J Epidemiol Community Health 2001;55:442–447

Recreation in coastal waters: health risks associated with bathing in sea water

M D Prieto, B Lopez, J A Juanes, J A Revilla, J Llorca, M Delgado-Rodríguez

Division of Preventive Medicine and Public Health, University of Cantabria, Santander, Spain
M D Prieto
B Lopez
J Llorca
M Delgado-Rodríguez

Department of Water Sciences and Environment, University of Cantabria
J A Juanes
J A Revilla

Correspondence to:
Dr Delgado-Rodríguez, Division of Preventive Medicine and Public Health, Department of Health Sciences, Edificio B-3, Paraje Las Lagunillas s/n, 23071-Jaén, Spain (mdelgado@ujaen.es)

Accepted for publication 14 November 2000

Abstract

***Study objective*—To find out whether bathing in sewage polluted waters implies a danger to bathers' health and to determine the best microbiological indicator to predict the relation between bathing and the appearance of some symptoms.**

***Design*—Cohort study.**

***Setting*—City of Santander (north of Spain).**

***Participants*—From the people going to four Santander beaches in the period from 1 July to 16 September 1998, a cohort of 2774 persons was recruited who agreed to participate in this study. Of those, 1858 successfully completed a follow up interview conducted in seven days. Respiratory, gastrointestinal, eye, and ear symptoms, and fever occurring during the seven day follow up were recorded.**

***Main results*—A total of 136 participants (7.5%) reported symptoms. Visitors reported experiencing symptoms with more frequency than residents. Incidence rates of gastrointestinal, cutaneous and high respiratory tract symptoms were higher in bathers, but the differences were not significant. Total symptoms were related with the amount of total coliforms, faecal coliforms, and faecal streptococci in the water. Gastrointestinal and skin symptoms kept a positive trend with the degree of water pollution by total coliforms in both crude and adjusted analyses. An increased risk was observed in 2500–9999 total coliforms per 100 ml, a figure over the proposed standard, although below the European Union mandatory limit.**

***Conclusions*—The results of this study suggest that total coliforms are the best predictors of the symptoms.**

(*J Epidemiol Community Health* 2001;**55**:442–447)

Most beaches and bathing areas are near cities. The dumping of urban and industrial waste waters into the sea, with their high level of pathogenic and other polluting agents, raises concern about its consequences for both health and ecology. The wide range of pathogenic micro-organisms in water and their low concentration make their determination difficult. Therefore, some indicator organisms used for water quality are to reflect the presence of pollution.

Wide ranging discrepancies exist in the results obtained after carrying out epidemiological studies to establish the possible relation between bathing and certain infections.[1 2] There is no agreement on which indicators are the best predictors for conditions related to bathing. Faecal coliforms,[3 4] enterococci,[5 6] and faecal streptococci[7 8] are the most often accepted bacteriological indicators. *Escherichia coli*[9] and staphylococci[10] have also been used.

The European Union Directive 76/160/EEC[11] sets out the limits of certain physical chemical and microbiological parameters in order to ensure that the environment and public health in bathing areas are protected throughout the European Community. Nevertheless, there are doubts as to whether this Community Directive should be applied in areas with very different environmental features and uses.[12]

The aims of this work are to find out whether bathing in sewage polluted waters implies a danger for bathers' health and to determine the microbiological indicator most clearly related to the symptoms produced by bathing.

Methods

The study was carried out in the summer of 1998 (from 1 July to 16 September) at four beaches of Santander (north of Spain).

The collection of water samples met the requirements established in the norms concerning the quality of bathing waters, maintaining the sampling points throughout the whole bathing season in an area with maximum density of swimmers and collecting the water 30 cm below the surface in a shallow about one metre deep. The four beaches were sampled from 1 July to 15 September, every Monday, Wednesday and Sunday, around 10 am. The samples were taken in sterile bottles, and kept in the dark inside isothermal bags during their immediate delivery to the laboratory. Sunday samples were kept refrigerated until they were processed within 24 hours of collection. In the same way other quality indicators were studied such as the presence of floating matter, turbidity and persistent foam.

Sample processing was carried out according to Directive 76/160/EEC.[11] The following bacterial indicators were analysed and quantified in colony forming units (CFU/100 ml): total coliforms, faecal coliforms, faecal streptococci, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. To achieve this we used the methodology and culture medium proposed in the prevalent norms[11] for this matter or, in the case of indicators not demanded by current legislation, the methods specified in the Standard Methods (1996).[13]

The epidemiological study was performed in two parts: survey on the beach and follow up. Both surveys were carried out by people trained by research staff. The first survey was

Table 1 Results of water analyses

Variable	Geometric mean	Maximum	Standards§ Guide	Mandatory
Total coliforms (CFU/100 ml)				
Sardinero 2	271.6	4 400	10 **(24.4)**	0 (0)
Sardinero 1	156.0	2 670	10 **(24.4)**	0 (0)
Bikini	623.7	6 400	22 **(53.7)**	0 (0)
Peligros*	792.5	20 000	22 **(57.9)**	1 (2.6)
Overall	375.0	20 000	64 **(39.8)**	1 (0.6)
Faecal coliforms (CFU/100 ml)				
Sardinero 2	96.4	1 500	19 **(46.3)**	0 (0)
Sardinero 1	45.8	1 464	14 **(34.1)**	0 (0)
Bikini	230.1	3 000	30 **(73.2)**	2 (4.9)
Peligros†	326.6	10 000	30 **(75.0)**	4 **(10.0)**
Overall	134.3	10 000	93 **(57.1)**	6 (3.7)
Faecal streptococci (CFU/100 ml)				
Sardinero 2	33.1	500	12 **(29.3)**	—
Sardinero 1	15.3	196	7 (17.1)	—
Bikini‡	81.1	1 040	22 **(55.0)**	—
Peligros¶	78.7	1 230	20 **(51.3)**	—
Overall	42.0	1 230	61 **(37.9)**	—
Staphylococcus aureus (CFU/100 ml)				
Sardinero 2	133.1	1 456		
Sardinero 1	128.5	4 500		
Bikini	246.0	2 400		
Peligros	122.2	1 700		
Overall	150.7	4 500		
Pseudomonas aeruginosa (CFU/100 ml)				
Sardinero 2	1.4	49		
Sardinero 1	1.4	15		
Bikini	2.0	27		
Peligros	2.8	1 430		
Overall	1.8	1 430		

*Losses in 3 samples. †Losses in 1 samples. ‡Losses in 1 samples. ¶Losses in 2 samples. §Number of samples (%) exceeding the guide and mandatory standards of EU microbiological quality requirements. In bold the percentage of measurements that do not comply with the EU Directives.

Table 2 General characteristics and risk of reporting any symptom during follow up

Variable	Total cases Number	%	p Value
Sex			
Male	751	7.7	
Female	1054	7.4	0.86
Age (y)			
0–9	214	9.3	
10–19	226	6.2	
20–29	319	10.0	
30–39	367	8.7	
40–49	282	6.7	
50–64	271	5.9	
⩾65	116	2.6	
No answer	10		
Trend			0.024*
Use of sunglasses			
Yes	703	8	
No	1099	7.3	0.59
Not available	3		
Exposure to sun			
No	163	10.4	
<15 min/day	681	6.8	
15–30 min	531	8.5	
>30 min	424	6.6	
Not available	6		
Trend			0.45
Sun protector			
No	288	6.9	
Once	659	5.6	
Twice	597	9.2	
More than twice	260	9.2	
Not available	1		
Trend			0.048*
To eat on the beach			
Yes	346	9.2	
No	1459	7.1	0.18
Residential situation			
Resident	959	5.8	
Holiday maker	607	9.9	
Day trippers	239	8.4	0.011*

*p values below 0.05. **p values below 0.01.

completed in situ on each beach. The survey was of family type: once a person was selected, everybody on the beach and living in the same home was interviewed. The surveys were done on the same days the water quality was analysed (Monday, Wednesday and Sunday) between 11.30 am and 3 pm so as to obtain a daily average of 15 people interviewed. Subjects were selected using a random route procedure in the beach areas closest to the water sample points. To ensure that any group of people situated anywhere on the beach would have the same likelihood of being surveyed within the pre-established daily route, interviewers stopped at preset regular times (initially 1 minute) and the person nearest the interviewer was asked to participate. To detect a relative risk = 2, with a level of significance = 0.05 and a statistical power = 0.8, if the exposure prevalence = 0.5 and the basal risk (according to other publications) = 0.03, 1628 people are needed. We assumed a 30% rate of drop out in the follow up in this kind of study. So the recruited sample should include 2325 people.

The follow up survey was carried out, mainly by telephone, within seven days after the interview on the beach. Exceptionally, whenever the surveyed person had no telephone, the follow up took place on the beach itself. The aim was to find out possible affections attributable to the use of the beach. They were asked about nausea, vomiting, diarrhoea, abdominal pain, fever (>38°C), skin irritation, itching, otitis, conjunctivitis, cold, and sore throat. The follow up was done by two people only, who were previously trained. All the questions regarding the outcome were always asked for in the same way. In case of doubt, they consulted with another researcher to maintain the same criteria. The interviewers did not know the results of the water analysis.

Data were obtained on sex, age, job, place of residence, marital status, personal history of allergy, eating habits, sun and sea bathing habits on the beach, and symptoms suffered during the week before the interview. People were unaware of the main objective of the research. They were told that the aim of the study was to improve the quality of the beach services.

The total number of surveyed people was 2774. Of these, 916 were lost during the follow up, and 53 people were excluded because of losses in the bathing variables. Thus leaving 1805 people (65.1% of the recruited population).

People were classified as swimmers and nonswimmers. Each swimmer was assigned the bacteriological density of the water sample collected the day they were interviewed on the beach. A subject was considered as a case if they developed symptoms during the follow up and if they had not reported any symptoms at the survey or if reported they were unrelated to the new ones.

A bivariate analysis was carried out to examine the relation between exposure (to bathing, water quality and other variables) and health conditions. Odds ratios (ORs) and their 95% confidence intervals have been estimated. The χ^2 or Fisher's test for homogeneity of proportions were used. The linear trend was examined for continuous variables.

Table 3 Symptom incidence rates by swim status (n=1805)

	Total (%)	Non-swimmers (%)	Swimmers (%)	p Value
At least one reported symptom	7.5	6.1	7.7	0.489
Gastrointestinal symptoms	2.0	0.5	2.3	0.117
Skin disease	2.3	1.9	2.4	0.811
Ear disease	0.6	0.9	0.5	0.336
Eye disease	1.0	1.4	0.9	0.464
Upper respiratory tract disease	2.5	1.9	2.6	0.814

p Value from Fisher's test among non-swimmers and swimmers.

A multivariate analysis was carried out by means of multiple logistic regression. This analysis was thoroughly used to evaluate the dose-response relation between the bacterial concentrations and the health problems, after adjusting for confounding factors. All the statistical analyses were performed using the BMDP statistical package (version Dynamic).

Results

Throughout the study period a total of 220 water samples were collected, equally distributed among the four beaches. The microbiological quality of the water notably varied from day to day. The average temperature of water during the study was 19.1 ± 1.1°C.

The European Community Directive establishes that 20% and 5% of samples of water must not exceed the guide and mandatory standards, respectively. The guide standard for total coliforms is 500/100 ml, 100/100 ml for both faecal coliforms and faecal streptococci. The mandatory standards for total coliforms and faecal coliforms are 10 000/100 ml and 2000/100 ml, respectively. There is not any mandatory standard for faecal streptococci. The water quality exceeds the guide standard value for total coliforms in 39.8% of the samples, for faecal coliforms in 57.1% of the samples, and for faecal streptococci in 37.9% of the samples (and does consequently not comply with the guide standards of the EU directive). The results obtained for each beach are shown in table 1. At the Bikini Beach the number of faecal coliforms in two samples (4.9%) was higher than the EU mandatory standard. At Peligros Beach one sample (2.6%) passed the mandatory standard for total coliforms and in four samples (10%) the results for faecal coliforms were higher than the EU mandatory standard. All beaches showed higher faecal streptococci values than the guide standard. Therefore, three of the studied beaches can be classified as relatively polluted, as over 20% of their samples were above the guide limits. Only one beach, Peligros, showed 5% of samples higher than the EU mandatory value for faecal coliforms and can therefore be classified as polluted.

Participants were mainly women (58.4%), with a mean (SD) age of 33.8 (18.7) years (range 0–98 years). They were mainly residents (53.1%) and holiday makers (33.6%), whereas day trippers were in a lower proportion (13.2%). Most participants were students (31.6%) and housewives (15.3%).

It was not possible to contact 913 of the recruited people; in 53 the information on bathing was lacking. In addition, seven were excluded because their data were missing. Comparing the group of participants and the group of drop outs there were no differences in gender distribution (p = 0.44). However, there were some differences in age (p = 0.004), and censal situation (p < 0.0001). Lost participants were older (mean (SD) age of 35.6 (18.4)), holiday makers (60%), and day trippers (16.6%).

In the follow up 136 people (7.5%) reported one or more symptoms. The frequency of symptoms were similar in both men and women and tended to decrease with age (p = 0.023) (table 2). An increasing trend in symptom frequency with time exposed to sun was not noted, but there was observed a weak trend with the number of times sun protector was applied (p = 0.048). Neither the use of sunglasses nor eating on the beach were related to symptom frequency. The rate of symptoms was greater for holidaymakers (9.9%) and day trippers (8.4%) than for residents (5.8%) (p = 0.011).

Bathing and non-bathing people were compared. Among non-bathers there were more

Table 4 Variables linked to bathing and risk of reporting any symptom

Variable	Total cases Number	Total cases %	p Value	OR (1) (95% CI)
Head immersion*				
Non-swimmers	214	6.1		1
Yes	1261	7.4		0.96 (0.51, 1.8)
No	328	9.1	0.38	1.44 (0.72, 2.87)
Seabathing				
No	214	6.1		1
<15 min	558	7.0		1.03 (0.53, 1.99)
15–30 min	506	6.9		1.01 (0.51, 2.00)
>30 min	527	9.3		1.23 (0.62, 2.45)
Trend in swimmers			0.16	(p=0.456)
Total coliforms (CFU/100 ml)†				
Non-swimmers	214	6.1		1
0–499	859	5.6		0.78 (0.41, 1.50)
500–2499	500	9.2		1.40 (0.71, 2.73)
2500–9999	132	15.2		**2.57 (1.19, 5.57)**
⩾10 000	33	6.1		0.74 (0.15, 3.66)
Trend in swimmers			0.0001**	(p=0.00014**)
Faecal coliforms (CFU/100 ml)‡				
Non-swimmers	214	6.1		1
0–99	649	6.3		0.88 (0.45, 1.71)
100–499	510	7.5		1.04 (0.53, 2.06)
⩾500	415	10.1		1.58 (0.8, 3.12)
Trend in swimmers			0.026*	(p=0.017*)
Faecal streptococci (CFU/100 ml)¶				
Non-swimmers	214	6.1		1
0–39	641	7.2		0.95 (0.49, 1.84)
40–119	382	6.3		0.94 (0.46, 1.91)
120–500	358	9.2		1.39 (0.69, 2.79)
>500	177	11.3		1.72 (0.77, 3.84)
Trend in swimmers			0.096	(p=0.043*)
Staphylococcus aureus (CFU/100 ml)				
Non-swimmers	214	6.1		1
0	108	6.5		0.67 (0.25, 1.82)
1–99	402	6.7		0.87 (0.43, 1.77)
100–249	537	10.2		1.50 (0.78, 2.87)
⩾250	544	6.2		0.9 (0.45, 1.77)
Trend in swimmers			0.9	(p=0.49)
Pseudomonas aeruginosa (CFU/100 ml)				
Non-swimmers	214	6.1		1
No	1100	7.3		1.00 (0.54, 1.88)
Yes	491	8.8	0.4	1.29 (0.65, 2.55
Floating matter				
Non-swimmers	214	6.1		1
No	1204	7.7		1.13 (0.61, 2.10)
Yes	387	7.8	0.69	0.80 (0.38, 1.71)
Foam				
Non-swimmers	214	6.1		1
No	1276	8.1		1.12 (0.61, 2.09)
Yes	315	6.3	0.4	0.81 (0.38, 1.73)

(1) Adjusted for sex, age, personal history of allergy, beach, eating on beach, eating on restaurant, sun exposure, sun protector, and use of sunglasses. *Missing data: 2. †Missing data: 67. ‡Missing data: 17. ¶Missing organism exposure data in 33 cases. *p values below 0.05. **p values below 0.01.

Table 5 Variables linked to bathing and risk of gastrointestinal symptoms

Variable	Total cases Number	%	p Value	OR (1) (95% CI)
Seabathing				
No	214	0.5		1
<15 min	547	1.8		3.01 (0.38, 23.9)
15–30 min	506	2.6		3.66 (0.46, 28.9)
>30 min	538	2.5		3.25 (0.40, 26.5)
Trend in swimmers			0.45	(p=0.404)
Total coliforms (CFU/100 ml)				
Non-swimmers	214	0.5		1
0–499	558	1.5		2.35 (0.30, 18.4)
500–2499	506	2.2		3.27 (0.41, 26.4)
2500–9999	132	6.8		**10.3 (1.42, 85.7)**
≥10 000	33	0.0		0.0
Trend in swimmers			0.004**	(p=0.015*)
Faecal coliforms (CFU/100 ml)				
Non-swimmers	214	0.5		1
0–99	649	1.8		3.02 (0.38, 23.8)
100–499	510	1.8		2.49 (0.30, 20.3)
≥500	415	3.4		4.83 (0.61, 38.3)
Trend in swimmers			0.13	(p=0.23)
Faecal streptococci (CFU/100 ml)				
Non-swimmers	214	0.5		1
0–39	641	1.6		2.22 (0.28, 17.9)
40–119	382	2.1		3.66 (0.45, 30.0)
120–500	358	2.5		4.01 (0.49, 32.9)
>500	177	5.1		7.20 (0.84, 61.9)
Trend in swimmers			0.042*	(p=0.052)
Staphylococcus aureus (CFU/100 ml)				
Non-swimmers	214	0.5		1
0	108	1.9		1.75 (0.15, 20.6)
1–99	402	2.2		3.03 (0.37, 24.7)
100–249	537	3.4		5.11 (0.66, 39.4)
≥250	544	1.3		2.03 (0.24, 16.9)
Trend in swimmers			0.43	(p=0.9)
Pseudomonas aeruginosa (CFU/100 ml)				
Non-swimmers	214	0.5		1
No	1100	1.9		2.94 (0.39, 22.4)
Yes	491	3.1	0.072	4.22 (0.53, 33.4)
Floating matter				
Non-swimmers	214	0.5		1
No	1204	2.2		3.64 (0.48, 27.4)
Yes	387	2.6	0.19	2.16 (0.26, 18.2)
Foam				
Non-swimmers	214	0.5		1
No	1276	2.1		3.24 (0.43, 24.4)
Yes	315	2.9	0.16	3.56 (0.43, 29.6)

(1) Adjusted for sex, age, personal history of allergy, beach, and eating on beach. Missing data as for table 4. *p values below 0.05. **p values below 0.01.

women (56.2% versus 74.8%). They were older (mean (SD) age 32.7 (18.3) versus 41.7 (19.9) years) and most of them were at the Bikini and Sardinero 2 beaches. These differences were considered in multivariate analyses. There were also differences in the use of sunglasses, exposure to sun and eating on the beach. There was also a control for these variables in multivariate analysis of the symptoms that could have had any relation with them.

The incidence rate of each symptom is shown in table 3. Incidence was higher in swimmers for gastrointestinal, cutaneous and upper respiratory tract symptoms, but the differences were not significant. There were no differences in the incidence between those who submerged their head in the water (7.4%) and those who did not (9.1%) (p = 0.297).

Symptom incidence increased with the amount of total coliforms (table 4) (p = 0.0001). This trend was also observed (p = 0.00014) after adjusting for sex, age, personal history of allergy, beach, eating on the beach, sun exposure, sun protection, and use of sunglasses. For 2500–9999 total coliforms/100 ml in the water the risk was significantly higher in swimmers than in non-swimmers (OR = 2.57; 95% CI = 1.19, 5.57). In swimmers it was also possible to observe positive trends with the number of faecal coliforms and of faecal streptococci in water; however, an increased risk in swimmers versus non-swimmers was not found. Symptoms were unrelated to the remaining indicators, neither with the presence of floating matter nor foam in the water. The length of bathing or head immersion did not produce a higher risk of symptoms in both crude and adjusted analyses.

Gastrointestinal symptoms incidence increased with total coliforms and faecal streptococci amounts in both crude and adjusted analyses (table 5). For 2500–9999 total coliforms/100 ml in the water the risk was significantly higher in swimmers than in non-swimmers (OR = 10.3; 95% CI = 1.42, 85.7). Skin symptoms only increased with total coliforms (table 6). There was not any significant relation with other symptoms.

Discussion

At Sardinero 1 and 2 beaches there is not any faecal contamination, although some accidental, non-official discharges might have happened. The beaches of Peligros and Bikini are inside the bay of Santander, which is under the influence of some discharges of the combined sewer systems of the south of the city (about 160 000 inhabitants). There is no diffuse contamination at any of the four beaches. The higher contamination found at Bikini and Peligros beaches can be attributed to the existence of some sewer systems near them.

This study may have three limitations. Firstly, the high number of losses of follow up. Although there was a very high percentage of drop outs, mainly in holiday makers (more difficult to contact them by phone), a relation between censal situation and seabathing was not found (p = 0.47); therefore, this cannot be a confounding factor. Secondly, both an interviewer effect and a response effect might occur; however, the frequency of symptoms reported by phone are lower than those reported in other studies.[3 4 6–8] This fact together with blindness of interviewers regarding the results of water analysis, suggest that the above mentioned effects can be discarded. Finally, it is certain that only one measure of water quality may not accurately reflect the true exposure. This would produce a non-differential misclassification, which in most cases would lead to an underestimation of the effect of water quality on illness.[14] It may obscure some relations, but if one has been found, the true association is actually stronger. Besides, on every Monday during the study period another water sample was taken at 2 pm. A regression analysis between the results of the water analysis used as exposure in the present study and the other one yielded correlation coefficients higher than 0.7 for all the micro-organisms.

The rates found in this study are lower than those found in Israel,[6] England[4 7 8 15] and Sydney.[3] This discrepancy cannot be explained by differences in the study design alone, because apart from the experiments carried out in England.[4 7 8] the other studies applied a similar methodology to ours. There are not any

Table 6 Variables linked to bathing and risk of skin symptoms

Variable	Total cases Number	%	p Value	OR (1) (95% CI)
Seabathing				
No	214	1.9		1
<15 min	558	2.0		1.05 (0.33, 3.41)
15–30 min	506	2.4		1.39 (0.43, 4.55)
>30 min	527	2.8		1.60 (0.49, 5.30)
Trend in swimmers			0.35	(p=0.292)
Total coliforms (CFU/100 ml)				
Non-swimmers	214	1.9		1
0–499	859	1.7		0.96 (0.31, 3.01)
500–2499	500	2.6		1.64 (0.51, 5.32)
2500–9999	132	3.8		2.36 (0.60, 9.39)
⩾10 000	33	6.1		4.13 (0.64, 26.6)
Trend in swimmers			0.046*	(p=0.024*)
Faecal coliforms (CFU/100 ml)				
Non-swimmers	214	1.9		1
0–99	649	2.2		1.18 (0.38, 3.73)
100–499	510	2.2		1.16 (0.35, 3.82)
⩾500	415	2.9		1.71 (0.52, 5.65)
Trend in swimmers			0.47	(p=0.36)
Faecal streptococci (CFU/100 ml)				
Non-swimmers	214	1.9		1
0–39	641	2.8		1.46 (0.47, 4.51)
40–119	382	1.6		0.88 (0.24, 3.22)
120–500	358	2.2		1.27 (0.36, 4.44)
>500	177	3.4		2.05 (0.51, 8.29)
Trend in swimmers			0.79	(p=0.87)
Staphylococcus aureus (CFU/100 ml)				
Non-swimmers	214	1.9		1
0	108	0.9		0.42 (0.04, 4)
1–99	402	2.7		1.37 (0.42, 4.50)
100–249	537	2.4		1.32 (0.41, 4.23)
⩾250	544	2.4		1.32 (0.42, 4.21)
Trend in swimmers			0.76	(p=0.42)
Pseudomonas aeruginosa (CFU/100 ml)				
Non-swimmers	214	1.9		1
No	1100	2.5		1.34 (0.45, 3.98)
Yes	491	2	0.73	1.10 (0.32, 3.77)
Floating matter				
Non-swimmers	214	1.9		1
No	1204	2.3		1.28 (0.43, 3.78)
Yes	387	2.6	0.86	1.30 (0.35, 4.83)
Foam				
Non-swimmers	214	1.9		1
No	1276	2.8		1.48 (0.51, 4.34)
Yes	315	0.6	0.062	0.31 (0.05, 1.77)

(1) Adjusted for sex, age, personal history of allergy, beach, sun exposure, and sun protector. Missing data as for table 4. *p values below 0.05. **p values below 0.01.

KEY POINTS

- The risk of health problems associated with swimming is related to the microbiological quality of the water.
- This risk also exists in those bathing waters meeting the bacteriological criteria of the 76/160 Directive.
- The most commonly encountered illnesses in swimmers were of upper respiratory tract, skin, and gastrointestinal disease.

striking differences in the degree of water pollution that could explain the difference, except for a higher pollution at the beaches of Sydney. Nevertheless, at Hong Kong beaches,[9 16] with higher level of pollution than in our study, the observed rates were lower.

The rates are similar to those obtained in studies carried out in USA,[5] France,[17] and Canada,[18] although the incidence rates among swimmers are higher in our study, showing a smaller difference between those who bathe and those who do not. Because of this there are no significant differences between these two groups, although they have been observed in other studies.[3 5 9 15 16 18]

These discrepancies from those studies made in other countries can be attributed to three facts. Firstly, differences in water quality, as we have explained before. However, these differences cannot explain the contradictions we have found. Secondly, they can, on the other hand, be attributed to differences in bathing characteristics (duration, head immersion, etc). Regarding head immersion, our results differ from those obtained in other studies[17–20]: we have not found differences for any of the analysed symptoms between those who submerge their head and those who do not. In this way, we have considered swimmers all those people who get into water, both either with or without head immersion. We have not got enough information about the duration of the bathe in other studies, apart from the studies of England[4 7 8] where the duration is shorter than here. But in any case, we did not find differences in our study between the symptoms and the duration of the bathe. Finally, it can also be attributed to people's different susceptibility. This can vary from one country to another. Even more, the group of people who take part in each study can be different, as it happened in studies with volunteers carried out in England,[4 7 8] because these people are usually healthier. However, in these studies the rates obtained are higher. Another point favouring this hypothesis is that there are significant differences in our study between visitors and residents. The only Spanish study[19] available was done on the Mediterranean coast (southern Spain) and it shows higher rates. This result can be explained by the different applied methodology, by the higher temperature of the Mediterranean water, which changes the characteristics of bathing, and finally by a higher percentage of foreigners (11% versus 1.6%).

Furthermore, only those bathers exposed to the highest concentrations of exposure showed a statistically significant increase in the risk of acquiring symptoms in relation to non-bathers. An increase in the risk of gastrointestinal symptoms was also noted. Just one figure of coliforms is over the guide standard proposed, but below the mandatory limit of the EU. A threshold was not noticed for the rest of the bacterial indicators, but there was an increase in morbidity with the number of faecal coliforms and faecal streptococci. There are differences among the different studies about which micro-organism should be used as an indicator of health risk in swimmers. Our results suggest that the count of total coliforms is the best predictor of the analysed symptoms. These results differ from those found in other studies in which faecal coliforms[3] or staphylococci[9] were the best predictors. Moreover, we should say that in these studies no comparison with total coliforms was made, so that we cannot say they are worse indicators. Besides, a relation between gastrointestinal and skin symptoms and the degree of pollution by total coliforms was observed. This is another reason why total coliforms should be used as indicators of morbidity risk.

There is evidence in our study that the risk of gastrointestinal symptoms in swimmers is higher than in non-swimmers. Different studies relate gastrointestinal symptoms to pollution by faecal streptococci[7 8] and enterococci,[5] and furthermore, they show that the risk is detectable at extremely low levels of pollution. However, in this study, although there is a trend towards an increase in morbidity, a threshold value for faecal streptococci was not found, although 37.9% of samples shown >100 faecal streptococci/100 ml.

Regarding skin symptoms, no significant differences between swimmers versus non-swimmers were found. These results agree with those reported in the English study,[4] although they differ from others.[9 16–18] Notwithstanding this, we have reported an increase of skin symptoms with total coliforms, not observed in other studies. A relation between upper respiratory tract disease and faecal streptococci or between ear disease and faecal coliforms was not observed. These results differ from those obtained in England.[4] We should bear in mind that the lack of relation between the indicators and some symptoms, found by other authors, can be the consequence of the misclassification bias that can appear in this type of studies.

The results of this study suggest that the risk of health problems associated with swimming is related to the microbiological quality of the water. Total coliforms are the best predictors of the symptoms. A positive trend has been found in waters meeting the bacteriological criteria of the 76/160 Directive; if these results are confirmed in future studies, they should be taken into account in establishing recommended levels. Our results highlight the fact that using the same standard for all countries may not be valid, as the different degrees of water pollution and the different susceptibility of the people of each country should be taken into consideration.

The authors would like to thank the Regional Health Laboratory for providing assistance with microbiological analysis.

Funding: this work was supported by a grant from the Marcelino Botin Foundation.
Conflicts of interest: none.

1 Saliba LJ, Helmer R. Health risks associated with pollution of coastal bathing waters. *World Health Stat Q* 1990;**43**:177–87.
2 Prüss A. Review of epidemiological studies on health effects from exposure to recreational water. *Int J Epidemiol* 1998;**27**:1–9.
3 Corbett SJ, Rubin GL, Curry GK, *et al*. The health effects of swimming at Sydney beaches. *Am J Public Health* 1993;**83**:1701–6.
4 Fleisher JM, Kay D, Salmon RL, *et al*. Marine waters contaminated with domestic sewage: nonenteric illnesses associated with bather exposure in the United Kingdom. *Am J Public Health* 1996;**86**:1228–34.
5 Cabelli VJ, Dufour P, McCabe LJ, *et al*. Swimming-associated gastroenteritis and water quality. *Am J Epidemiol* 1982;**115**:606–16.
6 Fattal B, Peleg-Olevsky E, Agursky T, *et al*. The association between seawater pollution as measured by bacterial indicators and morbidity among bathers at Mediterranean bathing beaches of Israel. *Chemosphere* 1987;**16**:565–70.
7 Fleisher JM, Jones F, Kay D, *et al*. Water and non-water-related risk factors for gastroenteritis among bathers exposed to sewage-contaminated Marine Waters. *Int J Epidemiol* 1993;**22**:698–708.
8 Kay D, Fleisher Jm, Salmon RL, *et al*. Predicting likelihood of gastroenteritis from sea bathing: results from randomised exposure. *Lancet* 1994;**344**:905–9.
9 Cheung WHS, Chang KCK, Hung RPS, *et al*. Health effects of beach water pollution in Hong Kong. *Epidemiol Infect* 1990;**105**:139–62.
10 Seyfried PL, Tobin RS, Brown NE, *et al*. A prospective study of swimming-related illness. II. Morbidity and the microbiological quality of water. *Am J Public Health* 1985;**75**:1071–5.
11 Commission of the European Communities. Council directive of 8 December 1975 concerning the quality of bathing water (76/160/EEC). *Offical Journal of the European Community* 1976;**L/31**:1–7.
12 WHO/PNUMA. *Epidemiological studies related to environmental quality criteria for bathing waters, shellfish-growing waters and edible marine organisms.* Final report on project on relationship between microbial quality of coastal water and rotavirus-induced gastroenteritis among bathers. Mediterranean Action Plan Tecnical Report Series no 46. Athens: UNEP, 1991.
13 Eaton AD, Clesceri LS, Greenberg AE. *Standard methods for the examination of water and wastewater.* 19th ed. Washington (DC): American Public Health Association, 1995.
14 Fleisher JM. The effects of measurement error on previously reported mathematical relationships between indicator organism density and swimming-associated illness: a quantitative estimate of the resulting bias. *Int J Epidemiol* 1990;**19**:1100–6.
15 Balarajan R, Sonai Raleigh V, Yuen P, *et al*. Health risks associated with bathing in sea water. *BMJ* 1991;**303**:1444–5.
16 Kueh CSW, Tam T-Y, Lee T, *et al*. Epidemiological study of swimming-associated illnesses relating to bathing-beach water quality. *Water Science and Technology* 1995;**31**:1–4.
17 Foulon G, Maurin J, Nguyen Ngoc Quoi, *et al*. Étude de la morbidité humaine en relation avec la pollution bactériologique des eaux de baignade en mer. Étude préliminaire. *Revue Française des Sciences de l'eau* 1983;**2**:127–43.
18 Seyfried PL, Tobin RS, Brown NE, *et al*. A prospective study of swimming-related illness. I. Swimming-associated health risk. *Am J Public Health* 1985;**75**:1068–70.
19 Mujeriego R, Bravo JM, Feliu MT. Recreation in coastal waters: public health implications. In: Journées d'Études dur les Pollutions Marines. Cannes: CIESM, 1982:585–94.
20 Brown JM, Campbell EA, Rickards AD, *et al*. Sewage pollution of bathing water. *Lancet* 1987;ii:1208–9.