

APPENDIX E. EPIDEMIOLOGICAL AND OTHER STUDIES RELATED TO OCEAN WATER AND FRESH WATER RECREATION

E.1 OCEAN WATER

This section presents a brief overview of epidemiological studies of swimmers and other studies in ocean water and fresh water.

Cabelli, 1983

This study evaluated health effects of microbiological contamination on recreational use of marine waters and developed US EPA criteria, based on the mathematical relationship of the swimming-associated rate of gastrointestinal symptoms among bathers to the quality of their water. Enterococci were used as a fecal indicator.

The data, based on 26,686 subjects who responded to follow-up interviews, were collected in an epidemiological research program of the US EPA from beaches in three areas: (1) New York City, New York, in 1972, 1973 and 1974, 15,882 respondents; (2) Lake Pontchartrain, New Orleans, Louisiana, in 1977 and 1978, 6,751 respondents; and (3) Boston Harbor, Massachusetts, in 1978, 4,053 respondents. Water samples were collected from chest-high depths.

The recommended health effects criterion for marine recreation waters was described by the equation

$$\log X = 0.0456Y + 0.677 \quad \text{[Equation 1]}$$

where:

X is the mean enterococcus density per 100 ml., and

Y is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms).

Subsequent to the Cabelli study, US EPA developed guidance (US EPA, 1986) for marine recreational waters. This guidance is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 19 cases/1000 swimmers, developed from the Cabelli study. The rate of 19 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml. Its steady state geometric mean indicator density at the acceptable rate is 35 enterococci per 100 ml. An acceptable one-time exposure is 104 enterococci per 100 ml.

Cheung *et al.*, 1993

This study of bathers in Hong Kong found *E. coli* to be the best indicator of illness.

Corbett et al., 1993

This study found fecal coliforms to be the best indicator of health effects among Australian swimmers, better than fecal streptococci.

Fleisher et al., 1993

These authors found no difference in health effects between British bathers and non-bathers at fecal streptococci densities less than 40 per 100 ml.

Fleisher et al., 1996

This study of British swimmers found thresholds for febrile respiratory effects and ear effects at 60 and 100 fecal streptococci per 100 ml., respectively.

Kay et al., 1994

In a randomized experimental epidemiological study in which British swimmers were assigned to exposed or unexposed groups, fecal streptococci were the best predictor of gastroenteritis effects. The threshold for GI effects was 33 fecal streptococci per 100 ml.

Haile et al., 1996

This study evaluated health effects of microbiological contamination on recreational use of beaches at Santa Monica Bay in southern California, with attention to proximity of swimmers to large drains that empty onto the beaches. Total coliform, fecal coliform, enterococci, and *E. coli* were used as indicator organisms. The data, collected in 1995 and based on 13,278 subjects who responded to follow-up interviews, were collected at various distances from beach drains: 0, 100 yards downcoast, 100 yards upcoast, and 400 yards upcoast in three different areas: (1) Santa Monica Beach near Ashland Avenue, Will Rogers Beach at Santa Monica Canyon, and Surfrider Beach near Malibu Creek, respondents. Water samples were collected from ankle-high depths.

The authors concluded that swimming in (or near) storm drains resulted in a higher risk of gastrointestinal and respiratory illness, compared to swimming at a distance (~ 400 meters) from those drains. These authors considered the best predictor of swimming-related illness to be the ratio of total coliform organisms/fecal coliform organisms when this ratio was less than 5, when the total coliform level was greater than 5000 per 100 ml. Subsequent analyses (Haile and Witte, undated) showed increased illness when the ratio was lower (e.g., as low as 10 to 18), and when the total coliform level was greater than 1,000 per 100 ml.

Prüss, 1998

This evaluation of health risks associated with poor microbiological quality of recreational water reviews 22 epidemiological investigations, including 15 studies of marine waters and one study of fresh and marine waters.

Spear et al., 1996

The SWRCB (1995a) identified the choice of indicator organism (*i.e.*, coliform vs. enterococcus) for the water-contact bacterial standard and increased stringency of the water-contact fecal coliform standard as an issue to be addressed in its triennial review of the Ocean Plan. The SWRCB in 1990 required dischargers, if ordered by Regional Water Quality Control Boards (RWQCBs) to: (1) monitor for both coliform and enterococcus organisms, and (2) conduct sanitary surveys when either the coliform standards or a specified enterococcus level was exceeded. This approach, it was thought, would provide information on which organism was best for use in California. However, this was a controversial approach, so in 1992, the SWRCB convened an independent technical group, the Microbiological Advisory Committee (MAC), to provide advice on how to investigate the issue. Subsequently, a study was done under contract with the University of California, Berkeley to investigate the presence of each indicator organism at monitoring stations from two major ocean dischargers (City of San Diego and City and County of San Francisco). Those investigators found good correlation between enterococcus and coliform monitoring, and recommended no change from the total and fecal coliform monitoring, (Spear *et al.*, 1996).

E.2 FRESH WATER

Dufour, 1984

This study evaluated health effects of microbiological contamination on recreational use of freshwaters and developed US EPA criteria. These criteria were based on the mathematical relationship of the swimming-associated rate of gastrointestinal symptoms among bathers to the quality of their water. Enterococci and *Escherichia coli* were used as fecal indicators.

The data, based on 34,598 subjects who responded to follow-up interviews, were collected in an epidemiological research program of from beaches in two areas: (1) Lake Erie, Erie, Pennsylvania, in 1979, 1980 and 1982, 18,299 respondents; (2) Keystone Lake, near Tulsa, Oklahoma, in 1979 and 1980, 16,299 respondents.

The recommended health effects criteria for fresh recreation waters were described by the following equations:

$$\log Y = 1.464 + 0.0687 X \quad \text{[Equation 2]}$$

where

X is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms), and

Y is the mean *E. coli* density per 100 ml.

$$\log Y = 0.938 + 0.059 X \quad \text{[Equation 3]}$$

where

X is the swimming-associated rate per 1000 people for gastroenteritis (highly credible gastrointestinal symptoms), and

Y is the mean enterococcus density per 100 ml.

Subsequent to the Dufour study, US EPA developed guidance (US EPA, 1986) for fresh recreational waters. EPA's guidance for fresh recreational waters is based upon an "Acceptable Swimming Associated Gastroenteritis Rate" of 8 cases/1000 swimmers. The rate of 8 cases of illness per 1000 swimmers is estimated to result from exposures to waters containing bacteria using the fecal coliform indicator group at the maximum geometric mean of 200 per 100 ml. Its steady state geometric mean indicator density at the acceptable rate is 33 enterococci per 100 ml. . An acceptable one-time exposure is 65 enterococci per 100 ml.

Calderon *et al.*, 1991

In this study of recreational swimmers using a pond (Calderon *et al.*, 1991) found a greater correlation between infectious disease and the number of other swimmers/bathers than it did between infectious disease and various microbiological indicators.

Fresno County Community Health Department, 1996

A cryptosporidiosis outbreak at a water park in Fresno County was attributed to the ingestion of pool water that may have been contaminated by *Cryptosporidium* oocysts from fecal accidents by infected individuals(s) or from the rinsing off of water from an untreated pond adjacent to the pool area (Fresno County Community Health Department, 1996).

Kramer *et al.*, 1996

The Centers for Disease Control (Kramer *et al.*, 1996) reported 14 outbreaks of gastroenteritis in the US in 1993-1994, 10 of which were attributable to protozoan parasites in recreational water (e.g., *Cryptosporidium parvum* or *Giardia lamblia*) and the rest to *Shigella* spp., or *E. coli* O157:H7). Seven of these outbreaks occurred in lakes, one in a river, and six in pools.

Levy *et al.*, 1998

The Centers for Disease Control (Levy *et al.*, 1998) reported 37 outbreaks in the US in 1995-1996. Of these, 22 were gastroenteritis outbreaks; causes included *Cryptosporidium parvum* (6), *Giardia* (1), *E. coli* O157:H7 (6), *Shigella sonnei*(3), and *Salmonella* serotype Java (1). Thirteen of the 22 gastroenteritis outbreaks were associated with lake water, eight with swimming or wading pools, and one with a hot spring. There were nine dermatitis outbreaks, of which two were lake-associated (swimmer's itch caused by *Schistosoma* species) and seven were hot tub-associated

(*Pseudomonas*). The final six were single cases of primary amebic meningoencephalitis (all fatal, five in Texas and one in Florida, associated with a shallow lake, river, pond, or canal), caused by *Naegleria fowleri*.

Human feces appeared to be related to outbreaks associated with several lake-associated outbreaks.

Prüss, 1998

This evaluation of health risks associated with poor microbiological quality of recreational water reviews 22 epidemiological investigations, including six studies of fresh waters and one of fresh and marine waters.

Warner et al., 1996

This outbreak, associated with *E. coli* O157:H7, involved 12 individuals who had visited an Illinois state park with a lake swimming beach.

REFERENCES

See <http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Beaches.aspx>