Whirlpool-Associated Folliculitis Caused by *Pseudomonas aeruginosa*: Report of an Outbreak and Review

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An outbreak of folliculitis caused by *Pseudomonas aeruginosa* serotype O:7 occurred among the guests of a hotel in St. John's, Newfoundland, Canada, and the source of the infection was traced to the hotel whirlpool. Of 36 persons who used the whirlpool, 26 (72%) developed folliculitis within 1 to 5 days after exposure; the attack rate was significantly higher for children (90%) than for adults (50%). The rash characteristics were consistent with those of *Pseudomonas* folliculitis previously described (T. L. Gustafson, J. D. Band, R. H. Hutcheson, Jr., and W. Schaffner, *Rev. Infect. Dis.* 5:1-8, 1983). This is considered to be the first outbreak in which *P. aeruginosa* serotype O:7 has been incriminated. Published reports to date of outbreaks of *Pseudomonas* folliculitis associated with the use of whirlpools, hot tubs, swimming pools, etc., were reviewed.

Since 1975, outbreaks of *Pseudomonas* folliculitis associated with the use of whirlpools and hot tubs, and to a lesser extent with the use of swimming pools have been reported with increasing frequency; most of these outbreaks have been recognized in the United States, but a few have occurred in Canada and elsewhere (Table 1). *Pseudomonas aeruginosa* serotype O:11 has been the single most common etiological agent of recreationally associated folliculitis, accounting for more than half the number of outbreaks reported so far for which serotyping of the causative agent has been done. Other serotypes of *P. aeruginosa* recognized to date to cause this syndrome are O:1, O:4, O:6, O:9, and O:10 (Table 1). We describe an outbreak of whirlpool-associated folliculitis caused by *P. aeruginosa* serotype O:7. This outbreak occurred on 1 January 1984 among the guests of a hotel in St. John's, Newfoundland, and involved 26 persons. This appears to be the first outbreak in which serotype O:7 has been incriminated.

(A preliminary report, in part, of this outbreak was previously published [18].)

The outbreak. On 5 January 1984, the St. John's District Health Unit was notified by a local hotel of complaints of skin rash in guests who had attended the New Year's Eve celebration. A preliminary inquiry indicated that the affected individuals had used the hotel pool facilities which included a swimming pool, whirlpool, sauna, and showers. These facilities were believed to be the most likely sources of the infection, and investigations were initiated in this direction.

A list containing the names of 160 persons who had bought tickets for the New Year's Eve celebration was obtained; the list did not include the names of accompanying family members or friends. A questionnaire was drafted, and 90 (56%) of the 160 persons were contacted which resulted in 200 individuals being interviewed. Of these 200, 53 had used the pool facilities, and 26 (49%) had developed a skin rash. Those affected included 16 males and 10 females; 18 were children under 15 years of age, and 8 were adults. None of the 147 persons who had not used these facilities reported any skin disorders. The 53 persons who had used the pool facilities did so at different times, some on New Year's Eve, some on New Year's Day, and some on both days. None of

the 17 persons who had used the pool facilities on New Year's Eve alone developed a skin rash, whereas 12 of 14 (86%) persons who had used the facilities on New Year's Day and 14 of the 22 (64%) persons who had used them on both days developed skin rashes. This indicated that 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 was the most likely source of infection (Table 2). A comparison of exposure time and sex distribution indicated no differences between those infected and those not infected. However, among those infected, the attack rate was 90% for children (age range, 3 to 14 years, with a median of 9 years) and 50% for adults (age range, 17 to 48 years, with a median of 30 years). This difference in the attack rate was statistically significant ($P < 0.01$) and was directly related to exposure time in the whirlpool, i.e., an average of 55 min for children and 15 min for adults.

Of those infected, 10 sought medical attention. In most cases, the rash appeared 2 days after exposure (range, 1 to 5 days). Typically the rash began as a pruritic erythematous papule which progressed to erythematous macules or erythematous pustules. The lesions were distributed in the axilla and over the abdomen and buttocks area. Skin swabs obtained from two individuals with healing pustules were cultured by standard procedures, and the cultures were negative for bacteria, including *P. aeruginosa*. The rash resolved spontaneously over a 5-day period without residue. Characteristics of the rash were consistent with those of *Pseudomonas* folliculitis described by others (16, 22, 27, 42, 44).

On 4 January, water samples from the swimming pool and the whirlpool were examined quantitatively for total coliforms and *P. aeruginosa* by the membrane filtration technique in accordance with standard methods (2). A water sample from the whirlpool yielded *P. aeruginosa*, 900 colonies per 100 ml. On the next day, two samples of water collected from the same source were also positive for *P. aeruginosa*, with counts of 220,000 and 340,000/100 ml. Isolates from all water samples were identified as serotype O:7 according to the international antigenic typing scheme with the use of 17 antisera (Difco Laboratories, Detroit, Mich.) by the Laboratory Centre for Disease Control, Ot-

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TABLE 1. Outbreaks of *Pseudomonas* folliculitis associated with the use of whirlpools, hot tubs, swimming pools, etc.

Year of outbreak/report and location	No. of persons affected	Mean attack rate (%)	Source(s) of outbreak	Water pH ^a	Free halogen in water ^a (mg/liter)	<i>P. aeruginosa</i>				Reference or source
						Culture from patients	Culture from pool water/surroundings ^a	Density in pool water ^a	Serotype	
1972, St. Paul, Minn.	42	86	Whirlpool	7.8	0.2	+	+	NA ^b	O:4 ^c	27
1975, Minnesota	32	53	Whirlpool	7.6	0.3	+	+	<1/100 ml	O:11	44
			Swimming pool	7.2	1.0	+	+	3/100 ml	O:11	
1975, Arlington, Va.	49	67	Whirlpool	NA	NA	+	+	NA	O:11	45
1977, St. John, New Brunswick	8	100	Whirlpool	NA	NA	NA	+	Abundant growth	NA	3
1978, West Yellowstone, Mont.	21	NA	Swimming pool	7.2	None	+	+	NA	O:11	20
1978, South Paris, Maine	27	NA	Whirlpool	NA	0.7-1.2	+	+	NA	O:11	24
1978, Denver, Colo.	20	7	Whirlpool	7.6	>5.0	+	+	NA	O:11	35
1979, Montreal, Quebec	12	28	Whirlpool	NA	NA	NA	NA	NA	NA	32
			Swimming pool							
1979, North Dakota	2	67	Whirlpool	NA	NA	-	+	NA	NA	39
1979, Phoenix City, Ala.	27	21	Whirlpool	7.2	0.5	NA	NA	NA	NA	16
1979, Carroll County, Md.	12	19	Whirlpool	NA	NA	NA	NA	NA	NA	16
1980, Vermont	4	80	Whirlpool	7.5	0.3	+	+	NA	O:1	43
1980, McMinnville, Tenn.	37	62	Swimming pool	8.0	None	+	+	NA	O:11	16
1980, Harrison, Ark.	48	80	Swimming pool	7.6	0.1	NA	NA	NA	O:11	16
1980, Toledo, Ohio	2	100	Whirlpool	7.6	None	NA	NA	NA	NA	7
1981, Atlanta, Ga.	75	24	Whirlpool	7.2	0.6	+	+	5.4 × 10 ² /ml	O:9 ^d	22
			Swimming pool	7.4	1.0					
1981, Christchurch, New Zealand	7	88	Spa pool	NA	NA	+	+	8 × 10 ⁶ -1 × 10 ⁷ /ml	O:11 ^e	41
1981, New South Wales, Australia	8	100	Whirlpool	NA	NA	+	+	NA	O:6	15
1981, Albuquerque, N. Mex.	6	NA	Hot tub	NA	NA	+	+	High count	NA	4
1981, San Francisco, Calif.	9	82	Hot tub	NA	None	+	NA	NA	NA	38
1981, Hyannis, Mass.	38	76	Whirlpool	7.2	None	NA	NA	NA	NA	16
1981, Montreal, Quebec	4	80	Whirlpool	NA	NA	+	+	High concentration	NA	13
1982, Orange County, N.C.	6	25	Hot tub	7.6	<0.5	+	+	NA	O:10	28
1982, Vermont	8	80	Whirlpool	7.5	1.0	+	+	NA	NA	12
1982, New York	117	80	Swimming pool	7.8	4.0	+	+	NA	O:11	14, 42
1982, British Columbia, Canada	27	100	Whirlpool	NA	NA	+	NA	NA	O:11	26
1982, Ann Arbor, Mich.	8	100	Hot tub	NA	NA	+	NA	NA	NA	30
1982, Napa, Calif.	5	100	Hot tub	NA	NA	+	+	NA	NA	46
1983, Salt Lake City, Utah	265	41	Water slide	NA	NA	+	+	NA	O:4	29
1983, Pittsburgh, Pa.	4	100	Hot tub	7.6	0.3	+	+	NA	NA	37
1983, Vermont	16	33	Whirlpool	7.5	None	+	+	NA	O:4	20a
1984, St. John's, Newfoundland	26	72	Whirlpool	7.5	0.5	-	+	0.9 × 10 ¹ -3.4 × 10 ³ /ml	O:7	Present report
1984, Halifax, Nova Scotia	15	29	Physiotherapy pool	NA	NA	+	+	NA	O:10	Schlech et al. ^f
1984, Philadelphia	3	50	Hot tub	NA	NA	+	-	NA	O:4	8
1985, London, England	>4	100	Whirlpool	NA	NA	+	NA	NA	NA	5
1985, Guernsey, C. I.	4	100	Whirlpool	NA	NA	+	-	NA	O:6	9

^a Not necessarily indicative of conditions existing at the time of outbreaks.^b NA, Not determined, not applicable, or no information provided.^c Serotype O:11 was simultaneously isolated from a patient.^d Serotypes O:4 and O:11 were simultaneously isolated from the pool surroundings.^e Serotype O:6 was simultaneously isolated from the pool water.^f Abstr. Conjoint. Meet. Infect. Dis. Vancouver, 1984.

tawa, Ont., Canada. Throughout, all water samples were negative for coliforms, and water samples from the swimming pool were negative for *P. aeruginosa*. The pool facilities were closed on 5 January, and several corrective measures were instituted. These included draining, thorough

cleaning, and, superchlorination of the whirlpool; regular cleaning and disinfection of showers, pool decks, etc.; frequent monitoring of the whirlpool water pH and bromine levels, i.e., 7.2 to 7.8 and 1.5 to 3.0 mg/liter, respectively; weekly testing of whirlpool water for bacteriological quality;

TABLE 2. Facility-specific attack rate of *Pseudomonas* folliculitis

Facility	Persons who used specific facility			Persons who did not use specific facility			Difference in percent ill
	Total no.	No. ill	% Ill	Total no.	No. ill	% Ill	
Whirlpool	45	26	58	8	0	0	58
Swimming pool	44	24	55	9	2	22	33
Sauna	25	13	52	28	13	46	6
Shower	35	17	49	18	9	50	-1

and limiting the whirlpool bather load to four persons. Subsequent follow-up and culture surveillance involving several water samples indicated that conditions were satisfactory, and the facilities were reopened on 11 January. By using the above protocol, satisfactory results continued to be obtained after the reopening.

Discussion and review of the literature. This is one of an increasing number of outbreaks of *Pseudomonas* folliculitis associated with the use of whirlpools. Factors contributing to the occurrence of this syndrome include the high temperature of the water, water turbulence and aeration, heavy bather load per volume of water, the ubiquitous distribution of *P. aeruginosa*, and the ability of this organism to withstand chlorine and to multiply rapidly in water at elevated temperatures (16, 27, 35, 43, 44). In the outbreak reported here the whirlpool had an automatic disinfectant dispenser. Hotel records indicated that the pH of the whirlpool water was 7.5 and the bromine level was 0.5 mg/liter on the day of the outbreak. Although the pH was satisfactory, the concentration of bromine was well below the recommended ideal level of 1.5 mg/liter. Most likely the heavier bather load on New Year's Eve and Day interfered with maintaining an adequate disinfectant level, thus permitting rapid growth of *P. aeruginosa* which is frequently present in small numbers in and around swimming pools. As in previous outbreaks, the bacteriological quality of the whirlpool water at the time of the outbreak was unknown; in addition, cultures of skin lesions from two individuals had negative results. However, based on epidemiological and clinical features and on subsequent laboratory findings, an outbreak of *Pseudomonas* folliculitis was established.

The true incidence of whirlpool-associated *Pseudomonas* folliculitis is difficult to determine because the symptoms are often mild and self limited, and the patients frequently do not seek medical attention. However, the syndrome appears to be a widespread public health problem, especially in the United States as indicated by published reports (Table 1) and by a recent survey which identified 72 nonresidential whirlpool-associated outbreaks during the 10-year period between 1972 and 1982 (40). Published reports of outbreaks of recreationally associated *Pseudomonas* folliculitis to date are summarized in Table 1.

Although whirlpools appear to offer a particularly suitable environment, a few outbreaks of *Pseudomonas* folliculitis have occurred in association with the use of the conventional swimming pools (14, 16, 20) and, in one instance, a waterslide (29). A nosocomial outbreak involving a physiotherapy pool has also been observed (W. F. Schlech, J. N. Simonsen, R. Sumarah, and R. S. Martin, Abstr. Conjoint. Meet. Infect. Dis. Vancouver, 1984, PW 10, p. 160). Recent reports have also indicated familial outbreaks of this syndrome associated with privately owned whirlpools (7, 12, 37, 38, 46). The largest outbreak of *Pseudomonas* folliculitis reported to date occurred in Salt Lake City in 1983; it affected 265 persons and was associated with the use of a waterslide (29).

A recent survey in the United States indicated that outbreaks of *Pseudomonas* folliculitis are seasonal, the incidence being higher during the winter months (40). Of the 36 outbreaks summarized in Table 1, a large percentage occurred during the winter months, as did the outbreak reported here. This seasonal increase may be a reflection of the tendency of individuals to use facilities such as whirlpools and hot tubs more frequently during the winter months. Crowding is a significant risk factor (22, 44); however, outbreaks are not always associated with high bather load (43). Attack rates have varied from 7 to 100% (Table 1), and it is not known why there is such a wide range. Attack rates are similar regardless of sex (16, 40), but occurrence is higher in younger age groups (22, 29, 44), possibly because they tend to spend more time in the water (29); all of which is evident from the data obtained for the present outbreak. Although the length of contact with water did not appear to be important in all outbreaks (16), frequent and long hours of use of whirlpools may be a risk factor (13, 20a, 22, 28, 38). This is also supported by an earlier observation that superhydration of the stratum corneum favors colonization of skin with *P. aeruginosa* (19). Occlusion promotes *Pseudomonas* infection (35). The rash is most severe in areas occluded by a snug bathing suit (4, 12, 13, 30, 43, 44), and women wearing one-piece bathing suits are at increased risk (20a), and swimsuits worn for several hours after exposure may facilitate infection (14), but interestingly, this syndrome has also been reported in persons who did not have any clothes on while in the whirlpool (8, 43). Topical occlusive lotions, oils, or creams are not considered to be risk factors (43). Showering after the use of a contaminated pool may not be protective (13, 22, 29, 35, 42, 43).

The mean incubation period for *Pseudomonas* folliculitis is 48 h, with a range of 8 h to 5 days (16), but it could be as long as 14 days (26). The clinical picture of *Pseudomonas* folliculitis is now sufficiently well characterized; the papular or papulopustular rash of this syndrome has a characteristic distribution (16). Nevertheless, the rash is not unique in appearance and has been confused with insect bites, allergy (22, 45), scabies (14), contact dermatitis, herpes, hives (27), staphylococcal infection (22, 26), and chicken pox (5). 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 (12, 14, 16, 22, 24, 27, 29), but these symptoms do not imply systemic 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 (12, 13, 16, 20, 35, 42). However, no specific therapy is generally required for *Pseudomonas* folliculitis (15, 22, 30, 46). Failure to culture *P. aeruginosa* from skin lesions is not uncommon (12, 39). This may be owing to quick elimination of the organism by the polymorphonuclear neutrophils, with the inflammation being primarily caused by the bacterial

exotoxins produced (8). It is also significant that illnesses such as otitis externa, otitis media, urinary tract infection, and pneumonia can be caused by *P. aeruginosa* in association with the use of whirlpools (17, 28, 33, 34).

In the first outbreak of whirlpool-associated folliculitis described by McCausland and Cox in 1975 (27), *P. aeruginosa* serotypes O:4 and O:11 were isolated from skin lesions and serotype O:4 was isolated from pool water and the pool surroundings; these two serogroups, O:11 in particular, have since been found to be the most commonly encountered in this syndrome (Table 1). Serotype O:11 is also the predominant serogroup associated with otitis externa in deep-sea divers, competitive swimmers, and among whirlpool users (1, 17, 31). Serotype O:11 is not the strain found most frequently in potable waters or human feces (25), but it has been the most common serotype isolated from whirlpools during surveys (21, 23). Although serotype O:11 represents only about 8% of endemic hospital isolates (6, 10), a large percentage of outbreaks of *Pseudomonas* infections in hospitalized patients is also caused by this serogroup (10). Whether this is because of a specific pathogenic factor of O:11 or a greater adaptability of this serogroup to survive, colonize, and rapidly multiply in the environment and in humans needs to be determined. We found documentation of a single outbreak of folliculitis caused by serotype O:9 (22), but O:9 is being cited as one of the common serogroups associated with *Pseudomonas* folliculitis (11, 15). Serotype O:7, which was incriminated in the outbreak described herein, appears to be a relatively uncommon serogroup among clinical isolates (6); it is generally absent in whirlpool and swimming pool waters (23, 36) and is not known to be associated with folliculitis previously. Although serogroups other than O:11 have caused a relatively low number of outbreaks of folliculitis, it is clear now that various serotypes of *P. aeruginosa* are capable of causing an identical syndrome in association with the use of whirlpools, hot tubs, swimming pools, etc.

Despite numerous reports of outbreaks of *Pseudomonas* folliculitis, there are no data available correlating the number of viable *P. aeruginosa* in whirlpool water with the risk of acquiring infection. 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 (11). In the absence of this data, the detection of any number of *P. aeruginosa* could be indicative of a potential to cause folliculitis (40). *P. aeruginosa* has been isolated from whirlpools that had the recommended level of free available halogen residual and the proper pH (23, 40). 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 (11, 36). Nevertheless, in most outbreaks, as in the present one, improper maintenance, inadequate chlorine levels, or malfunction of the disinfecting equipment have been cited as the causes (7, 14, 16, 17, 20, 27, 28, 29, 41, 44). *P. aeruginosa* could occur in large numbers in pool water in the absence of coliforms, the traditional bacteriological indicator of water quality, as observed by us and others (21). This fact emphasizes the need to culture pool water for *P. aeruginosa* both routinely and in suspected outbreaks of recreationally associated folliculitis.

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