Changes in fish consumption patterns and knowledge pre-/post-fish consumption education by race in the Capital District of New York State

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CHANGES IN FISH CONSUMPTION PATTERNS AND KNOWLEDGE
PRE-/POST-FISH CONSUMPTION EDUCATION BY RACE
IN THE CAPITAL DISTRICT OF NEW YORK STATE

by

Donghong Gao

A Thesis
Submitted to the University at Albany, State University of New York
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ABSTRACT

Background: Current New York State fish advisories are designed to target anglers rather than the general public. Previously we found that Chinese consumed more fish and were less aware of fish warnings than non-Chinese. In the current study, we examined the changes in fish consumption patterns and knowledge among Chinese adults after educational intervention. We also evaluated race differences of fish consumption behavior and knowledge.

Methods: A cross-sectional study was conducted to investigate the changes of fish consumption patterns and knowledge among 638 adult participants. Information regarding demographics, fish consumption behaviors, and awareness of the warnings/benefits of fish consumption were collected from self-reporting questionnaire and analyzed via logistic regression both before and after a community educational campaign that taught members about benefits and warnings of fish consumption through presentations, health fairs and informational materials.

Results: More Chinese were aware of fish warnings after education (80.4%) than before education (49.8%). A higher proportion of Chinese consumed any very low-Hg fish after education (91.1%) than before education (84.1%). Also, fewer Chinese consumed any moderately high-Hg fish after education (44.1%) compared to before education (56.8%). Non-Chinese race, fish consumption three or more times per week, and awareness of heart benefits were the top risk factors of consuming high-Hg fish and consuming more than the recommended amount of fish.
Conclusions: Our education intervention showed positive impacts on knowledge of fish warnings and fish consumption behaviors. Future education efforts should be focused on specific knowledge of fish benefits/warnings, specific mercury contaminated fish species, and recommended consumption amounts.
To My Family
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INTRODUCTION

The National Health and Nutrition Examination Survey (NHANES) indicates that Asians, Native Americans, and Pacific Islanders have a higher prevalence of elevated blood mercury (Hg) concentration compared to all other race/ethnicity groups.\(^1,2\) Furthermore, according to the New York City Health and Nutrition Examination Survey (NYC HANES), the Asian population, especially foreign-born Chinese made up a significant portion of NYC adults with a blood Hg level \(\geq 5\) ug/L which is reportable to the New York State Heavy Metal Registry (NYS HMR).\(^3,4\) Although NYC adults with blood Hg concentration \(\geq 5\) ug/L declined to a half from survey years 2003-2004 to 2013-2014, the highest prevalence of reportable levels of blood Hg was still found among Asian New Yorkers, typically foreign-born adults of East or Southeast Asian origin in China, Hong Kong, or Taiwan.\(^5\) These studies suggest that foreign-born Asian-Americans, such as Chinese-Americans are at high risk of Hg exposure. It is generally believed that dietary intake of fish is the predominant source of methyl mercury (MeHg) exposure in people in the USA.\(^6\^-^8\)

In the fall of 2009, Dr. Lin et al. conducted a cross-sectional study to examine fish consumption and herbal medicine intake habits among Chinese-Americans and non-Chinese Americans in upstate New York (referred as the pre-education group in this article). The study showed \(^9,10\) that there were significant differences in fish consumption patterns and knowledge between Chinese and non-Chinese participants. In this study, more Chinese consumed fish in the past year than non-Chinese and they consumed fish more frequently compared to non-Chinese.
In addition, Chinese were less aware of fish warnings than non-Chinese, indicating that this Chinese population may not have an adequate knowledge of fish consumption risks.

Since 2004, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) have been jointly releasing a federal fish advisory to provide fish consumption recommendations for vulnerable populations, such as pregnant women, women who may become pregnant, nursing mothers, and young children.11,12 The NYS Department of Health and other states have developed fish educational materials which mainly target anglers for sport-caught fish.13-16 The effects of fish advisories had been evaluated among anglers.15,17,18

Although a growing body of research has been conducted to study fish consumption knowledge and behaviors, and the efficacy of related educational interventions, these studies were mainly focused on anglers. Furthermore, most studies did not take into account cultural considerations among anglers or those purchasing commercial fish. To address these gaps, from 2009 to 2013, the research team worked closely with the leaders of the Chinese community of the Capital District of New York State (NYS) to develop and implement a series of culturally sensitive educational activities about fish consumption in the Chinese community. The aims of this study were to 1) assess the efficacy of the culturally sensitive education intervention by evaluating the changes of fish consumption behavior and knowledge among Chinese adults in this community of interest; 2) compare race differences between Chinese and non-Chinese regarding fish consumption patterns and knowledge post-education; and 3) identify the predictive factors for risk behaviors of fish consumption among Chinese and non-Chinese.
METHODS

Study design and study population

A cross-sectional study was conducted to examine the changes in fish consumption patterns and knowledge pre-/post-culturally sensitive fish consumption education (pre-/post-education). The study population for the pre-education part of this study was pulled from a previous study conducted in 2009. The post-education part of this study was part of the Family Health Project funded by the National Institutes of Health (NIH) in 2013. This study had two components: non-epidemiological and epidemiological. The non-epidemiological component of the project was to test personal heavy metal exposure, including collecting samples of food, cosmetics, medicine, and other commonly used items from all participating homes. Samples were tested for heavy metals on site using a new Personal Exposure Analyzer. Results were later verified using a gold standard method in a laboratory of Inorganic and Nuclear Chemistry at Wadsworth Center in the New York State Department of Health (NYSDOH). The epidemiological component of the study was only conducted in those families that were interested in a home visit for sampling and testing.

The Chinese-Americans were mainly recruited from the Chinese Community Center and Chinese school (CCC/CS). A small percentage of them were recruited from the local Chinese church, universities, and businesses. Other Americans (non-Chinese) were recruited from the NYSDOH. All participation was voluntary, and the study was approved by the NYSDOH.
Recruitment, survey distribution, and data collection

The recruitment, survey distribution, and data collection for the pre-education part of this study were described elsewhere. Similar methods were used for the post-education part of this study. To recruit Chinese participants, a recruitment seminar was given at the CCC/CS. Recruitment posters were placed on the CCC website, the CCC and CS building doorways. The recruitment announcement was sent to CCC families through the weekly newsletter. In addition, an information table was set up at the CS and Chinese events (such as Chinese community annual picnic, Chinese school registration day) to answer questions and recruit additional CCC families. To encourage enrollment from the DOH, the principle investigator of the project gave a seminar at division meetings. A project introduction and recruitment message were sent out through the Insider, a DOH newsletter to the DOH employees. Furthermore, recruitment posters were displayed at the DOH hallways near the elevators, and the project staff was available to answer questions at the DOH office throughout the work week. Recruitment was ended when the enrollment goal had been achieved, which was to recruit 75 Chinese families and 25 non-Chinese families. When the participant pool was formed, the project coordinator sent the possible schedule of home visits to all participating families one or two weeks ahead of time through E-mail or phone calls. The questionnaires were delivered to the participants by E-mail or in person. Each participant family received two sets of surveys. One was a General Home Health questionnaire which was filled out once for a whole family. A separate questionnaire was filled out by each individual in a family, up to four family members. The questionnaire for Chinese
families was bi-lingual (English and Chinese), and the one for non-Chinese families was English only. The details of the questionnaire were described in previous publications.\textsuperscript{9,10} Since the survey packet distribution corresponded with home sampling and testing, it took place from August 2013 to July 2014. Most of the surveys were collected at participants’ homes when sampling and testing were conducted. A small proportion of the surveys were collected at the CS. An incentive was offered to all participants who completed the surveys.

\textit{Fish consumption education and intervention}

From 2009 to 2013, the research team worked closely with the leaders of the CCC/CS to develop and implement a series of culturally sensitive educational activities. The educational activities included a series of environmental health seminars and a fish consumption seminar; participated in the CCC Health Fair and other events to educate Chinese about fish consumption and health outcomes; invited NYC scientists to present fish testing results; invited NYS DOH scientists to present on heavy metal exposure and human health. The educational activities also included distributing color-coded pictures with bilingual fish names to the CCC members, posting the NYC commercial fish advisory flyer in the CCC and CS building, distributing fish flyers in classrooms at the CS, and posting the fish educational materials on the CCC and CS websites.

The contents of the educational activities covered 1) the sources of environmental heavy metal exposure from the home environment, food, Chinese herbal medicine; personal care products, and work-related exposure; 2) how heavy metal exposure impacts public health; 3) knowledge of fish consumption benefits and warnings; 4) fish species categories based on mercury contamination (based on NYCDOHMH flyer); 5) recommended fish consumption
frequency and amount; 6) fish consumption patterns by race, and 7) cooking methods to reduce chemical (e.g., PCBs) exposure from fish consumption. The most important message delivered to this community was: balanced fish consumption. More than thirty people attended each seminar, and more than one hundred Chinese participated in the Chinese Health Fair and other events.

Fish categorization

For comparison purposes, four categories of fish Hg contamination were adopted to interpret fish consumption behavior. In detail, they were high risk fish (Chilean sea bass, grouper, mackerel, marlin, orange roughy, shark, swordfish, tilefish, and tuna), moderately high risk fish (bass, blue fish, eel, halibut, lobster, monkfish, sablefish, scorpion fish, sheepshead, skate, snapper, and weakfish), low risk fish (butterfish, catfish, cod, crab, Atlantic croaker, flounder, haddock, jacksmelt, north Atlantic mackerel, mullet, mussels, ocean or white perch, scallops, American shad, sole, squid, trout, and whitefish), and very low risk fish (anchovies, clams, crawfish, hake, herring, oysters, pollack, salmon, sardines, shrimp, tilapia, and whiting). The participant exposure to a Hg contamination category was determined by whether they ate any fish species in that category. Four ounces (113 g) was used as a typical adult serving size. The total amount of fish consumption for each species was calculated by number of fish meals in the last 30 days, multiplied by the average amount of fish eaten per meal. The recommended consumption amounts were as follows: do not eat any high risk fish species; one serving or less per week for any moderately high risk fish species; and up to three servings per week for any low or very-low risk fish species.
Outcomes

The outcomes of this study were the changes in fish consumption patterns and knowledge among Chinese adult participants, as well as race differences in fish consumption patterns and knowledge between Chinese and non-Chinese adult Americans.

Data analysis

Data were analyzed using SAS 9.2 (SAS Institute, Cary, NC, USA). A chi-square test or Fisher Exact test was conducted to examine any significant differences in socio-demographics, fish consumption patterns, and awareness of fish benefits and warnings between Chinese and non-Chinese race groups, and between Chinese adults in a previous versus the current study. The means and ANOVA test were also used to calculate descriptive statistics. Unconditional multivariate logistic regression models were used to examine the risk factors for consumption of high-Hg, moderately high-Hg fish species, or consumption of more than recommended amounts of any fish while accounting for all other factors simultaneously. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated.
RESULTS

The total sample size was 638 including 421 adult participants pulled from the previous study in 2009 (pre-education)\textsuperscript{9,10} and 217 adult participants enrolled in the Family Health Project in 2013 (post-education). The response rate was 74\% (families) for the Chinese community and 60\% for the non-Chinese participants.\textsuperscript{9,10} Among them, a total of 469 Chinese adult participants (168 participants for post-education and 301 adults for pre-education) were used for the comparison study between before and after a series of educational activities on fish consumption. The distributions of gender and education background were similar between the two groups, but the age of Chinese adults in the current study (mean of age was 46.4 ± 13.0) was older than Chinese participants in the previous study (mean of age was 43.3 ± 11.0).

Table 1 shows a comparison of awareness of the benefits and warnings regarding fish consumption among Chinese adult participants pre-\textsuperscript{9} and post-education. Chinese adult participants who received fish consumption education had significantly more reported awareness of the warnings regarding fish consumption (80.4\%) than Chinese adult participants who did not receive the education (49.8\%). The significant improvement in awareness mainly occurred regarding warnings about “Other chemicals or pollution in fish/shellfish” (from 29.2\% to 55.5\% with 89.7\% increase), “Bacteria in shellfish” (from 13.3\% to 25\% with 88\% increase), and “Mercury in fish” (from 55.2\% to 65.5\% with 18.7\% increase). Although not significant, reported awareness of all other specific warnings increased among Chinese adult participants.
who received the education. There was no significant change in reported knowledge of the benefits of fish consumption between pre- and post-education.

Table 2 describes the frequency and amount of fish consumption in the previous 30 days by potential Hg contamination level among Chinese adult participants for pre- and post-education. Fewer Chinese adult participants who received the education reported consumption of any moderately high-Hg (44.1%) and low-Hg (64.3%) fish species than Chinese adult participants who did not (56.8% and 79.7%, respectively). On the other hand, more Chinese participants who received the education consumed any very low-Hg fish and had a significantly higher mean number of low-Hg fish meals than Chinese participants who did not receive the education. Although it seems that Chinese adult participants who received the education consumed a higher average amount of low-Hg fish (22.5 oz) and a lower average amount of very low-Hg fish (22.6 oz) compared to Chinese adult participants who did not receive the education (17.8 oz, 28.6 oz, respectively), the difference was not significant.

Figure 1 demonstrates the commonly consumed fish/shellfish among Chinese participants pre- and post-education. Panel A presents the commonly consumed any fish/shellfish between the two comparison groups. Panel B shows the top five commonly consumed high-Hg fish/shellfish between the groups. The top five commonly consumed fish species were shrimp, salmon, lobster, and crab. The main changes after the education were fewer Chinese adults consumed crabs and black sea bass, and tuna sushi instead of black sea bass became one of the commonly chosen fish/shellfish species among Chinese adult participants after the education. Five of the most commonly consumed high-Hg fish species remained the same for pre- and post-education, but the favorite order was changed. Although Chilean Sea Bass was still one of the
commonly selected fish species, significantly fewer Chinese adult participants consumed it after the education.

To evaluate race differences on awareness of fish consumption knowledge and behavior, a comparison was conducted between Chinese adult participants (N=168) who received the fish consumption education and non-Chinese adult participants (N=49). The groups of participants were middle aged and well educated. The mean age was 45.98 ± 12.86 years old, and nearly 80% of them had a Bachelor’s or higher degree. There were no statistical differences in age, gender, and education between Chinese and non-Chinese groups. However, a significantly higher proportion of Chinese participants were born in foreign countries (98.2%) compared to non-Chinese participants (12.2%). Furthermore, for those participants who were not born in the USA, non-Chinese adult participants (mean = 27.3 ± 4.8 years) lived in the USA statistically longer than Chinese adult participants (mean = 12.0 ± 7.6 years).

A comparison of fish consumption frequency and knowledge of fish consumption benefits and warnings is described for the current study between Chinese and non-Chinese adult participants in Table 3. In the month before the survey was conducted, 95.8% of Chinese and 89.8% of non-Chinese adult participants reported fish or shellfish consumption. Among those who ate fish, the frequency of fish or shell fish consumption was not significantly different between the two groups. Approximately half of those who ate fish did so once per week. About 30% of Chinese adult participants ate fish twice per week, while about 20% of non-Chinese adult participants did so. Nearly 12% of Chinese adult participants ate fish three or more times per week. Whereas, it was over 16% for non-Chinese adult participants. The frequency of “None” category of fish or shellfish consumption was defined as no fish or shellfish consumption or less than once per week. The proportion of participants in the “None” category was three times
higher in the non-Chinese group (14.6%) than in the Chinese group (4.2%). Over 90% of both Chinese and non-Chinese adult participants were aware of the benefits of fish or shellfish consumption. However, significantly more Chinese adult participants (58.3%) were aware of fish benefits for the brain than non-Chinese adult participants (36.7%). On the other hand, non-Chinese adult participants had better knowledge about high protein (63.3%) and heart health (75.5%) compared to Chinese adult participants (46.4% and 49.4%, respectively). 80% of Chinese adult participants reported having heard of warnings related to fish or shellfish consumption, which did not differ from non-Chinese adult participants. However, few Chinese were aware of specific warnings, such as “Bacteria in shellfish” (25%), “Avoid certain species” (25%), “Limit amount of fish” (27.4%), “Sushi/raw undercooked fish” (29.2%), and “Pregnant women should be careful” (29.8%). Their knowledge about these warnings was significantly limited compared to non-Chinese adult participants, which was 40.8%, 44.9%, 51%, 51% and 63.3%, respectively. More than two-thirds of Chinese adult participants (65.5%) reported an awareness of “Mercury in fish”, but it was still significantly lower than the percentage among non-Chinese adult participants (83.7%). In general, Chinese adult participants had better knowledge of the benefits (92.9%) than warnings (80.4%) about fish consumption. Unlike Chinese adult participants, non-Chinese adult participants were aware of both fish benefits (91.8%) and warnings (89.8%).

A comparison of fish consumption in the previous 30 days by potential Hg contamination level between Chinese and non-Chinese adult participants in the current study is presented in Figure 2. Potential Hg levels in fish were described in the previous publications.9,10 Significantly more Chinese adult participants consumed any very low-Hg fish (91.1%) than non-Chinese participants (73.5%). Interestingly, there was no race difference in consumption of high-Hg fish.
Moreover, there was no difference in the average number of meals of fish consumed or the average total amount of fish consumed in the previous 30 days between Chinese and non-Chinese adult participants (data not shown).

In addition to evaluating the effects of the educational intervention and race differences in fish consumption patterns and knowledge, we investigated the predictive factors for high Hg fish consumption. Table 4 demonstrates the factors contributing to the risk behavior of high Hg fish consumption among all participants in the previous and current studies. Chinese race was a significant protective factor for consuming any high-Hg fish (OR = 0.44, 95% CI: 0.29-0.67) or more than the recommended amount of any fish (OR = 0.48, 95% CI: 0.31-0.73). In contrast, fish consumption three or more times per week and being aware of heart benefits were significant risk factors of consuming any high-Hg fish (OR = 2.20, 95% CI: 1.29-3.75 and OR = 1.64, 95% CI: 1.11-2.42, respectively) or more than the recommended amount of any fish (OR = 3.34, 95% CI: 1.87-5.93 and OR = 1.71, 95% CI: 1.17-2.51, respectively). However, race and fish consumption three or more times per week were not significantly predictive for consuming any moderately high-Hg fish in the study. Interestingly, aware of protein benefit (OR = 1.64, 95% CI: 1.14-2.35) and heart benefit (OR = 1.59, 95% CI: 1.09-2.32) were risk factors for consuming any moderately high-Hg fish. Other factors such as age, education attainment, and awareness of any fish warnings did not play an essential role in prediction of fish consumption in this study.
DISCUSSION

Effects of fish consumption education

Knowledge change: Our data indicated a significant increase in reported general and specific knowledge of fish warnings among Chinese participants who received the education, indicating that culturally sensitive fish consumption education is effective in improving knowledge of fish warnings. No previous studies have looked at changes in knowledge of specific warnings regarding fish consumption. The changes in general knowledge after the education about fish warnings are similar to fish advisory effects found in anglers who lived in the Great Lakes region.\textsuperscript{15,17} Wisconsin Departments of Health Services and Natural Resources conducted an online survey from October 2011 through August 2013 targeting men aged 50 years or older who regularly fished in, and lived in Wisconsin. Christenson et al. found that a high percentage of the anglers knew the fish consumption guidelines, but they had knowledge gaps about mercury exposure and fish preparation, as well as PBCs in certain fish.\textsuperscript{15} Niederdeppe and his colleagues conducted a mail survey among licensed anglers that lived in Great Lakes states. They found that most adult anglers reported being aware of fish consumption advisories, but far fewer reported being aware of specific advice.\textsuperscript{17}

Behavior change: We also found that more Chinese consumed very low-Hg fish and fewer Chinese consumed moderately high-Hg fish after education. It suggests that the education intervention also influenced certain fish consumption behavior in this Chinese population. This finding does not completely agree with a previous study in which Lauber et al. found that anglers
reduced the number of meals for both high-Hg and low-Hg fish species.\textsuperscript{18} Lauber et al. conducted a randomized controlled trial to study the effects of fish consumption education on fish consumption behaviors among licensed urban anglers lived in three counties in the Great Lake region of the United States in summer 2014 and summer 2015.\textsuperscript{18} They found the anglers receiving education via a brochure reduced their fish consumption compared to the controls who didn’t receive the brochure education. Educated anglers reduced fish consumption of both high mercury contaminated purchased fish (by $\geq 0.2$ meals/summer) and sport-caught fish (by $\geq 0.4$ meals/summer), and low mercury contaminated sport-caught fish (by $\geq 0.3$ meals/summer). Unlike those anglers, Chinese adult participants in this study did not reduce their number of meals of fish consumption. In fact, the number of meals of low-Hg fish consumption was statistically increased after the education. The different findings could be due to the different study population and/or intervention strategy. Our study population was foreign-born Chinese-Americans (98.2%), their study population was mostly White Americans (93-97%). Our education was more focused on balanced fish consumption. We encouraged Chinese to continuous eat variety types of fish with less contamination. They were focused on not exceeding the guidelines.

Interestingly, the most popular types of fish or shellfish selected changed only slightly among Chinese adult participants between pre- and post-education in the current study, suggesting that this type of fish consumption behavior is less influenced by a series of educational activities. It may be due to cultural preference of types of fish/shellfish or it could be related to the accessibility of certain types of fish or shellfish. We also found that high-Hg fish consumption among Chinese was not significantly impacted after the education. We could not find any relevant studies to compare.
**Balanced fish consumption:** Fish is a rich source of healthful nutrients, such as high-quality protein, omega-3 long-chain polyunsaturated fatty acids (LCPUFAs), vitamin D, and various essential minerals.\(^6,7\) The health benefits of fish consumption may include but not be limited to protection against cardiovascular/cerebrovascular diseases, the prevention of hip fractures, the reduction of all-cause mortality, and the promotion of cognitive health among adults.\(^6,7,19-23\) Moreover, pregnant women consuming 8-12 ounces of seafood per week could enhance their child’s IQ by 3.3 points by age 9.\(^24\) On the other hand, fish consumption is associated with toxicant exposure and related health risks. Fish may be contaminated with persistent organic compounds such as dioxins and polychlorinated biphenyls (PCBs), pharmaceutical and perfluorinated organic compounds, and inorganic compounds such as MeHg and other heavy metals.\(^6,7\) The health risks of MeHg exposure can be impact of fetus and infant growth, and the effect on neurological outcome.\(^6,7,25,26\) Therefore, balanced fish consumption is critical. We should promote low- and very low-Hg fish consumption, whereas prevent high-Hg fish consumption.

**Race differences in fish knowledge and fish consumption patterns**

Our results suggest that Chinese adults may still have inadequate knowledge of fish consumption risks, especially lack of specific knowledge of fish warnings, although Chinese participants have significantly improved their general knowledge of fish warnings after the education.

In addition to race differences in knowledge of specific fish warnings, we also found race differences in knowledge regarding the awareness of specific benefits of fish consumption in the current study. More non-Chinese participants reported knowledge of fish being good for the heart and high in protein, but more Chinese participants were aware of fish benefits for the brain.
This finding is consistent with our previous findings that more Chinese had better knowledge of fish benefits for the brain and more non-Chinese were aware of fish being good for the heart.\textsuperscript{9,10}

In general, Chinese adult participants were still more aware of fish benefits than warnings. Unlike Chinese adult participants, non-Chinese adult participants knew both the benefits and warnings of fish consumption. This finding is consistent with other published studies which also suggest that there is race difference regarding awareness of fish knowledge.\textsuperscript{9,27,28} It implies that this type of difference may be due to a cultural belief passed on through generations. More Chinese consumed very low-Hg fish, but there was no increase in the number of meals or the amount consumed compared to non-Chinese. In the previous study, Chinese consumed significantly more meals and higher amounts of very low-Hg fish compared to non-Chinese.\textsuperscript{9} This is a promoted change in fish consumption behavior since even for very low-Hg fish species, people should not consume more than the recommended amounts.

It is surprised to find that non-Chinese participants also improved their fish consumption behavior. Previously we found that more non-Chinese consumed high-Hg fish compared to Chinese.\textsuperscript{9} Now, we observed no race difference of high-Hg fish consumption by race. No relevant studies can be found to compare with.

**Predictive factors for risk fish consumption behaviors**

This study found that non-Chinese race, frequency of fish consumption three or more times per week and awareness of heart benefits are risk factors for consuming high-Hg fish or eating more than recommended amounts of any fish. Awareness of protein benefits and heart benefits are risk factors for consuming any moderately high-Hg fish. These findings were consistent with our published results that non-Chinese race and fish consumption three or more times per week were risk factors for consuming High-Hg fish and consuming more than
recommended amounts of any fish. However, awareness of certain fish benefits as a risk factor for high-Hg fish consumption was not observed in the previous study. The factors causing the difference could be that different predictive variables were employed in this study, and the most current fish consumption guideline was used for determining the recommended amounts of fish consumption. It is surprising to find that specific knowledge of fish benefits is related to high-Hg fish consumption. It implies that the participants might not know what fish species belong to the high-Hg category, and what amounts of fish should be consumed in each fish category. It is also possible that the participants weigh the fish benefit/warning messages according to their own value. Future education about fish consumption should emphasize not only specific knowledge of fish benefits/warnings, but also about what types of fish are best to be consumed for heart and lean protein benefits.

**Strengths, limitations and strategies**

This sample population has high potential mercury exposure from fish consumption. In addition, we are not aware of any other studies showing such effects of culturally sensitive educational interventions targeting the general public rather than anglers. However, the conclusions of this study should still be carefully interpreted.

The results should be interpreted at the community level since we cannot link individual data pre/post education. Chinese participants were enrolled from the same Chinese community to control for socio-demographic differences in the design. There is possible selection bias. However, with a high response rate in these communities, selection bias could be reduced. To minimize recall bias, we asked fish consumption patterns including fish consumption frequency, number of meals and specific fish species eaten in the past 30 days. To minimize information bias, the questionnaire was supported with bilingual fish pictures, and a reference for
determining amount of fish consumed (size of a deck of cards). To avoid a possible correlation between adults and children within the same family, only adults were selected for the comparison study. We also used double data entry to control human entry error. Finally, generalizability could be a concern of this study, but we did include both Chinese Americans and non-Chinese Americans. The reason why we were focused on Chinese rather than other races/ethnicities is that Chinese have higher fish consumption rates in NHANES and other previous surveys. Furthermore, both Chinese and non-Chinese participants in this study were well educated, especially non-Chinese participants who were recruited from the NYS DOH. Since these non-Chinese were public health workers, they should have better knowledge of mercury exposure and fish consumption than the general public. Therefore, our results may underestimate the fish consumption risks in real general public.
CONCLUSIONS

Culturally sensitive education improved awareness of fish warnings among Chinese adult participants. However, compared to non-Chinese participants, Chinese still had limited knowledge of specific fish warnings. The fish consumption education resulted in increased consumption of very low-Hg fish and reduced moderately high-Hg fish consumption among Chinese participants. We found that non-Chinese race, frequent fish consumption, and awareness of heart benefit are the top risk factors for consuming high-Hg fish or exceeding consumption of recommended amounts of any fish. Continued efforts are needed to educate the public not only about specific knowledge of fish benefits/warnings, including mercury levels of specific fish species and recommended amounts to consume but also about what types of fish are best to be consumed for heart and lean protein benefits.
REFERENCES


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<td>Aware of benefits of fish or shellfish consumption</td>
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<td>Any knowledge</td>
<td>272 (90.4)</td>
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<td>193 (64.1)</td>
<td>95 (56.5)</td>
<td></td>
</tr>
<tr>
<td>High in protein</td>
<td>164 (54.5)</td>
<td>78 (46.4)</td>
<td></td>
</tr>
<tr>
<td>Good for the heart/makes you health</td>
<td>169 (56.2)</td>
<td>83 (49.4)</td>
<td></td>
</tr>
<tr>
<td>Good for the brain/makes you smart</td>
<td>195 (64.8)</td>
<td>98 (58.3)</td>
<td></td>
</tr>
<tr>
<td>Aware of warnings of fish or shellfish consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any knowledge</td>
<td>150 (49.8)</td>
<td>135 (80.4)</td>
<td>61.4%↑*</td>
</tr>
<tr>
<td>Mercury in fish</td>
<td>166 (55.2)</td>
<td>110 (65.5)</td>
<td>18.7%↑*</td>
</tr>
<tr>
<td>Bacteria in shellfish</td>
<td>40 (13.3)</td>
<td>42 (25.0)</td>
<td>88.0%↑*</td>
</tr>
<tr>
<td>Other chemicals or pollution in fish/shellfish</td>
<td>88 (29.2)</td>
<td>93 (55.4)</td>
<td>89.7%↑*</td>
</tr>
<tr>
<td>Avoid certain species</td>
<td>66 (21.9)</td>
<td>42 (25.0)</td>
<td></td>
</tr>
<tr>
<td>Pregnant women should be careful</td>
<td>75 (24.9)</td>
<td>50 (29.8)</td>
<td></td>
</tr>
<tr>
<td>Sushi/raw or undercooked fish</td>
<td>72 (23.9)</td>
<td>49 (29.2)</td>
<td></td>
</tr>
<tr>
<td>Limit amounts of fish</td>
<td>66 (21.9)</td>
<td>46 (27.4)</td>
<td></td>
</tr>
</tbody>
</table>

* Significant difference (*p* < 0.05).  
↑ increased % change.  
a Duplicated from the data used in a previous study.  

**Table 1.** Comparison of awareness of fish benefits/warnings among Chinese adults between pre- and post-education.
| Species of fish<sup>b</sup> | Pre-education<sup>a</sup>  
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N=301)</td>
<td>Mean number of meals</td>
<td>Mean of total amount consumed (oz)</td>
<td>N (%)</td>
<td>Mean number of meals</td>
</tr>
<tr>
<td>Any high-Hg</td>
<td>108 (35.9)</td>
<td>2.42</td>
<td>12.49</td>
<td>66 (39.3)</td>
<td>2.64</td>
</tr>
<tr>
<td>Any moderately high-Hg</td>
<td>171 (56.8)&lt;sup&gt;*&lt;/sup&gt;</td>
<td>2.66</td>
<td>12.65</td>
<td>74 (44.1)</td>
<td>2.67</td>
</tr>
<tr>
<td>Any low-Hg</td>
<td>240 (79.7)&lt;sup&gt;*&lt;/sup&gt;</td>
<td>3.68</td>
<td>17.75</td>
<td>108 (64.3)</td>
<td>5.38&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>Any very low-Hg</td>
<td>253 (84.1)</td>
<td>5.32</td>
<td>28.55</td>
<td>153 (91.1)&lt;sup&gt;*&lt;/sup&gt;</td>
<td>5.48</td>
</tr>
</tbody>
</table>

<sup>*</sup> Significant difference between before and after educational activities \( (p < 0.05) \).
<sup>a</sup> Duplicated from the data used in a previous study.<sup>9</sup>
<sup>b</sup> Category of potential Hg levels is based on New York City Fish Advisories.

**Table 2.** Frequency and amount of fish consumed in previous 30 days among Chinese adult participants between pre and post-education.
<table>
<thead>
<tr>
<th></th>
<th>Chinese (N=168)</th>
<th>Non-Chinese (N=49)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fish or shellfish consumption for past month</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>161 (95.8)</td>
<td>44 (89.8)</td>
</tr>
<tr>
<td>No</td>
<td>7 (4.2)</td>
<td>5 (10.2)</td>
</tr>
<tr>
<td><strong>Fish or shellfish consumption Frequency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None(^a)</td>
<td>7 (4.2)</td>
<td>7 (14.6)</td>
</tr>
<tr>
<td>One time/week</td>
<td>90 (53.6)</td>
<td>23 (47.9)</td>
</tr>
<tr>
<td>Two times/week</td>
<td>51 (30.4)</td>
<td>10 (20.8)</td>
</tr>
<tr>
<td>Three times/week</td>
<td>13 (7.7)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>Four or more times/week</td>
<td>7 (4.2)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td><strong>Benefits of fish or shellfish consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any knowledge</td>
<td>156 (92.9)**</td>
<td>45 (91.8)</td>
</tr>
<tr>
<td>Low in fat</td>
<td>95 (56.5)</td>
<td>25 (51.0)</td>
</tr>
<tr>
<td>High in protein</td>
<td>78 (46.4)</td>
<td>31 (63.3)*</td>
</tr>
<tr>
<td>Good for the heart/makes you health</td>
<td>83 (49.4)</td>
<td>37 (75.5)*</td>
</tr>
<tr>
<td>Good for the brain/makes you smart</td>
<td>98 (58.3)*</td>
<td>18 (36.7)</td>
</tr>
<tr>
<td><strong>Warnings of fish or shellfish consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any knowledge</td>
<td>135 (80.4)**</td>
<td>44 (89.8)</td>
</tr>
<tr>
<td>Mercury in fish</td>
<td>110 (65.5)</td>
<td>41 (83.7)*</td>
</tr>
<tr>
<td>Bacteria in shellfish</td>
<td>42 (25.0)</td>
<td>20 (40.8)*</td>
</tr>
<tr>
<td>Other chemicals or pollution in fish/shellfish</td>
<td>93 (55.4)</td>
<td>30 (61.2)</td>
</tr>
<tr>
<td>Avoid certain species</td>
<td>42 (25.0)</td>
<td>22 (44.9)*</td>
</tr>
<tr>
<td>Pregnant women should be careful</td>
<td>50 (29.8)</td>
<td>31 (63.3)*</td>
</tr>
<tr>
<td>Sushi/raw or undercooked fish</td>
<td>49 (29.2)</td>
<td>25 (51.0)*</td>
</tr>
<tr>
<td>Limit amounts of fish</td>
<td>46 (27.4)</td>
<td>25 (51.0)*</td>
</tr>
<tr>
<td>Other</td>
<td>3 (1.8)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

* Significant difference by race (p < 0.05).
** Significant difference within race (p < 0.05).
\(^a\) Includes the participants who did not consumed any fish/shellfish or consumed fish/shellfish for less than one time per week in previous 30 days when the survey was conducted.

**Table 3.** Fish consumption and awareness of benefits/warnings among adult participants by race post-education.
<table>
<thead>
<tr>
<th>Predictive indicators</th>
<th>Eat any high-Hg fish&lt;sup&gt;a&lt;/sup&gt; (n = 611)</th>
<th>Eat any moderately high-Hg fish&lt;sup&gt;a&lt;/sup&gt; (n = 611)</th>
<th>Eat more than recommended amount of any fish&lt;sup&gt;a&lt;/sup&gt; (n = 611)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.99 (0.98, 1.01)</td>
<td>0.99 (0.98, 1.01)</td>
<td>1.00 (0.98, 1.01)</td>
</tr>
<tr>
<td>Female</td>
<td>1.13 (0.80, 1.61)</td>
<td>1.36 (0.96, 1.91)</td>
<td>1.17 (0.83, 1.66)</td>
</tr>
<tr>
<td>Chinese adults</td>
<td><strong>0.44 (0.29, 0.67)</strong></td>
<td>1.07 (0.70, 1.62)</td>
<td><strong>0.48 (0.31, 0.73)</strong></td>
</tr>
<tr>
<td>Education-Associate degree&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.32 (0.06, 1.63)</td>
<td>0.41 (0.10, 1.69)</td>
<td>0.26 (0.05, 1.34)</td>
</tr>
<tr>
<td>Education-Bachelor's degree&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.60 (0.33, 1.10)</td>
<td>0.79 (0.44, 1.43)</td>
<td>0.64 (0.35, 1.17)</td>
</tr>
<tr>
<td>Education-Graduate degree&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.79 (0.46, 1.36)</td>
<td>1.22 (0.71, 2.08)</td>
<td>0.82 (0.47, 1.42)</td>
</tr>
<tr>
<td>Consume fish 3+ times/week</td>
<td><strong>2.20 (1.29, 3.75)</strong></td>
<td>1.68 (0.98, 2.85)</td>
<td><strong>3.34 (1.87, 5.93)</strong></td>
</tr>
<tr>
<td>Aware of Hg warning</td>
<td>1.07 (0.68, 1.66)</td>
<td>0.73 (0.47, 1.12)</td>
<td>1.03 (0.66, 1.61)</td>
</tr>
<tr>
<td>Aware of limit amount warning</td>
<td>0.82 (0.53, 1.27)</td>
<td>1.34 (0.87, 2.07)</td>
<td>0.95 (0.61, 1.47)</td>
</tr>
<tr>
<td>Aware of species warning</td>
<td>1.49 (0.96, 2.31)</td>
<td>0.86 (0.56, 1.33)</td>
<td>1.25 (0.80, 1.93)</td>
</tr>
<tr>
<td>Aware of other pollution warning</td>
<td>0.89 (0.60, 1.33)</td>
<td>1.14 (0.77, 1.69)</td>
<td>0.88 (0.59, 1.32)</td>
</tr>
<tr>
<td>Aware of low fat benefit</td>
<td>0.98 (0.66, 1.45)</td>
<td>0.95 (0.65, 1.38)</td>
<td>1.19 (0.81, 1.76)</td>
</tr>
<tr>
<td>Aware of protein benefit</td>
<td>1.06 (0.73, 1.54)</td>
<td><strong>1.64 (1.14, 2.35)</strong></td>
<td>1.14 (0.79, 1.64)</td>
</tr>
<tr>
<td>Aware of heart benefit</td>
<td><strong>1.64 (1.11, 2.42)</strong></td>
<td><strong>1.59 (1.09, 2.32)</strong></td>
<td><strong>1.71 (1.17, 2.51)</strong></td>
</tr>
<tr>
<td>Aware of brain benefit</td>
<td>1.14 (0.79, 1.65)</td>
<td>1.18 (0.82, 1.69)</td>
<td>1.16 (0.80, 1.68)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Category of potential Hg levels is based on New York City Fish Advisories.

<sup>b</sup> OR = Odds ratio; CI = Confidence interval.

<sup>c</sup> Reference is high school diploma or less.

Table 4. Multivariate analysis of predictive factors for fish consumption behaviors among all adult participants.
NA: Not available.
* Significant difference between pre- and post-education ($p < 0.05$).

\(a\) Category of potential Hg levels is based on New York City Fish Advisories.

\(b\) Tuna includes tuna-steaks, sushi or albacore.

**Figure 1.** The commonly consumed fish/shellfish among Chinese participants between pre- and post-education. A. Among any fish/shellfish species\(^a\); B. Among any high-Hg fish species.
*Significant difference by race ($p < 0.05$).

aCategory of potential Hg levels is based on New York City Fish Advisories.

**Figure 2.** Frequency of fish/shellfish consumption in previous 30 days by race.