Morbidity among bathers exposed to polluted seawater
A prospective epidemiological study

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Summary
As the first phase of a major programme to develop epidemiologically derived recreational water quality criteria for South Africa, a preliminary epidemiological-microbiological study was conducted in Cape Town during February and March 1990. Serial trials were carried out at a clean and at a relatively polluted beach over weekends. Participants were recruited at the beach, at which time information on swimming status and sociodemography was obtained. This provided for a beach-going but non-swimming control group. Symptoms which developed subsequent to the beach visit were obtained by follow-up telephone interviews conducted 3 - 4 days later. Water samples collected on trial days both before and during maximum swimming activity, were analysed for enterococci, faecal coliforms, staphylococci, coliphages and F-male-specific bacteriophages.

Significant differences in the indicator levels at the beaches were observed. An excess in gastrointestinal, respiratory and skin symptoms were found among swimmers relative to non-swimmers at the polluted beach. Although not statistically significant, the results are suggestive of a relationship between swimming-associated illness and water quality. The study demonstrated the feasibility of the methodology and the results of the overall programme will form the basis for the development of epidemiologically derived recreational water quality criteria for South African beaches.

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Potentially contractable diseases from swimming at marine bathing beaches subject to sewage pollution include gastro-enteritis, respiratory, ear, eye, and skin infections, hepatitis A, cholera and typhoid fever. There have been virtually no reported outbreaks of swimming-associated, pollution-related disease at marine beaches during the past 3 decades, although there have been a number of such outbreaks associated with the consumption of raw shellfish. However, the results of prospective epidemiological studies conducted in different parts of the world have shown an increased risk of infection associated with direct contact recreation (for example, swimming, diving, surfing).

At beaches considered acceptable for swimming according to local guidelines and standards, the most frequent and, in most cases, the only illness found to be both swimming-associated and sewage pollution-related, was an acute but relatively benign gastro-enteritis. Differences in disease rates at equivalent enterococcal (faecal indicator) densities have been documented among various population groups. These are thought to reflect differing levels of immunity. For instance, Cabelli found that the swimming-associated acute gastro-enteritis rates were lower in Egypt, where environmental sanitation is less developed, than in the USA.

As a result of the studies conducted in the USA and Egypt (and more recently France), relationships have been determined between the rates of swimming-associated gastro-enteritis and the mean enterococcus levels in the water. In addition, in 1986 the US Environmental Protection Agency accepted the USA guidelines and standards. However, in South Africa no epidemiological studies have been carried out to assess the health risk associated with exposure to polluted seawater. The present water quality guidelines are based on faecal coliform densities and are not derived from epidemiological data.

A major programme has consequently been launched to develop appropriate water quality guidelines and standards pertaining to waste-water and storm-water management in coastal areas. In parallel with sanitary surveys for the detection of sources and factors affecting variability in indicator organisms and pathogens, prospective epidemiological studies are being conducted over a number of years at various beaches and tidal pools in the Cape Peninsula.

This report presents the results of the first phase of the programme, a preliminary epidemiological study carried out at two beaches in Cape Town during February and March 1990. It had the following objectives: firstly, to test the prospective epidemiological-
methods under South African conditions; and, secondly, to obtain preliminary data on the nature of the potential health risk to swimmers associated with marine waste-water pollution.

Methods
A series of discrete, prospective trials was carried out at a relatively clean and a moderately polluted beach over weekends, following methodology similar to that devised by Cabelli in the USA.

Description of beaches
Two beaches, approximately comparable in respect of oceanographic and meteorological factors (for example, wind speed, water temperature) and the sociodemographic features of beach users (ethnic composition, size and composition of family groups present) were selected. Examination of potential pollution sources present at the beaches, and assessment of the available microbiological data, revealed that the two beaches differed significantly in respect of water quality.

Both beaches are situated on the Atlantic coast, where sea-surface temperatures in the summer range from 10 to 18°C. Potentially significant sources of pollution at beach 1 (moderately polluted) include septic tank overflows, stormwater run-off, and faeces-contaminated river water.

Wastes from an informal settlement area along the river are thought to be a significant source of human faecal wastes.

Study population
Individuals present at the beach in family groups were designated as swimmers or non-swimmers. 'Swimmers' were defined as those individuals who entered the water beyond the waist. 'Non-swimmers' were defined as those individuals who entered the water up to the waist, or who did not enter the water at all. This allowed for a beach-going but non-swimming control group, and minimised the bias from non-swimming-associated illnesses.

Exposure information
A workshop was held to train the postgraduate students used to conduct beach interviews. Interviewers regularly rotated between beaches so as to minimise sources of beach/interviewer bias. Interviews were conducted with family groups to obtain information on individuals' swimming activities, socio-economic/demographic characteristics and other relevant data.

A spokesperson was nominated by the family to answer questions relevant to the family group as a whole (for example, home address and time of arrival). In the majority of cases, this was the mother. Where possible, the respondent also answered questions about individual family members' swimming activities, especially in the case of very young children.

Respondents were questioned in detail about whether or not family members had entered the water that day, or who had entered the water later on in the day, or subsequent to the day of the beach interview.

Because of the relatively small size of the study population in this study, for ease of analysis, symptoms were grouped in the following way: gastrointestinal (diarrhoea, vomiting, stomach ache and nausea), respiratory (sore throat, cough, cold, runny/stuffy nose), and selected other symptoms.

Water quality monitoring
Water samples were collected on trial days, at three different locations at each beach, both before and during maximum swimming activity (mid-morning and early afternoon). Water samples were collected in sterile sampling bottles, stored at 5 - 10°C and processed within 6 hours of collection. Indicator organisms measured included: enterococci, faecal coliforms, coliphages, staphylococci and F-male-specific bacteriophages.

Both faecal coliform bacteria and enterococci were analysed using standard membrane filtration methods. The presence of Staphylococcus aureus was determined using the Baird-Parker agar and a commercial kit for identification (Mastastaph RST 101, Davis Diagnostic). Coliphages were detected by means of a plaque assay using Escherichia coli strain C as a host. The direct plaque assay for coliphages in 100 ml water samples was applied in accordance with Grabow and Cubrough. Male-specific bacteriophages were assayed according to the method of Debertolomeis and Cabelli.

Results
Exclusions
The study design required the exclusion from the study of the following individuals: (i) those who swam during the 5 days before the beach interview, in the interval between the beach interview and the follow-up telephone interview, or at another site on the day of the interview; (ii) families who could not be reached by telephone; and (iii) individuals who exhibited certain illness symptoms on the day of the beach interview.

Thus, the potential population recruited for the study was 1 024 persons, of whom 733 comprised the final study population, categorised as swimmers and non-swimmers at the two beaches. The sex and age distribution by beach was approximately similar, and there

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**TABLE I. Outcome information**

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td>Diarrhoea</td>
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<tr>
<td>Vomiting</td>
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<tr>
<td>Stomach ache</td>
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<tr>
<td>Nausea</td>
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<td>Sore throat</td>
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<td>Cough</td>
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<tr>
<td>Cold</td>
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<tr>
<td>Runny/stuffy nose</td>
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<tr>
<td>Wheezing, tight chest</td>
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<tr>
<td>Earache/runny ears</td>
</tr>
<tr>
<td>Sore/itchy eyes</td>
</tr>
<tr>
<td>Fever</td>
</tr>
<tr>
<td>Skin rash/itchy skin/welts</td>
</tr>
<tr>
<td>Allergy</td>
</tr>
<tr>
<td>Headache</td>
</tr>
<tr>
<td>Backache</td>
</tr>
<tr>
<td>Sunburn</td>
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<tr>
<td>Disabling</td>
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<tr>
<td>Medication taken</td>
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<td>Medical help sought</td>
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</tbody>
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listed in Table I. They also were asked whether or not they had entered the water later on in the day, or subsequent to the day of the beach interview.
was evidence of a bimodal age distribution, confirming the predominance of young adults with children sampled at the beaches. About 30% of the study population comprised children under the age of 10 years. Overall, about two-thirds of the study population was classified as swimmers, a value that is consistent with that from USA studies.

Swimmers tended to be younger than non-swimmers (62% versus 39% respectively under 25 years of age). While there was a slightly larger proportion of male swimmers than female swimmers (54.5% versus 45.5%), among the non-swimmers there was a higher proportion of females than males (64% versus 36%). In Table II the numbers of swimmers and non-swimmers by beach are tabulated for various subgroups.

Symptom rates
Comparative symptom rates by beach and swimming status are given in Fig. 1 and risk ratio estimates for swimmers and non-swimmers are given in Table III.

Microbiological measurements obtained at the beaches are given in Table IV (insignificant densities of \textit{S. aureus} and bacteriophages were detected and are therefore not included in the table).

The differences in microbiological water quality at the two beaches were statistically highly significant (median test performed, \( P < 0.0001 \)), and as indicated, beaches differed as regards both the density of faecal coliforms and enterococci. The insignificant densities of \textit{S. aureus} detected at the beaches suggest that bather-to-bather pollution is probably not of major importance in this study.

The rates for gastro-intestinal, respiratory and skin symptoms (but not other symptoms) were appreciably higher for swimmers than non-swimmers at the more polluted beach (beach 1) than the less polluted beach (beach 2). These differences, however, were not statistically significant, either for children (< 10 years of age) or for adults.

Discussion
The higher rate of respiratory symptoms noted among swimmers relative to non-swimmers at beach 1 was of some interest, as this has not been demonstrated (as far as we are aware) by workers who have examined the relationship between sewage-polluted marine waters and illness symptoms in bathers. The presence of other (unmeasured) influencing factors such as algae (dinoflagellate populations) in the water should be investigated further. Another explanation is that the sources of contamination were a more direct input from the bathers themselves, or more likely, from the sanitary facilities at the informal settlements. This explanation is more consistent with known sources of contamination at beach 1, and our inability to recover coliphases and F-phages from the water. These bacteriophages are sewage indicators, and their absence at the less polluted beach (beach 2). This seeming anomaly was also seen in the 1973 study in New York City. The relatively higher rates of respiratory symptoms reported at beach 2 may reflect the presence of a respiratory disease outbreak in this community. The fact that rates were higher among non-swimmers may possibly be attributed to the fact that mothers who perceived that their children were ‘unwell’ were more likely to restrict them from swimming, although overt symptoms were not necessarily present at the time of the beach interview. In light of the relatively small numbers, however, these findings should not be over-interpreted.
In conclusion, this study has shown that a prospective epidemiological-microbiological study design methodology can be successfully applied in the South African situation. The lack of statistical significance indicates that larger samples (± 4,000 individuals) are needed to detect real differences, especially since overall symptom rates for gastro-intestinal illness are relatively low. At this stage, the applicability and predictability of the data obtained at beach 1 are not known, owing to the rather ill-defined nature of the faecal sources and the relatively small size of the populations who contribute to them.

The results are nevertheless suggestive of some relationship between swimming-associated illness and water quality (findings are consistently in the same direction), and will form the basis for a comprehensive epidemiological and microbiological monitoring programme at Cape beaches in the 1990 - 1991 bathing season. Ultimately it is hoped to conduct a 'before-after' study at beach 1 where a marine pipeline is due to be constructed in the future.

REFERENCES


Environmental health risks of toxic waste site exposures — an epidemiological perspective

Y. E. R. VON SCHIRNDING, R. I. EHRLICH

Summary

A general account is given of the problems of assessing the impact of human exposure to toxic waste sites, including the identification of truly exposed populations and of exposure pathways. Epidemiological studies of populations at risk are briefly reviewed and methodological problems summarised. These include the use of relatively weak study designs, inadequate exposure assessment and recall biases associated with symptom reporting among anxious residents living in the vicinity of waste sites. In South Africa, health risks associated with exposure to toxic waste sites need to be viewed in the context of current community health concerns, competing causes of disease and ill-health, and the relative lack of knowledge about environmental contamination and associated health effects. A nonspecific deterioration of health and well-being is more likely to result from waste site exposures than is overt clinical disease. Socially acceptable policies and controls may have to be based on criteria other than demonstrable ill-health.

Detailed inventories and registries of the nature of disposed materials need to be maintained, sites of properly controlled disposal in the past identified and selective environmental monitoring conducted. Epidemiological studies may be justified in situations where exposures well in excess of acceptable norms are demonstrated. An integrated national waste management policy for the country is urgently needed.

REFERENCES