

# RADIATION Therapist

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# Risk of Patient Infection From Heating Appliances Used to Produce Thermoplastic Immobilization Devices

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**Purpose** To determine whether heating appliances used to fabricate customized thermoplastic immobilization devices carry a disease transmission risk.

**Background** Current literature provides ample evidence that water baths used in health care settings are potential reservoirs for microorganisms associated with patient infections. Such results suggest a similar potential for heating appliances used to fabricate thermoplastic forms.

**Methods** The authors conducted on-site surveys of both equipment and procedures used to produce immobilization forms in several medical facilities. Each heating appliance was sampled for its microbial content and the data analyzed for growth trends.

**Results** Twelve heating appliances were sampled. Five (42%) demonstrated bacterial growth on the lid, base surfaces, or both. The recovered bacteria included coagulase-negative *Staphylococcus* alone (25%), coagulase-negative *Staphylococcus* and *Corynebacterium* species (~8%), and *Bacillus* species (~8%). Study findings indicated that 4 of the 12 heating appliances were not specifically designed for immobilization form preparation.

**Discussion** Lids contaminated with common skin microbial flora suggest lack of gloved or cleaned hands. Warm-up times and water temperatures varied over the range of devices and water appearance did not always correlate with culture results. Nevertheless, the absence of written protocols for the use and maintenance of heating appliances at all sites suggests opportunities for quality improvement because a contaminated heating appliance is a potential disease transmission source.

**Conclusion** The use of heating appliances carries an inherent risk for infectious agent transmission; however, this risk can be substantially reduced by applying basic infection control procedures.

In 1982, Verhey et al published one of the first studies to demonstrate improved treatment accuracy and reproducibility through the use of thermoplastic immobilization devices in radiation therapy.<sup>1</sup> Today, customized thermoplastic devices are widely used for a variety of pathologies, allowing extremely accurate treatment delivery, particularly when coupled with image-guided techniques.<sup>2-6</sup> What has not been determined is the potential for disease transmission due to contamination of form-heating equipment such as water baths. This study examines the maintenance and use of these appliances to determine whether such potential exists.

Mesophilic bacteria grow best in temperatures between 25°C and 40°C. Most human pathogens belong to this category, growing well at the average body temperature of 37°C. However, some mesophiles exhibit increased heat tolerance when exposed to much higher temperatures for short periods.<sup>7</sup> The water used to prepare thermoplastic forms must be heated to 70°C to 90°C. Many microbes present in the water or on equipment surfaces are killed by the high temperature. However, this is not the case for certain heat-tolerant bacteria such as *Bacillus* species. This genus of aerobic rod-shaped, gram-positive bacteria, which includes the

causative agent of anthrax, responds to sudden environmental changes, such as heating, by rapidly forming spores.<sup>8</sup> In one study, the temperature needed to inactivate different *Bacillus* species spores was between 75°C and 121°C, which is at or above the range for form-heating appliances.<sup>9</sup> Moreover, this microbe is so heat tolerant that it is used to monitor the effectiveness of heat-based sterilization procedures.<sup>7</sup>

Radiation therapy safety has been studied from a number of perspectives in recent years. In 2010, a series of 4 articles in the *New York Times* captured the attention of both the public and the profession when it described treatment errors and tragic consequences suffered by patients.<sup>10-13</sup> In response, the American Society for Radiation Oncology and the American Association of Physicists in Medicine convened an international meeting focused on error prevention and patient safety. One of the 20 recommendations from that meeting was that each member of the treatment team “should pledge a commitment to protect the safety of each and every patient.”<sup>14</sup> Numerous studies have focused on highly technical aspects of the treatment delivery process, but other opportunities for improvement must not be overlooked. Current literature suggests that all opportunities should be taken to assess infection transmission risks associated with heating appliances used to fabricate either implantable or external thermoplastic devices.

This study assesses individual facility practices where water baths or other heating appliances are used to fabricate thermoplastic immobilization devices. The authors hypothesized that a water bath operating temperature of 74°C would preclude growth of most microorganisms, thereby minimizing infection transmission risk. The purpose of this study was to assess whether thermoplastic form heating appliances carry an inherent infection risk. The results offer insight that affects patient safety as it relates to thermoplastic heating appliance use and might help facilities develop or refine existing policies and practices.

### Literature Review Infection Transmission

Nosocomial infections are hospital-acquired infections occurring as a direct result of patient hospitalization or performance of procedures in a similar health

care setting. They are the fourth leading cause of death in the United States, with 2 million cases documented annually. The increased cost of medical treatment for these infections has been estimated to be more than \$5 billion each year.<sup>15</sup>

Microorganism transmission is a prerequisite for patient infection. A variety of pathogenic and usually nonpathogenic microorganisms have been implicated as the cause of nosocomial infections. They include viruses, bacteria, fungi, and even some parasites.<sup>16</sup> Health care-based microbe transmission can occur through several mechanisms, but all require an infective source or reservoir.

### Infection Reservoirs

Contaminated hospital equipment, plumbing, and ventilation systems are reservoirs for waterborne bacteria and have the potential for disease transmission. For example, *Pseudomonas aeruginosa* outbreaks in hospitals have always been problematic. Difficulty in treating this organism has been compounded by the appearance of several hard-to-treat, multidrug-resistant strains. In one study, the source of infection in one facility was water splashing from *Pseudomonas*-contaminated hand-washing sinks in intensive care or transplant units. During a 15-month period, 36 patients were infected with a multidrug-resistant strain of *P aeruginosa*. Seventeen patients died within 3 months, with 12 of those deaths linked to or directly attributed to the contaminated sinks.<sup>17</sup> This ubiquitous environmental bacterium grows easily in tap water and distilled water.<sup>18-20</sup>

The Centers for Disease Control and Prevention reported that pseudomonads, along with other waterborne bacteria such as *Burkholderia* and *Acinetobacter*, are associated with occasional infection outbreaks.<sup>18</sup> *Pseudomonas aeruginosa* alone is estimated to cause 1400 deaths annually in the United States as a result of pneumonia associated with contaminated water supplies in health care facilities.<sup>21</sup> Fatal respiratory tract infections also have been linked to water contaminated by *Legionella*, another gram-negative bacterium. This microbe is the causative agent of fatal Legionnaire's disease and also legionellosis, a self-limiting form of infection.<sup>21</sup>

A study that involved air sampling of transplant unit patient isolation rooms recovered coagulase-negative *Staphylococcus* (CNS), *Micrococcus* species, and *Bacillus*

*subtilis* in order of isolation frequency. The presumed microbial source was both the patients and medical staff.<sup>22</sup> *Bacillus* species, along with CNS, also have been implicated in surgical wound contamination introduced through nonsterile surgical instruments. In these cases, contamination was attributed to inadequate steam autoclave maintenance and poor handling practices by medical staff.<sup>23</sup>

Bacteria have been previously shown to adhere to and colonize moldable, implantable thermoplastic devices but vary in their capability to do so.<sup>24</sup> One study determined that thermolabile splints used in a burn ward posed a similar infection threat. More than 33% of splints were colonized with bacteria either associated with the underlying burn wound or as a result of external contamination. Recovered bacteria were primarily gram-positive species, including CNS, *Staphylococcus aureus*, *Bacillus* species, and viridans streptococci. A smaller number of gram-negative isolates also were detected.<sup>25</sup>

Water baths and similar heating appliances are an important source for bacteria such as pseudomonads.<sup>19</sup> Evidence links this type of contaminated equipment to outbreaks of serious waterborne nosocomial infections.<sup>21</sup> Sitting, nonsterile tap water represents a major source of potentially harmful microorganisms in patient care settings.<sup>18</sup> Microorganism-containing biofilms can develop on equipment surfaces in contact with water.<sup>26</sup> Biofilms harbor bacteria and other microorganisms that can cause disease in patients with impaired immune systems, and they can form easily on equipment that is not cleaned regularly.<sup>18,27</sup> However, studies have demonstrated that using distilled water is an effective method to reduce potential pathogens such as *Legionella*, mycobacteria, molds, viruses, and parasites.<sup>21</sup>

### Special Patient Populations

Environmental microorganisms are rarely identified as a source of nosocomial infections in immunocompetent or otherwise healthy patients.<sup>18</sup> However, patients with an impaired immune response (eg, immunosuppressed patients) are at higher risk of developing nosocomial infections from bacteria usually considered nonpathogenic. This group of organisms often is described as *opportunistic* pathogens. Nosocomial infection risk is heightened in individuals receiving radiation therapy for cancer treatment.<sup>16,18</sup>

Contaminated facility water reservoirs represent a potential hazard for this patient population.

## Methods

### Design

A mixed study format, primarily quantitative in nature, was selected to formulate the survey design parameters. This design method was chosen as best suited for a comparative study that would support examination of relationships between multiple variables. The survey assumed that most participating facilities would have a written procedure for water bath use and maintenance. It also was expected that most clinical sites would be using heating appliances specifically designed for preparing thermoplastic immobilization forms.

### Participants

Fourteen radiation therapy facilities in 3 states were invited to participate in this study, and a random sampling method was used. Selected facilities were located within a 200-mile radius that would allow timely culture submission to prevent microbial loss. A practical limitation of this study was the distance between the collection site and the testing facility. Two sites did not participate. The 12 participating sites were representative of radiation therapy facilities performing immobilization device fabrication in the region. Informed consent was obtained from administrative personnel, and an interview concerning heating appliance use and maintenance was conducted at each facility. Water bath samples were collected immediately following the interviews. This was done primarily to prevent deviation from the normal daily routine.

### Data Collection

A comprehensive participant survey checklist was designed to collect consistent site-specific information regarding thermoplastic heating appliance use and maintenance. Information gathered during interviews with designated clinical representatives was documented on the checklist (see **Table 1**).

### Sample Collection

Twenty-four culture samples were collected from 12 health care facilities over a period of approximately

# Peer Review

## Risk of Patient Infection From Heating Appliances

Table 1

### Survey Checklist

Section Title	Items/Questions
Facility information	<ul style="list-style-type: none"> <li>Person authorizing study.</li> <li>Date of authorization.</li> <li>Average number of patients treated daily.</li> <li>Culture results.</li> </ul>
Sample collection	<ul style="list-style-type: none"> <li>Date and time of collection.</li> <li>Date and time of delivery to lab.</li> <li>Time between collection and lab delivery.</li> </ul>
Water bath information	<ul style="list-style-type: none"> <li>Brand.</li> <li>Model.</li> <li>Location of water bath.</li> <li>Interior bath dimensions.</li> <li>Lining.</li> <li>Lid.</li> <li>Is a hose attached for draining?</li> <li>Is draining the bath at the current location practical?</li> <li>Is temperature adjustment possible?</li> <li>What is the current digital temperature reading?</li> <li>What is the actual water temperature when measured with a thermometer?</li> <li>Is there visible debris in the water?</li> <li>Is there visible film on sides or top?</li> <li>Is rust visible in the tank?</li> <li>Water depth in millimeters.</li> <li>Tank depth in millimeters.</li> <li>Are there lid locks on the heating appliance?</li> <li>Is an instruction label present on the appliance?</li> <li>Comments.</li> </ul>
Interview questions	<ul style="list-style-type: none"> <li>Date of interview.</li> <li>Name of the person answering questions.</li> <li>Date water bath was put in use.</li> <li>Is a written policy in place?</li> <li>Can you provide a copy of that policy?</li> <li>Can you provide a copy of the operator manual for the appliance?</li> <li>Is a water change included on the quality control checklist?</li> <li>Type of water used (eg, distilled, tap).</li> <li>Is the bath turned off after hours?</li> <li>Is it left on all day during business days?</li> <li>How often is the water bath typically used?</li> <li>When was the water bath last used?</li> <li>How long before the bath is ready to use (ie, warm-up delay)?</li> <li>What signals to staff that it is ready for use?</li> <li>When was water last added?</li> <li>Is the water emptied between uses?</li> <li>When was the water bath last emptied?</li> <li>Is the bath drained at the current location?</li> <li>How do you describe water bath maintenance (ie, water depth maintenance, cleaning, water change)?</li> <li>Is disinfectant used for cleaning?</li> <li>Is a growth inhibitor added (eg, algacide)?</li> <li>Is the water bath completely emptied and dried when cleaned?</li> </ul>

30 days. Samples were collected under the same conditions routinely used by each facility for thermoplastic form preparation. Sterile cotton-tip applicators with a wooden shaft (PSS Select) were used to collect 2 samples from each water bath. A clean pair of latex gloves was worn, and the underside of each water bath lid was sampled near the center using an S-shaped swiping motion approximately 25 cm long. A second swab was inserted in the water to a depth of approximately 1 cm. This swab

was moved in a 6-cm L-shaped pattern along the right side of the water bath. A similar sampling technique was used for all heating appliances: water baths, electric skillets, or food warmers. Five facilities used appliances other than a water bath to heat thermoplastic forms in lieu of the water bath designed for this purpose, which was manufactured by CIVCO Medical Solutions.

Each sample swab was immediately inserted into a sterile 15 mL conical tube (Fisher Scientific) containing

5 mL of lysogeny broth (LB Broth, Miller)(Difco). Lysogeny broth is a nutritionally rich medium used to recover and cultivate a variety of bacterial species. It was originally designed to support recombinant bacterial strains of *Escherichia coli*.<sup>28</sup> The upper portion of the swab's wooden shaft was broken off, leaving the sample applicator tip in the broth. The tube was tightly capped and wrapped with Parafilm M (Pechiney Plastic Packaging) to prevent leaking during transport. All sample tubes were labeled with a predetermined anonymous collection site code, sample source (ie, lid vs base), and the date and time of collection. Samples were transported at room temperature and submitted within 6 hours to the University of South Alabama Medical Center Microbiology Department clinical laboratory for growth determination.

### Sample Processing

Broth sample tubes were incubated for 18 to 24 hours in a 35°C ambient air incubator. After this initial incubation period, sample tubes were examined with the naked eye for signs of microbial growth (eg, cloudy appearance). A Gram stain was performed if the broth was cloudy. Each sample was thoroughly mixed, and 0.1 mL of broth was aseptically removed and transferred to a 5% sheep blood agar (SBA) plate (BBL Prepared Plated Media; Becton, Dickinson and Company). SBA is a common nutrient media composed of trypticase soy agar with 5% sheep's blood. It is widely used to recover and cultivate fastidious microbes. It has the added benefit of allowing detection of bacterial hemolytic patterns (eg, alpha vs beta hemolysis). A sterile plastic rod then was used to spread the sample volume evenly over the entire plate surface. SBA plates were incubated for 18 to 24 hours under the same conditions as the initially submitted broth tubes.

### Growth Determination

After 24 hours, each SBA plate was removed and evaluated for microbial growth. The SBA plates demonstrating visible colony growth were further evaluated. All negative growth plates were incubated for an additional 24 hours and reexamined for growth the next day. Bacterial growth was enumerated by counting the number of colonies on the plate. Resulting colony numbers were multiplied by a factor of 10 to account for the original sample dilution. Results were reported in

colony-forming units per milliliter of liquid (cfu/mL<sup>-1</sup>). Isolated representative colonies were subjected to a Gram stain to determine their Gram stain reaction (positive vs negative) and morphological characteristics (ie, cocci vs rods). Biochemical testing based on Gram stain result then was used to derive a limited identification of each colony isolate type. A negative report was assigned to samples without detectable growth after a total of 48 hours of incubation on the SBA plate.

### Quality Control

Positive and negative growth controls were processed and evaluated to determine the initial sterility of the broth medium. A negative control was prepared by inserting a sterile swab into the lysogeny broth in a manner similar to that used to sample the equipment. A positive control also was made to confirm the ability of the lysogeny broth to support microbial growth. A tube of lysogeny broth was lightly inoculated with *P aeruginosa* (27853; ATTC) bacteria by touching a single bacterial colony with the edge of a sterile swab and transferring it to a broth tube. Both controls were submitted as blind (anonymous) samples to the same laboratory at the University of South Alabama Medical Center.

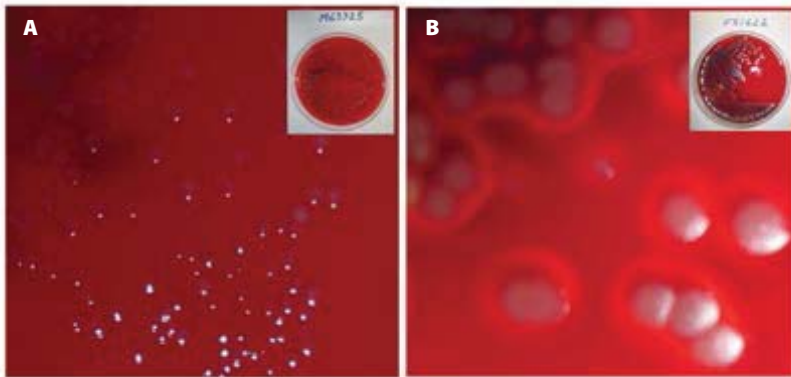
### Data Analysis

Interview results were compiled into an Excel spreadsheet (Microsoft Corporation) for trending analysis. Positive microbial culture results were similarly analyzed for any apparent microbial growth patterns. Statistical analysis was performed to derive comparative frequencies, percentages, averages, or a combination of the 3, including associated standard deviations.

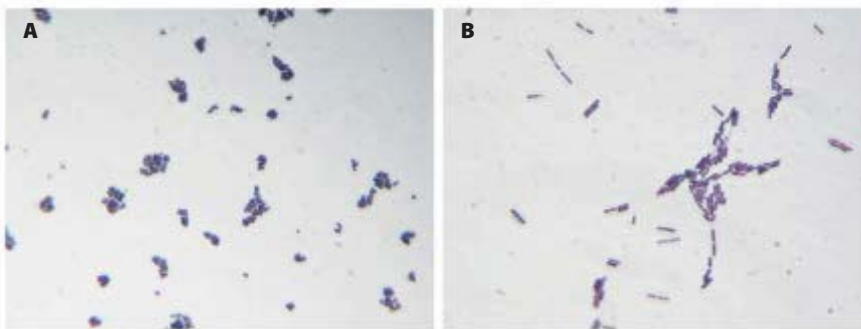
### Results

Both positive and negative growth controls worked as anticipated. *Pseudomonas aeruginosa* that was seeded into the positive control medium was recovered in culture in numbers too numerous to count. Correspondingly, the negative control without seeded bacteria did not demonstrate any microorganism growth, indicating broth medium sterility.

Sampled heating appliances included 7 MedTec/CIVCO water baths, 4 General Electric (GE) covered electric skillets, and 1 Vollrath food warmer. Use of these appliances varied from daily to more than every



**Figure 1.** These images show 5% sheep blood agar (SBA) plates demonstrating close-up images of bacterial colonies from 2 positive heating appliance cultures. Insets show the entire agar plate with corresponding culture identification numbers. A. Mixed culture containing both gram-positive coagulase-negative Staphylococcus (CNS) and gram-positive diphtheroids. B. Gram-positive Bacillus species recovered from a different heating appliance. Notice the clearing around each colony indicating  $\beta$ -hemolysis. Both images are representative of recovered bacteria as recorded using a Sony Cyber-shot Model DSC-W290 camera from an approximate working distance of 6 inches. Images courtesy of the authors.



**Figure 2.** Gram stain results from the 2 positive bacterial cultures shown in Figure 1. Displayed image labels correspond with respective colony types demonstrated in this figure. Gram-positive diphtheroids are not represented in either image. A. Brightfield view of clusters of gram-positive CNS recovered from heating appliances located at 4 different sites. B. Brightfield view of large rod-shaped gram-positive Bacillus species recovered from a heating appliance located at a different site. Both images illustrate recovered bacterial contaminants as recorded at 1000 $\times$  magnification (oil immersion) using a Leitz microscope equipped with a Nikon DSF11 digital camera. Images courtesy of the authors.

other week, with half of the sites using the heating appliance on a weekly basis. Equipment found to be positive for microbial growth included 2 MedTec/CIVCO water baths, 2 GE skillets, and 1 Vollrath food warmer (see **Figures 1** and **2**). Recovered microorganisms from sample lids and/or bases included CNS alone (25%); CNS and *Corynebacterium* species, also known as diphtheroids (~8%); and *Bacillus* species (~8%), with an overall positive rate of ~42% (see **Table 2**).

Temperatures were recorded from a digital readout on the appliances' front panel, if present. Thermometer readings from 11 appliances ranged from 68°C to 98°C, with a mean of 77.1°C (standard deviation [SD] = 8.7). Appliance warm-up times ranged from 5 to 30 minutes at 11 sites, with a single site indicating that the appliance was never turned off at its facility. Average warm-up time

reported for these 11 sites was 16.8 minutes (SD = 8.4), with a median of 20 minutes.

The ratio of centimeters of water depth to centimeters of appliance depth varied appreciably among the sampled appliances. This parameter indicates whether heating appliances were filled to the recommended water level according to manufacturer specifications. Direct measurements indicated ratios of approximately 1:3 for the Vollrath food warmer and 1:4 for GE skillets. Greater variation was found among the MedTec/CIVCO water baths, ranging from 1:6 up to 1:3. Three of 12 sites indicated that water baths were emptied between each use. Of these 3 sites, only 1 demonstrated measurable bacterial contamination.

None of the 12 sites sampled had an established written protocol specifying heating appliance use or

Table 2

Culture Results						
Site	Appliance	Lid	Base	Digital Temperature Reading (°C)	Thermometer Reading (°C)	Water Appearance
1	MedTec/CIVCO water bath	N	N	78	70	Film-like substance
2	MedTec/CIVCO water bath	N	N	69	70	Clear
3	MedTec/CIVCO water bath	CNS and <i>Corynebacterium</i>	N	76	NA <sup>a</sup>	Sediment, cloudy water
4	MedTec/CIVCO water bath	CNS	N	76	74	Sediment, cloudy water
5	MedTec/CIVCO water bath	N	N	73	72	Clear
6	MedTec/CIVCO water bath	N	N	74	77	Clear
7	Vollrath food warmer	<i>Bacillus</i> species	<i>Bacillus</i> species	NA <sup>b</sup>	68	Clear
8	GE skillet	N	N	NA <sup>b</sup>	98	Whitish scale
9	GE skillet	N	N	NA <sup>b</sup>	76	Clear
10	MedTec/CIVCO water bath	N	N	74	84	Clear
11	GE skillet	CNS	N	NA <sup>b</sup>	75	Whitish scale
12	GE skillet	CNS	CNS	NA <sup>b</sup>	84	Clear

Abbreviations: CNS, coagulase-negative Staphylococcus; GE, General Electric; N, negative; NA, not applicable.

<sup>a</sup> Too shallow to measure accurately.

<sup>b</sup> No digital readout present.

maintenance. Two of 12 sites possessed a copy of the manufacturer's procedure manual. Routine cleaning also was highly variable among participant sites. One site reported that the water bath in its facility "must be cleaned one time per rotation," with no time interval specified. One site indicated that an alcohol disinfectant was used during cleaning, but no cleaning interval was specified. The length of time since the heating appliance had been emptied ranged from zero days (the date of the site visit) to 7 months earlier. Timing regarding the addition of water to these appliances was just as variable, ranging from "unknown" and "yesterday" to "up to 14 days ago." Microbial growth inhibitors were not added to water at any sampled site. Eleven of 12 sites were using tap water, with the remaining site using distilled water. One site included heating appliance cleaning on departmental quality control documentation.

## Discussion

Lids contaminated with common skin microbial flora suggest lack of barrier usage (ie, latex gloves) or

clean hands. For instance, touching a lid's inner surface with an unwashed hand when opening it contaminates the lid. The presence of CNS and the *Corynebacterium* species on a lid or base is easily explained because of how the forms are handled. Both of these bacteria are present in large numbers on human skin surfaces as resident flora. However, the recovery of *Bacillus* species from one of the heating appliances is not as easy to explain. *Bacillus* is a common aerobic soil bacterium that forms spores when exposed to environmental stressors such as heat, and it has been associated with several types of human infections because actively growing bacteria produce exotoxins. *Legionella* isolation requires a special culture medium, which was not used during this study. Consequently, the presence or absence of *Legionella* in the heating appliances used in this study could not be established.

Actual heating appliance temperatures derived via a liquid-in-glass (stick) thermometer did not always correlate well with digital readouts (see **Table 2**). For example, the digital readout at site 10 registered a temperature of 74°C, whereas the thermometer-derived internal water



temperature indicated 84°C. No correlation between digital temperature readouts and thermometer-acquired temperatures could be determined for appliances lacking the digital temperature readout feature. The lack of a digital readout on the GE skillets and Vollrath food warmer resulted in a much greater variation in recorded temperatures (68°C to 98°C). These appliances possessed either a dial with a numeric setting (eg, 1-10) or descriptive designations such as “warm.” The mean temperature for all appliances was 80.2°C (SD = 11.5). The greatest temperature variation was seen with the nonstandard heating appliances. These appliances cannot be calibrated against a National Institute of Standards and Technology–referenced thermometer. Determining that a desired heating temperature has been obtained can only be accomplished using a quality stick thermometer.

Altered water appearance (eg, cloudy vs clear) did not always correlate with culture results. The presence of cloudy water, sludge like material, whitish scale, or a combination of these on the interior side near the appliance’s base correlated well with 3 out of 4 sites growing CNS from samples taken from lids. However, this was not the case for water samples taken from these same units. Only 1 unit of the 4 positive for CNS on the lid demonstrated a similar result for the base water sample. Additionally, 1 water bath that demonstrated a floating film like material approximately 6 cm × 10 cm was negative for both lid and base samples. Of particular note was the clear water sample from site 7 growing *Bacillus* species. Repeat cultures of this particular unit after what was thought to be a thorough cleaning still demonstrated *Bacillus* species from its base but not its lid. This could be most likely attributable to difficulty in completely cleaning a bulky base with numerous nooks and crannies vs the ease in cleaning a relatively flat lid. A few missed *Bacillus* species spores on the base surface would allow for easy microbial recolonization after cleaning. This particular unit from site 7 has been removed from service.

MedTec/CIVCO recommends that its water bath be filled with 7.6 cm (3 in) of water. The internal tank depth for this manufacturer’s units is 12 cm (4.7 in). Thus, the desired ratio of water to tank depth is approximately 8:12 or about two-thirds filled. This was not the case for the MedTec/CIVCO appliances sampled, whose fill ratios ranged from 1:6 to 1:3. The

use of tap water or distilled water was not specified by the manufacturer.

Likewise, appliance warm-up times varied greatly. MedTec/CIVCO recommends allowing 2 to 3 hours to heat water after the unit is turned on. One out of 7 sites using a MedTec/CIVCO water bath kept the unit on at all times. The remaining 6 sites allowed anywhere from 10 to 30 minutes warm-up time after turning the unit on. None of the sites using MedTec/CIVCO appliances completely followed the manufacturer’s suggested protocol. Although the thermoplastic forms were adequately heated to mold into shape, it is possible that more heat-tolerant microbes could survive such shortened heating times.

In addition, the MedTec/CIVCO water bath reference guide specifically states that “[u]sers of this product have an obligation and responsibility to provide the highest degree of infection control to patients, co-workers and themselves.”<sup>29</sup> The guide goes on to state that users must avoid the potential for cross-contamination by following local infection control policies and suggests a periodic maintenance protocol for draining the tank and cleaning it with a disinfectant. No specific time interval for cleaning is mentioned in the MedTec/CIVCO guide, but standard equipment maintenance practices suggest that cleaning should be performed at least monthly or when, upon inspection, visible debris or cloudiness is present. Smaller appliances such as skillets, which are easier to handle, can be cleaned more frequently.

Discussion of the MedTec/CIVCO water bath reference guide does not imply that the authors recommend this particular manufacturer or its products. The MedTec/CIVCO guide was the only source of water bath information available at the clinical sites surveyed. Therefore, the MedTec/CIVCO guide was used to assess the GE and Vollrath devices in the absence of individual guides for those appliances. Each facility using this type of appliance must select one that meets its particular needs and allows a certain degree of quality control standardization.

The absence of written protocols for the use and maintenance of heating appliances at all the sites suggests significant opportunities for quality improvement. Sufficiently detailed written protocols should be developed, as recommended by equipment manufacturers.

Table 3

**Recommendations for Preventing Contamination of Water Baths and Other Heating Appliances**

Preventive Technique	Recommendations
Hand washing and gloving	Wash hands and wear gloves prior to working with the water bath, the patient, and forms.
Appliance maintenance	Follow the manufacturer's recommendations for water bath maintenance. <sup>a</sup> In the absence of specific recommendations, apply safe practice measures such as: <ul style="list-style-type: none"> <li>▪ Drain water bath at least once a month.</li> <li>▪ Empty smaller bath appliances after each use.</li> <li>▪ Clean lid and base with approved disinfectant soap.<sup>b</sup></li> <li>▪ Rinse thoroughly and let dry before adding water.</li> </ul>
Water type	Use distilled water rather than tap water.
Warm-up procedure	Follow manufacturer's recommendations for heating water. In the absence of specific manufacturer's recommendations: <ul style="list-style-type: none"> <li>▪ Heat to a target temperature of approximately 75°C.</li> <li>▪ Maintain the target temperature for at least 30 minutes prior to using appliance.<sup>c</sup></li> </ul>
Departmental protocol	Develop a department protocol for water bath use and maintenance.
Quality control	Include water bath maintenance on a quality control checklist.

<sup>a</sup> Also consider performing periodic culturing of water and equipment to detect microbial contaminants.

<sup>b</sup> Per local facility infection-control policies.

<sup>c</sup> This step should preclude growth of most, but not all, mesophilic organisms.

**Table 3** contains recommendations to assist in developing a written protocol. Appliances such as electric skillets that are not designed for preparing thermoplastic devices might be acceptable for use after adequate written protocols are developed. Minimizing patient exposure to tap water is potentially effective in reducing the risk of nosocomial waterborne infections. Including periodic water bath maintenance on a quality control checklist could serve as a valuable reminder for staff.<sup>14</sup>

A contaminated heating appliance is a potential disease transmission source. However, confirming contamination does not necessarily mean that transmission of an infectious agent occurred; it only suggests its possibility. Contamination further suggests that individuals handling heated forms did not use adequate barrier precautions such as latex gloves, had not recently cleaned their hands, or that they contaminated their hands after washing them by touching a dirty object before touching the water bath lid or handling a form. Consequently, microbes on the radiation therapist's hands could be transferred directly to the form before it was applied to the patient. If a patient has an open surgical wound, this

is an easy route for microbial entry. The authors did not find any documented case of infection transmission via this process. However, results of this study suggest that further examination of disease transmission via water baths used to prepare thermoplastic forms for radiation therapy is warranted. Future studies could expand the sample population size, evaluate outcomes before and after implementation of a water bath maintenance protocol, or both.

### Limitations

To the best of the authors' knowledge, this is the first attempt to examine the potential for disease transmission from contaminated water baths. A small sample size is an inherent feature of any initial study. However, the sites participating in this study represent a diverse group of health care facilities located within a 200-mile radius having a combined average daily treatment volume of 500 patients. For this reason, the authors believe that this research contributes valuable new information to the radiation therapy literature, although extrapolating results to other facilities warrants a degree of caution.

#### Conclusion

Breaking the chain of infection is essential in preventing nosocomial disease. This research demonstrated that proper hand hygiene and water bath maintenance are important to minimize the risk of infection transmission to radiation therapy patients. Radiation therapists should follow manufacturer guidelines and consistently apply recommended infection control procedures and practices so water baths and other heating appliances are used safely in thermoplastic form preparation. Timely and effective routine maintenance procedures such as scheduled cleaning, an adequate warm-up time, and temperature monitoring will most likely reduce or eliminate the potential for disease transmission. If further concerns remain, consultation with an infection control officer or infectious disease specialist might be warranted. Facilities are encouraged to institute periodic culture monitoring if recommended by these officials. The radiation therapist's efforts to minimize the risk of infection can help keep patients who are already battling serious disease from developing infections as a result of avoidable contamination.

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