Investigation of single-use versus reusable infectious waste containers as potential sources of microbial contamination

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Background: Laws require that infectious waste be segregated from noninfectious waste. Companies certified to dispose of infectious waste offer both reusable and single-use containers. The focus of this study was to determine if there would be a microbiologic advantage to the use of one type of container over another in a burn hospital.

Methods: Monthly swab cultures were taken from the tops of > 250 infectious waste containers during 2 years. Bacteria and fungi were identified. In a substudy swab cultures were taken from an area of reusable tops before and after cleaning to evaluate the efficacy of cleaning on both the number and type of microbes present. Infection rates for acute patients were compared before and after control measures were instituted to decrease microbial transfer from infectious waste containers to patients.

Results: Cultures taken from reusable boxes when received from the container company showed that > 99% were contaminated with bacteria or fungi; most were normal environmental or skin flora, but some cultures showed microorganisms that can be potentially harmful to patients with compromised immunity. Wiping the lids with a phenolic disinfectant decreased both the total microbial load ($P < .001$) and the variety of microbes present ($P < .001$). In contrast, only 10% of the incoming single-use boxes showed any contamination. Infection rates dropped from 5.8 to 3.2 per 100 burn patients ($P < .05$) after the institution of cleaning and other changes made to decrease the possibility of microbial transfer from the infectious waste boxes to the patients.

Conclusions: Upon delivery, significantly fewer single-use infectious waste boxes were contaminated than reusable ones ($P < .001$). Extra infection control measures were needed when reusable infectious waste boxes were used in areas housing patients with compromised immunity. Facilities need be aware of the possible contamination of reusable infectious waste containers with microorganisms capable of causing nosocomial infections in patients who are compromised. (Am J Infect Control 2003;31:13-7.)

Nosocomial infections are a growing concern in medical facilities, in part because many of these infections tend to result from microorganisms that are resistant to antimicrobials and are therefore difficult to treat.[1,2] An infection is the result of an interaction between a susceptible host and a pathogenic microbe. For an infection to occur, the microbe must first come in contact (aerosol, touch, etc) with the host. One means of reducing nosocomial infections is to identify previously unrecognized fomites and then provide some measure of infection control for those contaminated objects, thereby reducing the opportunity for microbes to establish an initial contact with a susceptible individual. As a result of an observation of some soiled incoming infectious waste boxes by a housekeeping technician, a systematic study of the microbiology of incoming infectious waste containers was undertaken.

To ensure public safety, federal laws require that infectious waste be segregated from noninfectious waste. Generally, companies certified to dispose of infectious waste offer both reusable and single-use containers. There are advantages and disadvantages to both types of boxes. For example, the single-use

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0196-6553/2003/$30.00 + 0

doi:10.1067/mic.2003.17

Table 1. Percentage of incoming infectious waste containers positive for microorganisms

	Bacteria (n*)	Fungi (n*)
Reusable containers	94.3 (123)	79.5 (117)
Single-use containers	9.5 (63)	4.8 (63)
P <	.001	.001

*n = number of containers sampled.

containers used at the study hosptial are cardboard and arrive collapsed so they have the advantage of requiring little room for storage. However, they require time to be folded into a box and have no lid when in use because the flaps on the top of the box are kept open by the plastic liner that folds over the top edge. The single-use containers are not as strong as the reusable ones, are not suitable in a wet area, and are added to the waste stream at disposal. In contrast, the reusable containers, which are made of plastic, have the advantages of not adding to the waste stream, being stronger, maintaining their integrity when wet, and having removable lids that provide better aesthetics by covering contents and containing odors when in use. However, the reusable plastic containers sometimes arrive looking dirty, and there is an odor to the container itself. The companies with which the study hospital has worked supply both containers at no cost difference.

Single-use cardboard containers are generally handled only when they are folded open for use and lined with a plastic bag, and then they are not handled again until they are full; the plastic bag is closed and the flaps of the box secured over the top to close the box. On the other hand, the reusable boxes, which have a removable lid, are frequently touched by health care workers who need to have contact with the lid to open the box whenever it is used. Because the lid is always contacted when the reusable boxes are used, the single-use containers and the lids of the reusable containers were cultured when first received, and the efficacy of in-house cleaning of a subpopulation of these lids was examined. In addition, to determine if these cleaning and other procedural changes may have benefitted the patients, the nosocomial infection rates before and after these changes were initiated were compared.

METHODS

Screening of infectious waste containers

The same supplier has provided this burn hospital with infectious waste containers for a number of years, and they have generally appeared to be clean. However, a few years ago the observation of some soiled incoming containers triggered this study. Between April 1999 and July 2001, monthly swab cultures (Culturette; Becton Dickinson and Co, Cockeysville, MD) were taken from 380 infectious waste boxes. Reusable and single-use boxes were sampled upon arrival. The lids of reusable boxes were sampled after cleaning and when the boxes were in use in patients' rooms. Swabs, moistened with the medium contained in the culturette for precleaning cultures and with letheen broth to neutralize the disinfectant for postcleaning cultures, were streaked onto BBL TSA II 5% SB agar (Becton Dickinson and Co, Cockeysville, MD) for identification of bacteria and onto Sabouraud dextrose agar with chloramphenicol (Becton Dickinson and Co, Cockeysville, MD) for identification of fungi. Differences between the number of contaminated incoming reusable boxes versus incoming single-use boxes were determined by χ^2 and a significance of $P < .05$.

Cleaning of infectious waste lids

To determine if in-house cleaning of part of the containers would be effective, a small controlled experiment was conducted with 2 areas in the same predetermined locations on the lids of 12 boxes. One area was sampled without cleaning, and the other was cultured after being cleaned with disinfectant. The cleaner-disinfectant used was Ovation (Puritan/Churchill Chemical Co, Atlanta, GA), a phenolic used at its recommended concentration for routine cleaning of all general surfaces in the patients' rooms.

To obtain semiquantitative information for the cleaning study, each of two 25 cm^2 areas of the lids was sampled by rolling a Culturette moistened with letheen broth 10 times in one direction and 10 times in the direction at right angles to the first. With the use of standard streak plate procedure,[3] the primary streak was made with the swab onto BBL TSA II 5% SB agar; secondary and tertiary cross hatchings were made with the use of a flamed loop. All microorganisms were identified. The numbers of each microorganism present were estimated by recording growth of that microbe in each area: no growth on the plate = 0 microbial units; growth only in the primary streak = 1 microbial unit; growth only in the primary and secondary streak = 2 microbial units; and growth in all areas = 3 microbial units. For example, a swab showing growth of *Cladosporium* sp in only the primary streak = 1 unit of *Cladosporium* sp; growth of *Aspergillus* sp in only the primary and secondary streaks = 2 units of *Aspergillus* sp; and growth of

Table 2. Microorganisms isolated from incoming infectious waste containers*

Reusable containers		Single-use containers	
Bacteria (%)	**Fungi (%)**	**Bacteria (%)**	**Fungi (%)**
Bacillus sp (89.2)	*Alternaria* sp (2.5)	*Bacillus* sp (8.1)	*Aspergillus flavus* (1.6)
Gram-negative rods (25.0)	*Aspergillus flavus* (2.5)	Coagulase-negative Staphlococci (6.5)	*Aspergillus fumigatus* (1.6)
Micrococcus sp (2.5)	*Aspergillus fumigatus* (2.5)		*Aspergillus terreus* (1.6)
Pseudomonas aeruginosa (0.8)	*Aspergillus glaucus* (1.7)		*Aspergillus* sp (1.6)
Pseudomonas sp (1.7)	*Aspergillus niger* (15.0)		*Cladosporium* sp (1.6)
Coagulase-negative Staphylococci (30.8)	*Aspergillus* sp (14.2)		*Penicillium* sp (1.6)
Staphylococcus aureus, including MRSA (1.7)	*Aureobasidium pullulans* (2.5)		
Alpha-hemolytic Streptococci (23.3)	*Cladosporium* sp (18.3)		
Nonhemolytic Streptococci (1.7)	*Curvularia* sp (0.8)		
	Fusarium sp (2.5)		
	Penicillium sp (30.8)		
	Rhodotorula sp (27.5)		
	Trichoderma sp (5.0)		
	Ulcladium sp (0.8)		
	Verticillium sp (0.8)		

*% = percentage of incoming containers that cultured positive for that microorganism.

Bacillus sp in all 3 areas = 3 units of *Bacillus* sp. This is a total of 3 units of fungi and 3 units of bacteria for that sample. Statistical differences for both the number of different species present before and after cleaning and for the number of units of microorganisms present before and after cleaning were calculated with the Mann-Whitney test with $P < .05$ as significant.

Calculation of infection rates

To determine if the procedural changes initiated as a result of the findings of contamination levels on reusable infectious waste containers decreased the infection rate in the study hospital's patients, the nosocomial infection rate, calculated quarterly for the 2 1/2 years after the changes, was compared with the infection rate in the 2 1/2 years before the changes were implemented. A 1-tailed Student *t* test was used with $P < .05$ as significant. At this burn hospital, the nosocomial infection rate is defined as the number of patients with a microorganism that was both acquired (ie, not present in admission cultures) and that required antimicrobial treatment (indicating an infection rather than a colonization), divided by the total number of patients.

RESULTS

Comparison of microorganisms on incoming reusable versus on single-use infectious waste containers

Approximately 120 reusable containers, cultured upon arrival, showed 94.3% positive for bacteria and 79.5% positive for fungi (Table 1). In contrast, of 63 single-use containers cultured, only 9.5% were contaminated with bacteria and 4.8% with fungi. On average, the reusable containers were each contaminated with 2 (range, 0-5) different bacteria and with 1.6 (range, 0-5) different fungi.

When the data were grouped and analyzed by seasons, there were no statistical differences in the percentage of contaminated containers from one season to another.

Most of the isolated microorganisms were common environmental microbes or normal skin flora; however, a few microorganisms that were found are capable of causing serious infections in hosts with compromised immunity (Table 2).

Effect of cleaning

The controlled study to determine the efficacy of cleaning the infectious waste lids with the routine phenolic disinfectant showed that the cleaning significantly decreased both the number of different species of microorganisms present (Table 3) and the total number of microorganisms cultured (Table 4).

After adapting the cleaning procedure for containers placed in patients' rooms, results showed that for the actual in-use situation, cleaning the infectious waste lids with the routine daily cleaning of the room significantly decreased the total number of different microorganisms on the lids. A statisti-

Table 3. Number of different species of microorganisms present on infectious waste lids before and after cleaning with a phenolic disinfectant*

	Fungi	Bacteria	Total
Before cleaning	2.5 (1.5, 3.0)	2.0 (1.0, 2.0)	4 (3.5, 4.5)
After cleaning	0 (0, 1.0)	1.0 (1.0, 1.0)	1 (1.0, 2.0)
P <	.001	.001	.001

*12 infectious waste lids were studied. Number in parentheses indicate median number of species (25%, 75%).
P value determined by Mann-Whitney test.

Table 4. Quantitative assessment of microorganisms present on infectious waste lids before and after cleaning with a phenolic disinfectant*

	Fungi	Bacteria	Total
Before cleaning	3.0 (2.0, 3.0)	2.0 (1.0, 3.5)	5.5 (4.0 6.5)
After cleaning	0 (0, 1.0)	1.0 (1.0, 1.5)	1.5 (1.0, 2.0)
P <	.001	.02	.001

*12 infectious waste lids were studied. Number in parentheses indicate median microbial units (25%, 75%).
P value determined by Mann-Whitney test.

cally significant decrease in the number of fungi was noted, but a significant decrease in the number of bacteria was not (Table 5).

Effect of procedural changes in response to the contaminated waste containers on infection rate

To determine if the various changes in procedure (eg, cleaning the infectious waste lids) decreased the nosocomial infection rate, the infection rates for the $2^1/_2$ year period after the change were compared with those for the similar period before the changes. During this time the infectious waste containers were received from the same company. The mean infection rate before the infection control changes was 0.0576 ± 0.0352, or 5.8 nosocomial infections per 100 patients. In contrast, the mean infection rate after the infection control changes were made was 0.0318 ± 0.0190, or 3.2 infections per 100 patients. These differences are significantly different at $P < .05$.

DISCUSSION

Surveillance of incoming infectious waste containers during 2 years showed that the reusable con-

Table 5. Number of different species of microorganisms present on infectious waste lids when received versus after being cleaned with a phenolic disinfectant and placed in a patient's room*

	Fungi	Bacteria	Total
When received (114 lids)	1.5 (1.0, 2.0)	2.0 (1.0, 3.0)	4.0 (2.0, 5.0)
In patient room (100 lids)	1.0 (0, 1.5)	2.0 (1.0, 2.0)	3.0 (1.0, 4.0)
P <	.001	.120	.001

*Number in parentheses indicate median microbial units (25%, 75%).
P value determined by Mann-Whitney test.

tainers arrived at the burn hospital with significantly more microbial contamination than did the single-use boxes (Table 1). Although most microorganisms identified were generally harmless environmental contaminants, some, such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Aspergillus fumigatus*, are capable of causing serious infections in patients who are compromised by AIDS or by transplantation or cancer therapy, and in patients with an increased susceptibility to infection as a result of diabetes or severe burns.

Because of the increased risk that the reusable infectious waste containers could present to burned patients, the use of these containers throughout the hospital was reviewed. In areas such as the operating rooms, where the boxes are filled rapidly and in which microbial contamination must be minimal, the single-use cardboard boxes are used. However, in other areas, such as the patients' rooms, the reusable plastic boxes are desirable because they can be closed during the variable time intervals needed to fill them to limit visibility and odor. However, studies have shown that both bacteria and fungi can live for extended periods of time on plastics,[3-6] and microorganisms can efficiently be transferred from plastics to human hands.[7] In turn, a number of studies, often associated with the value of handwashing, have indicated that microorganisms can be transferred from person to person or from health care workers to patients.[8-10] Therefore a number of options were considered to reduce the possibility of transfer of microorganisms from the plastic infectious waste lids to the burn patients. For example, researchers examined foot pedal devices for automatically opening the lids and therefore negating the need for health care workers' hands to touch the boxes. However, these devices are rather expensive (at least $200 each) and would need to be cleaned at least each time the patient in the room

changed. Cleaning studies indicated that the disinfectant-cleaner routinely used to clean surfaces in the patients' rooms could decrease the microbial load on the lids (Tables 3-5). Therefore all lids are cleaned with the disinfectant before placement in the patients' rooms and are then spray disinfected daily during the regular room-cleaning process. The spraying requires little time, and the additional use of the regular disinfectant is minimal. Hence, adding this procedure to the regular room-cleaning routine has had little cost effect, especially when compared with the cost of a single nosocomial infection. In addition, other procedural changes were initiated. When in patients' rooms, health care workers are instructed to not touch the waste lid and then the patient without changing gloves, if gloved, or washing their hands, if ungloved. Finally, during times when the need to dispose of infectious waste is great, such as during a dressing change, the lid is removed and left off, so the box is accessible throughout the procedure without a need of touching the lid.

The above changes were introduced in June of 1999. The nosocomial infection rate for the 2 1/2 years after these changes was significantly lower than the infection rate before the changes. Although there is no direct proof that microorganisms from the infectious waste boxes caused nosocomial infections in patients, the strong temporal relationship between the decreased microbial load after cleaning the lids and the decrease in infection rate suggests that the contaminated infectious waste containers could have contributed to the infection rate. As mentioned above, the changes that were undertaken included not only disinfecting the lids, but also the institution of certain behavioral changes in handwashing and gloving relative to the infectious waste boxes. It is certainly possible that the increased emphasis on handwashing may have helped improve the infection rate as well. In addition, during the 5 year study period some changes in patient care occurred, some of which may also have positively affected the infection rate. However, none of these changes occurred simultaneously with the changes discussed in this article (ie, they were instituted months before or months after the changes relative to the infectious waste containers). Therefore, the recognition of the contaminated containers and the undertaking of measures to control this contamination markedly contributed to the improved infection rate that followed the institution of these changes.

Lastly, this study illustrates the value of multidisciplinary communication and cooperation among departments. When housekeeping alerted infection control of the soiled incoming containers, infection control undertook some structured studies. The outcomes of those studies resulted in changes in use and cleaning of various infectious waste boxes, as well as in changes in the training of patient care staff in areas such as nursing and respiratory care as to contacting the infectious waste lids.

In summary, upon receipt, reusable infectious waste boxes can be contaminated with microorganisms capable of causing serious infections in patients who have an increased susceptibility to infection. Therefore, facilities, such as hospitals and nursing homes, might take added infection control precautions with infectious waste boxes in areas that serve these compromised patients.

We thank Anne Cahill, Paula Durkee, Margaret Hartzel, and Dana Maraan for excellent technical assistance.

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