61	66	69	68	72
HCF-E	n/a	74	n/a	69	n/a	74
HCF-F	n/a	91	n/a	91	89	97
HCF-G	n/a	61	n/a	73	n/a	59
All sites (average)	81	82	82	85	83	88

hand hygiene sinks or ABHR availability with improved hand hygiene compliance rates. This indicates that factors other than facility design are also influencing these rates.

The unique facility and unit culture has a large impact on hand hygiene compliance rates. Health Canada has invested significant time and funding in an effort to improve compliance rates and the culture of patient safety. Several campaigns and increased awareness over the past several years have resulted in a significant improvement of hand hygiene compliance rates. Improved and standardized data collection methods have also played an important role. Many of the facilities included in our study had high rates of hand hygiene compliance to begin with, even in the absence of sufficient sink fixtures. This finding is not surprising given the high numbers of ABHR available and the associated campaigns to educate staff on its use as a preferred method of hand hygiene when hands are not visibly soiled.

The available data and research indicate that hand hygiene compliance depends on a range of factors, including physical design and location of sinks and ABHRs, staff education, and the HCF's safety culture.

8.3 CDI rates

The initial data on CDI surveillance suggests a general decrease in infection rates at the total hospital level in five of the facilities surveyed. Two of the participating HCFs had a statistically significant decrease in CDI rates. Refer to Table 4 on page 15 for more information.

A few notable highlights from this data include:

- HCF-B experienced a decrease of its CDI rate for both its medical/surgical units and overall hospital numbers. There was no significant change in the ICU, but it is interesting to note that all of the rooms were already single patient in the previous building, with a CDI rate of 0.51/1,000 patient days. By comparison, the medical surgical units had a "before" rate of 0.98/1,000 patient days with only 24 per cent single patient rooms. When the percentage of single patient rooms increased to 80 per cent, the CDI "after" rate decreased to 0.4/1,000 patient days. This facility reported using point of care Hygiene bags and disposable bedpans in the medical/surgical units both before and after moving to the new facility.

TABLE 4: CDI RATES PER 1,000 PATIENT DAYS, BEFORE AND AFTER CHANGES IN HOSPITAL DESIGN

	ICU			MEDICAL/SURGICAL UNITS			TOTAL HOSPITAL (Green shading shows decreases; Blue shading in RH column indicates statistically significant)		
	BEFORE	AFTER	P-VALUE	BEFORE	AFTER	P-VALUE	BEFORE	AFTER	P-VALUE
HCF-A	0.92	0.05	n/a	1.35	0.44	n/a	0.40	0.15	n/a
HCF-B	0.51	0.53	0.93	0.98	0.40	0.02	0.75	0.29	0.01
HCF-C	n/a	n/a	n/a	0.01	0.07	0.21	n/a	n/a	n/a
HCF-D	0.62	0.29	0.33	1.05	0.40	0.02	0.62	0.29	0.01
HCF-E	n/a	0.08	n/a	n/a	0.26	n/a	0.29	0.17	0.12
HCF-F	n/a	n/a	n/a	n/a	n/a	n/a	0.58	0.27	0.05
HCF-G	n/a	n/a	n/a	n/a	n/a	n/a	0.49	0.54	0.26
All sites (average)	0.68	0.29		0.85	0.33		0.52	0.29	

Note: Results with a p-value of less than 0.05 (bolded figures in the right-hand columns) are considered statistically significant. The p-value for HCF-A could not be calculated because there were too few data points.



MRSA

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The initial data on MRSA surveillance suggests a general decrease in infection rates at the total hospital level in all five facilities for which this measure was available

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TABLE 5: MRSA INFECTION RATES PER 1,000 PATIENT DAYS, BEFORE AND AFTER CHANGE IN HOSPITAL DESIGN

	ICU			MEDICAL/SURGICAL UNITS			TOTAL HOSPITAL (Green shading shows decreases; Blue shading in RH column indicates statistically significant)		
	BEFORE	AFTER	P-VALUE	BEFORE	AFTER	P-VALUE	BEFORE	AFTER	P-VALUE
HCF-A	0.02	0	n/a	0.05	0.01	n/a	0.05	0.02	n/a
HCF-B	1.92	1.41	0.20	1.29	0.61	<0.001	1.01	0.44	<0.001
HCF-C	No ICU			0.08	0.06	0.27	n/a	n/a	n/a
HCF-D	0.27	0.14	0.53	0.56	0.50	0.56	0.37	0.34	0.72
HCF-E	0	0	n/a	n/a	0.08	0.48	0.38	0.10	0.01
HCF-F	n/a	n/a	n/a	n/a	n/a	n/a	0.07	0.02	0.56
HCF-G	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.24	n/a
All sites (average)	0.55	0.39		0.50	0.30		0.38	0.18	

Note: Results with a p-value of less than 0.05 (bolded figures in the right-hand columns) are considered statistically significant. The p-value for HCF-A could not be calculated because there were too few data points.

- HCF-D had a similar result to HCF-B regarding its medical/surgical units and overall hospital CDI rates. The ICU did not experience a significant rate change, but had 100 per cent single patient rooms both "before" and "after." However, the medical/surgical units had just 7 per cent single patient rooms "before," rising to 67 per cent in the new facility. This facility reported it did not have washer disinfectors or macerators in the old ICU, but it had a central macerator in the old medical/surgical unit. In the new facility, there are washer disinfectors in each patient washroom (point of care) for both the ICU and medical/surgical units. In addition, the medical/surgical units now have central washer-disinfectors in their soiled utility rooms.
- HCF-F was unable to provide HAI rates at the unit-level, but had an overall decrease in CDI rates from the "before" and "after" comparison (p-value, 0.05). Information was not available for the number of single patient rooms for the old ("before") building. The facility reported having macerators available in the new unit – both centrally (medical/surgical units) and at point of care (ICUs).

8.4 MRSA rates

The initial data on MRSA surveillance suggests a general decrease in infection rates at the total hospital level in all five facilities for which this measure was available. When the data was analyzed using standard statistical procedures, it was concluded that two of the participating HCFs had a statistically significant decrease in MRSA rates.

A few notable highlights from this data include:

- HCF-B experienced a decreased MRSA rate in both its medical/surgical units and overall hospital MRSA rates. In the medical/surgical units, the rate decreased significantly from 1.29 to 0.61 per/1,000 patient days. The hospital total also decreased significantly, from 1.01 patient days to 0.44 per/1,000 patient days. As with the CDI rates, no significant change was found in the ICU, however the majority of the rooms were already single-patient.
- HCF-E reported a significant decrease in the overall MRSA hospital rate (0.38 to 0.10 per 1,000 patient days). The older building had 52 per cent single patient rooms while that total rose to 87 per cent in the newer building.



9 CONCLUSION

Infection prevention and control is a complex, multi-factorial issue. The authors of this study recognize that health care facility design is only one element in the overall effort to prevent health care-associated infections. That said, it is important that an HCF's design supports rather than undercuts good practices in patient management, hand hygiene, and human waste disposal.

The data from our study questionnaire indicated overall improvements to CDI and MRSA rates for new hospital buildings that had implemented key hospital design elements in line with those recommended in Z8000. These include well designed and positioned hand hygiene facilities, physical separation of patients in single rooms, and proper disposal of human waste. Subsequent analysis for statistical significance tended to support this conclusion.

As noted above, there were some challenges in terms of accessing reliable historical data, and in using the available data to draw specific conclusions about the effect of individual design features. Other contributing factors such as changes in environmental cleaning products, testing procedures, clinical practice changes and other infection control measures may have influenced the before and after rates and were not taken into account in this study.

Nevertheless, as health care facilities continue to follow best practices in design, and improve the monitoring of key patient safety metrics, it should also become increasingly possible for hospitals to demonstrate where efforts have resulted in increased patient safety and where to focus efforts for continued improvements. These trends will also allow national standards developers and advisory groups to better conduct research to help guide and improve their documents.

ANNEX A. RESOURCES

The following documents were reviewed for the purposes of this research paper:

Canadian Institute for Health Information (CIHI). (October 30, 2008). Patient safety in Ontario acute care hospitals: A snapshot of hospital-acquired infection control practices. *Analysis in Brief*. Retrieved from https://secure.cihi.ca/free_products/PSAF_AIB_2008_10_23_e.pdf

Ontario Ministry of Health and Long-Term Care (MOHLTC). (2017). Patient safety indicator results at Health Quality Ontario (HQO). Retrieved from http://www.health.gov.on.ca/en/public/programs/patient_safety/

Provincial Infection Control Network of British Columbia (PICNet). (October 2016). Annual surveillance report of healthcare-associated infections in BC health care facilities, Fiscal Year 2015/16. Retrieved from <https://www.picnet.ca/wp-content/uploads/PICNet-Annual-Surveillance-Report-2015-2016.pdf>

Provincial Infection Control Network of British Columbia (PICNet). (November 2017). Annual surveillance report of healthcare-associated infections in BC health care facilities, Fiscal Year 2015/16. Retrieved from <https://www.picnet.ca/wp-content/uploads/PICNet-Annual-Surveillance-Report-2016-2017.pdf>

Public Health Agency of Canada (PHAC). (2013). The Chief Public Health Officer's report on the state of public health in Canada 2013 – Healthcare-associated infections – Due diligence. Retrieved from <https://www.canada.ca/en/public-health/corporate/publications/chief-public-health-officer-reports-state-public-health-canada/chief-public-health-officer-report-on-state-public-health-canada-2013-infectious-disease-never-ending-threat/healthcare-associated-infections-due-diligence.html>

Public Health Agency of Canada (PHAC). (2014). Methicillin-resistant *Staphylococcus aureus* in Canadian acute-care hospitals Surveillance report January 1, 2008 – December 31, 2012. Retrieved from <https://www.ammi.ca/Update/12.ENG.pdf>

Public Health Agency of Canada (PHAC). (2015). Canadian Nosocomial Infection Surveillance Program (CNISP) Overview, HAI case definitions & rates. Retrieved from <https://ottawa.ipac-canada.org/photos/custom/CNISP%20overview%20-%20SAEIG%20Feb%2010%202015.pdf>

Public Health Agency of Canada (PHAC). (2017). Canadian Antimicrobial Resistance Surveillance System. Retrieved from <https://www.canada.ca/content/dam/phac-aspc/documents/services/publications/drugs-health-products/canadian-antimicrobial-resistance-surveillance-system-2017-report-executive-summary/CARSS-Report-2017-En.pdf>

A photograph of a hospital room. In the foreground, there is a white ceramic sink with a chrome faucet. In the background, there is a hospital bed with blue bedding, a white bedside table, and a large mirror on the wall. The wall is covered in white tiles. A blue semi-transparent box is overlaid on the middle of the image, containing the text 'ACKNOWLEDGEMENTS' and a paragraph of text.

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About CSA Group

CSA Group is an independent, not-for-profit membership association dedicated to safety, social good and sustainability. CSA's strategic focus and core service offering includes: standards development; training solutions; consumer product evaluation; and global testing & certification. CSA products and services target a range of key businesses, including: hazardous location & industrial; plumbing & construction; medical safety & technology; appliances & gas; alternative energy; lighting; and sustainability. The CSA certification mark appears on billions of products worldwide. For more information about CSA Group visit www.csagroup.org.

