

# Outbreaks Caused by *Pseudomonas Aeruginosa* Associated with Whirlpool Spas, Hot Tubs, and Swimming Pools

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*Disease outbreaks involving public pools and hot tubs have been reported frequently since their use became popular. Because public pools are often used by persons who have only transient contact, infections resulting from their use are often difficult to identify, and published reports probably represent only a small fraction of a larger public health problem. The organism most commonly published in outbreaks is the bacteria *Pseudomonas aeruginosa*. This bacteria can grow to high numbers in hot tubs if proper disinfectant levels are not maintained, causing skin, ear, urinary, and eye infections. Several major outbreaks are reviewed and likely causes are identified. Proper pool and spa maintenance and disinfectant levels are needed to prevent illness associated with this organism. To prevent outbreaks, chlorine levels must be maintained above 1.0 mg/l (pH 7.2-7.8). Most published outbreaks have reported *Pseudomonas aeruginosa* contamination as a result of failure to operate the pool according to recommended practices. Maintaining the microbiological quality of pool water and preventing infection require regular operation and maintenance, including monitoring and record keeping by qualified personnel.*

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## Introduction

*Pseudomonas aeruginosa* has been associated with more outbreaks of illness with spas and hot tubs than any other organism. It is an aerobic rod-shaped

bacteria that is widely distributed in nature and can be isolated from soil, water, plants, and animals. It produces soluble fluorescent pigments and its colonies range in color from blue, green, dark red to black. It is generally divided into 17 serotypes but only a few have been associated with spas and hot tubs. It prefers water and moist environments and can actually grow to large numbers in distilled water. It is sometimes present as part of the normal microbial flora of man, who is probably the source for most outbreaks. It is most commonly found in the stool (3 to 24 percent of persons) although it has been isolated from the skin, nose and throat. It is common on some raw vegetables, sinks, bathtubs and sponges (Mandell et al, 1990).

*Pseudomonas aeruginosa* can cause serious life threatening illness in immunocomprised individuals and those with other underlying illnesses, such as serious burns and cystic fibrosis. However, in most healthy individuals less serious skin and ear infections are more likely. Infections in swimming pools or spas result when proper levels of disinfectants are not maintained and *P. aeruginosa* grows to large numbers. Such large numbers can overwhelm natural host defense mechanisms.

Usually only those outbreaks of pool or spa associated disease are reported in which a local health department has made the effort to investigate. There is no requirement in the United States that such outbreaks must be studied or reported. Thus, the actual number of outbreaks are undoubtedly far greater, and reported outbreaks only represent the tip of an iceberg in the true number of cases associated with pools and spas.

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In all the reported outbreaks in which complete data can be obtained on pool operation, the incriminated pools were not maintained properly. Common errors included failure to maintain adequate germicide concentrations, pH, and temperature, and failure to change water and clean or replace filters. Even though improper maintenance has been identified as the major factor leading to an outbreak, there is a tendency for investigators to hypothesize the existence of additional risk factors.

The term "spa" identifies a whirlpool which is often called a "whirlpool spa". Reference to a "hot tub" signifies a whirlpool-type that may be similar in operation but is significantly different in construction. There is some disagreement among investigators with usage of this terminology, which leads to some confusion in the published literature.

Spas and hot tubs are pools designed for recreational and therapeutic use and for physiological and psychological relaxation. These pools are not drained, cleaned, and refilled after each use and may include, but are not limited to these types: hydrojet circulation, hot water, cold water, mineral baths, air induction systems, or some combination of these. Spas and hot tubs are shallow in depth and not meant for swimming or diving. However, these facilities, like swimming pools, are closed cycle water systems and may be designed with complete water circulation, filtration, heating, and in some cases, disinfectant and overflow systems integrated with the water circulation system.

*Pseudomonas aeruginosa* can quickly establish itself in a whirlpool spa if disinfection is allowed to fall below recommended levels, even for a period as brief as 24 hours. Hoses, for example, used to fill whirlpools can be reservoirs of *P. aeruginosa*. Flushing of a used hose with tap water for five to ten min-

utes was found to reduce densities of *P. aeruginosa* found in freshly filled whirlpools. The ability of *P. aeruginosa* to adhere to PVC piping and filters makes removal of all *P. aeruginosa* from a whirlpool system extremely difficult.

The biofilms continue to harbor *P. aeruginosa* even when disinfectant levels of halogens are present in the water. Therefore, the frequent monitoring and adjustment of free available halogen levels and the application of periodic halogen shock treatments appear to be the primary precautions for preventing health problems associated with pseudomonads in whirlpool baths.

Of the 17 serotypes of *P. aeruginosa* only 4, 6, 7, 9, 10, and 11 have been associated with outbreaks. The greater prevalence of *P. aeruginosa*, serogroup 11, among isolates from patients and pools led to hypotheses that: (1) these strains of serogroup 11 are particularly adapted for survival and growth in water at high temperatures even in the presence of chlorine, and (2) they possess a sufficient enzymatic complement of proteases and lecithinases so that in the presence of heat and hydration they can provoke an inflammatory reaction or infect the skin.

### Course of Illness

*P. aeruginosa* infections normally associated with hot tubs and spas are associated with skin infections such as dermatitis and folliculitis although ear infections (otitis or swimmer's ear) is another common infection. The characteristics of these infections and number of outbreaks are described in Tables 1 and 2.

Dermatitis is an inflammation of the skin evidenced by redness, itching, and skin lesions (infected patches of skin). This rash illness is called follicular dermatitis when there are pustule lumps present

Responsible Organism	Type of Illness	Number of Associated Outbreaks	Number of Persons Affected
<i>Pseudomonas aeruginosa</i>	Dermatitis (mild skin rash)	7	189
	Folliculitis (severe skin rash)	22	492
	Otitis externa (painful ear infection; swimmers ear)	16	29
	Keratitis (corneal ulcer)	1	2
	Urinary tract infection (painful urination)	3	2
	TOTAL		49(outbreaks)

**Table 1 – Infections caused by *P. aeruginosa***

Illness	Year	Location	No. of cases	Age/Group	Attack Rate	Incubation Period
Dermatitis	1972	Minnesota	60*	13 yr.old	86%	4 days
Dermatitis	1977	New Brunswick	8	2 adult 6 child	100%	1-3 days
Dermatitis	1978	Maine	27	16 male 11 female	100%	2 days
Dermatitis	1981	New Zealand	7	NS	75%	8-48 hours
Dermatitis	1981	Atlanta	75	5-43 yrs.	24%	6 hrs. to 5 days
Dermatitis	1982	Vermont	8	2 families	25%	2-5 days
Dermatitis	1983	Vermont	16	NS	67%	NS
Folliculitis and Keratitis	1975	Virginia	49	students	67%	2.2 and 2.8 days
Folliculitis	1975	Minnesota	32	8-42 yrs.	53%	8-48 hrs.
Folliculitis	1981	Australia	8	2 families	100%	8-82 hrs.
Folliculitis	1978	Colorado	20	NS	6.5%	8-48 hrs.
Folliculitis	1981	Quebec	3	8, 10, and 17 yr old girls	60%	24 hrs.
Folliculitis	1983	British Columbia	27	Students	71%	1-14 days
Folliculitis	1983	Vermont	14	Adults	74%	2.5 days
Urinary Tract Infection (UTI)	1983	NS	2	13 and 15 yr old girls	100%	24-48 hrs.
Folliculitis	1980	Ohio	2	Adults	100%	8-72 hrs.
Folliculitis	1984	New Foundland	26	NS	72%	2 days
Folliculitis and Keratitis	1985	Georgia	12	Adults	70%	18-24 hrs.

NS = Not specified

\* = 56 were 13 year old children.

\*\* = One patient duration of rash, 14 days; another, 20 days.

**Table 2 - *P. aeruginosa* Infections Acquired in a Whirlpool-Spa**

(small elevations of skin filled with pus). The mean duration of skin rash is 8 days. This rash involves primarily the trunk and proximal extremities (Figure 1). Sometimes the rash develops associated symptoms such as earache, itching, and malaise (discomfort). The face is usually unaffected. Folliculitis is initially an inflammation of the skin that advances to

severe dermatitis. The clinical picture is well characterized: The papular (red elevated areas of the skin) or papulopustular rash (filled with pus). Skin rash is predominant; however symptoms that are often present include earache, sore throat, sore eyes, conjunctivitis (inflammation), lymphadenopathy (lymph node infection), rhinitis (inflammation of na-

Duration of Rash	Sero-type	Probable Cause	Remarks
NS	0:11	Defective pool equipment inadequate disinfection	First whirlpool outbreak of <i>P. aeruginosa</i>
6 days	NS	Abundant growth of <i>P. aeruginosa</i>	Motel at St. John
7 days	0:11	Heavy use of whirlpool	Racquet club
NS	0:11	Inadequate chlorination	First outbreak of <i>P. aeruginosa</i> in New Zealand
8 days	0:09	Bather overload	Largest outbreak of dermatitis
5-7 days**	NS	NS	NS
NS	0:04	Too much time in whirlpool	Risk to females unexpected
NS	0:11	Excessive time in whirlpool	Large amount of detergent added to pool as a prank
Up to 7 days	0:11	Defective equip.; heavy bather load	Motel whirlpool
1 to 3 weeks	0:06	Inadequate chlorination	Guest lodge
8 days	0:11	Use of whirlpool in excess of 10 minutes	Health spa
NS	NS	Excessive use of whirlpool	Private club
7 days	NS	Improper pool care	Students at a ski resort
NS	0:10	Excessive time in whirlpool	Convention
NS	NS	Excessive time in whirlpool	Privately owned whirlpool
NS	NS	Inadequate maintenance	New private spa
5 days	0:07	Excessive time in pool	200 guests at a hotel
10-14 days	NS	Excessive time in pool	One person with severe eye pain

**Table 2 - (continued)**

sal mucosa), swollen and painful breasts, nausea, vomiting, abdominal cramps, malaise, fatigue, headache, myalgias (muscle pain), chills, and low-grade fever. These symptoms, however, do not imply systemic spread of infection. Otitis externa is an inflammation of the outer ear canal, characterized by pain, swelling, drainage, and occasional fever. It is more

commonly known as "swimmer's ear". Keratitis is an infection of the eye usually accompanied by severe eye pain and headache. Urinary tract infections are rarely associated with hot tubs. They are characterized by severe urinary urgency and inability to void, associated with chills, nausea, and vomiting.

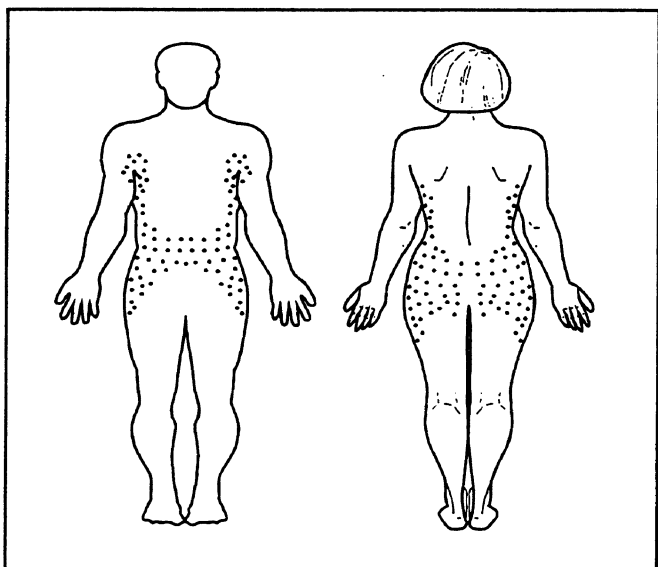
## Outbreak Summaries

This review presents a selection of representative outbreaks caused by *Pseudomonas* infections acquired from recreational water facilities. The listing in current literature is extensive and beyond the scope of this document. Yet it is of considerable value relating to investigations recorded, usually by qualified health department officials.

Between 1981 and 1991, 19 recorded outbreaks occurred, resulting in 329 cases. Spa pools are used in health clubs, motels/hotels, apartments, and public parks, and in some private homes (Table 2). Hot tubs are usually privately owned and reside in the family backyard (refer to Table 6). There were 7 outbreaks that involved 46 patients. There were fewer outbreaks involving swimming pools; not more than six. However, two of these involved significant numbers of individuals. One was a slide pool that resulted in 265 cases and another was a weekend trip to a dude ranch where 117 patients (mostly youngsters) got severe rash infections while bathing in the indoor swimming pool.

## Hot Tub–Spa Acquired–Dermatitis

Dermatitis is an inflammation of the skin evidenced by itching, redness, and various skin lesions (infected patches of skin). The rash illness is often called follicular dermatitis, when there are pustule lumps present (small elevations of skin filled with pus). The first outbreak of whirlpool-associated *Pseudomonas aeruginosa* dermatitis occurred in 1972



Skin rash can occur on any hair-bearing skin surface but is characteristically concentrated in the areas shown. (Adapted from Gustafson et al., 1983)

**Figure 1 – Distribution of *Pseudomonas folliculitis***

but was described in 1975. This outbreak, like those in several reports that have followed, occurred among whirlpool users exposed to *P. aeruginosa* serotype 0:11. This observation has left investigators to speculate that *P. aeruginosa* serotype 0:11 either may be more invasive than other serotypes or may be better adapted to survive in chlorinated water. In most instances, however, the involved whirlpools have been adequately chlorinated (Khabbas et al., 1983).

- In April, 1972, the St. Paul, Minnesota Division of Public Health investigated a complaint regarding skin infections allegedly caused by the use of a heated whirlpool spa by people who attended a bar mitzvah party at a local motel. The complaint was made four days after the party. Sixty people were involved, 56 of whom were 13–yr-old children. Findings of the investigation established the importance of pool maintenance. Two pools were involved – a motel sized swimming pool and an adjacent heated whirlpool spa. None of the four adults or seven children used either pool and none developed skin infections. Of the 49 children who used both pools, 42 contracted varying degrees of skin rash (or infection), some over their entire bodies. Some of the children reported other symptoms, such as severe itching, ear infection, vomiting, diarrhea, sore throat, runny nose, and swollen breasts. (Table 3).

Physicians who treated the children described the infection variously as folliculitis or contact dermatitis, a parasitic type rash; herpes virus type infection; and hives. Some lesions looked like insect bites or pimples similar to swimmer's itch. The heated whirlpool spa with a capacity of approximately 1200 gallons was rectangular, approximately two feet deep, and utilized a high rate sand filter system with a flow rate of 28 gallons per minute. There were two return inlets, one skimmer, one main drain, two Jacuzzi drains, and five Jacuzzi inlets (for high intensity movement of 42.2°C or 108°F water). The deck area was covered with indoor-outdoor carpeting. The bottom of the pool was covered with debris and the floor was cracked. The free available chlorine residual was 0.2 ppm (0.2 mg/l) and the pH was 7.8. The skimmer was not functioning since the outlet at the bottom of the skimmer well was sealed with a removable steel plug. The skimmer well was partially filled with a sludge-like material. When the Jacuzzi portion of the pool was turned on, this sludge material was sucked out into the main body of the pool. There was no automatic chlorination system. Disinfection was by sporadic hand-feeding of calcium hypochlorite. There was a direct connection to the fresh water supply, with no backflow protection.

Symptoms	Number of Persons
Mild to severe skin rash	36
Sore Throat	6
Sore Eyes	3
Rhinitis	3
Pruritis	7
Swollen Breasts	2
Fever	3
Malaise	9
Nausea and/or vomiting	9
Abdominal Cramps	1
Otitis ear infections	1
Infected Skin Lesions	6
Diarrhea	1
Head Cold	2
No Ill Affects	7

\*Most persons reported more than one symptom.  
Two persons not contacted.

**Table 3 – Reported Symptoms of Persons Who Utilized Whirlpool Spa**

In the larger pool, the clarity of the water was only fair, free available chlorine residual was 3.0 ppm (mg/l), with a pH of 7.8 to 8.0. Water temperature was 27.8°C (83°F). Pool capacity was approximately 35,000 gallons, shaped rectangular, and a diatomaceous earth filter was used. The pool had three return inlets, two skimmers, one main drain, and one vacuum

fitting. Both skimmers were non-functional. The skimmer well at the deep end contained a diatomaceous earth sludge accumulation. There were no skimmer wells. There was no automatic chlorination, and pool disinfection was by sporadic hand-feeding of calcium hypochlorite. Paint was peeling from the pool bottom and some cracks and holes were evident. The over-the-rim fill-spout was not functioning, and there was a direct connection of the fresh water supply to the recirculation system, with no backflow protection. The deck area was covered with indoor-outdoor carpeting. Water samples (Table 4) were collected from the main body of water, and swabs were taken of carpet areas using the same techniques as with the whirlpool. An extremely high total plate count, a high coliform level, and the presence of *Pseudomonas* were characteristics of the water samples taken from within the skimmer well. Even though the free chlorine residual was very low, apparently the main body of water had not had sufficient time to become contaminated after draining and refilling after the party. Also, the Jacuzzi system was not turned on at the time of sampling, nor had it been activated after refilling the pool (McCausland and Cox, 1975).

The presence of carpeting immediately adjacent to a pool may be a contributing factor to bacterial contamination of a pool, as seemed to be the case in this incident, but the real key to the problem is proper operation of all pool equipment and proper maintenance of free available chlorine and pH levels.

- The largest reported outbreak of whirlpool-associated dermatitis caused by *P. aeruginosa* and the first in which serotype 0:9 was implicated,

	Whirlpool Spa	Whirlpool Spa Skimmer Well	Main Pool
Residual Chlorine	0.2 ppm	0.2 ppm	3.0 ppm
pH	7.8	7.8	7.8
Total Plate Count*	10	Too numerous to count	108
Coliform Test †	0	5	0
Pathogens Isolated ‡	None	<i>Pseudomonas</i>	None

\* Number of bacteria per milliliter of pool water sample

† Number of 10 cc tubes positive for coliform organisms

‡ Broth cultures for coliform test were used as indicators of *Pseudomonas* bacteria (no attempt at quantification made).

**Table 4 – Bacterial Results of Water Samples Collected from Whirlpool- Spa and Main Pool**

occurred among 75 persons from March 5 to 11, 1981, in Atlanta.

In a five-day period, dermatitis developed in nearly one-fourth of the guests staying at a large Georgia hotel (Table 5). Dermatitis was associated with use of the hotel's whirlpool and indoor swimming pool. Attack rates were highest among persons more frequently exposed to the whirlpool, in persons under 10 years of age, and during periods of heaviest bather load. *P. aeruginosa* was isolated from skin lesions of 13 to 20 patients from whom culture specimens were taken. Ten isolates were serotype 0:9. This whirlpool's water grew *P. aeruginosa* serotype 0:9; however, the whirlpool's automatic chlorinator was functioning properly, the pH of the water was 7.2, and the free chlorine level was 0.6 mg/liter. These findings suggested that the strain may not be readily sensitive to recommended chlorine concentrations.

This outbreak was related with an amateur hockey tournament. Twenty-four teams from six states and two teams from Canada participated. The majority of players and out-of-town guests stayed in one Atlanta-area hotel. Its was a relatively new 220-room facility; its recreational area features a whirlpool spa, and indoor and

outdoor swimming pools.

Attack rates were higher in whirlpool users who were under 10 years of age. Use of the whirlpool on March 7 appeared to be associated with significantly increased risk. Daily attack rates did not vary significantly by time of day of whirlpool use, and there was no significant difference in attack rates between hockey players and others. From a reported maximum of 10 bathers per day before March 4, the number of whirlpool users increased during the outbreak period to 76 persons on March 7. Showering with or without soap after use of the whirlpool did not appear to have a significant protective effect. Forty-one infected individuals sought physician care.

The indoor swimming pool and whirlpools had separate sand filters and automatic chlorinators that functioned properly at the time of inspection. The free chlorine levels in the swimming pool and whirlpools were 1.0 and 0.6 mg/liter, respectively; pH levels were 7.4 and 7.2, respectively. *P. aeruginosa* serotypes 0:4 and 0:11 were isolated from the side of the whirlpool. Serotype 0:9 was isolated from the whirlpool water and from a swab of the floor drain. The whirlpool water sample contained 540 colony forming units/ml. Serotypes 0:9 and 0:11 were isolated from the side of the two control whirlpools but not from the water itself. Specimens from skin lesions in 20 persons were cultured. *P. aeruginosa* was isolated from 13; 10 were serotype 0:9, and three could not be serologically typed.

The investigation suggested that the whirlpool was the primary source of infections because the epidemic strain of *P. aeruginosa* could not be isolated from the swimming pool and because the incidence of otitis reported by swimming pool users was not high. A significant risk factor in this outbreak appeared to be crowding; crowding has also been suggested as a contributory factor in previous outbreaks. However, unlike previous outbreaks, in which the highest attack rates were observed in the 10- to 19-year old age group, attack rates in this outbreak were higher for bathers under 10 years of age.

It has been suggested that factors other than the mere presence of *Pseudomonas* in the water may contribute to the pathogenesis of the disease, including the dilatation of skin pores from the elevated temperature of whirlpool water. This hypothesis is supported by the small number of reported outbreaks in swimming pool users despite the common isolation of *P. aeruginosa* from swimming pool waters. Since recent exercise would presumably cause dilatation of skin pores, hockey players might be expected to a higher risk; however, attack rates were similar in players and non-players. As in previous reports, secondary

	Number	Percent*
<b>Rash</b>		
Legs	52	69
Front trunk	45	60
Arms	44	59
Pelvis-buttocks	42	56
Back	27	36
Neck	12	16
Face	10	13
Ears	4	5
Hands	2	3
<b>Associated symptoms</b>		
Itching	45	60
Earache	36	48
Malaise	24	32
Headache	21	28
Sore Throat	21	28
Axillary lymphadenopathy	13	17
Fever	12	16
Nausea	10	13
Painful breasts	5	7

\* Of 75 patients. (Ref: Khabbaz et al., 1983)

**Table 5 - Distribution of Pseudomonas Rash and Other Associated Symptoms**

transmission to friends and household members could not be documented.

In whirlpool-associated dermatitis, the face is usually unaffected. In this outbreak, 13 percent of rashes involved the face; this may be explained by anecdotal reports of users pushing each other into the whirlpool. The two patients who gave no history of whirlpool use had unusual rash distributions; neither had culture of lesion samples or a history of intimate contact with other patients.

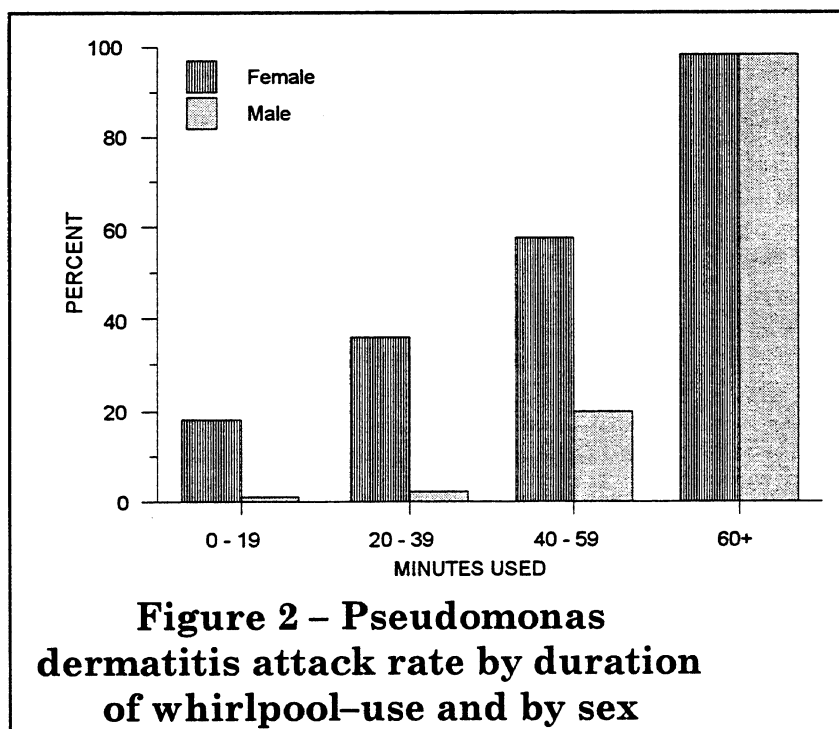
Investigations of other outbreaks have revealed inadequate chlorine levels or malfunction of the disinfecting equipment. However, *P. aeruginosa* has been repeatedly recovered from whirlpool waters adequately chlorinated and has also been recovered from whirlpool water containing 2 mg/liter of free chlorine residue. In this outbreak, the automatic chlorinator was functioning properly, and organisms were isolated from what is considered an "adequate" chlorine level for swimming pools. However, swimming pool standards may not be appropriate for whirlpools for several reasons. First, the conditions present in whirlpools – high turbulence and 40°C (104°F) temperature – result in rapid loss of chlorine by evaporation. Second, chlorine is inactivated by ammonium compounds and organic matter excreted by bathers; the density of bathers is probably greater for public whirlpools than for swimming pools. Whirlpool operation guidelines should probably restrict the number of users. Fortunately, dermatitis acquired from whirlpools has been a self-limited condition in otherwise healthy persons (Khabbaz et al., 1983).

In an outbreak of dermatitis caused by *P. aeruginosa* serotype 0:4, Hudson et al., (1985) first documented a relationship between duration of whirlpool use and development of *P. aeruginosa* dermatitis. The outbreak occurred among 16 guests at a hotel whirlpool spa. The attack rate among guests with 30 min or more of whirlpool spa use was 50% (13/26), in contrast to 13% (3/23) among guests with briefer exposures. The increased risk was observed for both one-time bathers and those who used the whirlpool more than once on the weekend. Figure 2 displays the attack rate by duration of whirlpool use. Logistic regression analysis also identified duration of whirlpool spa use as the variable which was most important in predicting illness among pool users. Illness was not correlated with duration of swimming pool use which was also in the same area.

Forty percent (10/25) of the female whirlpool-spa bathers became ill in comparison with 25% (6/24) of males (difference not significant). However, after adjustment for time spent in the whirlpool, sex was the second variable to enter the logistic regression model and improved the fit at  $r = 0.02$ . According to the model, females were two and seven times more likely to develop rash than males for whirlpool-spa exposure duration of 50 and 10 min., respectively. All but one of the women wore one-piece bathing suits. Five of the 10 women who developed a rash had an extensive rash on the trunk above the waist, generally conforming to the bathing suit distribution; none of the six men with rash had a rash above the waist. The attack rate did not vary with age or the practice of showering after pool use.

The whirlpool-spa water had a pH 7.5 and a trace of free chlorine. *P. aeruginosa* was identified in the water taken from the whirlpool-spa itself, as well as from the filter backwash, hair strainer, and swabs of sides of the whirlpool-spa. All isolates were identified as *P. aeruginosa* serotype 0:4.

The findings of this outbreak suggest that an individual whirlpool bather may decrease the risk of *Pseudomonas* dermatitis by limiting the time spent in the water. The study also suggested that women may be more predisposed to illness by wearing one-piece bathing suits which trap *P. aeruginosa* contaminated water next to the skin.



### Spa-Swimming Pool Acquired Folliculitis



A recent survey in the United States indicated that outbreaks of *Pseudomonas* folliculitis are seasonal, the incidence being higher in the winter months. The seasonal increase may be a reflection of tendency of individuals to use whirlpools and hot tubs more frequently during winter months.

The rash is most severe in areas occluded by a snug bathing suit, and women wearing one-piece bathing suits are at increased risk, and swimsuits worn for several hours after exposure may facilitate infection, but interestingly, this syndrome has also been reported by persons who did not have any clothes on while in the whirlpool. Topical occlusive lotions, oils, or creams are not considered to be risk factors. Showering after the use of a contaminated pool may not be protective.

The mean incubation period for *Pseudomonas* folliculitis is 48 hours, with a range of 8 hours to 5 days, but could be as long as 14 days. The clinical picture is well characterized: the papular or papulopustular rash of this syndrome has a characteristic distribution. Nevertheless, the skin rash is not unique in appearance and has been confused with insect bites, allergy, scabies, contact dermatitis, herpes, hives, and staphylococcal infection. Associated symptoms include earache, sore throat, sore eyes, conjunctivitis, lymphadenopathy, rhinitis, swollen and painful breasts, nausea, vomiting, abdominal cramps, malaise, fatigue, headache, myalgias, chills, painful axillary nodules, and low-grade fever, but these symptoms do not imply systematic spread of infection.

Although generally considered to be self-limiting, the symptoms may last for several weeks, and the initial infection could result in recurrent folliculitis and chronic abscess. Usually no specific therapy is required. Most physicians are aware of the association of *P. aeruginosa* with the blue-nail syndrome, swimmer's ear, and toe-web infections in the normal host. This is mainly because of the inherent delay in commencing investigations. Consequently, it has not been possible to determine the concentration of *P. aeruginosa* present in the whirlpool at the time the users acquired the infection. In the absence of this data, the detection of any number of *P. aeruginosa* could be indicative of a potential to cause folliculitis. *P. aeruginosa* has been isolated from whirlpools that had the recommended level of free available halogen residual and the proper pH. This however, may not indicate innate resistance of the agent to chlorine, but rather the ability of the organism to shield itself by secreting a protective substance around it. In most outbreaks, improper maintenance, inadequate chlorine levels, or malfunction of the disinfecting equipment have been cited as the causes. In the outbreaks accrued from an intensive search of current literature, well in excess of 500 cases of folliculitis were identified and reported (Clark and Smith, 1992).

- A generalized pruritic pustular rash was reported by 32 of 61 (53%) persons who had used the swimming pool and whirlpool spa at a Minnesota motel in March 1975. A questionnaire survey indicated that attack rates were highest in periods of heaviest bather load. The rash appeared 8 to 48 hours after exposure and resolved within seven days. No rash was reported by 37 motel guests who did not use the pool. *Pseudomonas aeruginosa* serogroup 11 was isolated from skin lesions of two patients and from the water in both pools. Circumstantial evidence implicated the whirlpool spa as the most probable source of infection.

Other symptoms reported by swimmers with a rash included three cases of earache, two cases each of sore throat and swollen breasts, and one case each of sore eyes, sore nose, and abdominal cramps. Swimmers without rash did not report any of these symptoms. Six of the 32 with rash (19%) consulted a physician. Their rash was described as pruritic, erythematous, maculopapular, and vesiculopustular. Although it was most evident in the areas covered by bathing suits, all other skin areas were affected with the exception of the head and neck. The rash resolved in all cases within seven days without specific treatment.

The two pools were adjacent to each other in an enclosed area. The main pool had a capacity of 140,000 gallons and used a sand-filtration system. The disinfectant, bromine, was fed into the pool by a manually operated pump. The pool water was slightly cloudy. The temperature was 25.5° C (78° F), pH was 7.2, and the free-bromine level was 1.0 ppm. The most probable number (MPN) of coliforms per 100 ml was less than 2.2. The concentration of *P. aeruginosa* organisms was 3/100 ml. The *P. aeruginosa* strain isolated from the swimming pool water was serogroup 11.

The whirlpool spa also used a sand filter. The water was clean and clear. The temperature was 43.8 C (110F), pH was 7.6, and free-chlorine level was 0.3 ppm. The lowest acceptable level in Minnesota is 0.5 ppm. The MPN of coliforms was less than 2.2/100 ml. *P. aeruginosa*, serogroup 11 was isolated from whirlpool water in a concentration of less than one organism per 100 ml (Washburn et al., 1976).

- An outbreak of skin-rash infection (folliculitis) occurred on January 5, 1984, among guests of a hotel in St. John's, New Foundland, involving 26 persons. This was the first outbreak in which serotype 0:7 had been incriminated. The affected individuals had used the hotel pool facilities that included a swimming pool, whirlpool spa, sauna, and showers. A survey showed that 53 of 200 guests that had used the pool facilities, 26

developed a skin rash. The outbreak occurred on New Year's Day, with an attack rate of 72% (26 of 36 persons). A facility-specific attack rate analysis indicated that the whirlpool spa was the most likely source of infection. Among those infected, the attack rate was 90% for children and 50% for adults. This difference, statistically significant, was directly related to exposure time in the whirlpool, an average of 55 minutes for children and 15 for adults. Of those infected, 10 sought medical attention.

The pool facilities were closed immediately for corrective measures. These included draining, thorough cleaning, and super-chlorination of the whirlpool spa. Weekly testing of the whirlpool spa was instituted and the whirlpool bather load was limited to four persons (Ratman et al., 1986).

### Urinary Tract Infections Acquired in a Whirlpool Spa

- Urinary tract infections, although less commonly reported, have also been associated with whirlpool baths. The first outbreaks among healthy individuals was reported by Salman et al., (1983), associated with a hotel whirlpool spa. The outbreak was identified when a young 25-year-old man reported to an emergency room complaining of severe urinary urgency and inability to urinate, chills, nausea, and vomiting. Cultures of urine yielded *P. aeruginosa*. The individual had recent exposure to a hotel whirlpool.

A similar infection was reported in two young girls (15 and 13 years of age) who had used a newly purchased spa in their home. The spa did not contain a functioning filter and had only been intermittently chlorinated. After the two girls became ill, the water was changed and chlorinated. Cultures of the water obtained after the spa was chlorinated yielded *P. aeruginosa*, 9,000 colonies/100ml. Antibiotic sensitivity patterns of the isolated organism from urine specimens and the spa were identical, indicating that the spa was the source.

### Folliculitis and Keratitis Acquired in a Whirlpool Spa

- There has been one spa outbreak associated with an eye infection involving *P. aeruginosa*. This occurred during an outbreak of folliculitis among 12 persons using the same whirlpool spa. A corneal ulcer developed in one patient within 48 hours of using the whirlpool. A second patient, who had not showered immediately after leaving the whirlpool, was left with areas of skin hyperpigmentation and scarring despite treatment with

ultraviolet rays and tetracycline.

### Ear Infections Associated with a Pool

Ear infections, or otitis externa, with *P. aeruginosa*, are probably more common than reported. In one outbreak, 18 of 25 members of a competitive team which trained daily developed painful discharging ears (Reid and Porter, 1981). This group of swimmers trained twice daily in the same pool, in early morning and late afternoon. Investigation revealed that chlorination was often inadequate during these times of day. In contrast, a group of competitive swimmers in the early afternoon, when the chlorine levels were adequate, were free of illness.

*P. aeruginosa* were isolated from various sites around the pool and from the bag at a vacuum used to clean the pool.

The ocular symptoms had begun with pain, redness, and eyelid edema 24 hours previously. These steadily worsened so that she was unable to use her extended-wear soft contact lens. She had worn extended-wear contact lenses successfully for three years. The patient stated that less than two days previously she had been submerged in a whirlpool spa to her neck. She had not placed her face in the water, but may have had contact through splashing.

The daughter began to have small (1-mm), erythematous, raised lesions on her trunk and proximal upper and lower extremities. The sites were pruritic, leading her mother to believe that they were flea bites. During the following two days, the lesions enlarged (becoming 1 to 5 mm in diameter), becoming maculopapular and pustule, and the child was taken to a dermatologist. The rash followed the area enclosed by the bathing suit she had worn on while in and out of a hot tub. She had not showered, as the others had, immediately after swimming.

At the time of the examination, the patient also complained of malaise, weakness, and abdominal cramps that had begun one day previously. Cultures taken from the exudates grew *P. aeruginosa*. Treatment included 50 seconds beneath ultraviolet rays and topical tetracycline. The lesions dried within two weeks, but areas of hyperpigmentation and scarring remain.

### Discussion

In all the reported outbreaks in which complete data were obtained on pool operation, the incriminated pools were not maintained properly. Common errors included failure to maintain adequate germicide concentrations, pH, and temperature, and failure to change water and clean or replace filters. Even though improper maintenance has been identified as the major factor leading to an outbreak, there is a tendency for investigators to hypothesize the exist-

ence of additional risk factors. Duration of whirlpool use had been postulated to be a risk factor for the development of *Pseudomonas* dermatitis among whirlpool bathers but the evidence to support these hypothesis is not conclusive (Hudson et al., 1985). Water slide pools are essentially similar to whirlpool-spas with respect to turbulence (constant splashing), excessive bather load, chance for contamination by urine due to numerous youngsters (who generally stay in the pool for extended periods), and head under water to cause infection by bathers (Perrott et al., 1983).

Operators of whirlpools need to be aware of the complications of inadequate sanitation and be competent in pool disinfection and management. No known reports of outbreaks have occurred in pools where the pool water has been continuously maintained at pH 7.2–7.8 with free residual chlorine level of at least 1.0 mg/ml (Stafford et al., 1982). At present, more frequent monitoring of disinfectant levels, especially during heavy bather load, and adherence to prevailing standards may prevent additional outbreaks. The use of automatic disinfection equipment can facilitate maintenance of proper levels.

Physicians who see patients with an unexplained pustular rash should inquire about whirlpool exposure. Instances of whirlpool-related skin rash should be reported to responsible health officials so that corrective actions can be taken (Washburn et al., 1976).

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