Risk of otitis externa after swimming in recreational fresh water lakes containing *Pseudomonas aeruginosa*

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Abstract

***Objective*—To determine whether an outbreak of otitis externa was due to bathing in recreational fresh water lakes and to establish whether the outbreak was caused by *Pseudomonas aeruginosa* in the water.**

***Design*—Matched case-control study.**

***Setting*—The Achterhoek area, the Netherlands.**

***Subjects*—98 cases with otitis externa and 149 controls matched for age, sex, and place of residence.**

***Main outcome measures*—Odds ratios for type of swimming water and frequency of swimming; presence of *P aeruginosa* in ear swabs and fresh water lakes.**

***Results*—Otitis externa was strongly associated with swimming in recreational fresh water lakes in the previous two weeks (odds ratio 15·5 (95% confidence interval) 4·9 to 49·2) compared with non-swimming). The risk increased with the number of days of swimming, and subjects with recurrent ear disease had a greatly increased risk. The lakes met the Dutch bathing water standards and those set by the European Commission for faecal pollution in the summer of 1994, but *P aeruginosa* was isolated from all of them, as well as from the ear swabs of 78 (83%) of the cases and 3 (4%) of the controls.**

***Conclusions*—Even when current bathing water standards are met, swimming can be associated with a substantial risk of otitis externa because of exposure to *P aeruginosa*. People with recurrent ear disease should take special care when swimming in waters containing *P aeruginosa*.**

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Introduction

The standards relating to bathing water are a burning issue. Many studies have shown that bathing in sea or fresh waters that meet current standards may lead to illness.[1-12] In their recent study of randomised exposure to British sea waters Kay *et al* even found a robust dose-response relation between the faecal pollution of sea waters and risk of gastroenteritis.[13] This relation existed in waters that met current bathing water standards and therefore should be considered seriously when the European Commission revises bathing water standards.[14]

Non-faecal microbial pollution of bathing waters has received much less attention. Bathing water standards, for example, do not include guidelines for non-faecal pathogens. Nevertheless, with high water temperatures autochthonous pathogens may flourish, and high densities of bathers in the summer months may be an important source of pathogens in the water.

In July and August 1994 an outbreak of otitis externa occurred in the Achterhoek area, an eastern part of the Netherlands. Bathing in recreational fresh water lakes was suspected as the cause of the epidemic, which occurred in an extremely warm summer.[15] Our microbiological investigation of one of the lakes showed *P aeruginosa* to be present in concentrations of <1-17 (median 2) colony forming units/dl, and *P aeruginosa* was isolated from the ear swabs from several cases. All the lakes remained open to the public as they met the Dutch and the European Commission's bathing water standards, which do not include reference to *P aeruginosa*. Known risk groups for otitis externa, however, were warned, and the medical inspectorate of health was informed. Meanwhile, the inspectorate became aware of outbreaks of otitis externa in areas outside the Achterhoek area. On 28 July the National Institute of Public Health and Environmental Protection became involved—we started a case-control study in the Achterhoek area (population about 240 000) to investigate whether the risk of otitis externa was associated with bathing in recreational fresh water lakes and whether a causal relation with *P aeruginosa* could be established.

Methods

On 4 August all 101 general practitioners in the area were asked to report all cases of otitis externa to the district health authority. Otitis externa was defined as a diffuse, non-specific inflammation of the external auditory meatus, which is accompanied by itching, pain, discharge, hearing loss, erythema, or oedema of the skin.[16] Cases were enrolled between 8 August and 19 August.

For every case, we randomly selected five controls, matched for place of residence, age (plus or minus 1 year), and sex, from the municipality registries within two days of reporting. They were approached in order of selection. We aimed to match two controls to each case, but owing to lack of time or to controls who were inaccessible or refused to participate, some cases had only one or no matched control. We included only local residents. In the two week period 164 cases were reported; four refused to participate. They were matched to 216 controls: 77 cases had two controls, 62 had one, and 25 had none.

We interviewed the cases and controls by telephone using standardised questionnaires. We contacted them, if possible, on the day of reporting. The mean duration between interviewing the cases and the controls was three days. We obtained information on age, sex, general health, symptoms of otitis externa, swimming in the previous two weeks, and possible confounding factors associated with otitis externa. From each case, and from one of each matched control an ear swab was taken—by the general practitioner for cases and by a doctor or nurse during a home visit for controls. The swabs were cultured for *P aeruginosa*

and one isolate per swab was investigated by serotyping and phagetyping.[17] The combination of serotype and phage pattern was given a type designation.

Four weeks after the first interview we telephoned all cases again to ask about ear complaints and about the use of drugs, consultation of a general practitioner, and disabling conditions (bed rest or discontinuation of daily activities) in the intervening period. Controls were asked whether they had developed otitis externa within one week of the first interview. Two cases and four controls were lost to follow up.

Between 9 August and 24 August all five recreational fresh water lakes in the area were monitored for *P aeruginosa*.[18] One to seven positive isolates per sample were serotyped and phagetyped.[17] Estimates of the number of bathers were recorded at the time of sampling.

Thirty seven cases and 28 controls who had had otitis externa for two weeks or longer before baseline interview were excluded from further analysis because illness was present before the beginning of the risk period under study (the two weeks before the baseline interview). One case and two matched controls were excluded because no data were available for the confounding factor of recurrent ear disease. Of the remaining 126 cases, 98 were matched to 149 controls: 51 cases had two controls, 47 had one control. Twenty eight cases had no matched control and were therefore excluded. These cases had ear complaints less frequently and were less likely to have swum in a recreational lake than the 98 cases that were included; these differences, however, were not significant. Of the 149 controls, four reported ear complaints at the baseline interview for which they had consulted a general practitioner, and one control developed otitis externa within one week of the baseline interview. These controls were included because they were sampled from the total source population.[19]

TABLE I—*Baseline characteristics of cases and controls. Values are numbers (percentage) unless stated otherwise*

	Cases (n=98)	Controls (n=149)	P value
Median (5th; 95th centile) age (years)	20·5 (7;51)	20 (7;51)	Matching variable
Sex (male)	61 (62)	95 (64)	Matching variable
Earache	94 (96)	8 (5)	<0·001
Hearing loss	60 (61)	2 (1)	<0·001
Itching	56 (57)	2 (1)	<0·001
Oedema	45 (46)	1 (1)	<0·001
Erythema	31 (32)	1 (1)	<0·001
Discharge	27 (28)	0	<0·001
Scaling	16 (16)	0	<0·001

TABLE II—*Risk factors for otitis externa among cases and controls. Values are numbers (percentage) unless stated otherwise*

Risk factor	Cases	Controls	Odds ratio (95% confidence interval)
Swimming in previous 2 weeks	86/98 (88)	91/149 (61)	4·9 (2·3 to 10·6)
Regular swimming ≥ once/week*	28/94 (30)	49/130 (38)	0·9 (0·5 to 1·8)
Regular swimming 1-3 times/month*	33/94 (35)	31/130 (24)	1·5 (0·7 to 3·3)
Recurrent ear disease	37/98 (38)	10/149 (7)	16·4 (5·0 to 53·6)
Eczema	8/98 (8)	16/149 (11)	0·8 (0·3 to 1·9)
Psoriasis	3/98 (3)	1/149 (1)	5·2 (0·5 to 50·4)
Diabetes mellitus	4/98 (4)	0/149	NA
Grommets	3/97 (3)	2/148 (1)	3·2 (0·3 to 32·1)
Hearing aid	1/97 (1)	1/148 (1)	1·4 (0·08 to 23·6)
Ear cleaning with cotton buds ≥ once/week†	55/80 (69)	109/137 (80)	0·5 (0·3 to 1·1)

NA=not applicable. *Versus < once/month. †Versus < once/week.

TABLE III—*Relation between otitis externa and type of swimming water. Values are numbers (percentage) unless stated otherwise*

Type of swimming water	Cases (n=98)	Controls (n=149)	Odds ratio (95% confidence interval)	
			Non-adjusted	Adjusted for recurrent ear disease
No swimming	12 (12)	58 (39)	1·0	1·0
Recreational fresh water lake	64 (65)	35 (23)	10·0 (4·0 to 24·9)	15·5 (4·9 to 49·2)
Swimming pool, river, or sea	22 (22)	56 (38)	2·0 (0·8 to 4·9)	2·2 (0·7 to 6·7)

STATISTICAL ANALYSIS

The significance of differences in medians of baseline characteristics and risk factors between cases and controls was tested with a median test, and of differences in proportions with a Mantel-Haenszel χ^2 test with the SAS programme.[20] Swimming in the previous two weeks was first analysed as "yes" or "no". Answers of "yes" were then subdivided as (*a*) swimming in a recreational lake only or swimming in a recreational lake as well as in a swimming pool, river, or the sea, and (*b*) swimming only in a swimming pool, river, or the sea. The frequency of swimming was defined as the total number of days that a respondent bathed in the previous two weeks. This exceeded 14 for some who swam in more than one type of water in the same day. Crude odds ratios and 95% confidence intervals of otitis externa were calculated. To account for the matching variables, this was done with conditional logistic regression analysis with EGRET.[21] To check whether the association between otitis externa and swimming was modified by the matching factors age and sex, an interaction term was included in the models. This was also done for recurrent ear disease and swimming because recurrent ear disease emerged as a significant risk factor for otitis externa in the univariate analyses. No such interactions were found. We therefore included people with recurrent ear disease in the analyses and incorporated this factor ("yes" or "no") as a covariate in the regression models. Other possible risk factors for otitis externa were not significant in the univariate analyses, and did not change the risk estimates of swimming substantially. All P values were two sided.

Results

Table I shows the baseline characteristics of the 98 cases and 149 controls. As cases and controls were matched for age and sex the distribution of these variables was almost identical. As expected, cases reported ear complaints more often than controls.

SWIMMING IN FRESH WATER LAKES

The cases reported swimming in the two weeks before the interview more frequently than the controls (table II). They were also more likely to have recurrent ear disease. Diabetes mellitus, psoriasis, and grommets were more common among cases than controls. The numbers were too small, however, to draw definite conclusions.

Otitis externa showed a strong correlation with swimming in a recreational lake, and this correlation became even stronger after adjustment for recurrent ear disease (table III). A significant association with swimming in a swimming pool, river, or the sea was not observed.

The risk of otitis externa for people with recurrent ear disease who swam in a recreational lake was 325 (95% confidence interval 28·8 to 3670) compared with those without recurrent ear disease who did not swim at all. For swimming in a swimming pool, river, or the sea this risk was 64·7 (7·5 to 555).

The risk of otitis externa was also investigated according to the type of swimming water (recreational lake *v* swimming pool, river, or the sea) in combination with the frequency of exposure. For both types of water categories the odds ratio increased with the number of days' exposure and was 27·5 (6·4 to 118·3) for those who had swum more than five days and who had been in a recreational lake, compared with non-swimmers (table IV). For swimming in a swimming pool, river, or the sea, borderline significance was

TABLE IV—*Relation between otitis externa and location and frequency of swimming. Values are numbers (percentage) unless stated otherwise*

Type of swimming water and frequency of swimming	Cases (n=94)	Controls (n=139)	Odds ratio (95% confidence interval)	
			Non-adjusted	Adjusted for recurrent ear disease
No swimming	12 (13)	58 (42)	1·0	1·0
Fresh water lake:				
≤5 Days	22 (23)	20 (14)	5·8 (2·1 to 16·3)	9·3 (2·5 to 35·2)
>5 Days	39 (41)	12 (9)	15·6 (5·2 to 46·8)	27·5 (6·4 to 118·3)
Swimming pool, river or sea:				
≤5 Days	9 (10)	33 (24)	1·6 (0·5 to 4·8)	2·0 (0·5 to 8·1)
>5 Days	12 (13)	16 (12)	3·8 (1·2 to 11·9)	3·8 (0·9 to 15·6)

Values for the number of days' swimming were missing for four cases and 10 controls.

observed when swimming for five days or more was compared with no swimming (P=0·07).

An increased risk of otitis externa was observed for swimming in the five lakes that were monitored (odds ratio for all lakes combined 9·8 (2·7 to 35·3)) as well as for swimming in lakes outside the area (33·4 (3·9 to 283·5)).

WATER QUALITY

Four lakes met Dutch and the European Commission's mandatory standards for thermotolerant coliforms in the summer of 1994 (data provided by the province of Gelderland). The remaining lake failed marginally as one out of seven samples taken in the bathing season exceeded the level for thermotolerant coliforms; in the other six samples the faecal pollution was low. Total coliform counts were all below the guide level. In 69% (83/120) of the samples *P aeruginosa* was detected, and the median (10th; 90th centile) concentration was 4 (1;63)/l. The concentrations showed considerable variation in location and day and time, with deviations almost up to three log units. During the monitoring period the air temperature was falling and hardly any bathers were observed. Therefore, a quantitative relation between otitis externa and concentrations of *P aeruginosa* could not be investigated.

P AERUGINOSA IN EAR SWABS

P aeruginosa was found in 78 out of 94 (83%) of the ear swabs from cases and in 3 out of 71 (4%) from controls. Of the cases whose ear swab yielded a positive result, 72 had swum: 55 in a recreational lake (32 in the lakes that were monitored), 10 only in a swimming pool, and 7 in a swimming pool, river, or the sea. Of the three controls whose ear swab yielded a positive result, two had swum in both a swimming pool and a recreational lake and one had swum in both a swimming pool and the sea.

Serotyping and phagetyping of the positive isolates showed no clear relation between the type of *P aeruginosa* isolated from ear swabs and lake water. Forty nine different types were found among 71 cases and three controls, and 81 types were identified in 174 isolates of 83 water samples from the five lakes. In each lake a large variation in types was found.

FOLLOW UP

At follow up 18 of the cases still had ear complaints: 13 reported hearing loss, 8 itching, 6 ear ache, and 5 discharge. A doctor was consulted twice by 36 cases and three or more times by 14. All subjects had used ear drops: 34 received a prescription more than once and 6 three or more times. Discontinuation of daily activities was reported by 35 cases (median duration four days), and 21 had to rest in bed for a median duration of three days.

Discussion

The occurrence of otitis externa in the Achterhoek area of the Netherlands in August 1994 was strongly associated with swimming in recreational fresh water lakes. As *P aeruginosa* was detected in all lakes monitored and isolated from the ears of most cases and few controls, this organism was almost certainly the causative agent. *P aeruginosa* has been identified as one of the predominant isolates recovered in cases of otitis externa.[22] Increased risk existed after swimming in fresh water lakes, even though these complied with the Dutch and the European Commission's bathing water standards. Recurrent ear disease was strongly related to otitis externa. Psoriasis, diabetes mellitus, and the presence of grommets were also associated with otitis externa, although the numbers were too small to draw definite conclusions. People with recurrent ear disease should take special care when swimming in waters containing *P aeruginosa* because they have an increased risk of otitis externa.

The estimated risks do not have a direct causal relation with the concentration of *P aeruginosa* that we measured in the study period. Because the weather conditions worsened at the start of the study, almost no cases or controls swam in the lakes in the period that these were monitored. In the preceding period of good weather concentrations of *P aeruginosa* may well have been higher due to resuspending sediment, which may contain a larger concentration of *P aeruginosa*,[23,24] through the activities of swimmers or the direct inoculation from their bodies. Occasional water samples taken in the period before monitoring did have higher concentrations of *P aeruginosa* than the average found in the monitoring period. Because only a few people swam in the lakes in the period during which we measured water quality, we could not investigate a dose-response relation between risk of otitis externa and concentrations of *P aeruginosa*. The fact that many different serotypes of *P aeruginosa* were found among cases suggests that otitis externa was not caused by one single type.

Our findings are probably not strongly biased. In general, case recruitment through a general practitioner might result in selection bias on swimming if people with otitis externa are more likely to consult a general practitioner when they have been swimming. Consultation will depend, however, on the severity of symptoms, not on whether the individual has been swimming. Selection bias is also possible if the swimmers were more likely than non-swimmers to participate in our study or be reported by their general practitioner. Only four cases (three of whom had swum), however, refused to participate. Besides, the general practitioners were instructed to report cases independently of swimming activity. About 40% of the general practitioners participated in case reporting. Some of the non-participating general practitioners could not cooperate because of holidays, and others did not meet the new cases or just refused to participate. This could not, however, result in selection bias as these general practitioners reported neither swimmers nor non-swimmers. Selection bias among controls is unlikely as controls were recruited randomly from the same area as the cases, thereby having had an equal opportunity to swim in the recreational fresh water lakes. Recall bias is also not likely as information was requested for the previous two weeks.

This is the first time a large outbreak of otitis externa due to swimming in fresh waters has been reported in the Netherlands, and the extreme heat in the summer of 1994 is probably the cause of the epidemic. Our study was carried out at the end of the epidemic. Other investigators have estimated through telephone contacts that it spread over eight regions in the Netherlands in July and August 1994 (F de Bles, personal communication, province of Utrecht). Over 600 incident cases were reported, although this must be a severe underestimation of the real number. Fresh

Key messages

- Many studies have reported that bathing in sea or fresh waters that meet current safety standards may lead to illness
- Most attention has been given to faecal pollution of such water
- In this study a relation was found between otitis externa and swimming in fresh water lakes, due to *Pseudomonas aeruginosa* that was present in the lakes
- All the lakes met current bathing water standards, which, however, do not cover *P aeruginosa*
- Persons with recurrent ear disease should take special care swimming in waters containing *P aeruginosa* because they have an increased risk of otitis externa

water lakes outside the area also probably contained *P aeruginosa*. Otitis externa had a high disease burden, and after four weeks of follow up 19% of the participating cases still had complaints.

COMPARISON WITH OTHER STUDIES

Risk of otitis externa has previously been associated with swimming in fresh waters.[23 25 26] In one study *P aeruginosa* was isolated from ear swabs and lake water, but no risk estimate was calculated.[23] The other two studies did not try to relate or failed to relate risk to *P aeruginosa*.[25 26] We not only provided a risk estimate, which was high, but also isolated *P aeruginosa* from ear swabs and lake water. As in the other three studies the risk of otitis externa increased with the number of days that an individual swam. Subjects who swam on more than five days had a significantly higher risk than non-swimmers, regardless of whether they swam in fresh water lakes or in a swimming pool, river, or the sea. An explanation for this increased risk might be a diminishing protective layer of the meatus resulting from prolonged exposure to water.[27]

CONCLUSION

Our findings imply that, even if current bathing water standards are met, fresh water bathing may cause a substantial risk of otitis externa, because of exposure to *P aeruginosa*. The same might be true for illnesses caused by other autochthonous pathogens—for example, cyanobacteria, *Aeromonas* spp, *Plesiomonas* spp, *Vibrio* spp. These risks should be minimised, and studies must decide if standards can be developed. As the system of autochthonous pathogens in water is highly dynamic and can be controlled only marginally by outside factors, control requires a different approach from the current strategies, which are aimed at reducing faecal (mainly sewage) pollution. Further investigations are needed to study the ecology of the organisms to identify high risk areas, and prospective epidemiological studies should examine possible dose-response relations and identify risk groups.

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