

Comparative Analysis of Bedpan Processing Equipment

AGENCE D'ÉVALUATION DES TECHNOLOGIES
ET DES MODES D'INTERVENTION EN SANTÉ



Comparative Analysis of Bedpan Processing Equipment

Technical brief prepared for AETMIS by
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THE AGENCY

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FOREWORD

The safe reprocessing of medical devices is a major challenge in terms of both preventing the spread of infection to patients and staff and selecting equipment that meets expected standards. Senior health administrators are increasingly faced with making investment decisions that will have economic consequences throughout the years to follow. Reprocessing equipment is a major component of such investments. The Ministère de la Santé et des Services sociaux (MSSS) intends to play an active role in setting the policy directions that will guide these decisions as they arise.

As part of developing an action plan on reprocessing medical devices, the MSSS is considering currently available reprocessing technologies and alternative options. The Direction des investissements, the investment branch of the MSSS, therefore asked the Agence d'évaluation des technologies et des modes d'interventions en santé (AETMIS) to perform an assessment comparing two types of equipment used in bedpan management in health-care facilities: bedpan washers for reusable bedpans and macerators for disposable bedpans. The assessment should examine the effectiveness and safe use of the equipment, as well as organizational, economic and environmental issues.

Based on a literature review and discussions with practitioners in health-care facilities, this technical brief presents the analysis of the issues surrounding the use of bedpan washers and macerators, and examines an alternative option, hygienic bags. It provides Canadian and international perspectives, in addition to offering an acquisition and operating cost scenario.

Juan Roberto Iglesias, MD, MSc,
President and Chief Executive Officer

EXECUTIVE SUMMARY

Bedpans are medical devices used to collect the excreta of bedridden patients, and bedpan management requires strict hygiene measures to prevent these devices from becoming sources of contamination. Reusable bedpans are reprocessed in bedpan washers, while disposable bedpans are destroyed in macerators. An alternative solution for human waste disposal has recently appeared on the market: disposable hygienic bags.

In light of its analysis, AETMIS concluded that bedpan management cannot be uniform across health-care facilities in Québec and that it is up to each facility's infection prevention and control team to make an informed decision about the method to adopt, in conjunction with management and the rest of the medical and professional staff. For the purpose of guiding that choice, the following basic principles apply:

- Manual bedpan cleaning must be proscribed because it poses a very high risk of infection: staff must not empty bedpans into sinks or toilets and must no longer use spray wands.
- Use of automated bedpan washers or macerators for processing bedpans is recommended if it follows stringent infection prevention procedures.
- Bedpan washers and macerators must be installed in dirty utility rooms located a reasonable distance away from patients' rooms (to reduce the risk of workplace contamination) and soiled bedpans must always be covered during transport to reprocessing equipment.
- Dirty utility rooms must be large enough to house the reprocessing equipment and to allow supplies to be properly stored. The area provided for dirty supplies must be physically separate from that for clean supplies.
- Reusable bedpans must be disinfected after each use. Leaving soiled bedpans to pile up on counters must be avoided by making sure that each care unit (ward) has enough reprocessing equipment.
- Sterilization of reusable bedpans between patients must be considered if the aim is to have bedpans free of bacterial spores in order to better control sources of *C. difficile* infection.
- After patient discharge, disposable bedpan supports must be sent to the central processing department for disinfection in a washer-disinfector.
- If the use of bedpan washers is adopted, a backup option must be planned for isolated cases or outbreaks of diarrhea associated with *C. difficile* (disposable bedpans, hygienic bags) especially when reusable bedpans are not sterilized after use.
- Installation of modular bedpan-washer units or macerators in the washrooms of isolation rooms should be considered in order to minimize workplace contamination during bedpan transport to dirty utility rooms, and to monitor highly contaminated bedpans.
- Staff must be properly trained and must consistently comply with procedures for human waste management, bedpan reprocessing and equipment operation.
- The use of hygienic bags for all patients should be considered in the critical conditions of a *C. difficile* outbreak.
- Preventive maintenance and verification of the equipment's operational parameters must be monitored on a regular and ongoing basis.

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CONFLICTS OF INTEREST

None declared.

SUMMARY

As part of developing an action plan on medical device reprocessing, the Direction des investissements, the investment branch of Québec's Ministère de la Santé et des Services sociaux (MSSS), asked AETMIS to perform an assessment comparing the use of bedpan washers for reusable bedpans and that of macerators for disposable bedpans. This assessment examined their effectiveness and safety, as well as organizational, economic and environmental issues.

Description of the equipment

Bedpan washers are designed to help empty, clean and disinfect reusable bedpans. Disinfection is a process intended to reduce the greatest number of pathogenic micro-organisms found on medical devices to make them safe to reuse. Bedpan washers are capable of reprocessing up to two bedpans at a time. The average reprocessing cycle lasts from five to ten minutes. The disinfection stage usually occurs at a temperature of 80°C.

Macerators are used to cut disposable bedpans made of biodegradable recycled pulp paper. They can destroy up to four bedpans per two-minute cold-water cycle. When in use, disposable bedpans are placed on reusable plastic supports that must be reprocessed.

Safe use of the equipment

An exhaustive narrative review of selected articles and the grey literature was performed. Results indicated that bedpan washers make it possible to disinfect bedpans in nursing care units (wards) without the need to empty them beforehand, which reduces the risk of contaminating the workplace and the staff. However, bedpan washers do not always clean them effectively. Although the disinfection process eliminates a large share of the micro-organisms on bedpans, it does not destroy bacterial spores, including those of *C. difficile*. Considering the issue of nosocomial infections associated with these spores, bedpans should ideally be sterilized to ensure safer reuse from the viewpoint of prevention.

The use of macerators limits the handling of soiled bedpans because the bedpans are destroyed immediately after use. Macerators are less complex to run because there are no operational parameters to select. The risk of infection comes mainly from the aerosols (splashback) produced when these devices are blocked by solid objects often inadvertently dropped into them (e.g., gloves, diapers, plastic bags). The large amount of waste produced by macerators can lead to blocked sanitary sewage disposal pipes and wastewater overflows.

Organizational issues

Bedpan washers are easy to install, but their maintenance and slow operation would appear to hinder technicians' and nursing staff's time management. Dirty utility rooms may need to be redesigned when this equipment is installed. By contrast, owing to their fast cycles and output, macerators are an effective staff time management tool, despite the need to transport soiled bedpans, restock nursing care units and handle

administrative procurement formalities. Depending on the condition of the building, the drainage system may need to be adapted when macerators are installed.

Economic issues

Acquisition costs are higher for bedpan washers than for macerators, but the opposite is true in terms of their operating costs. While bedpan washers cost more in terms of energy consumption (electricity), macerators generate high expenditures for disposable supplies (bedpans), in addition to incurring extra costs for reprocessing bedpan supports.

Environmental issues

Bedpan washers are energy hungry compared with macerators. However, macerators produce a large volume of waste even though it consists of biodegradable recycled pulp paper. The legal aspect of connecting macerators directly to municipal sewage systems needs to be checked.

Québec context

Discussions with key actors in certain Québec institutions allow us to state that choosing a bedpan management method is currently a matter of concern to infection control practitioners. There is no uniform bedpan processing method across hospitals. Four are currently in use: conventional manual method, bedpan washers, macerators, and oxo-biodegradable plastic hygienic bags. The last option, hygienic bags, is a recent single-use concept that allows for the safe disposal of human waste. It would seem to be a promising option at a time of labour shortages and *C. difficile* outbreaks. Although the hygienic bag method requires no equipment or infrastructure, it entails very high operational costs and generates a large amount of environmental waste.

Discussion

Both bedpan washers and macerators still carry the risk of contaminating the work environment during bedpan transport outside rooms. Installing this equipment inside the rooms is not necessarily feasible because of the condition of the infrastructures and would not eliminate the other drawbacks associated with its use. Nevertheless, proper use of bedpan washers combined with other stricter preventive measures would be a safe and economical solution. Macerators would be appropriate infection-control devices if the drawbacks stemming from their mechanisms were solved. In this respect, the use of hygienic bags offers an advantage in that it allows contaminated material to be managed within isolation areas and does not require installing any equipment.

Conclusion

Analysis of the literature revealed that both types of bedpan processing equipment – bedpan washers and macerators – have benefits and drawbacks. The data helped identify the issues specific to each type of equipment, without determining the best choice for hospitals. Although consultation with professionals in the field shed light on several relevant aspects, it did not help establish a consensus guideline. The lack of clinical practice guidelines means that each health-care facility must make choices that meet their needs and means. Nevertheless, all the practitioners we met expressed a willingness to agree on procedures meeting acceptable infection-control standards. Beyond the

economic and environmental aspects, the main issues consistently raised by practitioners was the effectiveness of the equipment or procedures to reduce the risk of infection and to optimize work planning.

It is up to the infection prevention and control team at each health-care facility to make an informed decision about the method to adopt, in conjunction with management and the rest of the medical and professional staff. For the purpose of guiding that choice, the following basic principles apply:

- Manual bedpan cleaning must be proscribed because it poses a very high risk of infection: staff must not empty bedpans into sinks or toilets and must no longer use spray wands.
- Use of automated bedpan washers or macerators for processing bedpans is recommended if it follows stringent infection prevention procedures.
- Bedpan washers and macerators must be installed in dirty utility rooms located a reasonable distance away from patients' rooms (to reduce the risk of workplace contamination) and soiled bedpans must always be covered during transport to reprocessing equipment.
- Dirty utility rooms must be large enough to house the reprocessing equipment and to allow supplies to be properly stored. The area provided for dirty supplies must be physically separate from that for clean supplies.
- Reusable bedpans must be disinfected after each use. Leaving soiled bedpans to pile up on counters must be avoided by making sure that each care unit has enough reprocessing equipment.
- Sterilization of reusable bedpans between patients must be considered if the aim is to have bedpans free of bacterial spores in order to better control sources of *C. difficile* infection.
- After patient discharge, disposable bedpan supports must be transferred to a centralized sterilization area for disinfection in a washer-disinfector.
- If the use of bedpan washers is adopted, a backup option must be planned for isolated cases or outbreaks of diarrhea associated with *C. difficile* (disposable bedpans, hygienic bags) especially when reusable bedpans are not sterilized after use.
- Installation of modular bedpan-washer units or macerators in the washrooms of isolation rooms should be considered in order to minimize workplace contamination during bedpan transport to dirty utility rooms, and to monitor highly contaminated bedpans.
- Staff must be properly trained and must consistently comply with procedures for human waste management, bedpan reprocessing and equipment operation.
- The use of hygienic bags for all patients should be considered in the critical conditions of a *C. difficile* outbreak.
- Preventive maintenance and verification of the equipment's operational parameters must be monitored on a regular and ongoing basis.

On the whole, any decision concerning infection prevention must be based on eliminating the sources of risk. Doing so starts with reducing the handling, transport and processing delays related to soiled supplies. Manual bedpan cleaning and

disinfection must be avoided because the risk of contamination is too high. Recommending a single bedpan processing method would be inappropriate. Several variables come into play in that choice, primarily, bedpan use requirements, risk of infection and outbreaks, staff availability, possibility of redesigning infrastructures, geographic area and budgets. In considering the data gathered in this technical brief, health-care facilities must each define their own needs and make an informed and “green” choice.



ACRONYMS

AQIHS: Association québécoise des intervenants en hygiène et salubrité

ASSTSAS: Association paritaire pour la santé et la sécurité du travail du secteur affaires sociales

CINQ: Comité sur les infections nosocomiales du Québec

HSCM: Hôpital du Sacré-Cœur de Montréal

IICC: International Infection Control Council

NHS: National Health Service (United Kingdom)

PIDAC: Provincial Infectious Diseases Advisory Committee (Ontario)

WIP: Dutch Workingparty on Infection Prevention

GLOSSARY

Bedpan: a receptacle used in health-care facilities to collect the excreta of bedridden patients.

Bedpan washer: equipment used to clean and disinfect bedpans.

Cleaning: process that mechanically removes visible soil (dust, dirt) and visible or invisible organic matter (blood, secretions, excretions) to inhibit the reproduction or spread of micro-organisms. Physical cleaning removes micro-organisms but does not kill them.

Decontamination: process that cleans and eliminates pathogenic micro-organisms from devices to ensure safe handling.

Dirty utility room: room for storing housekeeping products and often containing a plumbing system.

Disinfection: process that inactivates most pathogenic micro-organisms (vegetative bacteria, mycobacteria, fungi, viruses) found on medical devices. Disinfection does not destroy spores. Disinfection levels include:

High-level disinfection: process that destroys vegetative bacteria, mycobacteria, fungi, and lipid-enveloped and non-enveloped viruses but not necessarily bacterial spores.

Intermediate-level disinfection: process that kills vegetative bacteria, mycobacteria, most fungi and viruses but not bacterial spores.

Low-level disinfection: process that kills most vegetative bacteria, some fungi and some lipid-enveloped viruses. This level of disinfection does not destroy mycobacteria or bacterial spores.

Grey literature: literature produced by all levels of government, academics, business and industry, in print and electronic formats, but which is not controlled by commercial publishers.¹

Macerator: equipment that destroys single-use paper pulp bedpans.

Oxo-biodegradation: primary degradation based on accelerated oxidation through the combined action of light, heat and oxygen.

Reprocessing: process that prepares medical devices for safe reuse.

Risk classification (Spaulding's Classification): classification based on the risk of infection associated with the use of medical devices after final reprocessing. Risk categories are:

Critical: devices that enter sterile body tissue, especially the vascular system. These devices must be reprocessed by meticulous cleaning followed by sterilization.

Semi-critical: devices that come in contact with non-intact skin and mucous membranes but do not enter them. These devices must be meticulously cleaned preferably with a high-level disinfectant; in some cases, intermediate-level disinfection may be acceptable.

1. Definition taken from the *INAHTA-HTAi Glossary*. Available at: <http://etmis.org/tiki-index.php?page=ListAllTerms>.

Non-critical: devices that do not come in direct contact with patients or only with intact skin but not the mucous membranes. These devices are reprocessed by meticulous cleaning followed or not by low-level disinfection.

Small items: any of the smaller containers designed for a patient's personal use.

Sterilization: process that destroys all forms of microbial life, including bacteria, viruses, spores and fungi. Although this process considerably reduces the probability of microbe presence on a device, the probability cannot be zero.

Thermal disinfection: heat disinfection based on preset temperature and time settings.

Washer-decontaminator: equipment used to clean medical devices with detergent (as do some bedpan washers). A chemical agent like chlorine may also be used. There is no guarantee as to antiseptic quality.

Washer-disinfector: equipment that uses heat to clean and disinfect medical devices.

Infection control is a fundamental aspect of the quality of hospital service, and reprocessing medical devices is one of its key components. Reprocessing involves cleaning, disinfecting and (or) sterilizing soiled reusable medical devices to make them safe for reuse. The alternative to reprocessing is to use disposable devices. Depending on the medical device and what it is used for, several reprocessing methods are available to disinfection and sterile processing professionals. This technical brief will analyze two types of equipment used to reprocess soiled bedpans: bedpan washers and macerators.

Bedpans are receptacles used in hospitals to collect the excreta of bedridden patients. Depending on their constituent material, bedpans may be single-use (disposable) or reusable. Given that bedpans come in contact with human waste, they must be disinfected before reuse. The equipments analyzed here have very different purposes. Macerators are used to destroy disposable pulp bedpans, while bedpan washers are used to reprocess reusable bedpans. Choosing between these two equipments or an alternative solution can be a rather complex decision for administrators.

With the aim of developing an action plan on reprocessing medical devices to help guide health administrators' decisions, the Ministère de la Santé et des Services sociaux (MSSS) is giving consideration to available reprocessing technologies and their alternatives. That is why the Direction des investissements, the investment branch of the MSSS, asked the Agence d'évaluation des technologies de la santé et des modes d'intervention (AETMIS) to perform an analysis comparing the use of bedpan washers with that of macerators for disposable bedpans.

This technical brief aims to answer the following assessment questions: How does the use of bedpan washers for reusable bedpans compare with that of macerators for disposable bedpans? What issues are involved? What are the Canadian and international perspectives on this matter? This comparative analysis will be based on four main aspects: safe use (infection control), organizational issues (infrastructures, human and material resources), economic issues, and environmental issues (production of disposable materials and waste management). Although not mentioned in the assessment request, the use of hygienic bags, a practice adopted by some hospitals in Québec, will also be addressed as an alternative to the two types of equipment mentioned above.

According to E. H. Spaulding's classification system,² the intended use of a device determines how it is reprocessed to prevent the transmission of infections. Bedpans are classified as *non-critical* devices, that is, devices that come in contact only with a patient's intact skin. Reusing bedpans therefore requires meticulous cleaning and low-level disinfection.³ Although Spaulding's classification dates back several years (1968), it is still used as a reference in Canadian and international practice guidelines and in articles published by professionals and experts in the field of medical device disinfection and sterilization. However, its great simplicity has been questioned by several authors [Rutala et al., 2008; Miles, 1991; Nyström, 1989]. While some state that the transmission of infectious agents from *non-critical* devices to patients remains a theoretical risk [Weber and Rutala, 1997, in Rutala and Weber, 2004], others consider that bedpans should undergo high-level disinfection [Miles, 1991].

According to Duncan and Edberg [1995], for an infection to occur, an organ must come in contact with sufficient microbes, these microbes must possess specific virulence factors, these factors must be expressed, and the organ's immune system must be overcome. The risk of infection can be described by the following model:

$$\text{Risk of infection } \propto \frac{[\text{Number of Microbes}] \times [\text{Virulence Characteristics}]}{\text{Immune Status of the Host}}$$

In other words, the presence of a highly virulent micro-organism acting against an organ with a weaker immune status is associated with a high risk of infection. If we relate this to the issue of bedpan use, it can be said that even a low number of highly virulent micro-organisms on a bedpan that comes in contact with a patient who has a very weak immune system can pose a high risk of infection; hence, the importance of knowing the virulence factor of the bacterial load that a bedpan may harbour, with a view to protecting patients from the risk of infection. Knowledge of that information can help in choosing the reprocessing method most likely to reduce that risk. While more complex than Spaulding's classification, Duncan and Edberg's concept is less practical to use. The Spaulding Classification will therefore be considered the reference in this technical brief.

2.1 Conventional method

The conventional method consists in cleaning and disinfecting bedpans by hand. After emptying the bedpan into the toilet bowl in a patient's room, staff cleans it with a spray wand hanging from the wall. This means that staff does not need to leave the patient's room or to transport bedpans containing feces in the corridors. Cleaned bedpans are then returned to patients' bedside tables. After patient discharge, the bedpans are soaked in a disinfectant solution for several minutes to complete the disinfection process or are

2. The Spaulding Classification divides medical devices into three infection risk categories according to their use: non-critical, semi-critical and critical [Spaulding, 1968]. Their level of reprocessing therefore depends on the category they belong to.

3. Disinfection is a process that reduces the number of pathogenic micro-organisms on a device to render it safe for use. It is either a chemical or a thermal process. There are different levels of disinfection. Low-level disinfection destroys most vegetative bacteria, some fungi and some lipid-enveloped viruses. Intermediate-level disinfection destroys vegetative bacteria, mycobacteria and most fungi and viruses. High-level disinfection destroys all the previously mentioned micro-organisms but not necessarily bacterial spores.

sometimes sent to the central processing department (CPD) where they are reprocessed in a washer-decontaminator. In both cases, the water pressure from the sprayer causes splashback, leading to the risk of workplace contamination and exposing staff to contaminated aerosols. Leaving soiled bedpans to pile up on counters as they wait for disinfection not only allows fecal matter to harden in the bedpans, making them more difficult to clean, but may also contaminate the work environment. Staff discomfort when handling chemical disinfectants (fumes, skin irritation) is also an important factor to consider. Lastly, this method involves the need to make space in dirty utility rooms and also requires efficient workflow management.

2.2 Bedpan washers

Bedpan washers are designed to help empty, clean and disinfect urinals, reusable bedpans and other accessories. For the purposes of this technical brief, our analysis will be limited to bedpans and the term “bedpan washer” will be used as meaning an equipment dedicated exclusively or not to the thermal disinfection of bedpans. The advent of bedpan washers has not totally eliminated the need to handle bedpans. For some of the older bedpan-washer models, staff still needed to empty them and flush them out with water before putting them into the washer for disinfection. The new generation of bedpan washers is designed to automate the entire process and to eliminate the need to empty the bedpan contents. Nevertheless, transporting bedpans containing human waste in the corridors is still an issue.

Bedpan washers are capable of disinfecting up to two bedpans and four urinals per cycle. To prevent bedpans from piling up on counters, staff may start the machine each time a soiled bedpan needs cleaning. The disinfection process involves steam or hot-water spray. The entire reprocessing cycle lasts from five to ten minutes. This depends on the washer model, water flow, temperature of the incoming water and selected disinfection program.

The cycles of a disinfection program may differ from washer to washer but are generally the following:

1. Pre-rinse.
2. Rinse.
3. Cleaning (with detergent if necessary). This step is very important because it ensures proper subsequent disinfection.
4. Second rinse to remove detergent residue, which can otherwise recontaminate the bedpan.
5. Steam or water-spray disinfection, according to preset time and temperature settings.⁴
6. Drying: This stage is not normally offered in bedpan-washer models used on wards. Drying is done by leaving the bedpans in the washer (heat effect), placing them on clean counters (natural air drying) or wiping them by hand.

Figure 1 below provides a more detailed description of a routine hospital procedure using reusable bedpans.

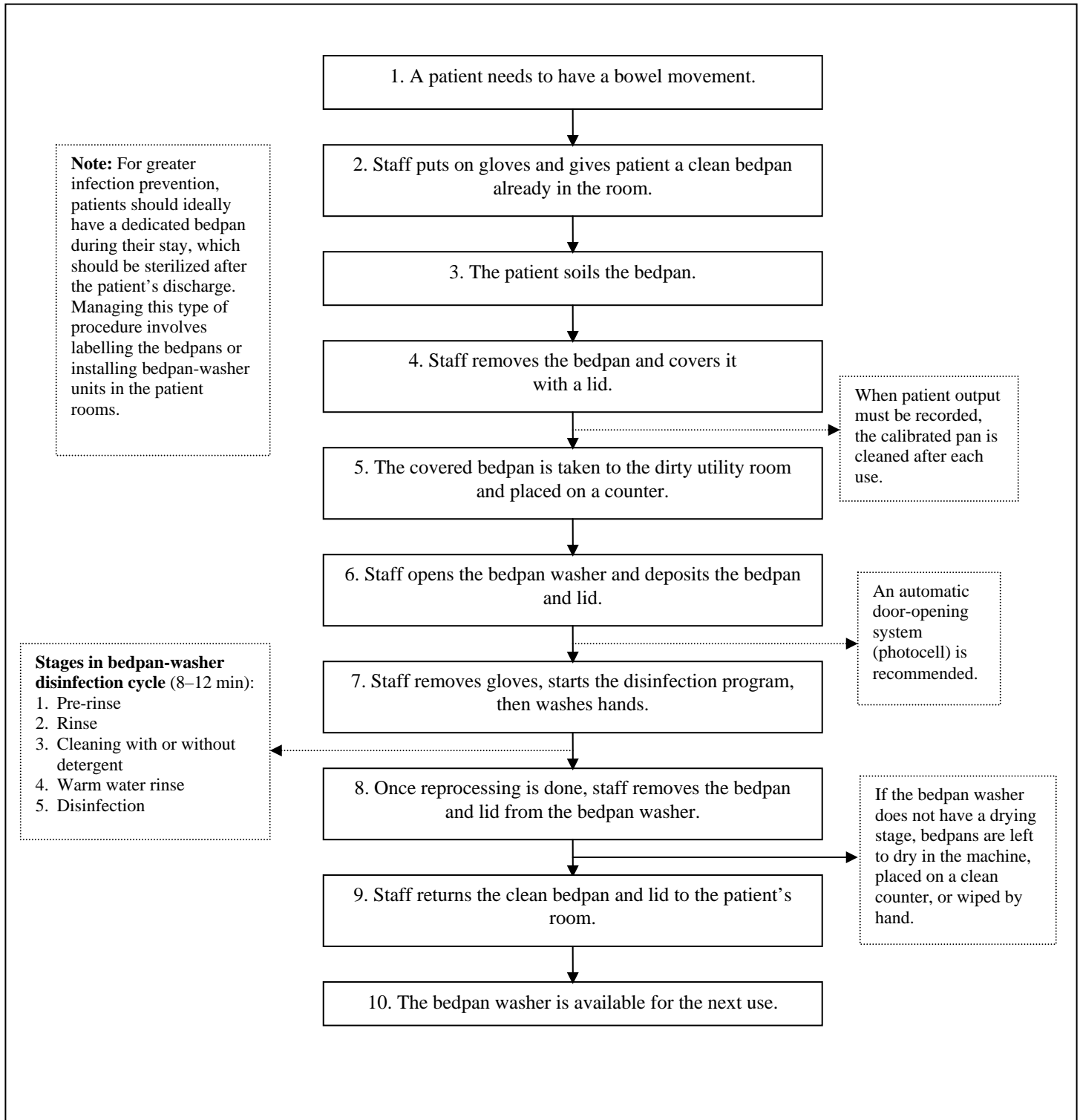
4. The international standard ISO 15883-3 [2006a, in Alfa et al., 2008] recommends that bedpans undergo thermal disinfection with a minimum value of $A_0 = 60$, that is, 80°C for one minute. This corresponds to low-level disinfection.

Functionalities for safe use

Given the growing technological progress in the field, the machines currently available on the market have totally new features that were absent in the past and that used to raise safety and effectiveness issues. Below are some of these newer functionalities:

- Automatic door opening: this function helps prevent soiled hands from contaminating the workplace. It also makes it impossible to open the door during the process, preventing exposure to contaminated aerosols.
- Insertion of soiled bedpans into the machine without the need for prior emptying, reducing handling and risk of contamination.
- Automatic cycle interruption if the ideal disinfection temperature is not reached or in case of a mechanical breakdown (warning light).
- Option to set the disinfection temperature as high as 91°C and to increase the disinfection time for heavily soiled bedpans.
- Integrated microprocessor to automate the process, allowing for safer use and more effective cleaning.
- Automatic dosage of detergent and descaler (to remove residues due to water hardness).
- Modular units for private rooms: these are automated bedpan washers built into the wall over the toilet, allowing staff to disinfect the bedpan in the washroom immediately after use.

FIGURE 1
Sequence of steps in a routine hospital procedure using reusable bedpans



2.3 Macerators

A macerator is a human waste disposal system. It is used “to dispose of human fecal waste, urine and stomach contents with a view to reducing the transmission of nosocomial infections associated with the handling of reusable bedpans” [AQIHS, 2007; free translation]. Macerators are designed to process single-use bedpans made of biodegradable pulp and beeswax. They are placed on plastic supports that are reprocessed in a washer-disinfector.

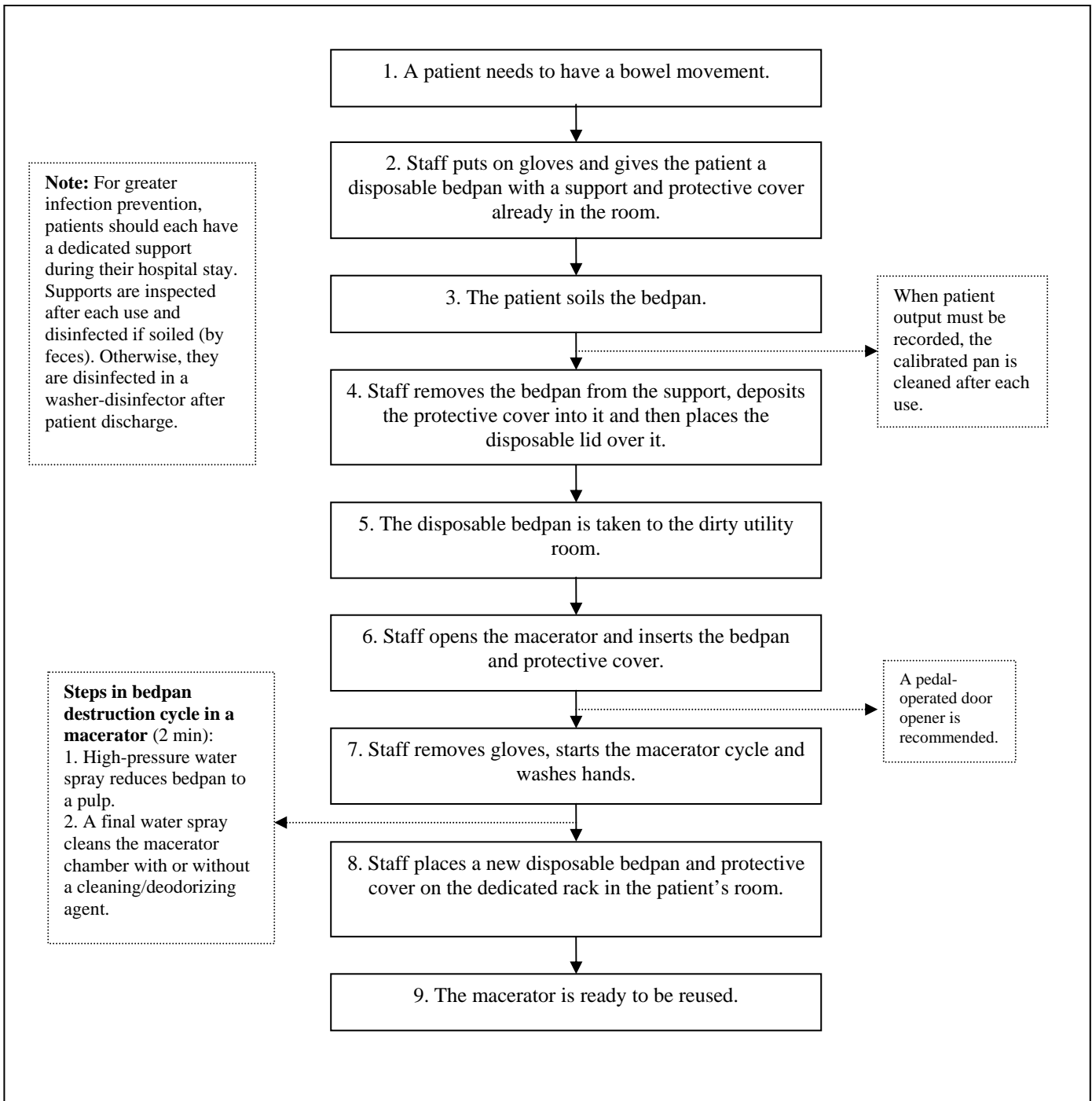
Soiled bedpans do not need to be emptied before being put into a macerator. This machine holds from two to four bedpans; however, in order to prevent soiled bedpans from piling up, the cycle may be started any time a bedpan is deposited into it. The macerator cycle lasts two minutes and takes place as follows:

1. A high-pressure cold-water spray and cutting blades macerate the waste into a pulp (the pulp is flushed into the drainage system).
2. A final spray cleans the interior chamber of the macerator for later use.

Figure 2 provides a more detailed description of the sequence of steps in a routine hospital procedure using disposable bedpans.

FIGURE 2

Sequence of steps in a routine hospital procedure using disposable bedpans



This technical brief consists of an exhaustive literature review and a brief descriptive analysis of interactions held with infection prevention and control practitioners and sterile processing practitioners. These practitioners work in different hospitals across Québec.⁵

Literature was searched in Medline/PubMed and the Cochrane Library. The search strategy is described in Appendix A. Given the sparse literature on the topic, any study addressing either of the two technologies or comparing them and published in English or French since the 1980s was selected. Considerable caution was exercised in selecting studies that evaluated the effectiveness of a particular model and funded by a manufacturer. The bibliographies of some of the articles were also examined to locate other studies of interest.

Grey literature was identified through searches in Nosobase (a database specialized in hospital hygiene and nosocomial infections), in government publications (technical guidances, reports, circulars and bulletins), and on the Web. Some manufacturers' Web sites were consulted to identify different models and their functionalities (bedpan washers and macerators) and alternative bedpan management options (hygienic bags).

5. Hôpital du Sacré-Cœur de Montréal, CHUM (Hôpital St-Luc, Hôpital Notre-Dame), Hôpital Maisonneuve-Rosemont, Hôpital Honoré-Mercier, the acute care facility of the CSSS Richelieu-Yamaska (Saint-Hyacinthe), CHUQ (Pavillon Saint-François d'Assise), Hôpital Ste-Croix, the acute care facility of the CSSS Drummond (Drummondville).

RESULTS OF THE LITERATURE REVIEW

The search strategy retrieved a small number of studies with a poor level of evidence, most dating ten years back. Although this equipment has been modernized since these studies were published, we included them in this technical brief since several of the issues they raise are still current.

4.1 Safety and effectiveness

In purchasing any medical equipment, safe use is an aspect required by all infection control teams. What is meant by safety is primarily a guarantee that an equipment is capable of neutralizing all sources of infection. The different study results are fairly consistent in terms of the level of safety afforded by bedpan washers and macerators.

There is obviously a risk of splashback when bedpans are emptied manually before being placed in a bedpan washer. The contaminated droplets pose an infection hazard to staff and the work environment. Although more recent bedpan-washer models no longer require bedpans to be emptied by hand, the staff still risk contamination if excretions are spilled during bedpan transport in the corridors (from patients' rooms to dirty utility rooms). The same risk applies when macerators are used.

Nine publications on the safe and effective use of bedpan washers or macerators were identified. These publications included:

- Two comparative studies on bedpan-washer disinfection methods [Alfa et al., 2008; Nyström, 1983].
- A descriptive study on the effectiveness of a washer-disinfector, partly industry-funded [Dempsey et al., 2000].
- Two narrative articles describing an infection control initiative or a survey on the effectiveness of macerators [Tomiczek et al., 2006; Collins et al., 1980]
- Two expert opinions and a survey on the procedures for using the two types of equipment under review [Rollnick, 1991; Hickman, 1989; Johnson, 1989]
- A letter to a journal editor on the effectiveness of bedpan-washer disinfection [Chadwick and Oppenheim, 1994]

Comparative studies

Nyström's study [1983] showed that bedpan-washer disinfection is effective when the final rinse water temperature is above 85°C rather than below 70°C. This study compared the degrees of contamination of bedpans, urinals and washbowls after disinfection in an automated bedpan washer using two different temperature settings for the final rinse water. The items were collected from an orthopedic surgery ward and emptied into a toilet before being processed in a bedpan washer with detergent.

In this study, 51 bedpans were disinfected with the final rinse water temperature above 85°C and 50 were disinfected with a water temperature below 70°C. For comparison purposes, the degree of contamination was measured before and after disinfection. After use by the patient and before disinfection, 81 bedpans had bacterial counts of more than 100 cfu/100 cm² and 8 bedpans had 10 cfu/100 cm² or less; the remaining bedpans (12) had from 11 to 100 cfu/100 cm² (see definition below⁶).

After disinfection with a final rinse water temperature below 70°C, 10 bedpans (20%) had bacterial counts of more than 100 cfu/100 cm², 34 bedpans (68%) had 10 cfu/100 cm² or less, and the 6 remaining bedpans (12%) had between 11 and 100 cfu/100 cm². After disinfection with a final rinse water temperature above 85°C, no bedpan had bacterial counts of more than 100 cfu/100 cm², 48 bedpans (94%) had 10 cfu/100 cm² or less, and the 3 remaining bedpans (6%) had between 11 and 100 cfu/100 cm².

In general, these results revealed that disinfection at over 85°C was effective ($p < 0.001$) in eliminating virtually all micro-organisms (enterobacteria, enterococci and *Staphylococcus aureus*) from the bedpans, washbowls and urinals. The principal bacteria that resisted in fairly large numbers were *Staphylococcus epidermidis* and Gram-positive rods. The author explained this by the fact that Gram-positive rods are spore formers and that the *S. epidermidis* strain may have contaminated the culture medium or the items after reprocessing in the bedpan washer. Although residual soil was still visible on the surface of the receptacles after cleaning (inefficient cleaning), Nyström concluded that the resulting risk of contamination between patients or from the hands of the hospital staff was negligible.

Very recently in Canada, Alfa et al. [2008] evaluated the efficacy (in terms of cleaning and inactivating *C. difficile* spores) of a reusable bedpan/urinal washer-disinfector located on a hospital ward (ward-WD) compared with that of a washer-disinfector (a single-chamber Steris Reliance 444) used for various medical instruments and located in the Central Processing Department in the same hospital (CPD-WD). Tests were carried out on metal bedpans, plastic bedpans and plastic urinals. The ward-WD cleaning cycle consisted of several washes and a disinfection stage at 80°C for one minute. The CPD-WD had a longer cycle consisting of several wash stages, a disinfection stage at 82°C for one minute, a final rinse and a drying stage at 116°C for 7 minutes. Cleaning efficacy was tested using an ultraviolet-visible marker (UVM), an indicator of cleaning efficacy (TOSI device)⁷ and artificial test soil (ATS)⁸. The ability of the two equipments to kill *C. difficile* spore was also evaluated.

The TOSI device showed that the ward-WD did not provide adequate cleaning but the CDP-WD completely removed all the soil. Nevertheless, the authors noted that improper installation of the ward-WD may have been the cause of the poor test results. Although the bedpans were visibly cleaner after the installation problem was corrected, it was shown that the disinfection standard for the ISO-registered ward-WD, that is, 80°C for one minute [ISO, 2006a, in Alfa et al., 2008] was not adequate to kill *C. difficile* spores, which would ensure safe bedpan handling and reuse.

Given that the initial bacterial suspension was on the order of 1.1×10^7 cfu/mL (5×10^5 cfu/site inoculated), after disinfection in the ward-WD and sampling using Rodac

6. CfU (colony-forming unit) is a measure of viable cells (bacterial or fungal).

7. Method to evaluate the cleaning efficacy of instrument washers. It simulates dried blood residues found on soiled instruments.

8. This test simulates the worst levels of hemoglobin, proteins, carbohydrates and endotoxins potentially found on a flexible endoscope after use.

plates,⁹ the plastic bedpans showed a level of *C. difficile* contamination of around 35 cfu/site inoculated. The stainless steel bedpans showed a level of contamination of around 5 cfu/site inoculated. Lastly, the contamination of the urinals exceeded 100 cfu/site inoculated. No contamination was detected after disinfection in the CPD-WD. The performance of the CPD-WD seemed to be attributable to a cumulative effect of the hot water rinses, steam disinfection and drying cycle. Moreover, a test designed to show the ability of the two washer-disinfectors to kill *C. difficile* helped determine that the drying stage (116°C for 7 minutes) in the CPD-WD played a crucial role in spore destruction. The result of the test to determine the probability of cross-contamination between two cycles was negative. However, to ensure that neither the washer-disinfectors nor the bedpans become vectors for bacteria spread to other patients and sources of exposure to staff, frequent machine maintenance and monitoring were advised [Alfa et al., 2008].

Descriptive study of the effectiveness of a washer-disinfector model

In Australia, Dempsey et al. [2000] evaluated the cleaning and disinfection efficacy of the DEKO-190 manufactured by Franke Ltd. and installed in a hospital emergency department. This device is designed to clean and disinfect bedpans, urinals and washbowls and to pre-clean minor surgical instruments before sterilization. The cycle selected for the study consisted of two preliminary 5-second rinses, a 1.5-minute wash with a detergent, a 15-second flush and thermal disinfection at around 90°C for 1 minute. The entire cycle took from 8 to 10 minutes. For the purpose of testing its disinfection efficacy, tubes containing either cultures of *Enterococcus faecalis* (3.6×10^6 /mL) or poliovirus type I strain (10^7 viral particles/mL at 4°C and 10^6 – 10^7 viral particles/mL at 37°C) or containing fecal suspensions were secured to the receptacles to be processed and to strategic positions in the washer-disinfector. The fecal suspensions had an anaerobic colony count of 9×10^5 /mL, a spore count of 2×10^5 /mL, and aerobic colony counts of 1.7/mL and 7.0×10^6 /mL. An assessment of cleaning efficacy was performed with receptacles used by patients (plastic urinals and bedpans).

After disinfection, results showed a reduction in *E. faecalis* by a factor of more than 10^6 , no reduction of *C. perfringens* spores in the anaerobic culture of fecal suspensions, a reduction of aerobic organisms in the fecal suspensions by a factor of at least 10^4 and a decrease of infectivity of poliovirus type I by a factor of at least 10^5 . The DEKO-190 washer-disinfector complies with the Australian Standard requiring disinfection to reach a temperature $\geq 85^\circ\text{C}$ for at least one minute [Standards Australia, 1998, in Dempsey et al., 2000]. Visual inspection of the disinfected receptacles found the cleaning of the bedpans and other items to be satisfactory. Despite the multi-functionality of this washer-disinfector, the authors indicated that no cross-contamination should occur inside these machines if they are used correctly [Dempsey et al., 2000]. Note that this study was funded by the company distributing this washer-disinfector.

Description of an infection control initiative

Considering the risks of infections, the Infection Control Service of the Toronto East General Hospital chose to install a macerator instead of a bedpan washer as one of the measures used to prevent *C. difficile* infections. Besides yielding conclusive results, that decision was very popular with the nursing staff. Faced with a growing number of patients acquiring *Clostridium difficile*-associated diarrhea (from 3 patients in January 2004 to 13 patients in January 2005), the hospital's infection control team developed a

9. Method that puts a culture medium in direct contact with a contaminated surface.

strategic prevention plan encompassing a range of services and procedures. As a result, it was found that using a spray wand to manually clean bedpans was a major contributing factor to the increased cases of infection. It was decided that a safer option needed to be found. Unfortunately, this article provided no information on the arguments that favoured adopting the macerator system over the bedpan washer. Following a combination of preventive measures, results showed a gradual return to baseline levels for *C. difficile*-associated diarrhea by early 2006 (from 2 to 6 patients) [Tomiczek et al., 2006].

Expert opinions and observations

Briefly describing the outcome of an epidemiological investigation to determine the source of an outbreak of vancomycin-resistant enterococci (VRE), Chadwick and Oppenheim [1994] mentioned in a letter to a journal editor that this type of outbreak may not have been directly related to improper bedpan disinfection. In fact, the backflow of drain contents caused by objects other than toilet paper or feces blocking the washer was a potential source of contamination of disinfected receptacles. These authors also concluded that the risk of cross-infection could be avoided if bedpan washers were maintained and used properly.

Johnson's article [1989] combined a literature review with interviews with staff (nurses, engineers) and bedpan users (patients). According to the data collected through observation and from users, the author reported that 22% of bedpans needed to be disinfected a second time because of poor cleaning after a bedpan-washer cycle, and 10% needed to be scrubbed by hand because feces had baked onto the bedpans. However, no raw data (total number of bedpans and users) were provided. Note also that the disinfection cycle of the bedpan washers under observation did not include a detergent cleaning stage. That point should be kept in mind because it is known that thoroughly cleaning soiled items guarantees effective disinfection. With respect to some infections, Johnson [1989] reported medical staff's concerns over the difficulty of maintaining ideal disinfection conditions in bedpan washers. It needs to be pointed out, however, that this publication dates back almost 20 years and that technological advances now provide more powerful equipment with visible temperature indicators.

At the same time, except for bedpan transport to dirty utility rooms, the use of macerators means that bedpans are no longer handled after use because they are entirely pulverized. The plastic supports used with them must nevertheless be disinfected in a washer-disinfector. Collins et al. [1980] carried out a survey in different hospitals in the U.K. to identify problems with the use of macerators. The authors asked 150 infection control nurses to complete a questionnaire on the frequency and causes of macerator breakdowns and their associated infection hazards. Analysis of the 48 returned questionnaires revealed that macerator breakdowns were chiefly due to drain blockages caused by accidental insertion of solid objects (gloves, diapers, plastic bags, etc.) into the machine. This leads to the risk of infection, and the maintenance staff repairing the macerators may be more exposed to contaminated aerosols. Blocked drains can lead to flooding the ward, which poses a contamination risk. This article also revealed that the leaks and aerosols caused by blockages were proportional to the age of the machine: macerators in use for five or more years tended to leak more [Collins et al., 1980]. The same problems with blockages and leakage raised in that dated publication are still current.

According to an expert who compared his experience with bedpan washers and macerators [Hickman, 1989], the problems with the macerators were due to installation

in old buildings without consideration for the existing drainage system, and to irregular maintenance and improper machine adjustment. Hickman recommended macerators over bedpan washers because they are faster to service and safer to use. Any malfunction stops the macerator and requires immediate service from the maintenance department. By contrast, bedpan-washer malfunctions are not always obvious to users and so may go unnoticed, entailing the risk of improper disinfection. Like Johnson [1989], Hickman [1989] also observed that it was difficult to maintain the proper temperature for disinfecting bedpan washers ($\geq 80^{\circ}\text{C}$ for one minute) throughout the process. Another expert concurred with that view by stating that the key to good bedpan-washer performance is regular maintenance and monitoring of parameters such as cycle, time and temperature, given that improper adjustment can be the source of infections [Rollnick, 1991].

4.2 Organizational issues

Organizational issues cover everything related to building infrastructure, time management, and human and material resource management. Each type of bedpan processing equipment requires specific infrastructure and installation.

Description of an infection control initiative

In Sweden, Fryklund and Marland [1994] described a procedure for disinfecting reusable receptacles. In the authors' opinion, each care unit should ideally have its own dirty utility room and bedpan washers to clean and disinfect bedpans immediately after use. This would help prevent the risk of contaminating the work environment, the patients and the staff during bedpan transport. Also, bedpans, urinals and washbowls would not need to be sent to the CPD because the entire process would be carried out near the rooms.

Expert opinions and observations

According to an expert, the steam generator in a bedpan washer (a component required for the steam disinfection stage) generates temperatures that produce heavy scale deposits if the hard water is not treated, which may hinder its operation. The author therefore suggests that each machine should ideally be provided with its own water treatment unit. This does not apply to macerators because they use cold water for grinding disposable bedpans into a pulp [Rollnick, 1991]. However, the drainage system would need to be adapted depending on whether the macerator was installed before or after construction of the building. It should be recalled that drainage systems can become blocked if overloaded with excess volumes of waste. Using macerators requires a fairly large quantity of disposable bedpans and plastic bedpan supports, extra storage space for supplies and an efficient supply and distribution system. Finally, Rollnick states that, unlike bedpan washers, macerators offer virtually trouble-free use because they are simple in design and require less performance monitoring and maintenance [Rollnick, 1991]. Considering the mechanical structure and operational parameters of bedpan washers, not to mention the need for a water treatment unit, Hickman [1989] classified them as fairly complicated mechanical equipment. Space is also needed for storing the reusable bedpans before and after disinfection.

Users frequently complain about the slow operation and limited capacity of bedpan washers. According to Rollnick [1991], bedpan washers capable of processing one bedpan per cycle of 3 to 4 minutes have a processing rate of approximately 20 bedpans per hour. In comparison, a macerator with a load capacity of 3 bedpans per cycle can destroy 90 per hour. Owing to the accumulation of soiled bedpans when the washers are

not available, Rollnick advises against the use of bedpan washers in very busy care units. The gap between the two machines is even larger, considering the data on the more recent models. Modern washer-disinfectors with a capacity of up to 2 bedpans per 8-minute cycle can reprocess up to 15 bedpans per hour; while macerators with a 2-minute cycle and a maximum capacity of 4 bedpans can destroy 120 bedpans per hour. This analysis leads to the deduction that, to process a comparable number of bedpans, a hospital would need to install more bedpan washers than macerators.

The nursing staff survey conducted by Johnson [1989] revealed that the single-use system was popular because it saved time: macerators would do the work of two to three bedpan washers during the unit's busiest hours. Furthermore, disposable bedpans are never too hot for those handling them nor too cold for patients. According to the same 1989 nursing staff survey, choosing to use bedpan washers instead of macerators would be viewed as a retrograde step. Hickman [1989] wrote that technicians spent less than half the time maintaining or repairing macerators than they did on bedpan washers because they did not need to monitor the macerators' performance.

Lastly, if macerators are to be adopted as the bedpan processing system, staff must be given training, just as they would for bedpan washers. The data from the survey led by Collins et al. [1980] indicated that, of the 151 macerators inspected, 53% were blocked or broken down and that 53% of the blockages were due to solid items (gloves, incontinence pads, plastic bags, etc.) having been put into the machine. Staff training should therefore focus on maximizing the machine's potential. Yet, breakdowns and blockages due to improper use are still an issue today.

4.3 Economic issues

Expert opinion

According to Rollnick [1991], it would be misleading to compare the costs of the two bedpan processing systems without reference to the number of receptacles processed per day, while knowing that this total varies from ward to ward.

Comparative modelling

In his article, Johnson [1989] compared the capital costs and operating costs of using bedpan washers vs macerators. No other more recent study was identified. Capital costs (non-recurring) include the costs of the machine, reusable bedpans, disposable bedpan supports and storage shelves, and installation costs. Operating costs (recurring) include the costs of electricity, water, disposable bedpans, and equipment depreciation. Results showed that the annual capital costs for a bedpan-washer system were much higher than those for macerators (£4195 and £2184 respectively); however, there was no significant difference in the annual operating costs for both machines (£1221 and £1260 respectively). Analysis of the results (see Appendix B) revealed that bedpan washers generally cost more in energy (electricity and heating), while macerators incurred higher expenditures on disposable supplies. In the author's view, macerators would therefore be less expensive to use than bedpan washers.

It should be stated, however, that in estimating the costs tied to bedpan washers, the author took into account the use of bedpans and urinals, and in estimating those tied to macerators, the calculation was based on a care unit with 23 beds using an average of 1.23 bedpans per patient per day. Moreover, the author did not consider other macerator-related costs, such as reprocessing disposable bedpan supports. Finally, the article dates back several years and refers to the U.K. context prevailing at that time; the results do not reflect today's reality and may not be applicable. Inclusion of the parameters that

Johnson omitted would lead to the conclusion that macerators have higher operating costs than bedpan washers, as will be shown in the section below on the Québec context.

4.4 Environmental issues

Description of initiatives

None of the retrieved studies actually assessed the environmental effects resulting from the use of bedpan washers or macerators. Nevertheless, according to the article by Fryklund and Marland [1994], Swedish hospitals opted to use reusable supplies because, in addition to saving costs, it reduced the volume of waste produced and the use of chemical products.

According to a circular issued by the Health Department of Western Australia, because of the solid waste produced, the Water Corporation decided to charge an annual levy per macerator to hospitals choosing to connect macerators to its waste water system. One of the requirements for obtaining approval for this connection was to give notice before installing them [Gill, 2001].

Literature review

Johnson's article [1989] revealed that bedpan washers used much more electricity owing to the length of the disinfection cycle and the use of hot water. Bedpan washers took from three to five minutes to disinfect a single bedpan, while macerators took only two minutes of electricity to destroy four bedpans. According to Johnson, from an environmental viewpoint, the heavy use of energy (hot water) required by bedpan washers could be comparable to the large volume of waste produced by the use of disposable supplies (macerators).

5.1 Standards

The Canadian Standard CSA Z314.8-08 Decontamination of Reusable Medical Devices [CSA, 2008] provides only a few details directly applicable to reprocessing bedpans. According to that Standard, before reusable human waste containers can be transported to the reprocessing area, they should be emptied and rinsed in the area where they are used. Given that dried residues are more difficult to remove, the Canadian Standard recommends organizing a system for collecting and transporting soiled receptacles so that they can be decontaminated immediately after use. In order to prevent liquid spills, all soiled receptacles must be transported in closed containers to the decontamination area. If there is no automatic drying mechanism, the receptacles must be hand-dried with a clean cloth before storage.

The International Standard ISO 15883-1 inform that thermal disinfection corresponding to a minimum A_0 value of 60 seconds is the usually acceptable minimum for decontaminating devices that come in contact with intact skin (*non-critical* devices) and that do not contain a high number of heat-resistant micro-organisms. The value $A_0 = 60$ corresponds to thermal disinfection at 80°C for one minute¹⁰ [ISO, 2006b]. That figure is endorsed in the third section of ISO 15883-3, which relates specifically to bedpan washers [ISO, 2006a, in Alfa et al., 2008].

5.2 Practice guidelines and technical memoranda

Practice guidelines on the disinfection process issued by the health authorities in some Canadian provinces do not explicitly state which equipment to use for bedpan processing. In Health Canada's *Infection Control Guidelines* [1998] and Ontario's *Best Practices for Cleaning, Disinfection and Sterilization* [PIDAC, 2006], bedpans are classified as *non-critical* devices and their decontamination requires low-level disinfection. In another publication, the Provincial Infectious Diseases Advisory Committee (PIDAC) recommends using disposable bedpans for the management of *C. difficile* infections. These bedpans should be emptied and disposed of in the patient's washroom [PIDAC, 2009].

In the Netherlands, the practice guidelines on bedpan washers produced by the Dutch Workingparty Infection Prevention group stipulate that thermal disinfection must be carried out at a temperature of 80°C for at least 60 seconds. This group also stated that no bedpan washer could guarantee thorough cleaning, but proper machine use and maintenance could limit the risks. They went on to say that it would not be useful to perform routine bacteriological examinations to determine the effectiveness of disinfection. This type of evaluation should be carried out only if it is suspected that bedpan washers are a possible source for an increase in infectious cases [Dutch WIP, 2005].

10. The concept of A_0 is explained in Appendix B in ISO 15883-1 [ISO, 2006 b]. A_0 is defined as the measure of micro-organism inactivation following a thermal disinfection process. This value is based on the principle whereby the higher the temperature, the faster the micro-organisms are inactivated.

For bedpan decontamination, in applying the general standards of the National Health Service (NHS), U.K. health-care institutions (trusts) have adopted policies or guidelines endorsing either the exclusive use of macerators with disinfection of plastic bedpan supports in a washer-disinfector [Leaver and Hill, 2004] or the use of bedpan washers or macerators [Johnson-Roffey, 2008]. Contrary to these British practices, as pointed out above, Swedish hospitals favour reusable supplies and therefore use bedpan washers [Fryklund and Marland, 1994]. A report published in Belgium strongly advises against the use of macerators for technical and personal comfort reasons: problems with blocked machines, production of a large amount of cellulose (drain blockages), discomfort for heavier patients, need to clean bedpan supports, and lack of backup option in the event that the macerator breaks down [Haxhe and Zumofen, 2003].

In the U.K., a technical memorandum drew attention to the safety precautions to adopt in using washer-disinfectors for bedpan processing. Staff members were advised to protect themselves in order to prevent heat burns, to take precautions when handling descaling agents, as these are considered toxic, irritant and corrosive, and to have the appropriate equipment nearby to deal with spillage from the containers during transfer to the washer-disinfector. Since most bedpan washers have a single door, the memorandum states that the environment housing these machines must permit a clear separation of processed loads and unprocessed loads [NHS Estates, 1997].

In a circular, the Health Department of Western Australia proposed macerators as an alternative human waste disposal method owing to the following advantages: comfort of patients who benefit from having a clean bedpan for each use; remove of the risk of health care workers contamination from the aerosols produced during bedpan emptying; low maintenance costs; the larger capacity of macerators; and energy savings (use of cold water) [Gill, 2001]. The decision whether or not to use this equipment was left up to each hospital.

Lastly, at a consensus conference organized by the International Infection Control Council¹¹ with the objective of preventing and controlling *Clostridium difficile*-associated diarrhea, experts made the following recommendations concerning the issue of bedpan processing [IICC, 2007]:

- Provide access to a bedpan washer or macerator. Empty bedpans into a bedpan washer or a macerator. Use single-use bedpans if storage space is available.
- Do not use sprayers to clean bedpans in patients' bathroom; do not manually clean bedpans in the toilets in patients' bathroom. Avoid sluicing bedpans and other such containers in order to reduce aerosols.
- Pay attention to the condition of bedpans particularly if chipped or scratched, as they are more difficult to clean.
- Allocate a bedpan to an individual patient and sanitize bedpans or bedpan supports between patients. Do not transport uncovered soiled bedpans from one place to another; use solidifying gel if possible.

11. Partnership formed by three infection prevention and control organizations from the U.S. (Association for Professionals in Infection Control and Epidemiology, Inc. – APIC); from Canada (Community and Hospital Infection Control Association – CHICA) and from the U.K. (Infection Control Nurses Association – ICNA, now called the Infection Protection Society – IPS).

5.3 New process: hygienic bags

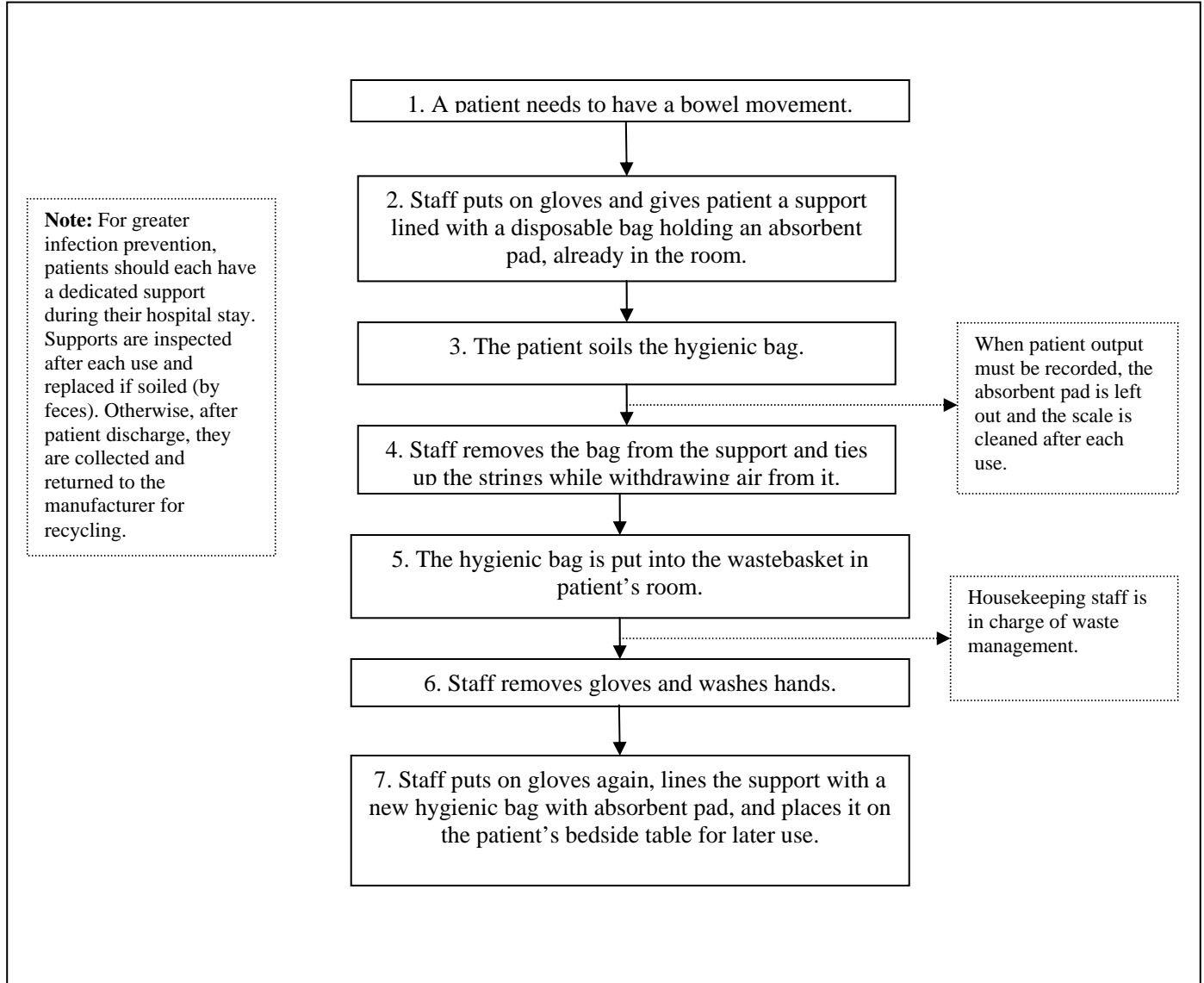
The literature search revealed an apparently safe and effective alternative to bedpan washers and macerators: single-use hygienic bags with super-absorbent pads (roughly half a litre). These bags are used to line bedpans and commode pans and can also be used to collect vomit and urine [ASSTSAS, 2007]. Recently, manufacturers have made available recyclable plastic supports¹² for these bags, which replace reusable bedpans and supports. The procedure for using hygienic bags is described in Figure 3.

This procedure avoids soiling the bedpans and supports and safely disposes of human waste. Soiled bags can be placed on a scale to record patient output and then discarded in a wastebasket because they are not considered biomedical waste. This system has been used especially in Europe for the past few years. Moreover, for the sake of the environment, an ecological (oxo-biodegradable)¹³ version has recently come on the market in Canada. Although this procedure was not the object of this technical brief, it seemed useful to present this alternative to bedpan washers and macerators. A more in-depth evidence-based analysis should ultimately be done.

12. The manufacturer melts down the plastic supports and reuses the plastic to manufacture other supports.

13. Demand has increasingly been growing to reduce or ban the use of single-use plastic bags because of their negative effects on the environment. Their primary component, polyethylene, is not naturally biodegradable. Oxo-biodegradable bags are made of polyethylene and pro-oxidant additives. Left outdoors, they disintegrate into tiny particles because of accelerated oxidation due to the combined action of light, heat and oxygen. These bags become invisible to the naked eye within a few months. The particles buried under the earth then undergo biodegradation (the length and long-term effects of which are not yet fully known, but some claim that it takes 25 years for these bags to degrade rather than 400 years for regular plastic bags).

FIGURE 3
Sequence of steps in a routine hospital procedure using disposable hygienic bags.



6.1 Consultations with practitioners

To compensate for the lack of literature and obtain contextual information, discussions were held with practitioners in infection control/prevention and sterile processing in seven Québec hospitals. The exercise was designed to gain a clearer picture of the parameters surrounding the use of bedpans in health-care facilities, not to evaluate work procedures or work organization. During the meetings, the practitioners were asked to describe their daily experiences. The discussions were based on the following points:

- Former bedpan processing method used.
- Current method used: reasons for the change, procedure in use.
- Appraisal of the current equipment or product in use: safety, work organization, costs, environmental issues.
- Reasons that alternative reprocessing methods were not selected.
- General comments on the issues surrounding the use of bedpans.

A written questionnaire with identical criteria was sent to practitioners who were not met in person because of geographic distance.

Given that bedpan processing methods differ across hospitals, a summary of the discussions and comments gathered from the practitioners is presented in Table 1. Of the seven hospitals approached, two use the conventional method, two use macerators, one uses bedpan washers and two use hygienic bags.

TABLE 1

Summary of interactions with practitioners*				
HOSPITAL #	FORMER SITUATION	CURRENT METHOD	BENEFITS (CURRENT METHOD)	DRAWBACKS (CURRENT METHOD)
1 & 2	N/A	<p><u>Conventional method</u></p> <ul style="list-style-type: none"> - After each use, bedpans are emptied in the toilet bowl and rinsed with a spray wand (the sink in the patient's room is sometimes used). - Bedpans are stored in patients' bedside tables. - After patient discharge, all the small reusable items and the bedpans are sent to the central processing department (CPD) for reprocessing in a washer-decontaminator. - The Flexi-Seal[†] system is used with patients who have severe diarrhea. 	<ul style="list-style-type: none"> - Bedpans do not leave patients' rooms. 	<ul style="list-style-type: none"> - Risk of staff contamination from aerosols and splashback produced during emptying and flushing of bedpans. - Risk of contaminating patient's environment (bedside table, toilet bowl and sink, room). - Risk of cross-contamination of receptacles, risk of workplace and staff contamination during bedpan transport to CPD.
3	Conventional method <i>C. difficile</i> episodes led to the change in procedures.	<p><u>Automated bedpan washers</u> (average cycle from 5 to 7 minutes, excluding drying)</p> <ul style="list-style-type: none"> - Bedpan washers are installed in dirty utility rooms in each care unit. - After each use, soiled bedpans are covered and sent to the dirty utility room. - Bedpans are left on a counter until the washer is free. - In case of machine breakdown, two separate sinks are used to rinse and clean bedpans after contents are emptied into toilet. - Isolation areas have dedicated bedpan washers to prevent the risk of cross-contamination. After reprocessing, bedpans are soaked in a chlorine solution and sent to the CPD, when appropriate. 	<ul style="list-style-type: none"> - Standardized procedure, reduced risks. - No handling of soiled bedpans. - Possibility of disinfecting small reusable items on the ward. 	<ul style="list-style-type: none"> - Difficult to change habits of some employees who worry about dropping bedpans or their contents during transport and so continue to empty them into toilets. - Bedpans not always visibly clean. - Major conversion of dirty utility rooms to guarantee effective functionality.

* The information is reported exactly as gathered from practitioners. [Free translation]

[†] Catheter with a silicon bag used in the management of diarrhea in bedridden or immobilized patients.

TABLE 1 (cont'd)

Summary of interactions with practitioners*				
HOSPITAL #	FORMER SITUATION	CURRENT METHOD	BENEFITS (CURRENT METHOD)	DRAWBACKS (CURRENT METHOD)
4	Conventional method	<p><u>Macerators</u></p> <ul style="list-style-type: none"> - Macerators are installed in dirty utility rooms in care units. - After each use, soiled bedpans are covered, sent to the dirty utility room and put into the macerator. - After patient discharge, the supports are collected and sent to the CPD for reprocessing in a washer-decontaminator. - In case of machine breakdown, the contents of the bedpan are turned into a gel and put in the wastebasket. 	<ul style="list-style-type: none"> - Prevents accumulation of soiled bedpans waiting to be cleaned. - Eliminates staff's handling of bedpans (no contaminated aerosols or splashback). - Saves time. - Provides an effective means of preventing infections (reduces outbreaks). 	
5	Conventional method	<p><u>Macerators</u></p> <ul style="list-style-type: none"> - Macerators are installed in dedicated rooms, dirty utility rooms or washrooms. - After each use, soiled bedpans are covered, sent to the dirty utility room and put into the macerator. - After patient discharge, the supports are transferred to the dirty utility room, soaked in a 1600 ppm solution of chlorine and cleaned. In case of <i>C. difficile</i> or VRE, initial disinfection is done in the room. - In case of macerator breakdown, hygienic bags are used. - Some units not equipped with macerators use the conventional method. - If <i>C. difficile</i> is suspected, disposable plastic bedpans and hygienic bags are used. - Other care units use disposable plastic bedpans and hygienic bags at all times. 	<ul style="list-style-type: none"> - More effective in eradicating the source of the problem. - Immediate detection of machine malfunction. - Time saver for staff. - More ecological than hygienic bags. 	<ul style="list-style-type: none"> - Need to establish strict procedures to guarantee safe use. - Occasional machine breakdowns (insertion of foreign objects). - Occasional drain backflows.

TABLE 1 (cont'd)

Summary of interactions with practitioners*				
HOSPITAL #	FORMER SITUATION	CURRENT METHOD	BENEFITS (CURRENT METHOD)	DRAWBACKS (CURRENT METHOD)
6	<p>Conventional method</p> <p><i>C. difficile</i> episodes led to the change in procedures.</p>	<p><u>Hygienic bags</u></p> <ul style="list-style-type: none"> - Method used only with <i>patients in isolation</i>, but with the intention of extending it to the entire hospital. - After use, hygienic bags are tied and put in the wastebasket in patient's room. The pad in the bag converts the waste into a gel and helps control odours. - After patient discharge, the plastic bedpans that hold the bags are thrown out. - Specimens can be collected and output recorded with a scale. - For other patients, plastic disposable bedpans are used and emptied into toilet bowls. - Macerators are used in the Emergency Department. 	<ul style="list-style-type: none"> - Effective for controlling infection and contamination risks (outbreaks, asymptomatic carriers, etc.). - Hygienic bags do not leave isolation rooms. This reduces the risk of workplace contamination. - Major gains in nursing-care hours. - Increase in bedside care (necessary supplies are available in the isolation area or the room). - Fast and simple procedure. - Works perfectly with commodes. This process is also applicable to the small items. - Eliminates use of water and chemical products. - Bags made of oxo-biodegradable plastic. 	<ul style="list-style-type: none"> - Production of large volume of environmental waste (bags, disposable bedpans).

TABLE 1 (cont'd)

Summary of interactions with practitioners*				
HOSPITAL #	FORMER SITUATION	CURRENT METHOD	BENEFITS (CURRENT METHOD)	DRAWBACKS (CURRENT METHOD)
7	<p>Conventional method</p> <p><i>C. difficile</i> episodes led to discussions on possible alternative procedures:</p> <ul style="list-style-type: none"> - Installing bedpan washers would entail major expenditures. Length of construction work would require considerable workflow planning and organization. Manufacturers could not confirm that bedpan washers killed <i>C. difficile</i> spores. - Use of macerators would generate the same organizational issues as bedpan washers, in addition to requiring bedpan support disinfection. 	<p>Hygienic bags</p> <ul style="list-style-type: none"> - Method used <i>for all patients at all times</i>. - After use, the hygienic bags are disposed of exactly like incontinence briefs. - Bedpans and commode pans lined with the bags are cleaned and disinfected with detergent and bleach after patient discharge. - When specimen collection and output recording are required, the absorbent pads are taken out of the bags. - Other small reusable items are disinfected with detergent or bleach. 	<ul style="list-style-type: none"> - Simple and effective method. - Use of hygienic bags has greatly contributed to reducing the incidence rate of <i>C. difficile</i> infections. - Reduces odours. - Makes the job easier for patient-care attendants. - Does not require staffing increases. - Staff training is short. - Easily adopted and very popular with staff. - Popular with patients: bedpans are less cold, reduces risk of soiling themselves during bedpan use. - Ideal method for facilities that have few rooms with private washrooms. 	<ul style="list-style-type: none"> - Problem of easily torn bags now solved. - Concerns about environmental issues. However, the use of reusable bedpans without hygienic bags would require thousands of gallons of bleach, causing plumbing problems. Moreover, the priority is still reducing the risk of <i>C. difficile</i> infections.

*The information is reported exactly as gathered from practitioners. [Free translation]

In addition to the information provided in Table 1, some infection control teams who have given thought to bedpan reprocessing methods, conducted pilot studies or used one of the methods in the past, expressed some reservations, as described below.

Several issues were raised concerning the use of macerators: transport of soiled disposable bedpans outside the rooms while avoiding contaminating the workplace, reprocessing bedpan supports, storage of disposable supplies, machine breakdowns caused by foreign objects (gloves, plastic bags), recurrent drain blockages or backflow. In one of the hospitals, the fact that the CPD did not have the capability to reprocess plastic disposable bedpan supports was an additional argument in favour of choosing bedpan washers over macerators. Finally, the issue of the high recurring costs of disposable supplies and the impact of waste on the environment was of course mentioned.

The use of bedpan washers, for its part, would cause the problem of bedpan availability. It would be necessary to provide several bedpans per patient (especially for those with diarrhea) and to arrange that soiled bedpans not pile up between disinfection cycles. For patient-care attendants, bedpan washers should ideally be easy to use, fast to operate, near the rooms (to prevent contamination hazards posed by transporting soiled bedpans outside rooms), quiet and easily accessible. They should not be installed in the rooms because there would be no other option if they broke down and it would be necessary to put up with the inconveniences of maintenance (noise, closing off rooms). Lastly, bedpan washers should meet high disinfection standards (destruction of spores); otherwise, soiled bedpans would need to be sent to the CPD after disinfection.

A sterile processing team noted several shortcomings in bedpan reprocessing management:

- The bedpans are not always rinsed before being sent to the CPD (risk of fecal contamination of work environment and staff).
- During transport of soiled bedpans to the CPD, bedpans are sometimes mixed up with other soiled supplies such as surgical instruments (risk of cross-contamination).
- Dirty utility rooms are not large enough. There is not enough distance between the storage shelves for clean supplies and soiled supplies. The storage conditions for clean bedpans, although they are still in their packaging, are not ideal and may lead to cross-contamination.
- Patient-care attendants need training. In fact, these attendants (students, orderlies) are very often not part of regular staff and are not always informed of the standards and procedures to follow for reprocessing receptacles.

The infection prevention and control practitioners consulted in the field believe that the main disadvantages of hygienic bags are recurring costs and impact on the environment. According to some others, however, the extra nursing-care hours provided by the use of hygienic bags and the fact that the system does not use water or chemical products would greatly offset their purchasing costs (around \$0.80/bag). Although aware of the environmental impact of using hygienic bags, the practitioners who adopted this method are still primarily concerned about patient and staff safety. Lastly, to minimize the volume of waste, hospitals could use the newer fully recyclable plastic bedpan supports instead of the current single-use plastic supports.

In summary, according to the data gathered in the literature and from practitioners, Tables 2 and 3 compare the characteristics of the three bedpan processing methods under review.

TABLE 2

Comparison of the procedures using reusable bedpans, disposable bedpans and hygienic bags			
COMMON STEPS	SPECIFIC STEPS		
	BEDPAN WASHERS	MACERATORS	HYGIENIC BAGS
1. A patient needs to have a bowel movement.			
2. The patient is given a bedpan or a hygienic bag.	→		
3. The patient soils the bedpan or hygienic bag.			
	1. Bedpan is taken to dirty utility room.	1. Disposable bedpan is taken to dirty utility room.	1. Hygienic bag is put in wastebasket in patient's room.
	2. Bedpan is put in bedpan washer.	2. Disposable bedpan is put in the macerator.	↓
	3. Bedpan washer cycle is started.	3. Macerator is started.	
	4. Bedpan is removed and dried.		
4. Staff member washes hands.	↓		
5. Bedpan is returned to patient's room.			
	↓	↓	Housekeeping staff in charge of waste management (empty wastebaskets).
→	After patient discharge, bedpan is sent to CPD if hospital has bedpan sterilization policy.	After patient discharge, bedpan support is disinfected in washer-disinfector. During hospital stay and if soiled, bedpan support is disinfected immediately.	After patient discharge, support is returned to supplier for recycling. During hospital stay, soiled support is replaced.

TABLE 3

General comparison of bedpan processing methods			
ISSUES	BEDPAN WASHERS	MACERATORS	HYGIENIC BAGS
<i>Safe use and effectiveness</i>	Limited handling of soiled bedpans (automatic emptying mechanism).	Limited handling of soiled bedpans (single-use). Handling of bedpan supports.	Limited handling of soiled bags (disposable system). Limited handling of supports (recycling system).
	Eradication of most micro-organisms found on bedpans, except for spores such as <i>C. difficile</i> , based on current decontamination standards (80°C/1 min).	Contribute to infection control (single-use bedpans). Prevent risk of infection from asymptomatic carriers.	Contribute to infection control (single-use items). Prevent risk of infection from asymptomatic carriers.
	Risk of cross-contamination between patients (bedpans not dedicated to single patients).	Risk of contamination from bedpan supports: contact with bedding, which may be soiled with stool or urine, transport to CPD.	Minimum risk of contamination: recyclable support is entirely covered by sturdy plastic bag.
	Cleaning often inadequate (bedpans not always visibly clean).		
	Low risk of leakage during use. Potential aerosol production when door is opened.	Potential production of contaminated aerosols during use (leakage) and door opening.	No equipment required.
	Transport of bedpans containing human waste in corridors poses risk of spills and workplace and staff contamination.	Transport of bedpans containing excretions in corridors poses risk of spills and contamination of the work environment and staff.	Safe transport of soiled bags outside patient rooms.
	Decontamination possible in care units, reducing transport of soiled supplies to CPD, if applicable, and risk of workplace contamination.	Possibility of processing bedpans in care units, which reduces distance for transporting soiled bedpans outside units.	
	Failures in operational parameters (temperature, time, etc.) not always easily detected by users.	Frequent machine blockages (due to improper use).	No equipment required.
	Low risk of contamination for maintenance staff.	Risk of contamination for maintenance staff unblocking machine.	No maintenance required.
For patients: reusable bedpans, risk of infection, and discomfort (cold bedpans if stainless steel).	For patients: new bedpan each time, reduced risk of infection.	For patients: new bag each time, reduced risk of infection and spills, comfort appreciated.	

TABLE 3 (cont'd)

General comparison of bedpan processing methods			
ISSUES	BEDPAN WASHERS	MACERATORS	HYGIENIC BAGS
Organization	Complex process with control settings (time, temperature). Many opportunities for error.	Simple process with fewer components.	No equipment required. Simple procedure.
	Slower cycle and smaller capacity (8–12 minutes for 2 bedpans). Large amount of time spent on bedpan disinfection.	Fast cycle and large capacity (2 minutes for 4 bedpans). Saves time.	No cleaning or disinfection required. Fast procedure. Major gains in nursing-care hours.
	Less time for patient care.	Less time for patient care.	More time for patient care.
	Specimen collection and output recording are possible.	Specimen collection and output recording are possible.	Specimen collection and output recording are possible, easy and safe (scale).
	Time may have to be planned to hand-dry bedpans after reprocessing, to sterilize bedpans after patient discharge (if applicable) and to restock rooms.	Time must be planned for reprocessing supports and restocking rooms.	Time must be planned for collecting and redistributing recyclable supports.
	Water-softening treatment is required to prevent mineral deposits (depending on region).	Potential drainage system alterations (minimum pipe diameter of 5 cm).	No major infrastructure is required but impact on solid waste management (garbage collection).
	More maintenance and monitoring of operation parameters (time, temperature, etc.) required.	No control settings but maintenance required.	No repairs or maintenance required.
	Less demanding in terms of supply management.	Administrative requirements for management of disposable supplies (ordering, storage space, shortages, etc.)	Administrative requirements for management of disposable and recyclable supplies (orders, storage space, shortages, etc.).
	Need to expand and equip dirty utility rooms: compliance with plumbing installation standards and planning of separate areas for clean and soiled supplies.	Need to expand and equip dirty utility rooms: compliance with plumbing installation standards and planning of separate areas for clean and soiled supplies.	No installation required. System that is easy to apply. Storage space required.
Staff must cover soiled bedpans for transport from rooms to bedpan washers.	Staff must cover soiled bedpans with disposable covers for transport from rooms to bedpan washers.	Soiled bags are deposited in wastebaskets in rooms or isolation areas.	

TABLE 3 (cont'd)

General comparison of bedpan processing methods			
ISSUES	BEDPAN WASHERS	MACERATORS	HYGIENIC BAGS
Organization	<p>Workflow management: Fill and empty bedpan washers; possibly collect bedpans for transport to CPD (where applicable).</p> <p>Alternative options must be planned for isolation cases, machine breakdowns.</p> <p>Small reusable items can be processed in machine.</p> <p>Staff need training on operating procedure.</p>	<p>Workflow management: Fill macerator, collect supports to send to CPD.</p> <p>Plan solution for reprocessing supports and small reusable items if necessary.</p> <p>Small disposable items can be destroyed in macerator.</p> <p>Staff need training on operating procedure.</p>	<p>Workflow management: Fill hygienic bag dispensers. No tasks transferred to CPD.</p> <p>Alternative must be planned in case of supply shortage.</p> <p>Availability of bags that can be used as small disposable items.</p> <p>Staff need training on operating procedure.</p>
Costs	<p>High acquisition costs (washer, reusable bedpans).</p> <p>Energy costs (hot water).</p> <p>Acquisition of additional equipment in cases where bedpan sterilization is contemplated. Water-softening treatment (depending on region).</p> <p>Possible acquisition of extra baskets to hold accessories in washer.</p>	<p>High operating costs (disposable bedpans and supports).</p> <p>Energy costs for washer-decontaminators to reprocess supports (hot water).</p> <p>Additional acquisition of washer-disinfectors (to reprocess supports).</p> <p>Recurring acquisition of single-use supplies.</p>	<p>High operating costs (bags and supports).</p> <p>No energy costs during use.</p> <p>No additional equipment required (supports are recyclable).</p> <p>Recurring acquisition of single-use supplies.</p>
Environment	<p>Reusable supplies. Spills of chemical cleaners (detergent, descaler).</p> <p>Greater energy use during operation.</p> <p>Increased use of chemical products (detergent, rinse agents and descalers). Use of water.</p>	<p>Biodegradable disposable supplies. Large volume of waste (0.88 lbs of pulp/cycle). Use of water.</p> <p>Energy used to manufacture large quantities of pulp bedpans.</p> <p>Energy used to decontaminate supports.</p> <p>Use of chemical products (deodorizers). Use of water.</p>	<p>Oxo-biodegradable disposable supplies. Recyclable supports. Large volume of waste (single-use plastic hygienic bags).</p> <p>Energy used to manufacture large quantities of plastic bags and supports.</p> <p>No use of chemical products or water.</p>

6.2 Acquisition cost scenario for bedpan processing equipment

With a view to helping decision makers, a cost scenario related to the use of either bedpan washers or macerators was developed. The following data are based on those provided by infection prevention and control teams or taken from equipment specifications available on manufacturers' Web sites. The same conditions were set for both bedpan washers and macerators. A non-exhaustive needs analysis, for each bedpan processing equipment, was developed and is included in Table 4.

TABLE 4

Needs analysis by selected equipment			
	BEDPAN WASHERS	MACERATORS	HYGIENIC BAGS
Fixed costs			
Bedpan processing equipment	✓	✓	✗
Equipment for reprocessing disposable bedpan supports (washer-disinfector)	✗	✓	✗
Machine for sterilizing reusable bedpans (steam sterilizer)	✓	✗	✗
Reusable bedpans	✓	✗	✗
Reusable bedpan lids	✓	✗	✗
Disposable bedpan supports	✗	✓	✗
Disposable bedpan racks	✗	✓	✗
Storage space for bedpans, hygienic bags or supports	✓	✓	✓
Water heater (where necessary)	✓	✗	✗
Water-softening unit (where necessary)	✓	✗	✗
Installation	✓	✓	✗
Alterations to drainage system	✗	Possible*	✗
Equipment replacement	✓	✓	✗
Recurring costs			
Disposable bedpans	✗	✓	✗
Paper bags to protect disposable bedpan supports	✗	✓	✗
Disposable hygienic bags	✗	✗	✓
Supports for recyclable hygienic bags	✗	✗	✓
Water	✓	✓	✗
Hot water	✓	✓ (Supports)	✗
Electricity	✓	✓	✗
Detergent	✓	✓ (Supports)	✗
Rinse agent	✓	✓ (Supports)	✗
Descaler (where necessary)	✓	✓ (Supports)	✗
Liquid cleanser – deodorizer	✗	✓	✗
Maintenance	✓	✓	✗
Administrative tasks (ordering supplies)	✗	✓	✓

* Depending on building.
Legend: ✓= yes, ✗ = no

The acquisition cost scenario was based on the assumption that an infection control team at Hospital X with a 400-bed capacity expressed the need for an initial overview of the purchasing and operating costs related to the three human waste management methods before deciding on a system. The use of bedpans in this hospital is equal to 33% of the total beds. Data regarding Hospital X are listed in Appendix C.

Although the scenario is not perfect in cost estimation terms, it still provides an overview of the range of costs. Given that the figures provided were not part of an economic analysis and were provided strictly for information purposes, they do not include some of the expenditures related to the technical equipment, such as installation, bedpan storage racks and dispensers, maintenance, replacement of equipment and supplies, and the possible need to purchase a hot-water heater for the bedpan washers. Moreover, the costs tied to administration, staff management (caregiving time) and the environmental impacts caused by use of the technologies under review were not considered. Lastly, the number of

bedpans calculated takes into account maximum usage and bed occupation rates. The cost per kWh used to calculate power consumption is modelled on that for an average hospital. Taxes and shipping/handling fees were not included in the calculations.

Irrespective of the machine capacity and speed, the results (Table 5) indicated that annual acquisition costs related to the use of macerators were slightly lower than those for bedpan washers (\$6,773 vs \$8,251). Conversely, the annual operating costs for the use of macerators were approximately 9 times higher than those for bedpan washers (\$145,293 vs \$16,349). As for the use of hygienic bags, although there were no equipment costs (capital costs), the operating costs (\$202,356) were 12 times higher than those for bedpan washers and roughly 1.5 times higher than those for macerators. In summary, given a fully occupied 400-bed hospital where 33% of patients use a bedpan during an average stay of 4 days, the use of macerators would cost approximately 6 times more than the use of bedpan washers, and the use of hygienic bags would cost 8 times more.

Note, however, that this exercise is not complete. Some of the items generating extra costs and definitely affecting the scenario presented here were not considered. These items include:

- Human resource and administrative expenditures: time and wages for nursing staff and maintenance staff, administrative fees for ordering disposable bedpans, etc.
- Work involved in infrastructure conversion: storage space, plumbing, electrical installation, utility room operation and maintenance, etc.
- Environmental impact: energy required to manufacture bedpans and hygienic bags, volume of solid and liquid waste.
- Purchasing and processing urinals and small items. Purchase of baskets and other accessories required to reprocess supplies in bedpan washers.
- Sterile processing of reusable bedpans if the necessary procedures are in place: equipment, room operation and maintenance.
- Transport of reusable bedpans and disposable bedpan supports to CPD (where applicable).

A field study of the concurrent use of the three methods would provide a cost scenario closer to clinical reality. The costs associated with managing nosocomial infections potentially caused by the use of bedpans should also be taken into account. In that regard, the average cost related to *C. difficile*-associated disease acquired during a hospital stay is estimated to be \$16,717¹⁴ per stay [O'Brien et al., 2007]. If the use of macerators is presumed to have a greater preventive effect, that effect would need to yield roughly 8 prevented infections (400-bed hospital with 33% of patients needing bedpans) to justify the additional expenditure incurred by the use of macerators compared with the use of bedpan washers. The use of hygienic bags would need to prevent 11 cases of infection compared with bedpan washers.

14. Represents 46% of total hospitalization costs for \pm 15.7 days, of which 2.9 days are attributable to *C. difficile*-associated disease. Physician consultation fees are not included.

TABLE 5

Acquisition and operating costs by selected method*

EQUIPMENT AND ACCESSORIES	ACQUISITION COSTS OVER AN ANNUAL BASIS (CAN\$)†		
	BEDPAN WASHERS‡	MACERATORS‡	HYGIENIC BAGS
Equipment	6,667	6,667	0
Reusable bedpans	1,584	0	0
Reusable supports for disposable bedpans	0	106	0
Subtotals	8,251	6,773	0
PARAMETERS	ANNUAL OPERATING COSTS (CAN\$)		
	BEDPAN WASHERS‡	MACERATORS§	HYGIENIC BAGS
Maintenance	5,000	5,000	0
Disposable bedpans	0	113,705	0
Disposable protective covers	0	21,199	0
Hygienic bags	0	0	154,176
Disposable supports for hygienic bags	0	0	48,180
Cold water	Not calculated	Not calculated	0
Hot water	Not calculated	Not calculated	0
Electricity	894	236	0
Detergent	7,747	249	0
Rinse agent and descaler	2,708	86	0
Cleanser-deodorizer	0	4,818	0
Subtotals	16,349	145,293	202,356
Totals (acquisition + operating)	24,600	152,066	202,356

* Detailed calculations are found in Appendix C.

† Costs are divided over the life span (15 years) of the equipment and supplies.

‡ Costs for sterilizing reusable bedpans are not included.

§ Acquisition and operating costs for washer-disinfectors used to reprocess disposable bedpan supports are included.

7.1 Assessment limitations

Given that biological waste management is a complex and sparsely documented topic, it was necessary to perform this assessment as a narrative review. While this type of review provides a good overall picture of the issue, it is based only on descriptive articles, often of poor scientific quality. Most of the articles consulted date back several years, so the value of their data on the features of each equipment remains debatable. Given the technical variability in the different equipment tested in the studies and the lack of uniformity in reprocessing parameters (times and temperatures), the findings are not very generalizable. Nevertheless, by drawing parallels between the study outcomes and the contextual evidence gathered, it is possible to arrive at relevant conclusions.

This technical brief is a methodical and contextual synthesis of the issues associated with the two types of bedpan processing equipment. It does not provide a technical analysis either of the technologies themselves or of their installation requirements. Nor did it intend to assess the work organization of the nursing staff and patient-care attendants. Pilot projects¹⁵ on the use of each type of ward equipment must be carried out to gain further insight into the degree of complexity involved in operating it, its related work organization, the prevalence of bedpan use and the risk level for nosocomial infections associated with such use. Experimental comparative studies on the safe use and effectiveness of the two types of bedpan processing equipment must also be commissioned to derive more sustainable conclusions on the safety and effectiveness of the equipment in relation to current parameters. Also, the capital cost issues that were not considered in this brief (equipment maintenance, redesign and infrastructure operation), should be rigorously assessed by experts in the field. The outcomes of such an assessment should help administrators make informed decisions. Finally, a complete economic analysis for each procedure should be undertaken.

7.2 Implications

Bedpan washers are used exclusively to disinfect reusable bedpans and therefore do not discharge solid waste into the environment. The cleaning and disinfection process may not always be effective, leaving a potential risk of infection. The safe use of bedpan washers primarily depends on strict control of parameters such as cycle, time and temperature. Owing to its complex operation, deficiencies in bedpan-washer operating parameters (temperature, length of cycle, etc.) are not easily detectable between regular maintenance periods. This may result in poor reprocessing and increase the risk of contamination. Staff training is therefore necessary to guarantee good results and maximize infection control, especially since the main users are patient-care attendants, not sterile processing experts. The best practices guide produced by Ontario's Provincial Infectious Diseases Advisory Committee (PIDAC) recommends that training be given to all staff involved in reprocessing medical devices [PIDAC, 2006]. Similarly, in its infection control guidelines, Health Canada recommends that disinfection and sterilization procedures should be entrusted to specialized staff [Health Canada, 1998].

With respect to workflow management, the slow operation of bedpan washers is criticized by staff because it wastes time and poses a risk of contamination owing to the accumulation of soiled bedpans waiting to be disinfected. This time management problem occurs mainly during peak hours of bedpan use (after meals) and when there are

15. A working group on bedpan washers ("Laveurs de bassins – CHUM 2010") has commissioned a pilot study on the use of bedpan washers with the assistance of infection prevention and control practitioners working at the CHUM. The study is expected to begin in the winter of 2009.

many patients with diarrhea. The solution to that inconvenience would be to increase the number of bedpan washers in each care unit. The waste of time is also exacerbated by the fact that attendants must not only walk over to deposit soiled bedpans into the bedpan washer but must also go back to collect them; the use of macerators cuts this travel time by half.

Macerators destroy disposable bedpans and their contents; the resulting waste is then discharged into the wastewater drainage system. Installing these washers could require altering the drainage system, especially in older buildings. Otherwise, the volume of pulverized waste could cause drainage system blockages or backflows. Macerators are safe and effective for reducing the risks of infection and cross-contamination because of the limited handling of soiled bedpans, provided that safety precautions are taken in transferring them to dirty utility rooms. Although the use of supports prevents direct contact between bedpans and patients, there is still a risk of contamination because the support touches the bedding and may be soiled with feces and urine during use, especially when protective covers are not used. Staff must be consistently supervised as to what macerators can and cannot pulverize to prevent malfunctions caused by the insertion of items other than bedpans. This is crucial especially since the options for disposing of soiled bedpans during a macerator breakdown are generally limited to using either regular garbage bags or the equipment in other care units, neither being a very safe solution.

The issue of environmental impacts requires considering the heavy use of energy and the use of descalers and detergents for bedpan washers, on the one hand, and the volume of waste in the form of liquid pulp produced by macerators, on the other hand. The costs associated with energy consumption and the environmental effects resulting from the manufacture of both disposable bedpans and reusable bedpans should also be borne in mind, along with the number of times that reusable bedpans are used compared with single-use bedpans. Even if macerators produce biodegradable solid waste, it still represents a significant volume discharged into municipal sewer systems. Some infection control practitioners stated that their hospitals did not need municipal approval to connect their macerators to the sewer system; however, other practitioners voiced concerns about this issue. After looking into this matter, the Communauté métropolitaine de Montréal (CMM) clarified the bylaws governing the connection of macerators to the sewer system.¹⁶ Under section 5 of the current municipal bylaw on wastewater management (Règlement numéro 2008-47), such connection is forbidden only in the case of household waste processors.¹⁷ Nevertheless, an environmental impact assessment on macerator waste and its effect on wastewater treatment should be conducted with the collaboration of environmental management experts and municipal authorities. The results of that assessment could be compared with the environmental impacts of the volume of detergents and descalers used by bedpan washers. The environmental and health impacts of disposing of soiled hygienic bags through the housekeeping system (garbage collection) also deserve to be examined.

From the viewpoint of infection prevention, the Comité sur les infections nosocomiales du Québec (CINQ) recommends the use of disposable bedpans in cases of *C. difficile* [CINQ, 2005]. When staff complies with the rules for transporting bedpans from the rooms to the macerator and applies good hygiene practices and when technical problems have been solved, macerators remain an effective and safe means of infection control. Alfa et al. [2008] pointed out that ward bedpan washers do not destroy *C. difficile* spores on reusable bedpans. These authors are also of the opinion that bedpan washers are even

16. Dr. Gilbert Pichette, medical microbiologist and infectious disease specialist, Hôpital du Sacré-Cœur, Montréal, personal communication, January 2009.

17. The bylaw came into force on December 11, 2008. The text (in French) can be downloaded from the CMM's Web site: http://cmm.qc.ca/fileadmin/user_upload/reglements/2008-47_v2.pdf.

less effective for processing plastic bedpans and urinals, while they yield fairly good results with metal bedpans. It is known that residues adhere more to plastic than to metal and that plastic is a poorer heat conductor; yet, heat is necessary for effective disinfection. The use of polypropylene bedpans would therefore increase the likelihood of improper reprocessing. Lastly, it has been demonstrated that the drying stage that is part of the cycle of washer-disinfectors in the CPD significantly contributes to killing spores. Yet, most ward bedpan washers do not have a drying stage.

The experimental aspect of the study by Alfa et al. [2008] should be stressed, since it does not necessarily reflect reality in the field. The authors left the soiled bedpans to dry overnight before reprocessing them. That delay would have allowed the spores to proliferate, with a resulting impact on the study outcomes. Nevertheless, the use of an inoculated and sealed Cryovial to evaluate the heat destruction of spores confirmed that the bedpan washer did not completely kill the spores. Despite these limitations, the study showed the importance that should be granted to the choice of equipment and its disinfection cycle (length of cleaning stage, temperature and length of drying stage).

Bedpans have so far been classified as *non-critical* devices requiring only low-level disinfection. Given the emergence of nosocomial infections, new data have demonstrated the need for a higher level of reprocessing to eliminate bacterial spores. Since bedpans are recognized as major sources of *C. difficile* spores, it is recommended that they undergo scrupulous reprocessing [Vonberg et. al. 2008].

Recall that bedpan washers are designed to disinfect not sterilize bedpans. Yet, disinfection does not kill spore-forming bacteria [Rutala et al., 2008]. It is therefore unrealistic to expect to see spore-free bedpans after reprocessing in a conventional bedpan washer. Bedpan sterilization should therefore be considered, along with its additional costs. Each patient should have a dedicated bedpan to ensure that no one else will use it and that it will be sterilized after the patient is discharged. Although there is no standard obliging the use of a sterile bedpan for each patient, the situation is cause for concern from an infection prevention point of view. Moreover, not all types of bedpans can be sterilized; plastic (polypropylene) bedpans deteriorate more quickly if they undergo high-temperature reprocessing. It would therefore be more appropriate to use disposable bedpans to control and prevent infections.

The use of bedpan washers and macerators as bedpan management methods do not fully prevent the risk of workplace contamination. The main reasons are bedpan transport outside the rooms and in the corridors; accumulation of soiled bedpans on counters until a machine is available; non-compliance with hygiene practices; the probability of leakage during macerator operation; regular breakdowns caused by blocked macerators or plumbing; transport to the CPD; and the likelihood of errors resulting from long and complex procedures. Even though the problem of bedpan transport outside isolation areas could be solved by installing modular bedpan-washer units or macerators in patients' rooms, the current infrastructure of some health-care facilities would not allow for that mainly because of the limited number of single rooms, the lack of space, and the extent of retrofitting that would be required to alter the plumbing system. And even if that option were selected, it would still be necessary, in the case of bedpan washers, to sterilize reusable bedpans between patients to address the issue of spore destruction. For macerators, this would involve solving their malfunctions and planning for bedpan-support reprocessing.

In that respect, hygienic bags would be a safer procedure because the supplies do not leave the isolation area. This alternative requires little or no infrastructure, so it would be easy to implement in hospitals and other health-care facilities. Compared with disposable pulp bedpans, hygienic bags provide a stronger barrier between human waste and bedpan supports. The supports are recycled after use by a single patient (during the

entire hospital stay) and the hygienic bags never leave the room (except when the wastebaskets are emptied), so the hazards of spore contamination and spread are minimal. Although hygienic bags incur high operating costs, they save many nursing-care hours because the procedure is fast. In a context of labour shortages, the hours saved enable staff to do other tasks or to provide more bedside care.

Again from the viewpoint of preventing *C. difficile* outbreaks, macerators for disposable bedpans or better yet hygienic bags for all patients are safer ways to limit the risk of transmission by asymptomatic carriers, compared with bedpan washers. In fact, from 1% to 3% of adults are carriers of *C. difficile* [Dubberke and Wertheimer, 2009]; that percentage can rise to 25% among hospitalized patients [Vonberg et al., 2008]. Nevertheless, the environmental impacts potentially caused by the use of hygienic bags as the main bedpan management method are still not known. In the meantime, the use of hygienic bags as a backup, emergency or extraordinary measure should be encouraged, particularly in situations where a single method or combined methods have been demonstrated to be ineffective in reducing infection sources.

Several bedpan processing or biological waste management scenarios could be contemplated. Any hospital could adopt a hybrid system that would allow a reasonable compromise among the issues of safety, economy, environment and work organization. Each facility should establish different scenarios taking into account the issues tied to infection prevention and control, labour shortages, optimal work organization, costs and building conversion potential.

The choice of bedpan processing equipment raises safety, organizational, economic and environmental issues. To provide the MSSS and health administrators with a decision-aid tool, this technical brief aimed to answer the following question:

How does the use of metal bedpans compare with that of macerators for disposable bedpans, and what issues does this raise?

Analysis of the literature revealed that both types of bedpan processing equipment – bedpan washers and macerators – have benefits and drawbacks. The data helped identify the issues specific to each type of equipment, without determining the best choice for hospitals. Although consultation with professionals in the field shed light on several relevant aspects, it did not help establish a consensus guideline. The lack of guides to good practice means that each health-care facility must make choices that meet their needs and means. Nevertheless, all the practitioners we met expressed a willingness to agree on procedures meeting acceptable infection-control standards. Beyond the economic and environmental aspects, the main issues consistently raised by practitioners was the effectiveness of the equipment or procedures to reduce the risk of infection and to optimize work planning.

It is up to the infection prevention and control team at each health-care facility to make an informed decision about the method to adopt, in conjunction with management and the rest of the medical and professional staff. For the purpose of guiding that choice, the following basic principles apply:

- Manual bedpan cleaning must be proscribed because it poses a very high risk of infection: staff must not empty bedpans into sinks or toilets and must no longer use spray wands.
- Use of automated bedpan washers or macerators for processing bedpans is recommended if it follows stringent infection prevention procedures.
- Bedpan washers and macerators must be installed in dirty utility rooms located a reasonable distance away from patients' rooms (to reduce the risk of workplace contamination) and soiled bedpans must always be covered during transport to reprocessing equipment.
- Dirty utility rooms must be large enough to house the reprocessing equipment and to allow supplies to be properly stored. The area provided for dirty supplies must be physically separate from that for clean supplies.
- Reusable bedpans must be disinfected after each use. Leaving soiled bedpans to pile up on counters must be avoided by making sure that each care unit has enough reprocessing equipment.
- Sterilization of reusable bedpans between patients must be contemplated if the aim is to have bedpans free of bacterial spores in order to better control sources of *C. difficile* infection.
- After patient discharge, disposable bedpan supports must be sent to the central sterilization department for disinfection in a washer-disinfector.
- If the use of bedpan washers is adopted, a backup option must be planned for isolated cases or outbreaks of diarrhea associated with *C. difficile* (disposable bedpans, hygienic bags) especially when reusable bedpans are not sterilized after use.

- Installation of modular bedpan-washer units or macerators in the washrooms of isolation rooms should be considered in order to minimize workplace contamination during bedpan transport to dirty utility rooms, and to monitor highly contaminated bedpans.
- Staff must be properly trained and must consistently comply with procedures for human waste management, bedpan reprocessing and equipment operation.
- The use of hygienic bags for all patients should be considered in the critical conditions of a *C. difficile* outbreak.
- Preventive maintenance and verification of the equipment's operational parameters must be monitored on a regular and ongoing basis.

On the whole, any decision concerning infection prevention must be based on eliminating the sources of risk. Doing so starts with reducing the handling, transport and processing delays related to soiled supplies. It would be inappropriate to recommend a single biological waste management method or bedpan processing method. Several variables come into play in that choice, primarily, bedpan use requirements, risk of infection and outbreaks, staff availability, possibility of infrastructure redesign, geographic area, and budgets. In considering the data gathered in this technical brief, health-care facilities must each define their own needs and make an informed and “green” choice.

APPENDIX A

Search Strategy

PubMed

Search conducted between March and April 2008 and updated on March 27, 2009.

Publication dates: 1980–2008

- #1 Macerator[All Fields] OR Macerators[All Fields] OR bedpan[All Fields] OR bedpans[All Fields] OR “bed pan” [All Fields] OR “bed pans” [All Fields] OR “washer-disinfector” [All Fields] OR “washer-sterilizer”
- #2 washer[All Fields] OR washers[All Fields]
- #3 decontaminators[All Fields] OR disinfect*[All Fields] OR sanitiz*[All Fields] OR steriliz* [All Fields]
- #4 #2 AND #3
- #5 #1 OR #4

Cochrane Library 2008, Issue 1

Search conducted on April 11, 2008, and updated on March 24, 2009

- #1 (Macerator* OR macerateur* OR bedpan* OR bed adj pan*):ti,ab,kw
- #2 (washer*):ti,ab,kw AND (disinfect* OR steriliz*):ti,ab,kw
- #3 #1 AND #2

Internet

Various search engines were used in March and April 2008.

Searches were conducted on specific equipment and more generally on hospital disinfection processes.

Macerator OR Macerators OR macerateur OR macerateurs OR bedpan OR bedpans OR “bed pan” OR “bed pans” OR (bassine* AND lit) OR “washer-disinfector” OR “washer-sterilizer” OR (washer* AND (disinfect* OR steriliz*))

(Disinfection OR disinfector OR disinfectors OR washer OR washers OR cleaner OR cleaners OR cleaning OR decontamination OR contamination OR “infection control” OR sanitation) AND (medical OR hospital OR hospitals OR “health service” OR “health services”)

APPENDIX B

Cost Comparison

TABLE B-1

Johnson's study [1989]					
Table 1. Total cost comparison over one year					
Reusable system	Capital cost (£)	Revenue cost (£)	Disposable system	Capital cost (£)	Revenue cost (£)
1. Machine cost			1. Machine cost		
Purchase + VAT	3220		Purchase price + VAT	1800	
Depreciation		322	Depreciation		180
2. Storage			2. Storage		
Heated cabinet	581		Blue supports 30 @ £3.90	117	
Depreciation		58	Dispenser	88	
3. Installation costs	250		Depreciation		9
4. Water (756 litres/day)		138	Support rack	79	
5. Boiler fuel		74	Depreciation		8
6. Electricity		394	3. Installation costs	100	
7. Additional water and energy costs approx. 15%		91	4. Water (40 litres/day)		77
8. Bedpans and urinals			5. Electricity		7
(a) Polypropelene bedpans 12 units @ £9	108		6. Disposable products		
Annual replacement		108	1.23 units @ £0.0948		
(b) Polypropelene urinals 12 units @ £3	36		x 23 beds x 365 days		79
Annual replacement		36			
Total purchase cost	4195		Total purchase cost	2184	
Total revenue cost		1221	Total revenue		1260

APPENDIX C

Cost Scenario

TABLE C-1

Data pertaining to Hospital X used for cost calculations			
DATA	SYMBOLS (FOR COST CALCULATIONS)	QUANTITY	UNIT COST (CAN\$)
Number of care units (wards)	U	10	
Total number of beds	N	400	N/A
Number of beds requiring a bedpan ($400 \times 33\%$)	n	132	N/A
Total estimated number of macerators*	Z	10	8,500
Total estimated number of bedpan washers*	W	10	10,000
Total number of washer-disinfectors for disposable bedpan supports†	D	1	15,000
Total number of <u>soiled</u> disposable bedpans per day (estimation based on 4 bedpans/beds = $4 \times n$)	B ₁	528	0.59
Total number of reusable bedpans with lids <u>available‡</u> per bed ($2 \text{ bedpans} \times n$)	B ₂	264	90
Total number of <u>soiled</u> reusable bedpans per day (estimation based on 4 bedpans/beds = $4 \times n$)	B ₃	528	N/A
Total number of supports for disposable bedpans <u>available‡</u> per bed ($1 \text{ support} \times n$)	S ₁	132	12
Total number of <u>soiled</u> disposable bedpan supports per stay § (estimation based on 1 support/bed = $1 \times n$)	S ₂	132	N/A
Total number of protective covers for disposable bedpan supports per day (same as B ₁)	P	528	0.11
Total number of <u>soiled</u> hygienic bags per day (estimation based on 4 bags/bed = $4 \times n$)	H	528	0.80
Total number of <u>soiled</u> supports for hygienic bags per stay § (1 support $\times n$)	S ₃	132	4
Number of macerator cycles run per day = $B_1/2$ [¶]	C ₁	264	N/A
Number of bedpan-washer cycles run per day = $B_3/2$ [¶]	C ₂	264	N/A
Number of washer-disinfector cycles run per stay for disposable bedpan supports = $S_2/8$ (capacity of 8 supports/cycle)	C ₃	17	N/A

* The number of macerators and bedpan washers was determined by estimating that at least one machine would be needed in each care unit. For 40 beds per unit, only 13 beds (33%) need bedpans.

† It is assumed that one washer-disinfector was purchased and installed in the central processing department.

‡ It is assumed that there is one bedpan or support available per bed.

§ It is assumed that the average hospital stay is four days after which one disposable bedpan support is disinfected or one hygienic bag support is recycled.

|| The unit cost varies in relation to the purchase contract; the average cost being between \$2 and \$4.

¶ To prevent the accumulation of soiled bedpans, staff may start the machine each time a bedpan is used. This will result in a greater number of cycles. In this scenario, it is assumed that 2 bedpans are reprocessed or destroyed per cycle.

TABLE C-1 (cont'd)

Data pertaining to Hospital X used for cost calculations			
DATA	SYMBOLS (FOR COST CALCULATIONS)	QUANTITY	UNIT COST (CAN\$)
Cold-water use by macerator per day (23 L/cycle) = $C_1 \times 23$ L	L_1	6,072	N/A
Cold-water use by bedpan washers per day (12 L/cycle) = $C_2 \times 12$ L**	L_2	3,168	N/A
Hot-water use by bedpan washers per day (9 L/cycle) = $C_2 \times 9$ L	L_3	2,376	N/A
Cold-water use by washer-disinfectors per stay (24 L/cycle) = $C_3 \times 24$ L	L_4	408	N/A
Hot-water use by washer-disinfectors per stay (18 L/cycle) = $C_3 \times 18$ L	L_5	306	N/A
Electricity use by macerators per day (0.037 kWh/cycle) = $C_1 \times 0.037$ kWh	E_1	9.77	0.058
Electricity use by bedpan washers per day (0.16 kWh/cycle) = $C_2 \times 0.16$ kWh	E_2	42.24	0.058
Electricity use by washer-disinfectors per stay (0.32 kWh/cycle) = $C_3 \times 0.32$ kWh	E_3	5.44	0.058
Use of cleaning-deodorizing agents by macerators per day (0.010 L/cycle) = $C_1 \times 0.010$ L	Y	2.64	5
Use of detergent by bedpan washers per day (0.015 L/cycle) = $C_2 \times 0.015$ L	D_1	3.96	5.36
Use of rinse agent and descaler for bedpan washers per day (0.003 L/cycle) = $C_2 \times 0.003$ L	R_1	0.79	9.39
Use of detergent by washer-disinfectors per stay (0.030 L/cycle) = $C_3 \times 0.030$ L	D_2	0.51	5.36
Use of rinse agent and descaler for washer-disinfectors per stay (0.006 L/cycle) = $C_3 \times 0.006$ L	R_2	0.10	9.39
Annual maintenance for macerators (estimation based on 5% of purchase price)	M_1	10	425
Annual maintenance for bedpan washers (estimation based on 5% of purchase price)	M_2	10	500
Annual maintenance for washer-disinfectors (estimation based on 5% of purchase price)	M_3	1	750
Volume of waste (pulp paper) produced by the macerator per day (0.88 lbs/cycle) = $C_1 \times 0.88$ lbs	A_1	232	N/A
Number of plastic hygienic bags disposed of per day (estimation based on 4 bags/bed = $4 \times n$)	A_2	528	N/A
Number of recycled supports for hygienic bags per stay [§] (1 support \times n)	A_3	132	N/A

** Some bedpan washers use 40 L of water per cycle and 0.40 kWh of electricity.

Data sources for cost calculations:

Bedpan washers: The cost of purchasing the machine and the technical data concerning the use of electricity, water and detergents were extracted from manufacturers' brochures and from a cost estimate developed by Arjo (Tornado model) for a working group on bedpan washers.

Macerators: The purchase price for a macerator was provided in a personal communication with a sales representative from Vernacare in Québec. The costs of the accessories were provided by practitioners at the Hôpital du Sacré-Cœur de Montréal. The technical data on energy and water use were taken from a brochure on the Vernacare system.

Hygienic bags: The cost information was provided through personal communications with health-care practitioners and a sales representative from Hygie Canada Inc., which sells this product under the name of "hygienic coversTM".

TABLE C-2

Acquisition and operating costs according to the selected method (33% of patients using bedpans or hygienic bags)					
Equipment and Accessories	Acquisition Costs Over an Annual Basis (CAN\$)				
	Bedpan Washers		Macerators		Hygienic Bags
Equipments	(W*\$10,000)/15 yrs	6,666.67	(Z*\$8,500)/15 yrs	5,666.67	0
			(D*\$15,000)/15 yrs	1,000.00	–
Reusable bedpans	(B ₂ *\$90)/15 yrs	1,584.00	–	0	0
Reusable supports for disposable bedpans	–	–	(S ₁ *\$12)/15 yrs	105.60	0
Totals		8,250.67		6,772.27	0
Parameters	Annual Operating Costs (CAN\$)				
	Bedpan Washers		Macerators		Hygienic Bags
Maintenance	M ₂ *\$500	5,000.00	M ₁ *\$425	4,250.00	0
			M ₃ *\$750	750.00	–
Disposable bedpans	–	0	(B ₁ *\$0.59)/365 d	113,704.80	0
Disposable protective covers	–	0	(P*\$0.11)*365 d	21,199.20	0
Hygienic bags	–	0	–	0	(H*\$0.80)*365 d
Disposable supports for hygienic bags	–	0	–	0	(S ₃ *\$4)*365 d/4
Cold water	L ₂	Not calculated	L ₁	Not calculated	0
			L ₄	Not calculated	–
Hot water	L ₃	Not calculated	L ₅	Not calculated	0
Electricity	(E ₂ *\$0.58)/365 d	894.22	(E ₁ *\$0.58)*365 d	206.83	0
			(E ₃ *\$0.058)*365 d/4	28.79	–
Detergent	(D ₁ *\$5.36)*365 d	7,747.34	(D ₂ *\$5.36)*365 d/4	249.44	0
Rinse agent and descaler	(R ₁ *\$9.39)*365 d	2,707.61	(R ₂ *\$9.39)*365 d/4	85.68	0
Cleanser-deodorizer	–	0	(Y*\$5)*365	4,818.00	0
Subtotals		16,349.17		145,292.75	202,356.00
Totals (acquisition + operating)		24,599.84		152,065.01	202,356.00

* Costs are divided over the life span (15 years) of the equipment and supplies.

† Costs for sterilizing reusable bedpans are not included.

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