Microbiological guideline values for recreational bathing in Canada: Time for change?

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B Lévesque, D Gauvin. Microbiological guideline values for recreational bathing in Canada: Time for change? Can J Infect Dis Med Microbiol 2007;18(2):153-157.

Recreational bathing is an activity practiced by thousands of Canadians every year. While its health benefits are numerous, bathing in polluted water can also be a source of health problems. These problems are generally nonspecific and are difficult to detect through usual health monitoring systems. Most involve ear and eye ailments, febrile respiratory illness and, particularly, gastroenteritis. In 1992, Health Canada recommended microbiological guideline values for recreational water quality. The values are based on the presence of fecal indicator bacteria, namely, enterococci for marine water, and *Escherichia coli* or fecal coliforms for fresh water. In marine water, the guideline value is set at 35 enterococci/100 mL, while in fresh water, the standard is 200 *E coli*/100 mL or 200 fecal coliforms/100 mL when experience demonstrates that over 90% of the fecal coliforms are *E coli*. Notwithstanding certain variances, many Canadian provinces apply these guidelines. However, in Ontario, the guideline is 100 *E coli*/100 mL. Over the past several years, many epidemiological studies, including randomized clinical trials, have examined the relationship between bathing in polluted water and ensuing health problems. On review of this literature, the Canadian guideline values for marine water seems appropriate, but scientific evidence argues toward lowering the Canadian guideline values for fresh water to 100 *E coli*/100 mL, in line with the standard currently in effect in Ontario.

Key Words: *Bathing; Enterococci;* Escherichia coli; *Fecal coliforms; Guidelines; Recreational water*

Valeurs limites de l'analyse microbiologique des eaux en vue de la baignade récréative au Canada : le temps est-il venu de les changer?

La baignade est une activité pratiquée par des milliers de Canadiens chaque année. Elle procure d'énormes bienfaits sur le plan de la santé. Cependant, la baignade en eau polluée peut également être une source de problèmes de santé. Ces problèmes sont souvent vagues et difficiles à relever par les systèmes habituels de surveillance sanitaire. Il est question ici, entre autres, d'atteintes des oreilles ou des yeux, de maladies fébriles respiratoires et surtout de gastroentérites. En 1992, Santé Canada a fixé des valeurs limites pour la baignade. Celles-ci reposent sur la présence d'indicateurs de contamination fécale, soit sur les entérocoques pour l'eau de mer et sur les *Escherichia coli* ou les coliformes fécaux pour l'eau douce. Les recommandations sont de 35 entérocoques/100 ml en milieu marin. En eau douce, elles sont de 200 *E. coli*/100 ml ou de 200 coliformes fécaux/100 ml si l'expérience montre que plus de 90 % des coliformes fécaux sont des *E. coli*. Plusieurs provinces canadiennes suivent ces recommandations, à quelques variantes près. Cependant, en Ontario, on applique une limite de 100 *E. coli*/100 ml. Ces dernières années, plusieurs études épidémiologiques, dont des essais cliniques hasardisés, ont été réalisées sur les problèmes de santé liés à la baignade en eau polluée. À la suite de l'examen de la documentation, la valeur limite de micro-organismes en eau de mer au Canada semble appropriée; par contre, les données scientifiques plaident en faveur d'un abaissement de la valeur limite de micro-organismes en eau douce à 100 *E. coli*/100 ml, à l'exemple de celle qui est actuellement en vigueur en Ontario.

Recreational bathing has always been a valued activity for Canadians. Whether it be for sport or relaxation, its benefits are substantial, not only in terms of its physical activity value, but also for the sense of well-being it provides. However, it cannot be denied that bathing in polluted waters can be a source of health problems.

Because of their nonspecific character, such problems are difficult to detect through usual health monitoring systems (1). Several epidemiological studies, particularly in coastal waters, have nevertheless demonstrated a relationship with gastroenteritis (2,3), as well as with febrile respiratory illnesses and, to a lesser extent, with ear and eye ailments (4). These pathologies are associated with exposure to feces-contaminated water (5) and are generally benign. However, in rare instances, certain infections may prove to be more serious and even potentially fatal (5), particularly in immune-altered individuals. For example, infections caused by *Campylobacter* species, *Escherichia coli* O157:H7, *Leptospira* species, *Salmonella typhi* and *Shigella* species bacteria have been epidemiologically linked with bathing. This is also the case for certain viral infections, notably for adenoviruses, coxsackieviruses and the hepatitis A virus, as well as for certain parasites such as *Cryptosporidium parvum* and *Giardia lamblia* (5).

There are new promising rapid molecular methods that will have to be validated in the future (6). However, in the meanwhile, despite a delay of 24 h to 48 h to assess the quality of recreational waters, monitoring agencies actually rely on microbiological methods that involve culturing fecal indicator bacteria (Table 1) (7-12). Since 1992, Health Canada has recommended the assessment of enterococci (equivalent to fecal

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Received for publication December 5, 2006. Accepted January 5, 2007

TABLE 1
Selection of current recommendations for quantitative levels of organisms in recreational water (geometric mean) in North America

Organization or province (reference)	Marine water/ 100 mL	Fresh water/ 100 mL	Marine and fresh water/ 100 mL
Health Canada (7)*	35 enterococci	200 *Escherichia coli* or fecal coliforms†	–
Alberta (8)	–	1000 total coliforms 200 fecal coliforms	
British Columbia (9)	–	–	77 *E coli* 200 fecal coliforms 20 enterococci 2 *Pseudomonas aeruginosa*‡
Quebec (10)	35 enterococci	200 fecal coliforms	
Ontario (11)		100 *E coli*	
US-EPA (12)	35 enterococci	126 *E coli* 35 enterococci	

**These criteria are applied by many Canadian provinces; †When experience has shown that greater than 90% of fecal coliforms are* Escherichia coli*; ‡75th percentile. US-EPA United States Environmental Protection Agency*

streptococci) for sea bathing because they tend to be more resistant in salt water than *E coli*. The recommended guideline limit is a geometric mean of 35 enterococci/100 mL calculated on at least five samples taken over a period of 30 days. Resampling must be performed if a sample exceeds 70 enterococci/100 mL. For fresh water, Health Canada recommends the assessment of *E coli* or fecal coliforms. The geometric mean of at least five samples over a period of 30 days must not exceed 200 E coli/100 mL. Resampling should be performed if a sample exceeds 400 *E coli*/100 mL. When experience shows that over 90% of the fecal coliforms are *E coli*, fecal coliforms may be used as bacteriological indicators (7).

Notwithstanding certain variances, many Canadian provinces apply these recommendations (Table 1). However, in Ontario, the geometric mean of a minimum of five samples taken over a period of 30 days must not exceed 100 *E coli*/100 mL, otherwise the beach is closed for bathing (11). Moreover, the United States Environmental Protection Agency has set a maximum geometric mean of 126 *E coli*/100 mL or 33 enterococci/100 mL as a quality threshold for fresh water. For marine water, the only recommended indicator bacterium is enterococci, with a guideline limit established at 35 enterococci/100 mL (12).

In 1999, a group of international experts under the aegis of the World Health Organization (WHO) examined the health risks associated with bathing in natural water basins. A more global approach with regard to assessment and risk management was proposed (1). This same concept now appears to be favoured by Health Canada as well, who have deemed that the management of recreational waters begins first and foremost by the identification of the risk hazards (microbiological, chemical and physical) that can impact a bathing area. To this end, an inspection of the beach area is recommended. Thereafter, appropriate management procedures or actions must be introduced to reduce these risks (13). If, for example, overland runoff from heavy rainfall constitutes an important source of pollution, authorities can quantitatively document this fact and therefore restrict bather access immediately following periods of heavy rainfall. Thus, microbiological guideline values no longer constitute the sole management tool but must be integrated within the framework of a much broader approach. Nevertheless, these guideline values remain an important cornerstone of the overall process.

In epidemiology, randomized clinical trials are regarded as having the most robust design, such that the Cochrane collaboration (14), insists on prioritizing these types of studies when performing systematic reviews of clinical practices performed under its aegis. In keeping with this view, WHO experts solely used this type of study in their risk assessment, published in 2003, of the effects of bathing in polluted waters on human health (1). Analysis pertained only to randomized trials performed in coastal waters in Great Britain between 1989 and 1992 (2,4). The WHO group recognized that:

> "These studies give the most accurate measure of exposure, water quality and illness compared with observational studies where artificially low threshold and flattened dose-response curve (due to misclassification bias) were likely to have been determined" (1).

These British studies (Table 2) were conducted in healthy adults in four trials performed at four different resort beaches. On the day of the trial, each participant was randomly assigned to one of two groups (bathers or nonbathers). Bathers had to bathe for at least 10 min, with at least three total immersions of the head during this period. Concomitantly, bathing water was repeatedly monitored to determine exposure indexes of each of the bathers to various microbiological indicators (total and fecal coliforms, fecal streptococci, *Pseudomonas aeruginosa* and total staphylococci). A total of 1216 individuals participated in the four trials, namely, 548 swimmers and 668 nonswimmers. The authors were able to demonstrate a dose-response relationship between fecal streptococci and gastroenteritis (2), as well as fecal streptococci and febrile respiratory disease (4), sampled at chest depth at concentrations starting at 32 fecal streptococci/100 mL and 60 fecal streptococci/100 mL, respectively, in addition to an increase of ear ailments at concentrations starting at 100 fecal coliforms/100 mL. No relationship was found between health problems and other tested indicators. These results strengthen the Canadian guideline limit of 35 enterococci/100 mL, the approximate concentration at which a rise in risk levels for gastroenteritis has been observed.

Based on these data, the WHO study group estimated risk levels using the 95th percentile of the distribution of enterococci/100 mL as an indicator rather than the mean. Obviously, for water basins, the higher the sampling rate, the greater the estimation value of this parameter. However, to achieve this, a compilation of data collected over several years of follow-up study may be necessary (1), and thus, the use of the 95th percentile in the management of a beach appears to be problematic. It is estimated that if this value is below or equal to 40 enterococci/100 mL, the risks of gastroenteritis and febrile respiratory diseases from exposure are less than 1% and 0.3%, respectively. A value between 41 enterococci/100 mL and 200 enterococci/100 mL incurs risks ranging from 1% to 5% and 0.3% to 1.9%, respectively, for both pathologies. A basin with a 95th percentile value between 201 enterococci/100 mL and 500 enterococci/100 mL generates risk levels between 5% and 10% for gastroenteritis and between 1.9% and 3.9% for febrile respiratory disease, respectively. Finally, a 95th percentile

TABLE 2
Randomized clinical trials to determine the health risks related to bathing in polluted water

	Marine water*	Fresh water†
Number of participants	1216	2067
Bathers	548	1033
Nonbathers	668	1034
Age, years	≥18	≥4
Number of beaches	4	5
Location of beaches	Great Britain	Germany
Indicators tested	Fecal streptococci	*Escherichia coli*
	Total coliforms	Enterococci
	Fecal coliforms	*Clostridium perfringens*
	Pseudomonas aeruginosa	Somatic coliphages
	Total staphylococci	*Aeromonas* species
		P aeruginosa
Medical follow-up	Interview and medical examination two days before exposure	Interview and medical examination two days before exposure
	Interview one week after exposure	Interview the day of exposure
		Interview and medical examination one week after exposure
	Mailed questionnaire three weeks after exposure	Mailed questionnaire three weeks after exposure
Bathing	At least 10 min with at least three complete immersions of the head	Exactly 10 min with at least three complete immersions of the head
Main outcomes	Bathing associated with gastroenteritis, acute respiratory febrile illness, and ear and eye ailments	Bathing associated with gastroenteritis and skin problems. There was a statistical tendency toward an association between bathing and ear ailments
	Relationship between fecal streptococci and gastroenteritis (>32 fecal streptococci/100 mL), and between fecal streptococci and acute febrile respiratory illness (>60 fecal streptococci/100 mL). Relationship between fecal coliforms and ear ailments (>100 fecal coliforms/100 mL)	Relationship between gastroenteritis and four indicators of fecal contamination (*E coli*, enterococci, *C perfringens* and somatic coliphages)
		Guideline values suggested: 100 *E coli*/100 mL, 25 enterococci/100 mL, 10 somatic coliphages/100 mL or 10 *C perfringens*/100 mL

**Data from references 2 and 4; †Data from reference 17*

value of over 500 enterococci/100 mL incurs a risk in excess of 10% for gastroenteritis and in excess of 3.9% for febrile respiratory illnesses (1).

However, the authors caution that these values must be interpreted as a function of local or national conditions. For example, such values would not be valid for children, elderly people or immunosuppressed individuals, all of whom may present a more problematic immune status and thereby require greater protection. In areas of heavy pathogen traffic, which is susceptible to being transmitted by bathing, the risks may be greater, notably for tourists with higher immune susceptibility. Moreover, these data are based on short bathing periods, which may not necessarily reflect the typical exposure of a bather. Finally, agencies also need to address the notion of acceptable or tolerable risk. Indeed, some have suggested a comparison with acceptable risks determined for drinking water or with baseline levels observed in the nonexposed population (1).

With regard to exposure to recreational fresh water in Canada, a prospective study conducted in the Ontario Great Lakes in the early 1980s involving a cohort of 4527 individuals showed a morbidity rate of 69.6 per 1000 bathers versus 29.5 per 1000 nonbathers. Reported illnesses consisted predominantly of respiratory, gastrointestinal, eye, ear and skin ailments (15). Globally, health problems have been associated with staphylococcal and fecal streptococcal counts, as well as fecal coliforms (16).

In fresh water, the WHO workgroup deemed that, at the time of its report, there were no published epidemiological studies allowing valid determination of the level of risk (1). However, the reader was alerted to a randomized trial in Germany for which the results were not yet published. According to the workgroup, until the complete results of this study were made available, there was insufficient evidence to accurately determine a guideline value for freshwater bathing.

The results of this study have since been published (Table 2) (17). The study of Wiedenmann et al (17), conducted in five different freshwater bathing sites, recruited a total of 2196 persons (after exclusions, 2067 participants: 1033 bathers and 1034 nonbathers) from the local population and included subjects four years of age and older. The participants were given a medical examination two to three days before exposure. On the day of exposure, subjects were randomly assigned to one of two groups – bathers or nonbathers. Participants were then directed toward a nonswimming zone or, accordingly, to one of four swimming zones. They underwent a second interview to verify the presence of symptoms since the initial interview. Bathers were exposed for exactly 10 min with at least three complete immersions of the head. Concentrations of *E coli*, enterococci, *Clostridium perfringens*, somatic coliphages, *Aeromonas* species and *P aeruginosa* were regularly documented for exposure. One week after exposure, the participants were interviewed again and underwent a second medical examination.

Participants received an additional questionnaire by mail three weeks later. The authors were able to define a 'no-observed-adverse-effect level' (NOAEL) index, defined as the concentration of an indicator organism for which the comparison between the effects on health of exposed bathers above versus below this level yields the greatest statistical difference (lowest P value) (17). For gastroenteritis illnesses, three different definitions were used, two of which were more restrictive: GE_UK (diarrhea and three or more bowel movements per day, or vomiting or nausea and fever or indigestion and fever); and GE_UK-wf (ie, GE_UK-without consideration of stool frequency). A third definition included a broader range: GE_NL-2 (diarrhea or nausea or vomiting or stomach pain). The ensuing discussion of observed results is limited to the first two definitions.

Bathing was statistically associated with gastroenteritis illnesses and skin problems and there was a statistical tendency toward ear ailments (P=0.065) (17). For the three definitions of gastroenteritis, a dose-response relationship was demonstrated for each of the four indicators of fecal contamination (*E coli*, enterococci, C *perfringens* and somatic coliphages). Based on the NOAELs demonstrated, the authors suggested the following guideline values: 25 enterococci/100 mL, 10 C *perfringens*/100 mL, 10 somatic coliphages/100 mL or 100 *E coli*/100 mL. For the two more restrictive definitions of gastroenteritis, the authors calculated respective NOAEL values of 180 *E coli*/100 mL (GE_UK) and 78 *E coli*/100 mL (GE_UK-wf). When instances of gastroenteritis were examined by quartiles of exposure to *E coli*, for GE_UK, the authors observed an incidence of 1.4% for nonbathers and 1.0% (comparison with nonbathers; P=0.62), 2.9% (P=0.14), 3.9% (P=0.02) and 5.8% (P=0.0001) for bathers exposed for 10 min to 71 *E coli*/100 mL, 181 *E coli*/100 mL, 379 *E coli*/100 mL and 4599 *E coli*/100 mL, respectively. For GE_UK-wf, the incidence was 2.8% for nonbathers and the quartiles were 1.9% (P=0.47), 5.2% (P=0.08), 6.6% (P=0.007) and 8.2% (P=0.0003) for bathers for the same concentrations of exposure. Therefore, for values up to 71 *E coli*/100 mL, the risk was comparable with nonbathers for both definitions of gastroenteritis. Between 71 *E coli*/100 mL and 181 *E coli*/100 mL, the risk was doubled compared with baseline values, with the proportion attributable to bathing reaching 1.5% and 2.4% for GE_UK and GE_UK-wf, respectively. Between 181 *E coli*/100 mL and 379 *E coli*/100 mL, the attributable risk increased to 2.5% and 3.8%, respectively. While the observed increase from 71 *E coli*/100 mL to 181 *E coli*/100 mL was statistically nonsignificant, possibly due to low sample size, approximately 60% of the risk of gastroenteritis documented at 379 *E coli*/100 mL could be attributed to exposure at these lower levels, a proportion far from negligible for a 10 min bathing interval with three full immersions of the head. By comparison, treatment standards in the province of Quebec for risks associated with exposure of drinking water to *Giardia lamblia*, a potential pathogen in recreational fresh waters (5), are based on American standards, namely, an acceptable risk of giardiasis of one case per 10,000 individuals annually (18,19).

Furthermore, Wiedenmann et al (17) demonstrated an increase in risk levels when subjects recalled having swallowed water, providing additional evidence for the observed link with bathing and the dose-response relationship with microbiological indicators. As already stated, based on the overall data, the authors suggested a guideline limit of 100 *E coli*/100 mL for fresh water bathing (17).

Other than the above study, there are few reports assessing the extent of risk relative to bathing in fresh water. Nevertheless, Wade et al (20) conducted a meta-analysis aimed at verifying the association between microbial indicators and gastroenteritis illness associated with bathing. For fresh water, only five observational studies were included in relation to concentrations of *E coli*. The authors deemed that *E coli* was the most adequate predictor of gastroenteritis. They also established that the RR of bathing in levels lower than the American standard (126 *E coli*/100 mL) was 1.22 (95% CI 0.99 to 1.51), whereas above this threshold, the RR reached 1.78 (95% CI 1.45 to 2.20). These numbers strengthen the notion that between 100 *E coli*/100 mL and 200 *E coli*/100 mL, there is a non-negligible increase in the risk. For coastal waters, the number of relevant studies was more notable, reaching a total of 28 studies relative to the presence of enterococci, clearly the indicator (P=0.05) most correlated with gastroenteritis. The RR of bathing below the American standard (35 enterococci/100 mL) was 1.36 (95% CI 0.91 to 2.03), whereas above this threshold, the RR value was 2.27 (95% CI 1.74 to 2.96).

In light of the above data, along with the fact that the Wiedenmann et al study documented a very short exposure period for healthy individuals, we propose that the scientific evidence applied to the Canadian context argues in favour of lowering the Canadian guideline value to 100 *E coli*/100 mL for freshwater bathing, in line with the standard currently in effect in Ontario. As for marine waters, the current value of 35 enterococci/100 mL remains, in our opinion, an appropriate guideline level.

ACKNOWLEDGEMENTS: The authors thank Mr Pierre Pothier for his contribution to the preparation of the present paper.

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