

Microbial Loads in Whirlpool Bathtubs: An Emerging Health Risk

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Abstract

Reports of whirlpool associated microbial infections are seen in the literature as early as 1972. Due to the increased popularity of whirlpool bathtubs for both personal home use and for hydrotherapy in hospitals and nursing homes, a preliminary study of microbial content and bacterial loads was undertaken. Initial analysis of the whirlpool tub samples yielded 100% of the samples showing microbial growth with 95% demonstrating the presence of enteric organisms, 81% with fungi, 56% with *Pseudomonas sp.*, 36% with *Legionella sp.*, and 34% with *Staphylococcus aureus*.

Recent reports of whirlpool and hot tub associated septicemia (12), skin infections (5), urinary tract infections (17), pneumonia (15) legionellosis and pontiac fever (2,8) raise serious public health concerns about the risks associated with whirlpool bathtubs. To assess the risks, whirlpool bath water samples were aseptically collected from private homes and hotels from across the United States. This report deals with whirlpool bathtubs that are filled and drained after each use, as distinguished from recreational spas and hot tubs.

A typical whirlpool bathtub incorporates a system of inaccessible air and water piping (10). When a bather fills the tub and activates the system, normal flora, dirt, sloughed skin, body fluids, bath oils and additives, fecal matter and soap scum circulate through the system and builds up inside the piping as biofilm. Biofilms are abundant in nutrient-containing aquatic environments and due to physiological cooperation are inherently more resistant to various antimicrobial treatments and cleaning methods (4). Manufacturers recommend flushing the system with automatic dishwasher detergent, bleach, vinegar, or baking soda, (13,14,21) but the effectiveness of those products is highly doubtful (4). Most systems permit dirty bath water to back-fill the air piping when the pump is turned off. Unlike the water circulation piping, the air piping will not admit fluid while the pump is operating. Even if industry-recommended cleaning agents were effective, they cannot reach the air piping, which makes the complete system uncleanable by any means (10). Additionally, although one drains the tub after bathing, it appears that the circulation system itself does not fully drain. The industry standards committee of the American National Standards Institute has adopted a standard that permits the typical circulation system to retain over 10 fluid ounces of bath

water when the bathtub is fully drained (1). Stagnant, organic-containing bath water trapped inside a system already rich in biofilm provides an ideal environment for bacteria to flourish. These factors combine to expose the bather to potentially pathogenic organisms. The hazardous effects are compounded by the fact that these organisms are delivered in aerosolized form due to aeration of the water through jets.

Forty-three whirlpool bath samples were collected from all over the United States from both private homes and hotels and subjected to bacterial analysis within 24 hours of collection. Aseptic technique was used to collect both tap and tub samples into sterile 100ml water collection containers with sodium thiosulfate tablets for chlorine inactivation (Corning, Corning, NY) (7). One container of tap water was collected after the tap was allowed to run for 1-2 minutes and 4 containers of tub water were collected after a clean tub was filled and the jets were engaged for 2-3 minutes. Bacteriological examination of the water first involved nutrient agar pour plates of water dilutions to assess relative bacterial numbers. Secondly, 100ml volumes of water were passed through nitrocellulose membrane filters with a 0.45 μm pore size and the filters were then aseptically placed on Eosin Methylene Blue (EMB) agar, Mannitol Salts Agar (MSA), Pseudomonas F agar, Buffered Cysteine Yeast Extract (BCYE) agar, and Sabaroud Dextrose Agar. All plates were incubated for 24-48 hours (72 hours for BCYE plates) at 37°C except for EMB which was incubated at 44°C. By elevating the incubation temperature to 44°C for this group, many of the non-enteric coliforms are eliminated.

Findings indicate that, as compared to tap water samples, the bacterial numbers were greatly increased in the whirlpool tub samples (138 cfu/ml vs. 2.17×10^6 cfu/ml respectively, $p < 0.001$, Jandel SigmaStat statistical software, San Rafael, CA)(Table 1). The bacterial numbers from whirlpool bathtubs were not significantly different based on the tub location (private 1.65×10^6 cfu/ml and hotel 2.64×10^6 cfu/ml, $p = 0.22$). Normal (nonjetted) tub water samples (1210 cfu/ml) were not significantly different from tap water samples, ($p = 0.99$). Additionally, all whirlpool tub samples yielded microbial growth whereas 68% of the tap samples showed no growth under the experimental conditions used in this trial. No data correlating the number of viable organisms in water with the risk of acquiring infection is currently available. However, the analysis of 100ml filtered samples yielded TNTC (too numerous to count or >300 cfu) in 61% of the tub samples tested indicating that the bacterial load for a 100 ml sample was fairly high in a majority of cases.

Observance of the plated filters yielded the following results (Table 2). Growth on EMB was followed by the use of Enterotube II, a commercial testing system (Remel, Lenexa, Kansas) for identification of gram negative, oxidase negative rods belonging to the Family Enterobacteriaceae. *Escherichia coli*, *Proteus mirabilis*, *Yersinia pseudotuberculosis*, *Shigella sp*, *Serratia sp*. and *Klebsiella sp*. were among the organisms identified in this group. Gram positive, catalase positive cocci that formed yellow colonies on MSA followed by a positive rabbit plasma coagulase test confirmed the presence of *S. aureus*. Pseudomonas F agar and OxiFerm tubes (Remel) a commercial test system for gram negative, oxidase positive rods were used to identify the presence of various Pseudomonas species. Growth on Sabaroud Dextrose Agar, colony morphology, and gram stain indicated the presence of fungi. Buffered charcoal yeast extract agar with PAV (Remel) was used for enhanced growth of presumptive Legionella species (vancomycin inhibits gram positive organisms, polymyxin B inhibits many gram negative bacilli, and anisomycin suppresses yeast). On BCYE agar, *Legionella pneumophila* produces green colonies and *Legionella*

micdadei produces blue colonies (Remel technical bulletin) and suspected *Legionella* sp. were further tested serologically using a latex bead agglutination test (Oxoid, Basingstoke, England).

Association of infections with whirlpool tubs has been recognized for a number of years but due to the increased popularity and the use in hydrotherapy (20), the matter should be brought to public attention. There are several explanations for this lack of association between whirlpool tub use and subsequent clinical disease in the public eye. The implication of whirlpool tub aerosol exposure may represent an unrecognized source of infection in the medical history of a high proportion of clinical cases. Upper respiratory and urinary tract infections acquired by whirlpool tub use may be clinically indistinguishable from those types of infections experienced regularly by the general population. Lastly, the source of many cases of upper respiratory tract infections, especially legionellosis, are never determined (19). However, whirlpool bathtubs as a source of infectious aerosols should come as no surprise in light of documented cases from similar sources- hot tubs and spas, shower heads, and aerosols from stagnant water in dental lines (3,6,15,17).

A previous study has shown the colonization of whirlpool baths with *P. aeruginosa* regardless of "the type of whirlpool bath, its length of time in use, exclusion of residents with incontinence, infection, or skin problems, type of disinfection or method and frequency of disinfectant used, and whether the bath was serviced regularly"(11). The results of the study has prompted the Public Health Laboratory Service Water Committee in the UK to investigate further the link between the use of whirlpool baths and infections so that health guidelines can be established. Likewise, the Dutch government has launched a plan to combat legionnaire's disease by implementing water safety measures after 242 cases of Legionnaires disease developed due to exposure to aerosolized bacteria from a whirlpool spa at the Westfriese Flower Exhibition in the Netherlands in February 1999 (18).

Due to the presence of pathogenic and potentially pathogenic organisms, education of the public on the hazards of piped whirlpool bathtub use should become a priority. Immunocompromised and post-operative individuals should discontinue use, and all individuals should avoid submersion of the head and possible ingestion of the water. Another concern, particularly in the hospital setting, is that a whirlpool bath could act as a reservoir of antibiotic resistant microorganisms (9,16). Exploration of potential preventative measures against whirlpool tub acquired infections should be a main focus regardless of the apparent lack of clinical evidence. New technology in design and the use of professional cleaning systems would be beneficial in reducing the risks associated with whirlpool tub microbial exposure.

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Table 1. Bacterial counts of tap versus whirlpool tub water samples

Water sample:	Tap (n=34) ^a	Tub (n=43) [private n=22, hotel n=21]
average cfu/ml ^b	1.38 x 10 ²	2.17 x 10 ⁶ [1.65 x10 ⁶ , 2.64 x 10 ⁶]
Low sample cfu/ml	0 (68% of samples)	700
High sample cfu/ml	3500	1.48 x 10 ⁷ (10% of samples >10 ⁷)
Standard deviation	6.04 x 10 ²	4.04 x 10 ⁶

^a Several tap samples were lost in transit due to container breakage.

^b Statistically significant difference between tap and tub average cfu/ml (P<0.001)

Table 2. Bacterial analysis of whirlpool tub water samples

	% of positive samples
Enterics	95% (41/43)
Fungi	81% (25/31)
<i>Staphylococcus aureus</i>	34% (13/38)
<i>Pseudomonas aeruginosa</i>	16% (7/43)
Other <i>Pseudomonas sp.</i>	56% (24/43)
<i>Legionella sp.</i>	36% (8/22)