Health Advisories for Consumers of Great Lakes Sport Fish: Is the Message Being Received?

John Tilden,[1] Lawrence P. Hanrahan,[2] Henry Anderson,[2] Charles Palit,[3] Joseph Olson,[2] William Mac Kenzie,[1] and the Great Lakes Sport Fish Consortium

[1]Epidemic Intelligence Service, Centers for Disease Control and Prevention, Atlanta GA 30333 USA; [2]Bureau of Public Health, Wisconsin Division of Health, Madison, WI 53703 USA; [3]Wisconsin Survey Research Laboratory, University of Wisconsin, Madison, WI 53703 USA

Nationwide, 45 states issue health advisories for sport fish consumers. Chemical contaminants in some Great Lakes (GL) sport fish include compounds suspected of causing adverse reproductive and developmental effects. Although advisories to reduce consumption of contaminated fish, especially by women, have been issued by GL states (i.e., Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) since the mid-1970s, little is known about advisory awareness and GL sport fish consumption in the general population. To estimate the prevalence of GL sport fish consumption and health advisory awareness, we conducted a population-based telephone survey of 8,306 adult residents of the eight GL states. We gathered information concerning respondents' demographic characteristics, fish consumption during the preceding year, and sport fish consumption advisory awareness. The survey response rate was 69%. GL sport fish were eaten during the preceding year by 8.4% [95% confidence interval (CI), 7.6–9.2] of adults in the GL states, approximately 4.7 million persons. Women accounted for 43.9% (CI, 39.4–48.4) of consumers. Although 49.9% of GL sport fish consumers were aware of a health advisory, awareness varied significantly by sex: 58.2% (CI, 51.7–64.7) of males and 39.1% (CI, 32.6–45.6) of females were aware. Using logistic regression, we found awareness associated with male sex [odds ratio (OR) = 2.3; CI, 1.5–3.5), white race (OR = 4.2; CI, 1.9–9.1), college degree (OR = 3.1; CI, 1.3–7.6), and consuming ≥24 GL sport fish meals/year (OR = 2.4; CI, 1.4–4.3). Only half of GL sport fish consumers reported awareness of a health advisory concerning eating GL sport fish. Awareness was especially low among women, suggesting the need of targeted risk communication programs for female consumers. *Key words*: compliance, Great Lakes, health advisories, Illinois, Indiana, Michigan, Minnesota, New York, Ohio, PCBs, population-based random-digit-dial survey, risk communication, sport fish consumption, Wisconsin.
Environ Health Perspect 105:1360–1365 (1997). *http//ehis.niehs.nih.gov*

Great Lakes (GL) sport fish consumption advisories were first issued in the 1970s after extensive testing detected chemical contaminants in fish tissue. Of particular concern were environmentally persistent lipophilic pollutants such as polychlorinated biphenyls (PCBs) and DDT. These compounds are often found in the highest concentrations in the older and larger predatory fish, which are sought and preferred by many sport anglers.

In 1991, an estimated 2.55 million licensed anglers fished on one or more of the Great Lakes (*1*). Thus, the popularity of this sport presents a significant potential for human exposure to chemical residues in fish tissue. Although two decades of environmental regulation have substantially reduced chemical residues (*2–3*), some sport fish still contain levels thought to be potentially harmful to human health (Anderson et al., unpublished data).

Studies of long-term consumption of GL sport fish confirmed an association between contaminated fish consumption and increased PCB or DDT\DDE body burdens (*4–7*). The potential adverse health effects of these contaminants have been studied extensively (*8–10*). The EPA has classified PCBs and DDT\DDE as probable human carcinogens. Consistent with low exposure effects observed in nonhuman primates, some human epidemiologic studies have found associations between maternal/fetal PCB levels, Lake Michigan sport fish consumption, and adverse reproductive and developmental effects (*11–13*). These studies are not conclusive, however, and scientists disagree regarding interpretation of their findings (*14–17*). This level of uncertainty complicates the process of communicating risk information to sport fish consumers.

Current GL sport fish consumption advisories seek to 1) inform the public about the chemical contaminants contained in some sport fish, 2) educate consumers as to how they can minimize their exposure to contaminants, 3) remind consumers of the health benefits of fish consumption (*18,19*), and 4) present advisory information in a manner conducive to maximal voluntary compliance (Anderson et al., unpublished data). Because of potential adverse reproductive and developmental effects, all current advisories make specific consumption frequency recommendations for women of childbearing age. GL advisories seek to help individual consumers make informed decisions regarding sport fish consumption.

In the GL states, the level of advisory awareness among licensed anglers has been used to assess the adequacy of advisory communication programs (*20*). Licensed anglers are a relatively easy-to-identify group of GL sport fish consumers who can be surveyed by mail (*5,21–22*). One drawback of this approach is that the results of surveys conducted solely on anglers with fishing licenses might not be generalizable to all persons who eat GL sport fish. To overcome this limitation, we conducted a random-digit-dial telephone survey of the general population. We surveyed adult residents of the eight GL states to characterize the types of fish eaten by the general population, the demographic characteristics of persons who ate GL sport fish, and the level of advisory awareness among these GL sport fish consumers.

Materials and Methods

Survey design. From April 1993 through February 1994, trained interviewers from the University of Wisconsin Survey Research Laboratory conducted a population-based random-digit-dialed telephone survey (*23–25*) of adults (i.e., persons ≥18 years of age) residing in Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin). One randomly selected adult from each participating household was interviewed. Interview dates were scheduled so that approximately equal numbers of interviews were completed during each of the four seasons. Informed consent was obtained before the start of the interview, and the data acquisition procedures maintained complete respondent anonymity.

Interviewers used a standard questionnaire to collect information regarding demographic characteristics, the types of fish eaten

Address correspondence to L.P. Hanrahan, Bureau of Public Health, Wisconsin Division of Health, Room 138, 1414 E. Washington Avenue, Madison, WI 53703 USA.

The Great Lakes Sport Fish Consortium includes James Boddy, Marvin Budd, Mandy Burkett, Claire Falk, Beth Fiore, Grace Lee, Bob Johnson, Marty Kanarek, Susan Monaghan, Dan Reed, Tracy Shelley, William Sonzogni, Greg Steele, and Dollis Wright.

This work is a result of research sponsored by the U.S. Public Health Service, Agency for Toxic Substances and Disease Registry under grant 75/ATH598322-03.

Received 11 February 1997, accepted 2 September 1997.

during the preceding 12 months, and an estimate of the average number of fish meals eaten during a time interval selected by respondents (e.g., during a week, month, or year). Respondents were characterized as persons who either 1) ate no fish, 2) ate only commercially purchased fish, 3) ate sport fish not caught in a Great Lake, or 4) ate some GL sport fish. Respondents who reported eating GL sport fish provided additional information, including estimates of the number of GL sport fish meals they consumed during the preceding 12 months, whether they had heard of their state's health advisory for sport fish consumers, and if they had followed specific advisory recommendations (e.g., cleaning and cooking practices). They provided consumption estimates for six GL sport fish groups: lake trout, carp/catfish, brown trout, rainbow trout/chinook salmon/coho salmon, perch/smelt/walleye, and all other GL sport fish. These fish species were grouped according to the level of chemical contaminants reported by federal and state monitoring programs. These groups are listed in approximate rank-order, from highest to lowest, by level of chemical contaminants detected. We defined advisory awareness as a self-report of having heard of the health advisory. Compliance was defined as a self-report of always or usually following an advisory recommendation. None of the self-reported information was independently verified.

Analytic methods. We calculated overall and state-specific response rates using standard procedures (*26*) (see Appendix 1). To obtain population-based estimates, we weighted each respondent's information (*27,28*). Appendix 2 describes the case weighting methodology.

The low number of respondents with less than a high school degree was insufficient to weight separately; thus, only two categories of educational attainment were used to calculate weights. These categories were persons with a high school degree or less and persons with at least some post-high school education. In all analyses, respondent age was coded as a three-level categorical variable (i.e., 18–34 years, 35–44 years, and 45 or more years of age) based on the likelihood of childbearing. We initially explored the data through univariate and stratified analysis. Using SUDAAN statistical software (Research Triangle Institute, Research Triangle Park, NC) (*29*), we calculated overall prevalence estimates for four different fish consumption patterns, advisory awareness among GL sport fish consumers, and self-reported compliance among GL sport fish consumers who reported advisory awareness. We conducted a stratified analysis to determine how advisory awareness varied by sociodemographic group and we conducted a multivariable logistic regression analysis (*30*). Possible interactive effects between sex and other variables were assessed. Models of significant variables were derived by a backward model-selection method (*31*) and by comparison of hierarchical models using likelihood ratio chi-square statistics. Age group and state of residence variables were kept in all models. To adjust for the study's sampling design, the final logistic regression analysis used SUDAAN software.

Results

A total of 8,306 persons were interviewed, including over 1,000 adult residents per state. The overall survey response rate was 69% (see Appendix 1). State-specific response rates ranged from 57% in New York to 78% in Wisconsin. Persons who had less than a high school degree were underrepresented, comprising 14% of our weighted sample compared with the 23% indicated by the 1990 census for these states (*28*).

Fish consumption. The estimated percentages of persons in the eight GL states who ate fish obtained from different sources are shown in Table 1. The median number of total fish meals eaten (from all sources) was not significantly different between groups. An estimated 8.4% [95% confidence interval (CI), 7.6–9.2] of adult residents in the GL states had eaten GL sport fish during the preceding year (approximately 4.7 million persons). Ninety-two percent of GL sport fish consumers in this survey were white, the median age was 39 years, 44% were women, and 52% lived in either Michigan or Ohio. Results of the 1990 census indicates that, among adult residents of the GL states, 84% were white, 53% were women, and 26% lived in either Michigan or Ohio.

The estimated distribution of GL sport fish consumers by fish consumption level and sex is shown in Figure 1. A median of 6.5 fish meals were eaten per year (range, 1–292 fish meals per year). We estimated that 830,000 persons in the eight GL states had eaten ≥24 GL sport fish meals per year. Men reported having eaten GL sport fish more frequently than did women. The median consumption levels for men and women were 8.2 (CI, 6.7–9.6)] and 5.8 (CI, 5.0–7.6) meals, respectively.

The median number of GL sport fish meals reportedly consumed by whites and nonwhites were 6.4 (CI, 5.8–7.2) and 9.8 (CI, 6.1–18.8), respectively. This difference was not statistically significant because of

Table 1. Estimated prevalence and frequency of consumption by adult residents of Great Lakes states[a], by type of fish consumed during the preceding year (1993–1994)

Type of fish consumed	Sample size	Percent estimated prevalence	Median fish meals[b] eaten/year	CI
Ate commercial fish only	4,825	61.3	33.6	32.4–36.0
Ate non-GL sport fish	1702	18.3	34.8	31.2–37.2
Did not eat fish	872	12.0	–	–
Ate GL sport fish	679	8.4	34.8	31.2–38.4
Total	8,078[c]	100.0	28.8	27.6–30.0

Abbreviations: GL, Great Lakes; CI, 95% confidence interval.
[a]Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin.
[b]Fish of all types.
[c]Information missing for 228 of 8,306 survey respondents.

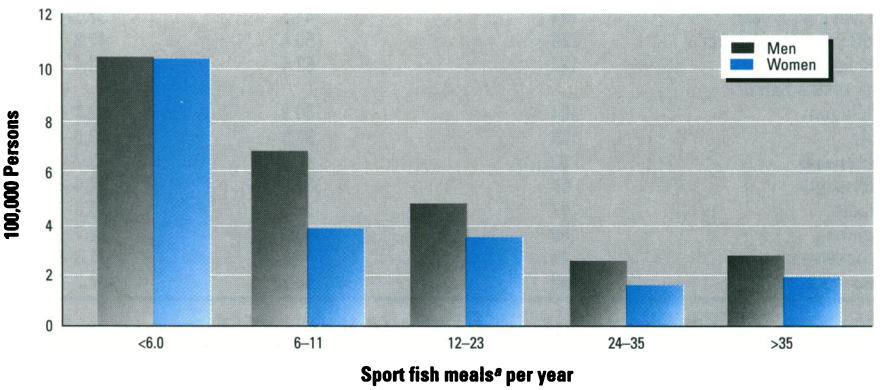

Figure 1. Number of Great Lakes sport fish consumers by consumption level and sex in eight Great Lakes states (Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) from April 1993 to February 1994).
[a]Sport fish caught in the Great Lakes.

the small number (n = 50) of nonwhite GL sport-caught fish eaters in our unweighted sample.

The GL sport fish group eaten by the greatest number of respondents was perch/smelt/walleye (n = 500) followed by rainbow trout/chinook salmon/coho salmon (n = 316), lake trout (n = 254), other GL sport fish (n = 162), brown trout (n = 73), and carp/catfish (n = 64).

Sport fish consumption advisory awareness. The prevalence of advisory awareness among adult GL sport fish consumers by various sociodemographic characteristics is shown in Table 2. Approximately half of all GL sport fish eaters reported that they had heard of their state's health advisory. Advisory awareness varied significantly by race, sex, educational attainment, GL sport-caught fish consumption level, and state of residence. Advisory awareness was not significantly different by age category. Our sample contained small numbers of GL sport fish eaters from some states. This resulted in unstable state-specific estimates of advisory awareness as indicated by wide 95% confidence intervals. In Minnesota and New York, the level of awareness indicated by the weighted sample was approximately 10% less than that indicated by the unweighted data. In these states, persons with relatively high weighting (e.g., males 18–34 years of age who did not have a high school degree) tended to report that they had not heard of the advisory.

The final logistic regression model for variables associated with advisory awareness among GL sport fish eaters is shown in Table 3. The risk estimates displayed in Table 3 are odds ratios (OR). In the analysis, Wisconsin was used as the referent group in the logistic regression model because the level of GL sport fish consumption and advisory awareness among Wisconsin anglers had been documented previously. Statistical significance (p<0.05) was assessed by 95% confidence intervals. Parameters with confidence intervals that did not include an OR of 1.0 were therefore the ones that were significant. After adjusting for other variables in the model, advisory awareness was significantly associated with male sex, white race, having a college degree, and eating ≥24 GL sport fish meals per year. GL sport fish consumers in Ohio were significantly less likely than GL sport fish eaters in Wisconsin (the referent state) to be aware of an advisory. None of the interaction terms investigated were statistically significant.

Of those GL sport fish consumers who were aware of an advisory, compliance with advisory recommendations differed significantly between men and women (Table 4). Use of recommended cleaning and cooking methods was the most frequently reported risk reduction practice, reported by 69% of men and 55% of women. Compliance was significantly lower for advisory recommendations that required changes in fishing

Table 2. Prevalence of advisory awareness[a] among adults who had eaten sport fish caught from the Great Lakes by sociodemographic characteristics[b] April 1993–February 1994

Characteristic	Sample size	Percent prevalence advisory awareness	CI
Total	671	49.9	45.2–54.6
Age (years)			
18–34	215	46.9	38.7–55.1
35–44	188	56.1	47.9–64.3
≥45	268	49.2	41.8–56.6
Race[c]			
White	618	52.1	47.2–57.0
Other	50	22.1	9.4–34.8
Sex			
Male	347	58.2	51.7–64.7
Female	324	39.1	32.6–45.6
Educational attainment			
<High school degree	49	33.7	17.6–49.8
High school graduate	272	47.9	40.5–55.3
Some college	189	49.9	41.1–58.7
College graduate	161	61.7	52.9–70.5
GLSCF consumption level[d]			
<6 fish meals/year	291	44.7	37.5–52.0
6–23.9 fish meals/year	256	50.4	42.8–58.0
≥24 fish meals/year	122	62.4	52.4–72.4
State of residence			
Michigan	184	60.3	52.7–67.9
Ohio	135	37.9	28.9–46.9
Wisconsin	92	65.3	53.7–76.9
Minnesota	67	37.5[e]	24.4–50.6
Illinois	57	51.3	36.8–65.8
Indiana	50	42.0	26.7–57.3
Pennsylvania	44	47.8	31.3–64.3
New York	42	50.2[e]	32.2–68.2

Abbreviations: CI, 95% confidence interval; GLSCF, Great Lakes sport-caught fish.
[a]Awareness defined as having heard of the sport fish advisory; 8 of 679 consumers had missing information on advisory awareness.
[b]Prevalence estimates based on analysis of weighted data using SUDAAN software (Research Triangle Institute, Research Triangle Park, NC).
[c]Three individuals missing race information.
[d]Two individuals were missing GLSCF consumption level information.
[e]This weighted estimate is unstable, being 10% less than the estimate derived from unweighted data.

Table 3. Multivariable logistic regression model[a] for advisory awareness[b] among adult Great Lakes states residents who had eaten sport fish caught in the Great Lakes during the preceding 12 months (telephone survey dates: April 1993–February 1994)

Characteristic	Odds Ratio	CI
Age (years)		
18–34	Reference	–
35–44	1.6	0.9–2.6
≥45	1.3	0.8–2.1
Race		
Other	Reference	–
White	4.2	1.9–9.1
Sex		
Female	Reference	–
Male	2.3	1.5–3.5
Education		
<High School	Reference	–
High school graduate	1.7	0.7–4.0
Some college	1.8	0.8–4.3
College graduate	3.1	1.3–7.6
GL sport fish consumption level		
<6 fish meals/year	Reference	–
6–23.9 fish meals/year	1.3	0.8–2.1
≥24 fish meals/year	2.4	1.4–4.3
State of residence		
Wisconsin	Reference	–
Illinois	0.5	0.2–1.2
Indiana	0.5	0.2–1.1
Michigan	0.9	0.5–1.6
Minnesota	0.5	0.2–1.0
New York	0.7	0.3–1.7
Ohio	0.4	0.2–0.7
Pennsylvania	0.7	0.3–1.7

Abbreviations: CI, 95% confidence interval; GL, Great Lakes.
[a]Model includes 666 out of the 671 total persons for whom complete data was known for all variables in the model; three persons had missing race information and two persons had missing GLSCF consumption level information (see also Table 2 for category frequencies).
[b]Awareness is defined as having heard of the sport fish advisory.

behavior (e.g., changing fishing locations to catch fish with lower levels of chemical contamination).

Discussion

The popularity of sport fishing on the Great Lakes is indicated by our estimate that approximately 4.7 million persons had eaten GL sport fish during the year preceding the survey. Our results indicate that the majority of these persons infrequently ate GL sport fish and that they tended to eat fish species that contain relatively low contaminant levels (i.e., perch/smelt/walleye). The GL sport fish consumption levels reported by most respondents were highly unlikely to result in body burden levels previously associated with adverse human health effects. However, the frequency of GL sport fish consumption varied widely, suggesting substantially different potentials for chemical contaminant exposure among individual consumers. Because environmentally persistent chemical contaminants are present in some GL sport fish, consumers will probably continue to seek information regarding the risks and benefits of eating GL sport fish.

In the United States, state governments are primarily responsible for managing potential risks associated with contaminants in locally caught sport fish (*32*). As of September 1993, 45 of the 50 states had issued one or more fish or shellfish consumption advisories or bans (*33*). Each of the eight GL states has issued sport fish consumption advisories since the mid-1970s. The overall effectiveness of sport fish advisory programs depends on the effectiveness of both the recommendations made and communication methods used (*21,34,35*). Unfortunately, inconsistency between state-issued advisories has been recognized as a nationwide problem (*32*). Inconsistencies in GL sport fish advisories have at times confused consumers and limited the effectiveness of advisories in the region. Representatives of the eight GL states have drafted a uniform advisory for the Great Lakes (Anderson et al., unpublished data), but it has not yet been adopted. In this survey, although ability to make interstate comparisons was limited, state of residence predicted the level of advisory awareness, suggesting that significant differences in advisory programs continue to exist.

In general, GL sport fish advisories encourage sport fish consumers to eat fewer of the fish species and sizes known to contain elevated levels of chemical contaminants and recommend the use of cleaning and cooking methods that can substantially reduce the levels of PCBs and other fat-soluble contaminants contained in a fish meal [Anderson et al., unpublished data; (*36–38*)]. Since GL advisories were first issued, several studies have documented a decline in GL sport fish consumption (*22,39,40*). In our survey, the most widely accepted advisory recommendation was cleaning and cooking methods. The results of a survey of New York anglers indicated that the use of these cleaning and cooking methods was significantly higher among persons who were aware of that state's health advisory (*21*). These findings support the belief that sport fish consumption advisories can decrease chemical contaminant exposures among sport fish consumers if effective communication programs are used.

Communication programs in the GL states have traditionally targeted licensed anglers, who are predominantly white men. Written advisory information (e.g., fishing regulation booklets and advisory brochures) has usually been distributed through the recreational fishing industry and governmental offices. GL sport fish consumers who do not purchase licenses might not have access to information distributed in this way. Because we did not ask respondents if they had purchased fishing licenses, we could not directly assess advisory awareness among licensed anglers and nonlicensed GL sport fish consumers. However, our estimated number of GL sport fish consumers was roughly twice that of the most recent estimate of licensed GL anglers, suggesting that a substantial proportion of GL sport fish consumers were not licensed anglers. Only half of the adults in our population-based survey who had eaten GL sport fish had heard of their state's health advisory. When contrasted with the overall high levels of advisory awareness found by previous mail surveys of licensed GL anglers (*7,21,22*), it appears that substantial numbers of nonanglers are not receiving advisory messages.

Our survey results indicate that existing advisory communication programs are less effectively reaching women, nonwhites, and persons with lower levels of educational attainment. The results of previous surveys of licensed GL anglers also support this conclusion (*21,22*). Well-accepted principles of risk communication indicate that messages designed for specific audiences are often needed to reach diverse subgroups within a population (*41,42*). The weight of evidence from the risk communication literature, surveys of licensed GL anglers, and this population-based survey of GL sport fish consumers suggests that expanded use of targeted advisory communication methods are needed.

To accomplish this, the EPA has developed a detailed and comprehensive guidance document (*42*) to assist health professionals with the task of fish consumption advisory risk communication. The manual provides specific advice to health professionals on all aspects of health advisory risk communication, including risk communication as a process of sharing information, problem analysis and program objectives, audience identification and needs assessment, communication strategy design and implementation, program evaluation, and methods of responding to public inquiries. By following the principles outlined in the EPA guidance, state jurisdictions can develop successful risk communication programs for those who have not been receiving this very important message.

In an era of shrinking governmental budgets, individual state agencies must balance the costs of managing potential health risks against the magnitude of the potential health risk. It is unlikely that sport fish advisory programs will have sufficient resources to mount extensive communication campaigns. However, targeted communication programs designed to reach specific groups are possible. Our results suggest that additional communication efforts are particularly needed to reach persons most sensitive to the effects of the chemical contaminants (i.e., women of childbearing age). Greater collaboration between government agencies and risk communication specialists would probably reduce the costs of developing and evaluating new communication programs, and this collaboration would reap the additional benefit of increased consistency among state-issued advisories.

Table 4. Self-reported compliance with health advisory recommendations by sex of consumers of Great Lakes sport fish[a] who had heard of the advisory

	Percentage following recommendations			
	Men		Women	
Area of recommendation	Percent	CI	Percent	CI
Cleaning and cooking methods	68.8	61.5–76.5	54.6	44.6–64.6
Consumption frequency	50.1	41.9–58.3	42.8	33.0–52.6
Fish species and size	50.3	42.1–58.5	29.4	20.4–38.4
Fishing locations	43.6	35.6–51.6	28.2	19.1–37.2

CI, 95% confidence interval.
[a]Adult residents of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin who reported eating Great Lakes sport fish during the year preceding their interview (survey dates were April 1993–February 1994).

Appendix 1

Conference of American Survey Research Organizations (CASRO) (*26*) response rate calculation

Final sample outcome summary
a, Known nonworking number
b, Known nonresidential or nonprimary residential number
c, Known ineligible residential/no eligible respondent
d, Impaired respondent/language barrier; all
e, Call never answered; all
f, Call answered, eligibility not ascertained; all
g, Known eligible nonresponse; all
h, Completed interview total

The CASRO response rate formula

$$\frac{h}{\{g + h + [(g + h)/(a + b + c + d + g + h)]\}(e + f)}$$

CASRO response rate by state and wave

State	April 1993	July 1993	October 1993	January 1994	Overall
Illinois	64%	65%	68%	67%	67%
Indiana	67%	68%	74%	80%	73%
Michigan	65%	66%	73%	76%	70%
Minnesota	73%	74%	78%	83%	77%
New York	51%	53%	61%	62%	57%
Ohio	66%	66%	76%	74%	71%
Pennsylvania	60%	59%	74%	74%	67%
Wisconsin	79%	77%	79%	79%	78%
Total	61%	61%	69%	70%	69%

Appendix 2

Weighting method

To obtain population-based estimates, we weighted each response by the inverse of the probability of household selection, the state response rate, the number of adults residing in the household, and the quantity of telephone numbers assigned to the household. Additionally, 1990 census data were used to weight each state's data according to the population age, sex and educational attainment distribution (*27,28*).

Thus standard telephone survey weighting methods were used in the study (*23–25*). The computation of the final weight for each observation is described in the following equations.

$$FW = DW \times PSW \times 0.25,$$

where FW = final weight, DW = design weight, and PSW = poststratification weight.

$$DW = (SRR \times HSP \times NRP)/(100 \times NAH),$$

where SRR = state-specific response rate percent, HSP = household unit selection probability, NRP = number of residential phones in the household unit, and NAH = number of adults in the household unit.

$$PSW = CPC/SDW,$$

where CPC = state-specific census population in the stratification cell and SDW = sum of the design weights for the completed sample cases in the stratification cell.

The final weight is a product of the design weight and the poststratification weight, and the constant 0.25. The constant is included so that all four sampling waves could be used in one data set to estimate annual prevalence. The design weight is constructed from the state-specific response rate, the household unit selection probability, the number of residential phones in the household unit, and the number of adults residing in the household sampling unit.

Poststratification weights were constructed for each cell combination of eight states, three age groups, two sexes, and two education groups. Design weights were summed over each observation in the stratification cell to serve as the denominator. The 1990 census population estimate was obtained for each stratification cell. Thus, the poststratification weight was the ratio of the census population estimates to the sum of the design weights in each stratification cell.

References

1. U.S. Department of the Interior, Fish and Wildlife Service and the U.S. Department of Commerce, Bureau of The Census. National Survey of Fishing, Hunting and Wildlife-associated Recreation. Washington, DC:U.S. Government Printing Office, 1993.
2. U.S. EPA. Proceedings of the U.S. EPA's National Technical Workshop "PCB's in Fish Tissue." EPA-823-R-93-003. Washington, DC:U.S. Environmental Protection Agency, 1993.
3. DeVault DS, Clark JM, Lahvis G. Contaminants and trends in fall run coho salmon. J Great Lakes Res 14:23–33 (1988).
4. Schwartz PM, Jacobson SW, Fein G, Jacobson JL, Price HA. Lake Michigan fish consumption as a source of polychlorinated biphenyls in human cord serum, maternal serum, and milk. Am J Public Health 73:293–296 (1983).
5. Fiore BJ, Anderson HA, Hanrahan LP, Olson LJ, Sonzogni WC. Sport fish consumption and body burden levels of chlorinated hydrocarbons: a study of Wisconsin anglers. Arch Environ Health 44:82–88 (1989).
6. Dar E, Kanarek MS, Anderson HA, Sonzogi WC. Fish consumption and reproductive outcomes in Green Bay, Wisconsin. Environ Res 59:189–201 (1992).
7. Humphrey HD. Population studies of PCBs in Michigan residents. In: PCBs Human and Environmental Hazards (D'Itri FM, Kamrin MA, eds). Ann Arbor, MI:Ann Arbor Science Publishers, 1983;299–310.
8. Conner MS. Comparison of the carcinogenic risks from fish vs. groundwater contamination by organic compounds. Environ Sci Technol 18:628–631 (1984).
9. ATSDR. Toxicological profile for selected PCBs (Aroclor -1260, -1248, -1242, -1232, -1221, and -1016). ATSDR/TP-88/21. Atlanta GA:Agency for Toxic Substances and Disease Registry, 1989.
10. ATSDR. Toxicological Profile for DDT, DDE, and DDD. ATSDR/TP-89/08. Atlanta GA: Agency for Toxic Substances and Disease Registry, 1989.
11. Fein GG, Jacobson JL, Jacobson SW, Schwartz PM, Dowler JK. Prenatal exposure to polychlorinated biphenyls: effects on birth size and gestational age. J Pediatr 105:315–320 (1984).
12. Jacobson SW, Fein GG, Schwartz PM, Dowler JK. Perinatal exposure to an environmental toxin: a test of multiple effects model. Dev Psychol 20:523–532 (1984).
13. Jacobson JL, Jacobson SW, Humphrey HEB. Effects of *in utero* exposure to polychlorinated biphenyls (PCBs) and related contaminants on cognitive functioning in young children. J Pediatr 116:38–45 (1990).
14. Humphrey HEB. Environmental contaminants and reproductive outcomes. Health Environ Digest 5:1–4 (1991).
15. Tilson HA, Jacobson JL, Rogan WJ. Polychlorinated biphenyls and the developing nervous system: cross-species comparisons. Neurol Teratol 12:239–248 (1990).
16. Paneth N. Human reproduction after eating PCB-contaminated fish. Health Environ Digest 5:4–6 (1991).
17. Kimbrough RD. Consumption of fish: benefits and perceived risk. J Toxicol Environ Health 33:81–91 (1991).
18. Knapp HR, FitzGerald GA. The antihypertensive effects of fish oil: a controlled study of polyunsaturated fatty acid supplements in essential hypertension. N Engl J Med 320:1037–1043 (1989).
19. Olsen SF, Sorensen JD, Secher NJ, Hedegaard M, Henriksen TB, Hansen H, Grant A. Randomized controlled trial of effect of fish-oil supplementation on pregnancy duration. Lancet 339:1003–1007 (1992).
20. Knuth BA, Connelly NA. Objectives and Evaluation Criteria for Great Lakes Health Advisories: Perspectives from Fishery, Health, and Environmental Quality Agencies. Human Dimensions Research Unit Series No. 91-11. Ithaca, NY:Department of Natural Resources, Cornell University, 1991.
21. Connelly NA, Knuth BA, Vena JE. New York State Angler Cohort Study: Health Advisory Knowledge and Related Attitudes and Behavior, with a Focus on Lake Ontario. Human

Dimensions Research Unit Series No. 93–9. Ithaca, NY:Department of Natural Resources, Cornell University, 1993.
22. Connelly NA, Knuth BA. Great Lakes Fish Consumption Health Advisories: Angler Response to Advisories and Evaluation of Communication Techniques. Human Dimensions Research Unit Series No.93-3. Ithaca, NY:Department of Natural Resources, Cornell University, 1993.
23. Palit CD. Design strategies in random digit dialing sampling. In: Proceedings of the Annual Meeting of the American Statistical Association, August 1983, Toronto, Ontario, Canada. Alexandria, VA: American Statistical Association, 1983;627–629.
24. Palit CD, Sharp HP. Strategies in RDD sampling. Presented at the International Conference on Telephone Survey Methodology, 8–11 November 1987, Charlotte, NC.
25. Palit CD. Some comments on stratified RDD designs. Presented at the 10th Annual Meeting of the Behavioral Risk Factor Surveillance System, 6 June 1993, Atlanta, GA.
26. CASRO. Report of the CASRO Task Force on Completion Rates. Port Jefferson, NY: Council of American Survey Research Organizations, 1982.
27. CDC. Using Chronic Disease Data: A Handbook for Public Health Practitioners. Atlanta, GA: Centers for Disease Control and Prevention, 1992.
28. U.S. Bureau of the Census. Education in the United States. Washington, DC:Government Printing Office, 1994.
29. Shah BV, Barnwell BG, Bieler GS. SUDAAN User's Manual: Software for Analysis of Correlated Data, Release 6.35. Research Triangle Park, NC:Research Triangle Institute, 1993.
30. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York:John Wiley & Sons, 1989.
31. SAS/STAT Users Guide; Version 6. 4th ed. Cary, NC:SAS Institute Inc., 1990.
32. Reinert RE, Knuth BA, Kamrin MA, Stober QJ. Risk assessment, risk management, and fish consumption advisories in the United States. Fisheries 16:5–12 (1991).
33. Center for Environmental Analysis. National Listing of State Fish and Shellfish Consumption Advisories and Bans. Research Triangle Park, NC:Research Triangle Institute, 1993.
34. Belton T, Roundy R, Weinstein N. Urban fishermen: managing the risks of toxic exposures. Environment 28:19–20,30–37 (1986).
35. Knuth BA. Risk communication: a new dimension in sport fishery management. N Am J Fish Manage 10:374–381 (1990).
36. Voiland MP, Gall KL, Lisk DJ, MacNeill DB. Effectiveness of recommended fat–trimming procedures on the reduction of PCB and Mirex levels in brown trout (*Salmo trutta*) from Lake Ontario. J Great Lakes Res 17:454–460 (1991).
37. Skea JC, Simonin HA, Harris EJ, Jackling S, Spagnoli JJ, Symula J, Colquhoun JR. Reducing levels of Mirex, Aroclor 1254, and DDE by trimming and cooking Lake Ontario brown trout (*Salmo trutta Lanais*) and smallmouth bass (*Micropterus dolomieui Lacepede*). J Great Lakes Res 5:153–159 (1979).
38. Zabik ME, Zabic MJ, Booren AM, Daubenmire S, Pascall MA, Welch R, Humphrey H. Pesticides and total polychlorinated biphenyls residues in raw and cooked walleye and white bass harvested from the Great Lakes. Bull Environ Contam Toxicol 54:396–402 (1995).
39. Fitzgerald EF, Hwang G, Brix KA, Bush B, Quinn J. Chemical Contaminants in the Milk of Mohawk Women from Akwesasne. Albany, NY:New York Department of Health, 1992.
40. Hovinga ME, Sowers MF, Humphrey HEB. Historical changes in serum PCB and DDT levels in an environmentally-exposed cohort. Arch Environ Contam Toxicol 22:362–366 (1992).
41. National Research Council. Improving Risk Communication. Washington DC:National Academy Press, 1989.
42. U.S. EPA. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol 4: Risk Communication. Washington, DC:Office of Science and Technology, 1995.