Health effects of attending a public swimming pool: follow up of a cohort of pupils in Paris

Isabelle Momas, Françoise Brette, Anne Spinasse, Fabien Squinazi, William Dab, Bernard Festy

Abstract

Objectives—This study aimed to determine the health effects of attending a well-kept school swimming pool maintained according to French public health regulations.

Methods—This prospective month long study was carried out on a randomised sample of pupils aged 5 to 18 years who attended a private French school with two swimming pools. The children surveyed, helped by their parents, had to fill in questionnaires about their bathing habits and symptoms during the survey period. Inspections of the pool complex were made and these included physicochemical and bacteriological analyses of the pools' water.

Participation—The response rates achieved were 70% at primary and middle school levels but only 25% in the high school pupils. Because of this older teenagers were excluded from the final analysis (of 246 children).

Results—Compared with non-bathers, bathers experienced fatigue and eye irritation significantly more often ($p<0.001$). The eyes were red (38% of bathers) and/or watery (16%) after swimming but this resolved spontaneously within 24 hours. Bathing behaviour (bath duration, head immersion, wearing swimming goggles) did not affect these incidence rates noticeably. There were no differences between bathers and non-bathers with regard to other symptoms, especially otolaryngological ones. This survey does not allow definite conclusions to be made about verrucas because 22% of non-bathers were exempted from swimming because of verrucas that they might have caught previously in a pool.

Conclusions—Except for verrucas, the methodology was adequate and daily self reporting of symptoms was feasible. This college largely recruits pupils from higher social classes and is not therefore representative of schools in Paris.

knowledge, none have examined the occurrence of ailments in standard, well-kept swimming pools.

To investigate this situation, a prospective descriptive survey was designed in one school. The study population was therefore young, well defined, easy to follow up and perhaps more susceptible to ailments. This investigation was carried out in a private school in Paris.

The objectives of this one month study were to determine the incidence or the prevalence of different symptoms, especially ocular, otolaryngological, and cutaneous symptoms, and to examine whether these were more frequent in pool users than in those who did not swim.

Methods

STUDY POPULATION

The study was carried out on 600 children selected at random from the register of pupils attending College S during the 1990-91 academic year. This college was attended by approximately 3000 pupils aged between 5 and 20 years. The sample was stratified by age (children from 5 to 11 years old attending primary school, those from 12 to 15 years old attending middle school, and teenagers over 15 at high school).

SWIMMING POOL

The swimming pool complex of this college comprised two large pools (12.5m by 25m) with different water depths. They were served by the same continuous treatment system: sand for filtration and chloro-isocyanurates for disinfection. The hydraulics was classic. Inspection of the pool complex showed that it was operating properly. The maintenance was satisfactory: showers were cleaned three times a day and the pools in the evening. In addition to the college pupils, children from other schools and members of different clubs used the pools; thus about 10 000 people were using the swimming facilities each week.

Six water samples were taken from each pool in the morning or in the afternoon—one before and one subsequent to the survey and one per week during the survey. The first and last samples were analysed for the complete assessment of physicochemical and microbiological water quality. The physicochemical quality was measured in terms of temperature, turbidity, conductivity, pH, and chlorine levels (available, free, combined, and total). The microbiological quality was based on faecal coliforms, faecal streptococci, coagulase-positive staphylococci, and *Pseudomonas aeruginosa*. The other four analyses measured only pH, chlorine levels, and all the bacteria previously mentioned. Techniques used were in accordance with standard French methods.¹³

Laboratoire
d'Hygiène et de
Santé Publique,
Faculté des Sciences
Pharmaceutiques et
Biologiques, 4 Avenue
de l'Observatoire,
75270 Paris CEDEX
06, France

I Momas
F Brette
A Spinasse
F Squinazi
B Festy
Laboratoire
d'Hygiène de la Ville
de Paris, Paris,
France

I Momas
F Brette
A Spinasse
F Squinazi
B Festy
Ecole Nationale de La
Santé Publique,
Saint-Maurice, France
W Dab

Correspondence to:
Dr I Momas

Accepted for publication
June 1993

J Epidemiol Community Health 1993; 47: 464-468

Epidemiological investigations conducted in swimming pools have always been motivated by accidental outbreaks of gastroenteritis,^{1 4} of pharyngoconjunctival fever,^{5 8} or of hepatitis⁹ occurring in inadequately maintained pools—that is those with poor filtration⁵ or chlorination.^{1 4 6 8} Epidemiologists have only been interested in these unusual conditions and, more recently, in "new" pools such as spas or jacuzzi^{10 12} but, to our

STUDY DESIGN

The survey lasted four weeks from March 18 to April 12, 1991. Before the investigation, surveyed children and their parents received a letter informing them of this study and requesting their written agreement to participate. Confidentiality of collected information was stressed. Primary school teachers and vice principals hand-delivered and collected questionnaires. Three questionnaires had to be filled in for each child.

The first questionnaire dealt with medical history, (previous diseases including allergy, operations, vaccination) and the wearing of spectacles or contact lenses.

The second one described bathing habits: the number of baths at College S and elsewhere (including spas, jacuzzi and Turkish baths); length of time spent in the water; whether the child took a shower and washed before and after each bath, whether swimming goggles or cap were worn, whether the head was immersed in the water and whether the child practised other sports that might be related to the symptoms studied in this investigation. Those pupils who never bathed during the survey were referred to as non-bathers.

The third questionnaire concerned morbidity and was in a tabular form where local or general symptoms presented by each surveyed child were ticked off as soon as they occurred. These signs could be confirmed by the school nurse and if necessary, by a physician specially recruited for the survey. This doctor then filled in a questionnaire designed to show diagnosed morbidity. Ocular, otolaryngological (runny nose, sore throat, sinusitis, ear infection), and skin abnormalities only were considered. Gastrointestinal diseases and amoebic meningoencephalitis were excluded because they rarely occur in well-kept swimming pools.

STATISTICAL ANALYSES

Statistical analyses were performed with BMDP software. Incidence rates were evaluated for ocular and otolaryngological signs, but for cutaneous symptoms, only prevalence rates could be determined because the latency period might be longer than the duration of this survey.

Comparisons between bathers and non-bathers were made using χ^2 or Fisher's exact test for categorical variables, and analysis of variance for continuous variables after verification of the normality of the distributions.

An unconditional multiple logistic regression was performed to determine the odds ratio (OR) of getting ill or presenting a sign depending on whether the child attended the pool or not and adjusting for potential confounders: gender, level of schooling, and practice of sports which might be related to the sign examined. The ORs were

estimated using the method of maximum likelihood and 95% confidence intervals based on the standard error of coefficient estimates and normal approximation.

The relative risk (RR) can be deduced from the OR since, as underlined by Hogue *et al.*¹⁴ RR may be expressed as a function of OR and of the probability of disease (D) among the exposed population (E) $P(D/E)$; the formula is:

$$RR = OR - (OR - 1) \cdot P(D/E)$$

A method for obtaining approximate confidence intervals of this estimator is given by Hogue *et al.*¹⁴

Results

CONTROL OF THE QUALITY OF THE SWIMMING POOL

The overall quality of the water was very good with reference to the French regulations. We could find very minor anomalies only: slightly high combined chlorine levels (0.7 to 1 instead of 0.6 mg/l) on three occasions and the presence of coagulase-positive staphylococci (2 and 3 /100ml instead of 0 in 95% cases) in the shallow pool, and a slight depletion of available free chlorine (1.55 instead of 2 mg/l) on one occasion and a slight excess of combined chlorine (0.8 to 1 mg/l) on three occasions in the deeper pool. Pool chlorination, filtration, and maintenance procedures were adequate.

RESPONSES

Eighty four (69.4%) primary school children, 165 (67.6%) middle school, but only 54 (22.9%) high school pupils filled in the three questionnaires. Because of the poor response rate among the older pupils, only those results for children aged less than 16 were analysed.

After sending reminder letters (up to three) a further 11% of questionnaires were received. Incomplete responses (10.1%) were not taken into account in this analysis. The percentage of refusers was higher for children below age 11 (19.8%) than for children above 11 years old (4.9%). A total of 246 responses were finally obtained and could be analysed.

DEMOGRAPHIC AND SCHOOL LIFE CHARACTERISTICS (table I)

The age, gender, and socioeconomic distribution of this sample of 246 children is similar to that for all pupils (adolescents excluded) at the college. Boys are predominant in this population; only a few girls attend the primary school and none the middle or high schools. Most pupils are day-boarders. The children's socioeconomic status is largely above average and quite homogeneous.

BATHING HABITS

Only 36 pupils (14.6%) never bathed during the survey. Most pupils (83.1% at the primary school, 86.5% at middle school) bathed in the swimming pool of the college. Most of them swam during the swimming class but few of them (8.4% at primary school, 9.2% at middle school) also attended these pools individually.

Bathing behaviour (table II) is very similar at primary and middle school. On average, children

Table I Follow up of a cohort of French pupils (Paris, 1991). Characteristics of surveyed pupils

Gender (%)	97.2 boys	2.8 girls
Age (y):		
Mean (SD)	11.3 (2.4)	
Range	5-15	
Day/boarders (%)	32/68	
Socio-professional group (%):		
I	Father (n=232) 87.0	Mother (n=225) 48.8
II	3.9	16.5
III	6.5	3.2
IV	0.0	0.0
V	0.0	0.4
Retired	2.6	0.0
Unemployed	0.0	31.1

bathed once a week, for 45 minutes. Most of them took a shower but omitted to wash themselves before and after each bathing session. Only 22% of bathers wore swimming goggles. Swimming caps were not often used but were more commonly worn by the youngest pupils.

DECLARED MORBIDITY

Around 68% of the pupils suffered at least one symptom during the survey. The local problems most commonly encountered were blotchy skin, runny nose, itch, verruca, and watery eyes. In terms of general signs, fatigue, headache, and fever were noted. Face rash (6.1% *v* 0, $p < 0.05$) and fever (13.8% *v* 4.9%, $p = 0.03$) were reported significantly more often in middle school than in primary school pupils. No statistically significant differences were observed between primary and middle school pupils with regard to other symptoms.

Compared with non-bathers, bathers had a significantly lower rate of verruca but experienced fatigue and eye disorders such as red or watery eyes significantly more often (table III). These results remain statistically significant after adjusting for potential confounders (level of schooling, gender, . . .). The eye disorders were constantly reported on each week and in each pool. Their incidence rates did not seem to be

noticeably affected by differences in bathing behaviour (table IV).

Table V shows that complaints about draughts are statistically related to over-reporting of four signs: itch, rash, runny nose, and cough.

DIAGNOSED MORBIDITY

There were no differences between bathers and non-bathers with regard to diseases diagnosed during the survey but only 10 children were diagnosed.

Discussion

To our knowledge this is the first study aiming to determine the frequency of ailments that might occur in a cohort of pupils attending an a priori well-maintained swimming pool, the quality of which is corroborated by physicochemical and bacteriological analyses.

Such an investigation based on daily self reporting of symptoms was feasible in College S at both primary and middle school levels where a response rate of about 70% was achieved. "Non-responses" in total, which included non-responders per se, incomplete responses, and refusals, did not differ statistically significantly from "responses" with regard to sociodemographic and school characteristics. Therefore, the 246 children who answered seemed to be representative of all the children aged less than 16 years attending this college.

With regard to diagnosed morbidity, the investigation was weak, probably because the study period was too short. The small number of illnesses diagnosed does not therefore permit definite conclusions to be drawn.

The college selected for this study is not representative of schools in Paris. Most of the pupils are boys and day-boarders. Some 70% of mothers have a job and there is a very large predominance of children from the higher social classes. Thus findings from such a sample cannot be extrapolated to the general population. Nevertheless, while avoiding generalisation, we can discuss bathing habits and symptoms presented by this surveyed population.

Table II Follow up of a cohort of French pupils (Paris, 1991). Bathing habits in surveyed pupils attending the swimming pool during the survey

Bathing habits	All bathers surveyed (n=210)	Primary school (n=69)	Middle school (n=141)	p value
No of baths per child:				
Mean (SD)	3.87 (1.82)	3.84 (1.85)	3.94 (1.78)	NS
Median	4	4	4	
Duration of bath (min):				
Mean (SD)	42.5 (11.2)	41.8 (9.4)	44.2 (14.6)	NS
Median	45	45	45	
Taking a shower (%):				
Before bathing (n=195)	96.4	96.9	96.2	NS
After bathing (n=190)	84.7	80.0	86.9	NS
Washing (%):				
Before bathing (n=190)	1.1	3.2	0.2	NS
After bathing (n=187)	4.3	6.3	3.2	NS
Wearing swimming goggles (%) (n=193)	22.3	25.4	20.8	NS
Wearing swimming cap (%) (n=194)	5.2	11.1	2.3	$p = 0.024$
Head immersion (%) (n=194)	94.8	95.3	94.6	NS
Opening eyes (%)	78.9	73.8	81.5	NS

Table III Follow up of a cohort of French pupils (Paris, 1991). Declared morbidity according to bathing exposure during the survey

Symptoms experienced at least once during the survey (%)	Bathing exposure		p value	Odds ratio	(95% CI)
	No (n=36)	Yes (n=210)			
Blotch:	11.1	41.9	$p = 0.0004$	5.03*	(1.68, 15.1)
Face	0	2.9	NS	—	—
Eye	5.6	37.6	$p = 0.0002$	10.2†	(2.36, 43.9)
Body	2.8	4.3	NS	1.27*	(0.15, 10.8)
Foot	2.8	3.8	NS	1.16*	(0.13, 9.95)
Itch:	8.3	23.3	$p = 0.0417$	3.14*	(0.86, 11.4)
Face	0	3.4	NS	—	—
Eye	2.8	12.9	NS	5.84†	(0.72, 47.4)
Body	2.8	7.7	NS	2.57*	(0.30, 21.8)
Foot	2.8	5.8	NS	1.94*	(0.24, 15.7)
Rash:	2.8	7.7	NS	2.22*	(0.28, 17.8)
Face	0	4.8	NS	—	—
Body	2.8	4.3	NS	1.04*	(0.12, 8.94)
Crack in skin	2.8	3.8	NS	1.13*	(0.13, 9.62)
Verruca	25.0	11.6	$p = 0.0302$	0.36*	(0.15, 0.89)
Watery eye	0	15.8	$p = 0.0215$	—	—
Runny nose	36.1	36.5	NS	0.99†	(0.47, 2.08)
Sore throat	8.6	11.0	NS	2.16†	(0.62, 7.59)
Cough	16.7	10.1	NS	0.54†	(0.20, 1.46)
Earache	8.3	9.0	NS	1.10†	(0.31, 3.96)
Fever	5.7	11.6	NS	2.06†	(0.46, 9.28)
Headache	16.7	19.1	NS	1.16†	(0.45, 2.99)
Fatigue	8.6	25.8	$p = 0.0255$	3.70†	(1.08, 12.7)
Any one of those symptoms	47.2	71.8	$p = 0.0034$	2.86*	(1.37, 5.99)

CI=confidence interval

*Logistic regression model including gender, level of schooling, practice of sport, that may be related to the studied symptom and bathing exposure at College S.

†Logistic regression model including gender, level of schooling and bathing exposure at College S.

Table IV Follow up of a cohort of French pupils (Paris, 1991). Relative risks (RR) of "eye irritation" and of "watery eyes" according to bathing behaviour (logistic regression model adjusted for duration of bathing)

Bathing behaviour	Eye irritation		Watery eyes	
	RR	(95% CI)	RR	(95% CI)
Wearing swimming goggles:				
No	1.00		1.00	
Yes	0.88	(0.67, 1.16)	0.54	(0.44, 0.63)
Head immersion:				
No	1.00		1.00	
Yes	1.87	(0.83, 4.23)	0.98	(0.76, 1.26)
Opening the eyes underwater:				
No	1.00		1.00	
Yes	0.81	(0.61, 1.07)	0.41	(0.36, 0.47)
Wearing spectacles:				
No	1.00		1.00	
Yes	1.03	(0.42, 2.54)	1.35	(1.14, 1.59)

Table V Follow up of a cohort of French pupils (Paris, 1991). Statistically significant associations between user's opinion about the quality of the pool environment and self reporting of symptoms

Proportion of bathers reporting the following symptoms at least once (%)	Sensation of draughts		p value
	No	Yes	
Itch	19.3	44.1	p=0.0023
Rash	6.3	17.6	p=0.0449
Runny nose	32.9	61.8	p=0.002
Cough	7.0	23.5	p=0.009

Bathing behaviour was quite similar at primary and at middle school, and was probably enforced by swimming instructors. Showering before and after bathing and wearing swimming goggles and caps were, however, individual habits. It is unfortunate that washing was so infrequent because, according to Perron¹⁵ a shower subsequent to bathing using soap at a pH close to skin pH is necessary to avoid skin xerosis. Use of swimming goggles and caps was particularly common in the primary pupils, perhaps because they are more affected by the water than older children and probably because their mothers insist.

Self reporting of symptoms is, of course, a subjective action. Moreover, subjects are aware of their exposure and bathers who are dissatisfied with the comfort of the swimming pool environment are inclined to over-report their symptoms. There are statistically significant relationships between the sensation of draughts and reporting of four signs. Such results are difficult to explain and it may be wondered whether the sensation of draughts is a cause or a consequence of the reported signs. In spite of these four associations, over reporting of symptoms seems to be a minor source of bias in this study.

Comparison of symptoms in bathers and non-bathers supports the not surprising conclusion that swimming generally increases the risk of minor ailments, particularly of eye disorders. Findings concerning eye irritation support a causal relationship between exposure and red or watery eyes. These troubles were observed on each week and in each pool; their latency and their duration were short since they occurred on the bathing day and resolved spontaneously over one day.

This outcome agrees with results from several authors. According to Peyronnet *et al.*,¹⁶ 42.3% of bathers complain of eye disorders. Haag and Gieser¹⁷ found that 68% of public pool users experienced halo effects after an average of 34 minutes' swimming; 94% of subjects also exhibited corneal erosions. Soni *et al.*¹⁸ noted greater than average corneal thickness in a group of competitive swimmers.

Is eye irritation caused by chlorine or its mineral or organic byproducts?¹⁹ Rylander *et al.*²⁰ think that monochloramine is more irritating than free

chlorine or organic chloramine. According to Laurent *et al.*,²¹ the trihalomethanes may contribute to mucocutaneous irritation and their role must be explored. Chiswell and Wildsoet¹⁹ suggest that the corneal reactions in competitive swimmers are pH related and recommend that the pH of pool water be slightly alkaline because lower pH values favour the formation of HOCl, the more powerful oxidising but also disinfecting agent. At least some of the symptoms experienced by swimmers can be attributed to the hypotonic nature of swimming pool water. The normal environment of the external eye is the tear film which has a salt concentration between 0.90 and 0.95% of NaCl while the salt concentration in standard chlorinated swimming pool water is negligible (<0.05%). The corneal epithelium is extremely sensitive to hypotonic solutions.

This study does not allow us to support any one particular hypothesis. Chloramines, indirectly estimated through combined chlorine levels, were in slight excess on three occasions during the survey but the frequency of eye irritation was not consequently changed. The salt concentration was determined and came to about 10 MEq NaCl/l—that is below the values corresponding to the occurrence of corneal reactions. pH is slightly alkaline.

Is there any advice that can be given to bathers to help avoid eye irritation? No single piece of advice for action seems to be mandatory. Nevertheless, it seems advisable to wear swimming goggles. It is not necessary to reduce the duration of exposure to water since eye irritation does not depend on bathing duration. The contribution of head-immersion as a risk factor is unclear. According to our findings, swimming with the head under water and the eyes open would protect against watery eyes! But this illustrates bias—the "healthy worker effect".

The incidence of otolaryngological disorders (runny nose, sore throat) was higher, but the difference not statistically significant, in bathers compared with non-bathers. This result could be explained by a lack of statistical power, the number of children being small. But the most likely reason is that these disorders are not due to contamination in situ; sometimes they may occur after bathing, in subject pathogen carriers, after fatigue and changes in temperature or draughts.

This survey does not allow us to draw clear conclusions from results relating to earache and verrucas. Indeed, only 36 pupils never bathed during the survey and were referred to as non-bathers: 58% of them were exempt from swimming because of ill health, 22% because of verrucas, and 17% because of recurrent otitis. With these "controls" it is probable that the frequency of these symptoms is overestimated in non-exposed subjects. For instance, 8.3% of non-bathers suffer from earache in our study *v* 3% in other reports.²² On the other hand, the prevalence of this sign in bathers seems to be consistent with that published elsewhere.²³ This issue would involve an underestimation of risk associated with swimming in a pool. However, Seyfried *et al.*²⁴ showed a relationship between ear infections and the presence of *Pseudomonas aeruginosa* in the pool water. Our bacteriological analyses did not find this bacterium.

As for verrucas, their frequency in this investigation is overestimated in children who did not swim and underestimated in those who did since pupils exempted from swimming because of verrucas might have caught these verrucas after a previous exposure in a pool. Only the prevalence of verrucas in the college can therefore be estimated.

These last two problems deserve further consideration. Overall, bathing in a well-kept school swimming pool does not produce any major health hazard except eye irritation.

The authors wish to thank the director of the College, the director of the pool complex, the school physician and his colleagues, the teachers, the vice-principals, and the parents of pupils attending this College for their participation. They are also grateful to Dr Houette and to Mrs Morlaye and Mrs Saunoi for their able technical assistance.

- 1 Kappus KD, Marks JS, Holman RC, *et al.* An outbreak of Norwalk gastroenteritis associated with swimming in a pool and secondary person-to-person transmission. *Am J Epidemiol* 1982; **116**: 834-9.
- 2 Porter JD, Ragazzoni HP, Buchanan JD, Waskin HA, Juranek DD, Parkin WE. Giardia transmission in a swimming pool. *Am J Public Health* 1988; **78**: 659-62.
- 3 Holmes SE, Pearson JL, Kinde MR, Hennes RF. Gastroenteritis outbreak: diseases linked to swimming pool and spa use. *J Environ Health* 1989; **51**: 286-8.
- 4 Lenaway DD, Brockmann R, Dolan GJ, Cruz-Urbe F. An outbreak of an enterovirus-like illness at a Community wading pool: implications for Public Health Inspection Programs. *Am J Public Health* 1989; **79**: 889-90.
- 5 Caldwell GG, Lindsey NJ, Wulff H, Donnelly DD, Bohl FN. Epidemic of adenovirus type 7 acute conjunctivitis in swimmers. *Am J Epidemiol* 1974; **99**: 230-4.
- 6 D'Angelo LJ, Hierholzer JC, Keenlyside RA, Anderson LJ, Martone WJ. Pharyngoconjunctival fever caused by adenovirus type 4: report of a swimming pool related outbreak with recovery of virus from pool water. *J Infect Dis* 1979; **140**: 42-7.
- 7 Martone WJ, Hierholzer JC, Keenlyside RA, Fraser DW, D'Angelo LJ, Winkler WG. An outbreak of adenovirus type 3 disease at a private recreation center swimming pool. *Am J Epidemiol* 1980; **111**: 229-37.
- 8 Turner M, Istre G, Beauchamp H, Baum M, Arnold S. Community outbreak of adenovirus type 7a. Infections associated with a swimming pool. *Southern Medical Journal* 1987; **80**: 712-5.
- 9 Mahoney FJ, Farley TA, Kelso KY, Wislon SA, Horan J, MacFarland LM. An outbreak of hepatitis A associated with swimming in a public pool. *J Infect Dis* 1992; **165**: 613-8.
- 10 Spitalny KC, Vogt RL, Witherell LE. National survey on outbreaks associated with whirlpool spas. *Am J Public Health* 1984; **74**: 725-6.
- 11 Ratnam S, Hogan K, March SB, Butler RW. Whirlpool-associated folliculitis caused by *Pseudomonas aeruginosa*: report of an outbreak and review. *J Clin Microbiol* 1986; **23**: 655-9.
- 12 Bornstein N, Marmet D, Surgot M, *et al.* Exposure to legionellaceae at a hot spring spa: a prospective clinical and serological study. *Epidem Inf* 1989; **102**: 31-6.
- 13 (i) Loi n°78-733 du 12 Juillet 1978. Relative aux piscines et aux baignades aménagées. Paris: *Journal Officiel* du 13 Juillet 1978.
- (ii) Décret n°81-324 de 7 Avril 1981. Fixant les normes d'hygiène et de sécurité applicables aux piscines et aux baignades aménagées. Paris: *Journal Officiel* du 10 Avril 1981.
- (iii) Arrêté du 7 Avril 1981. Fixant les dispositions techniques applicables aux piscines. Paris: *Journal Officiel* du 10 Avril 1981.
- (iv) Arrêté du 7 Avril 1981. Fixant les dispositions administratives applicables aux piscines et aux baignades aménagées. Paris: *Journal Officiel* du 10 Avril 1981.
- (v) Circulaire du 9 Mai 1983. Relative aux piscines et à la mise en conformité des installations existantes. *Journal Officiel* du 13 Août 1983.
- (vi) Arrêté du 28 Septembre 1989. Modifiant l'arrêté du 7 Avril 1981, fixant les dispositions techniques applicables aux piscines. Paris: *Journal Officiel* du 21 Octobre 1989.
- (vii) Décret n°91-980 du 20 Septembre 1991. Modifiant le décret n°81-324 du 7 Avril 1981 fixant les normes d'hygiène et de sécurité applicables aux piscines et aux baignades aménagées. Paris: *Journal Officiel* du 26 Septembre 1991.
- (viii) Arrêté du 29 Novembre 1991. Pris pour l'application du décret n°91-980 du 20 Septembre 1991 modifiant le décret n°81-324 du 7 Avril 1981 fixant les règles d'hygiène et de sécurité applicables aux piscines et aux baignades aménagées. Paris: *Journal Officiel* du 7 Janvier 1992.
- 14 Hogue CJ, Gaylor DW, Schulz KF. Estimators of relative risk for case-control studies. *Am J Epidemiol* 1983; **118**: 396-407.
- 15 Perron J. Pathologies des piscines. *Gazette Médicale* 1988; **95**: 34-40.
- 16 Peyronnet P, Spinasse A, Dab W, Le Moullec Y, Festy B. Perception par l'usager des facteurs d'environnement à l'intérieur des établissements de natation ouverts au public à Paris. *Journal Français d'Hydrologie* 1988; **19**: 217-30.
- 17 Haag JR, Gieser RG. Effects of swimming pool water on the cornea. *JAMA* 1983; **249**: 2507-8.
- 18 Soni PS, Pence NA, De Leon L, Lawrence S. Feasibility of extended wear lens use in chlorinated swimming pools. *American Journal of Optometry Physiology and Optics* 1986; **63**: 171-6.
- 19 Chiswell B, Wildsoet CF. The causes of eye irritation in swimming pools. *Water Science and Technology* 1989; **21**: 241-4.
- 20 Rylander R, Victorin K, Sorensen S. The effect of saline on eye irritation caused by swimming pool water. *Journal of Hygiene* 1973; **71**: 587-92.
- 21 Laurent AM, Le Moullec Y, Festy B. Formation de composés haloformes dans les eaux de piscines traitées par le chlore ou le brome. *Journal Français d'Hydrologie* 1983; **40**: 89-103.
- 22 Spinasse A, Squinazi F, Festy B. Risques infectieux et piscines. *Infectiologie* 1989; **28**: 8-14.
- 23 Calderon RL, Mood EW. Epidemiological studies of otitis externa: report of a prospective and of a retrospective study of otitis externa among swimmers. *Environmental Protection Agency* 1981; **600/S1** 81.053.
- 24 Seyfried PL, Tobin RS, Brown NE, Ness PF. A prospective study of swimming-related illness. I Swimming-associated health risk. *Am J Public Health* 1985; **75**: 1068-70.