Measuring the impact of Maine's 'Safe Eating Guidelines':

A Fish Consumption Advisory for at-risk women

A Report to the Environmental Health Unit,

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Eating fish provides several benefits, including: reducing the risk of heart disease (Mozaffarian and Rimm 2006) and arthritis (Cleland et al. 2003), and promoting healthy brain (Hibbeln et al. 2007; Uauy and Dangour 2006), eye and skin health (Nettleton 1995; Akabas and Deckelbaum 2006). However, nearly all fish and shellfish (hereafter, fish) contain at least some methylmercury, MeHg (hereafter, mercury), which is distributed in the tissue (Davidson, Myers, and Weiss 2004), thereby making fish preparation methods ineffective in reducing mercury risk (USEPA 2006; Mahaffey, Clickner, and Bodurow 2004). Mercury levels in people[1] increase with fish consumption (Knobeloch et al., 2005; Johnsson et al., 2005); indeed, eating mercury-laden fish is the primary mechanism of mercury exposure (Knobeloch et al 2005). Chronic exposure to mercury can impair human health (Davidson, Myers, and Weiss 2004),[2] as can the consumption of a single-meal of highly contaminated fish (Ginsberg and Toal 2000).

Issuance of advisories have traditionally been the favored response, but have the disadvantages of being voluntary, of communicating a complex message, and making the assumption that people's behaviors act in line with new information (Jakus et al. 1997; Halkier 1999). The risk communication literature is clear that an iterative approach with public participation is necessary to develop advisories that result in the intended behavior change (NCI 2002; USEPA 1995). While federal advisories have been issued since the 1970s, early efforts rarely attempted to measure the impacts of those advisories. More recent efforts at evaluation highlight the poor performance of such advisories (Connelly

[1] After consuming mercury, it spreads through the body (NRC 2000) and is inefficiently excreted (Risher, Murray, and Prince 2002; NRC 2000).
[2] Including, at doses relevant to typical US exposure, subtle neurological damage, such as IQ deficits, abnormal muscle tone, decrements in motor function, attention and visuo-spatial performance (NRC 2000).

and Burger 2000; Jardine 2003; Roosen et al 2006). Oken et al. (2003) and Shimshack et al (2007) indicate advisories led to an overall reduction in fish consumption. Reducing fish consumption can have the unintended impact of reducing the health benefits from consuming fish.

States have also developed similar fish advisories; however, most of these have traditionally focused on the angling public. In turn, much of the research on the effectiveness of advisories (e.g., see Anderson et al. 2004; Burger and Campbell 2008; Burger and Gochfeld 2006; Dawson et al. 2008; Ginsberg and Toal 2000; Habron et al 2008; Imm et al 2005; Jakus et al. 1998; MacDonald and Boyle 1997; MacNair and Desvousges 2007; Pflugh et al. 1999; Surgan, et al 2008; Westphal et al. 2008) include few women since anglers are predominantly male (Silvera et al. 2007). Newer efforts have focused on the ultimate consumer and at-risk women in their evaluation efforts, but little of this information is published in the peer reviewed literature (Anderson 2007; McCann 2007; Knaebel 2007; Silvera et al. 2007).

A central function of government information programs is to communicate product attributes that are not obvious to consumers. A central question for evaluating such programs is to what extent do they improve consumer decision making, and for which consumers? In the case of fish advisories, the benefits of providing information can be measured by its ability to inform consumers as to both the positive and negative attributes of their potential choices (Burger 2005), which would lead to targeted changes in behavior.[3] Importantly, the targeted change may not be to reduce overall fish

[3] Programs that highlight only a subset of important information impedes consumer decision making processes (Roe, Teisl, Rong and Levy, 2001).

consumption[4] (because of a loss of the nutritional benefits) but to induce a switch away from fish that are highly contaminated to those which are less contaminated.[5] Although studies document how advisories can lead to declines in overall fish consumption (e.g., see Verger et al 2007; Oken et al. 2003; Shimshack et al 2007), few have studied whether advisories lead to such switching behavior (e.g., see McCann 2007).

In addition, when contradictory health messages are provided (eat fish, but some fish is bad for you) it can lead to several unintended, but negative effects (Vardeman and Aldoory 2008); e.g., consumers not considered to be at-risk may reduce consumption in response to an advisory (Shimshack et al 2007), or individuals who may be a target of the message may misinterpret it and reduce overall fish consumption (instead of the intended behavior of switching from high-risk to low-risk fish). It is generally not the intention of fish advisories to lead to permanent reductions in fish consumption. We have not identified any studies documenting whether the advisory-induced declines in fish consumption for at-risk women rise to normal levels once the period of heightened risk has passed.

Other possible negative reactions to conflicting information are an increased skepticism (Covello and Peters 2002; Cozzens & Contractor, 1987; Rowsell et al., 2000) and confusion (Vardeman 2005) with the information. Skepticism and confusion degrade information effectiveness (Pieniak et al 2007) by diminishing information search (Vardeman and Aldoory 2008); especially with respect to a person being able to perceive

[4] Because of the health benefits to born and unborn children (Park and Johnson 2006), many fish advisories do not aim to reduce fish consumption (Vardeman and Aldoory 2008), even among at-risk women (FDA & EPA, 2004b; Lyman, 2003).
[5] Because fish bioaccumulate mercury, fish higher on the foodchain (such as shark and swordfish) have higher concentrations of mercury than fish lower on the food chain (such as sardines, cod, and salmon).

an issue as a problem (Vardeman and Aldoory 2008) and in weakening the link between the awareness of the problem and behavior (Henry and Gordon 2003).

Minimizing these unintended impacts can partly be addressed by the use of focus group and key informant testing during the development of the messaging (NCI, 2002; USEPA, 1995; Lapka et al. 2008). The use of evaluation tools to both evaluate the impact of the advisory as well as inform the next iteration of the risk communication message, is often rarer. Much traditional evaluation of fish consumption advisories has focused on awareness of the advisories, but ultimately the goal is to determine whether or not the advisory has resulted in intended changes of behavior. Here, we explore the effects of a state-level program for at-risk women, informing them about the benefits and risks of fish consumption. The effects we explore include changes in: specific mercury-related knowledge[6], the perception of the healthiness of fish consumption and changes in fish consumption behavior. We demonstrate such changes in behavior both during pregnancy and after pregnancy.

Program background

The centerpiece of Maine's risk communication program has been the distribution of an easy-to-read brochure that described safe eating guidelines for commercial and sport-caught fish. This brochure was developed with USEPA funding under a Cooperative Grant and was recently recognized in a top 10 national listing of examples of best practices in public health education. The brochure was developed using an iterative process of key informant and focus group testing among new mothers and women of childbearing age across the state of Maine.

[6] Few studies have examined the specific messages people receive from these advisories (Burger and Gochfeld 2008).

Beginning in April 2000, the brochure was distributed to pregnant women through Maine's Women, Infant and Children (WIC) Nutrition Program and offices of health care providers. Maine has approximately 14,000 births per year and WIC provides nutritional assistance to about 40% of all pregnant women. Brochures are delivered in bulk to all Maine regional WIC clinics. WIC clinic staff were instructed to give brochures directly to clients at their first prenatal visit (usually early in the 1st trimester). Brochures were also delivered in bulk (N=14,000) to offices of health care providers (obstetricians & gynecologists, family medicine physicians practicing obstetrics, and nurse midwifes), with amounts delivered based on number of obstetric deliveries performed in the preceding year (available from a state database). A database was created to track each office, requests for additional brochures, and check on distribution based on obstetric deliveries performed. Brochures were given as part of a packet at first prenatal visit, and were placed on display for all patients to take. In 2000, Maine also distributed materials to households having both a young child and someone with a fishing license (N = 17,000 households). This targeted mailing was based on a match between the State of Maine fishing license and birth certificate registries.

Methods

Sampling and survey administration - Between January and April of 2004, Maine conducted a mail survey of women who had given birth in the previous three months. The sample was drawn from Maine's Birth Certificate Registry. Selected families were contacted with a first class letter telling them the survey was coming. Additional mailings included the survey itself, a follow-up post card that either thanked them for responding or encouraged them to participate, and second and third mailings of the survey to non-respondents. A total of 769 women completed the survey, for a response rate of 62%.

Survey design - The final survey consisted of 80 questions intended to assess awareness of the state's mercury advisory (general & specific knowledge), receipt of the brochure, where they obtained the brochure, and any change in fish consumption behavior. For the pretest, 35 phone numbers were obtained from the 100 baby names and addresses. These numbers were called to ask the mothers whether or not they would like to participate in the pretest of the survey. Of the 35 numbers, a total of 23 mothers were mailed surveys on December 4, 2003 (loss due to incorrect numbers or lack of interest in participating in the pretest). The 23 pretest mothers were called between December 15 and 18, 2003 for a follow up phone call. Of the 23, nine mothers completed the phone interview and provided feedback for the draft version of the survey.

Data analysis - To evaluate the effects of Maine CDC's fish consumption advisory we first need to examine whether the advisory was known and read by Maine's at-risk women. Second, to evaluate whether the messages of the fish advisory were successfully transmitted we need to examine whether the advisory significantly altered respondents' knowledge and perceptions of fish consumption risks. Finally, to see if the advisory successfully altered fish consumption, we examine whether overall fish consumption dropped during the women's pregnancies, whether consumption returned to normal after the child was born and whether women switched consumption away from highly contaminated fish species toward species that have low contamination levels.

To determine what factors affected women's knowledge or reading of the Maine Safe Eating Guidelines, we estimated two models which differ in their dependent variables but were of the general form of:

$$DEP = \alpha + \delta_1 AGE + \delta_2 ED + \delta_3\ COUPLE + \delta_4 FIRSTPREG + \delta_5 EATFISH + \delta_6 INCOME + \delta_7 FISHING + \varepsilon$$

where DEP denotes one of two dependent, binary variables. One variable (AWARE) measures women's response to the question: "Did you know that Maine has 'Safe Eating Guidelines' to help you make decisions about how often to eat fish and shellfish?". The AWARE variable is coded 1 if the woman stated yes; 0 otherwise. Sixty percent of survey respondents stated they knew about the guidelines.

The other variable (READ) measures whether the woman had read the guidelines. Due to the skip patterns in the survey, we need to examine the responses to three related questions to design our READ variable. To be considered to have read the guidelines the respondent had to first be aware of the guidelines (said yes to the above question), had to have received a copy of the guidelines (said yes to the question "Have you ever received a copy of Maine's 'Safe Eating Guidelines' for fish and shellfish?"),[7] and stated they read the guidelines (said yes to the question "Did you read the 'Safe Eating Guidelines' for fish and shellfish?").[8] Individuals who stated no to the first (awareness) question skipped the second (received) question and those who stated no to the second skipped the READ question. In turn, individuals who said no to the awareness question and those who stated they did not receive a copy of the guidelines were assumed to have not read the guidelines. Thus, the READ variable is coded 1 if the woman stated yes to the read

[7] Thirty-three percent of respondents stated they received a copy.
[8] Thirty-one percent of respondents stated they read the guidelines (94 percent of those who received a copy).

question; 0 if the woman stated no to the read variable or if the women indicated she was unaware or had not received the guidelines. Given the binary form of the dependent variables, the models were estimated using binary logistic regression. For the binary logistic there is one intercept term (one α).

We include several demographic characteristics.[9] AGE, denoting the respondents' age (in years), is included to account for increased experiences with food and food related issues; Park and Johnson (2006) indicate an increased awareness of fish consumption advisories among older women. ED denotes the respondents' education level (in years). Education is included to control for differences in the respondent's cognitive abilities, access to information, and trust in information. Shimshack et al (2007) indicates that the first two factors are important in increasing the effectiveness of fish advisories and that education is a reasonable proxy for both factors. More educated individuals generally face lower information processing costs (Morris et al. 1995; Moorman 1990) and may be able to process more information (Gumpper 1998). Pieniak et al (2007) highlights that trust improves information effectiveness, and Frewer et al (1999) demonstrates that education is a key variable that influences the use of and trust in food information. Awareness has been positively related to education (Park and Johnson 2006; Silvera et al. 2007).

COUPLE denotes whether the respondent is part of a married or unmarried couple (if couple then coded as 1; 0 otherwise), and is meant to control for differences in time constraints faced by single and non-single mothers. Individuals with more binding time

[9] Mercury awareness varies across ethnic groups (Park and Johnson 2006; Anderson et al., 2004; Imm et al., 2005; Silvera et al. 2007), and although we collected data on the woman's race, the sample is predominantly white (95 percent) and shows little racial variation. Initial results indicated no significant racial effects on the dependent variables; as a result, race was dropped from further analysis.

constraints may prefer to process less information (Teisl et al. 1996). FIRSTPREG denotes whether this is the woman's first pregnancy (if yes then coded as 1; 0 otherwise); we hypothesis that women in their first pregnancy are more receptive to searching and examining new information.

EATFISH denotes whether the woman stated she ate fish in the year before becoming pregnant (if yes then coded as 1; 0 otherwise). We hypothesis fish-eating women are more receptive to searching and examining information about fish consumption because how close a person perceives they are to a risk increases a person's information seeking and processing behaviors (Vardeman and Aldoory 2008). Frequent fish eaters have been shown to be more willing to actively search for information (Vardeman and Aldoory 2008; Vardeman's 2005; Pieniak, et al 2007).

INCOME is a categorical variable that has been recoded to measure the household's annual income (in dollars). Awareness has been found to be positively related to income (Park and Johnson 2006; Anderson et al., 2004; Imm et al., 2005). FISHING denotes whether the woman lives in a household that has a licensed angler (if yes then coded as 1; 0 otherwise); we hypothesis that these women may have an increased knowledge of the Maine's Guidelines because they may be exposed to similar guidelines aimed at the angling public. Awareness of fish consumption advisories is higher in women with fishing licenses (Park and Johnson 2006).

ε denotes an error term.

To determine what factors affected whether the messages of the fish advisory were successfully transmitted, we estimated a series of models to examine whether reading the advisory significantly altered women's: knowledge and perceptions of fish consumption risks, and fish consumption behaviors. The models differed in their dependent variables but were of the general form of:

$$DEP = \alpha + \beta_1 READ + \beta_2 SGOODU + \beta_3 RGOODU + \beta_4 SGOODB + \beta_5 RGOODB + \beta_6 RBADB + \beta_7 AGE + \beta_8 ED + \beta_9 COUPLE + \beta_{10} FIRSTPREG + \phi$$

where DEP denotes the dependent variable which varies across equations. The dependent variables included four variables to measure respondent's knowledge of mercury-related fish consumption risks (Table 4), three variables to measure respondent's perceptions of these risks (Table 5) and eight behavioral variables (Tables 6 - 8). The dependent variables are binary, ordered-categorical or continuous (coding of these variables are summarized in Table 1). In turn, the models are estimated using either binary-logistic, ordered-logisitic or ordinary-least-squares (OLS) regressions, respectively. For the binary and OLS models there is one intercept term (one α); for the ordered models there is an n-1 vector of intercepts (n–1 α's) corresponding to the n number of ordered categories.

ϕ denotes an error term.

READ denotes whether the respondent read the Safe Eating Guidelines (coded as defined earlier). In turn, β_1 is our primary measure of the marginal effect of reading the fish consumption advisory. We hypothesize that the β_1's in the knowledge equations (Table 4) are positive; indicating that knowledge levels are higher among women who read the guidelines brochure. We also hypothesize that the β_1 in the first risk-perception equation (Table 5) would be positive; indicating that women who read the brochure had an increased perception that fish are contaminated with mercury.

Although not the primary focus of the guidelines brochure, the brochure was careful to remind readers that eating fish also promoted good health. In turn, we would expect the β_1's in the other risk-perception equations would be positive; indicating that women who read the brochure had an increased perception that eating fish was good for her and the baby, respectively. However, a key concern is that the brochure would inadvertently increase women's perceptions that eating fish was bad for them or for the fetus. Hence, we are interested if the β_1's in these two equations are negative.

There are a total of eight fish consumption models; three (Table 6) examine the relative changes in overall fish consumption across three times periods (pre-pregnancy/pregnancy; early pregnancy/late pregnancy[10]; pregnancy/post-birth); two (Table 7) examine whether there is a change in the types of fish consumed (indicating switching behavior) across two time periods (pre-pregnancy/pregnancy; pregnancy/post-birth); and two (Table 8) examine the switching behavior with respect to the amount of tuna consumed during late pregnancy.

We hypothesize that women who read the guidelines would reduce their fish consumption behavior during the course of their pregnancies; supporting negative β_1's in the first two equations[11]. It is unclear whether fish consumption would continue to be depressed after pregnancy among women who read the brochure (supported by an insignificant β_1); however, health professionals would generally want fish consumption to increase after pregnancy as the women and fetus are now at less risk. Thus a well-designed brochure should lead to a positive β_1 in this latter model. A well-designed

[10] Here we define early pregnancy as the first two trimesters; late as being the last trimester.
[11] While this is the hypothesis, it is not the goal. The goal remains to switch fish consumption from high mercury fish to low mercury fish. This brochure was developed at a time when that message was not as clearly articulated.

brochure should present a message that lead to changes in the types of fish consumed during pregnancy (switching behavior). Motivated similarly to the hypotheses above, we would expect that women who read the guidelines would be more likely to switch the types of fish they eat during the course of their pregnancies, supporting positive β_1's in these two switching equations.

The last two switching questions examine whether women who read the brochure ate relatively more or less light and white (albacore) tuna during late pregnancy. One aim of the brochure was to induce a switch toward the consumption of light tuna and away from white tuna, as light tuna is relatively low in mercury whereas white tuna is relatively high. Most individuals cannot identify the types of fish likely to be contaminated with mercury (Burger and Gochfeld 2008; Verger et al 2007). Hence, if this message was accurately delivered then β_1 should be positive in the light tuna equation and negative in the white tuna equation.

To help ensure that the parameter on READ (β_1) accurately reflects the effect of the advisory and does not inadvertently include the effects of other information, we include a vector of variables (SGOODU, RGOODU, SGOODB, RGOODB, RBADB) meant to measure and control for these other information effects (all variables are coded 1 it stated yes, 0 otherwise).[12] SGOODU denotes whether the respondent answered yes to the following question "Did anyone ever speak to you about how eating fish or shellfish is good for you?" RGOODU denotes whether the respondent answered yes to the following question "Did you hear or read that eating fish or shellfish is good for you from any other sources?" SGOODB denotes whether the respondent answered yes to the

[12] It is important to control for these other effects because individuals who read the advisory are also more likely to have searched for other information.

following question “Did anyone ever speak to you about how eating fish or shellfish while you were pregnant was good for your baby?” RGOODB denotes whether the respondent answered yes to the following question “Did you hear or read that eating fish or shellfish while you were pregnant was good for your baby from any other sources?” RBADB denotes whether the respondent answered yes to the following question “Did you hear or read that eating fish or shellfish while you were pregnant was bad for your baby from any other sources?” The remaining independent variables (AGE, ED, COUPLE and FIRSTPREG) are as defined earlier.

Results and Discussion

The presentation of the results is divided into two sections. The first section presents a descriptive overview of the data used in the regressions; the second section presents regression results.

Descriptive overview

In general, mercury-related knowledge varied across the questions being asked (Table 1); there was relatively high knowledge that fish differed in the amount of mercury contamination but knowledge was relatively low in terms of the factors that could impact mercury levels (e.g., age of the fish). Almost half of the women did not know that mercury cannot be removed by careful fish preparation. Knowledge levels are significantly higher among women who read the guidelines. In general, women thought about half of all fish were contaminated with mercury. A majority perceived eating fish was good for their health; however, only about half thought eating fish was good for their fetus. Women who read the guidelines were more likely to hold these perceptions.

In general, fish consumption declined during pregnancy with a slight rebound in consumption after birth of the baby; these movements in consumption were heightened among women who read the guidelines. A minority of women switched what types of fish they ate during pregnancy, and this switching behavior was significantly higher among women who read the guidelines. Consumption of white tuna was relatively higher than consumption of light tuna, which is unfortunate since white tuna is likely to have higher levels of mercury; this suggests the need for the fish advisory. Women who read the guidelines ate more meals containing the healthier light tuna relative to their non-reading counterparts.

Women were more likely to be exposed to information that eating fish was good for their own health rather than being good for the health of their baby (Table 2). This result parallels women's perceptions of the healthiness of eating fish reported earlier (Table 1). Compared to the information about the benefits of eating fish, a strong majority of women were exposed to information that eating fish was bad for their baby. Readers of the guidelines were significantly more likely to be exposed to all of this information. In terms of their socio-economic characteristics,[13] women who read the guidelines were slightly older, had more education, were less likely to be in a single-parent household, and, as a result, had higher incomes. That guideline reading is positively correlated with exposure to other types of information and to various socio-economic characteristics supports the use of regression analysis.

Regression results

[13] Maine is predominantly a white state (96 percent) so there was no difference in racial composition of women who read, or did not read the guidelines.

Women who were more educated and those who ate fish before they became pregnant, are significantly more likely to be aware of the Safe Eating Guidelines (Table 3). Similarly, women who were more educated, experiencing their first pregnancy and those who ate fish before they became pregnant, are significantly more likely to have read the Safe Eating Guidelines.

In all four knowledge equations (Table 4), the coefficient on READ is significant and positive; indicating that women who read the guidelines had higher levels of mercury-related knowledge, even when controlling for the other sources of information. This would suggest the guideline was designed to transmit knowledge successfully. As expected, knowledge is positively related to a mother's education level. Interestingly, age only becomes a significant factor in the fish preparation equations; older mothers had a more correct understanding that fish preparation cannot reduce mercury exposure.

The advisory was successful in increasing respondent perception that all fish have mercury in them (Table 5); in fact, this was the only information variable significant in the equation. At the same time, the advisory did not alter respondent perceptions that fish/shellfish contain things that are good for the consumer or that eating fish/shellfish while pregnant was good for the fetus. This may be because many women had already obtained positive information from other sources (as indicated by the positive coefficients on most of the 'GOOD' variables). Women exposed to other sources of negative information about fish eating did not alter their perceptions that fish contain things that are good for the fetus. These results suggest that the increased knowledge and awareness of mercury-related risks does not necessarily induce an unintended decline in the perceptions of the benefits of eating fish. Thus, our results support the contention of

Burger and Gochfeld (2008) that consumers can correctly process and weigh the benefit and risk information related to fish consumption when statements about the risks or benefits are clear, and there is a specific listing of which fish should be avoided, and which should be consumed.

Women who read the guidelines decreased their consumption of fish during pregnancy, particularly during the last three months of pregnancy (Table 6), relative to women who did not read the guidelines. Guideline readers also correctly readjusted (increased) their fish consumption after that baby was born. Similarly, women exposed to other sources of negative information about fish eating decreased their fish consumption during pregnancy; however, this group of women continued to decrease their fish consumption even after the child was born. Women who were told that fish eating was good for their baby increased their fish consumption during pregnancy. Age was also a factor; older women decreased their consumption of fish during pregnancy which rebounded after the child was born.

Women who read the guidelines were more likely than non-readers to switch the kinds of fish they ate as they became pregnant (Table 7); however, there was no similar switching behavior after the baby was born. This may suggest that the fish advisory may have induced a long-run switch away from some fish species. The direction of this switching behavior, at least with tuna, is in the correct direction (Table 8); women who read the guidelines significantly increased their consumption of the healthier light tuna and decreased their consumption of the white (albacore) tuna, relative to non-readers. To our knowledge there was no other similar communication occurring during the time frame, suggesting this switching behavior is primarily driven by the advisory. Previous studies have not found this sort of switching behavior as this type of behavior is rather difficult to induce (Verger et al 2007).

Conclusions

Fish consumption advisories are commonly issued by government agencies with an aim toward reducing fish consumption risks (e.g., mercury consumption). But because eating fish also provides health benefits, fish consumption advisories need to be carefully crafted so the main message of avoiding specific types of high risk fish does not lead to a general reduction in fish consumption. The impacts of an advisory are often untested and, when tested, often highlight the poor performance of the advisories (e.g., the advisories led to overall reductions in fish consumption, or to reductions among people not at risk).

A central function of fish advisories is to clearly communicate both the risks and the benefits of fish consumption. The benefits of providing information can be measured by its ability to inform consumers as to both the positive and negative attributes of their potential choices, which would lead to appropriate changes in behavior (specifically, to induce a switch away from fish that are highly contaminated to those which are less contaminated). We have been unable to find a journal-quality publication indicating whether advisories lead to such switching behavior.

The State of Maine used both qualitative (focus groups) and quantitative methods to design a fish advisory for pregnant women, and to evaluate its effectiveness in inducing appropriate behavior change. Although we find that the advisory temporarily reduced some women's consumption of fish (an undesired effect), we find the advisory successfully increased women's mercury-related knowledge, improved their perceptions of fish consumption risks and induced appropriate switching behavior, i.e., women reading the advisory decreased their consumption of high-risk fish and increased their consumption of low-risk fish. In general, we conclude that a well-designed advisory can successfully transform a complex risk/benefit message, leading to appropriate knowledge and behavioral changes.

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Table 1. Descriptive statistics of the dependent variables, overall and by whether the respondent read the *Maine Safe Eating Guidelines*[a]

	Overall	Read guidelines? No	Read guidelines? Yes	Value of test statistic[e]
Knowledge (Percent correctly stating that)				
Some types of fish/shellfish have more mercury than others	73	68	86	$\chi_{(1)}$ = 27.09***
Fish/shellfish that eat other fish/shellfish have more mercury	22	16	36	$\chi_{(1)}$ = 36.73***
Older fish/shellfish contain more mercury	28	22	40	$\chi_{(1)}$ =23.85***
Cleaning/cooking cannot remove mercury from fish/shellfish	56	49	71	$\chi_{(1)}$ =30.82***
Perceptions				
Increased perception that fish are contaminated with mercury[b]	0.48	0.46	0.51	t = -2.76***
Percent perceiving that fish/shellfish contain things good for the consumer	79	76	88	$\chi_{(1)}$ =13.18***
Percent perceiving that eating fish/shellfish while pregnant was good for the fetus	49	45	58	$\chi_{(1)}$ = 9.53***
Consumption				
Qualitative change in fish consumption during pregnancy relative to pre-pregnancy[c]	-0.60	-0.43	-0.96	t = 6.5***
Qualitative change in fish consumption during last three months of pregnancy[c]	-0.19	-0.13	-0.29	t = 2.58***
Qualitative change in fish consumption after the child's birth[c]	0.05	0.00	0.17	t = -2.57***
Percent changing the types of fish consumed during pregnancy relative to pre-pregnancy	19	14	30	$\chi_{(1)}$ =25.89***
Percent changing the types of fish consumed after pregnancy relative to during pregnancy	16	14	20	$\chi_{(1)}$ = 3.37*
Average number of monthly meals of light tuna during last three months of pregnancy[d]	0.60	0.52	0.82	t = -2.83***
Average number of monthly meals of white tuna during last three months of pregnancy[d]	1.24	1.28	1.17	t = 0.79

a Except where indicated, all variables are binary; coded 1 if the condition is indicated, 0 otherwise.

b Respondent was asked to indicate which response they most agreed with. Responses included: 'No fish or shellfish have mercury in them' (coded 0); 'Some fish or shellfish have mercury in them' (coded .33); 'Most fish or shellfish have mercury in them' (coded .66); and 'All fish or shellfish have mercury in them' (coded 1.00).

c Respondents were asked to qualitatively indicate how the amount of fish or shellfish consumed changed. Responses included: 'I ate a lot more fish or shellfish' (coded +2); 'I ate a little more fish or shellfish' (coded +1); 'I ate the same amount of fish or shellfish' (coded 0); 'I ate a little less fish or shellfish' (coded -1); 'I ate a lot less fish or shellfish' (coded -2).

d Based on continuous responses

e * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 2 Descriptive statistics of the independent variables, by whether the respondent read the *Maine Safe Eating Guidelines*

	Variable name	Overall	Read guidelines?		Value of test statistic[a]
			No	Yes	
Percent stating someone told them that eating fish was good for them	SGOODU	53	50	60	$\chi_{(1)} = 7.23$***
Percent stating they read that eating fish was good for them	RGOODU	50	45	61	$\chi_{(1)} = 16.24$***
Percent stating someone told them that eating fish was good for their baby	SGOODB	30	27	36	$\chi_{(1)} = 5.78$**
Percent stating they read that eating fish was good for their baby	RGOODB	24	19	35	$\chi_{(1)} = 22.99$***
Percent stating they read that eating fish was bad for their baby	RBADB	90	87	99	$\chi_{(1)} = 26.18$***
Average age (in years)	AGE	29.3	29.1	29.8	t = -1.66*
Mother's education level (in years)	ED	14.1	13.8	14.5	t = -3.68***
Mother is a member of a couple (percent yes)	COUPLE	85	83	88	$\chi_{(1)} = 3.17$*
Mothers first pregnancy (percent yes)	FIRSTPREG	44	40	53	$\chi_{(1)} = 11.16$***
Mother ate fish in the year before pregnancy (percent yeas)	EATFISH	88	85	98	$\chi_{(1)} = 27.54$***
Mother's annual household income ($)	INCOME	44,900	43,600	47,600	t = -1.87*
Percent stating a household member owns a fishing license	FISHING	45	46	41	$\chi_{(1)} = 1.71$

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 3. Regressions to explain respondents' awareness and use of Maine Safe Eating Guidelines

Parameter	Estimate[a]	Standard Error
Did respondent know about the Maine Safe Eating Guidelines?		
Intercept	-1.786**	0.712
AGE	-0.001	0.018
ED	0.103**	0.044
COUPLE	0.256	0.249
FIRSTPREG	0.279	0.171
EATFISH	0.768***	0.250
INCOME	-0.001	0.004
FISHING	0.157	0.161
Did respondent read the Maine Safe Eating Guidelines?		
Intercept	-4.863***	0.820
AGE	-0.001	0.020
ED	0.103**	0.045
COUPLE	0.410	0.296
FIRSTPREG	0.591***	0.184
EATFISH	2.192***	0.526
INCOME	-0.001	0.004
FISHING	-0.074	0.175

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 4. Regressions to explain respondents' knowledge of fish consumption risks

Parameter	Estimate[a]	Standard Error
Correctly understands some types of fish/shellfish have more mercury than others		
Intercept	-6.313***	0.847
READ	0.551**	0.241
SGOODU	0.633***	0.230
RGOODU	0.688***	0.232
SGOODB	0.369	0.281
RGOODB	-0.196	0.310
RBADB	2.436***	0.372
AGE	0.003	0.022
ED	0.285***	0.061
COUPLE	0.426	0.275
FIRSTPREG	0.042	0.221
Correctly understands fish/shellfish that eat other fish/shellfish have more mercury		
Intercept	-8.643***	1.250
READ	0.868***	0.207
SGOODU	0.463**	0.233
RGOODU	0.442*	0.229
SGOODB	0.054	0.270
RGOODB	0.182	0.272
RBADB	2.060**	1.024
AGE	0.006	0.023
ED	0.239***	0.050
COUPLE	0.778*	0.435
FIRSTPREG	0.164	0.217
Correctly understands older fish/shellfish contain more mercury		
Intercept	-5.851***	0.933
READ	0.560***	0.187
SGOODU	0.284	0.204
RGOODU	0.306	0.201
SGOODB	-0.128	0.242
RGOODB	0.069	0.250
RBADB	2.073***	0.732
AGE	-0.003	0.020
ED	0.151***	0.044
COUPLE	0.359	0.320
FIRSTPREG	0.004	0.192

Table 4 (continued)

Correctly understands that cleaning/cooking cannot remove mercury from fish/shellfish		
Intercept	-4.982***	0.668
READ	0.667***	0.187
SGOODU	0.331*	0.189
RGOODU	0.354*	0.185
SGOODB	0.133	0.223
RGOODB	-0.267	0.239
RBADB	1.400***	0.355
AGE	0.038**	0.019
ED	0.153***	0.044
COUPLE	0.154	0.247
FIRSTPREG	0.078	0.180

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 5. Regressions to explain respondents' perceptions of fish consumption risks

Parameter	Estimate[a]	Standard Error
Increased perception that all fish have mercury in them		
100% of fish have mercury	-3.081***	0.779
66% of fish have mercury	-1.534**	0.770
33% of fish have mercury	4.907***	1.032
READ	0.565***	0.182
SGOODU	-0.067	0.194
RGOODU	-0.085	0.191
SGOODB	0.045	0.230
RGOODB	-0.110	0.241
RBADB	0.434	0.524
AGE	-0.004	0.020
ED	0.018	0.043
COUPLE	0.336	0.298
FIRSTPREG	-0.219	0.184
Increased perception that fish/shellfish contain things that are good for the consumer		
Intercept	-5.084***	0.877
READ	0.367	0.274
SGOODU	0.688***	0.251
RGOODU	0.893***	0.264
SGOODB	1.043***	0.351
RGOODB	0.528	0.420
RBADB	0.488	0.324
AGE	0.057**	0.025
ED	0.229***	0.066
COUPLE	0.318	0.289
FIRSTPREG	0.262	0.242
Increased perception that eating fish/shellfish while pregnant was good for the fetus		
Intercept	-2.223***	0.647
READ	0.137	0.197
SGOODU	0.154	0.191
RGOODU	0.388**	0.189
SGOODB	1.102***	0.231
RGOODB	1.723***	0.277
RBADB	-0.022	0.314
AGE	0.038*	0.019
ED	0.008	0.044
COUPLE	0.105	0.270
FIRSTPREG	-0.044	0.189

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 6. Regressions to explain respondents' fish consumption behavior

Parameter	Estimate[a]	Standard Error
Qualitative change in fish consumption during pregnancy relative to pre-pregnancy?		
Intercept + 2	-0.627	0.552
Intercept + 1	0.916*	0.519
Intercept 0	3.349***	0.533
Intercept -1	4.375***	0.543
READ	-0.852***	0.162
SGOODU	-0.251	0.165
RGOODU	-0.182	0.163
SGOODB	0.480**	0.194
RGOODB	0.239	0.206
RBADB	-0.794***	0.263
AGE	-0.041**	0.016
ED	-0.056	0.037
COUPLE	-0.139	0.218
FIRSTPREG	-0.246	0.157
Qualitative change in fish consumption during last three months of pregnancy		
Intercept + 2	-3.892***	0.798
Intercept + 1	-2.080***	0.722
Intercept 0	2.123***	0.723
Intercept -1	2.883***	0.729
READ	-0.387*	0.208
SGOODU	-0.281	0.222
RGOODU	-0.089	0.217
SGOODB	0.321	0.258
RGOODB	0.175	0.270
RBADB	-0.586	0.384
AGE	-0.004	0.022
ED	0.054	0.049
COUPLE	-0.411	0.314
FIRSTPREG	-0.301	0.212

Table 6. (continued)

Qualitative change in fish consumption after the child's birth		
Intercept + 2	-5.279***	0.614
Intercept + 1	-3.300***	0.583
Intercept 0	0.043	0.563
Intercept -1	1.018*	0.574
READ	0.492***	0.175
SGOODU	-0.116	0.180
RGOODU	0.497***	0.179
SGOODB	0.051	0.213
RGOODB	-0.459*	0.226
RBADB	0.421	0.283
AGE	0.029*	0.018
ED	0.033	0.040
COUPLE	-0.028	0.239
FIRSTPREG	-0.008	0.169

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 7. Regressions to explain respondents' fish consumption behavior

Parameter	Estimate[a]	Standard Error
Percent changing the types of fish consumed during pregnancy relative to pre-pregnancy		
Intercept	-4.491***	0.844
READ	0.937***	0.227
SGOODU	-0.183	0.253
RGOODU	0.399	0.248
SGOODB	0.640**	0.280
RGOODB	-0.375	0.294
RBADB	-0.192	0.480
AGE	0.016	0.025
ED	0.126**	0.053
COUPLE	0.026	0.365
FIRSTPREG	0.486**	0.235
Percent changing the types of fish consumed after pregnancy relative to during pregnancy		
Intercept	-4.772***	0.921
READ	0.031	0.232
SGOODU	-0.337	0.256
RGOODU	0.978***	0.255
SGOODB	0.797***	0.280
RGOODB	-0.373	0.292
RBADB	1.085*	0.618
AGE	-0.007	0.025
ED	0.124**	0.055
COUPLE	-0.309	0.330
FIRSTPREG	0.393*	0.232

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level

Table 8. Regressions to explain respondents' tuna consumption behavior

Parameter	Estimate[a]	Standard Error
Average number of monthly meals of light tuna during last three months of pregnancy		
Intercept	0.579*	0.333
READ	0.260**	0.106
SGOODU	0.036	0.107
RGOODU	0.026	0.106
SGOODB	0.302**	0.125
RGOODB	0.130	0.135
RBADB	-0.160	0.162
AGE	-0.002	0.010
ED	-0.018	0.025
COUPLE	0.246*	0.139
FIRSTPREG	0.049	0.102
Average number of monthly meals of white tuna during last three months of pregnancy		
Intercept	0.385	0.528
READ	-0.282*	0.169
SGOODU	0.209	0.171
RGOODU	-0.075	0.170
SGOODB	0.226	0.199
RGOODB	0.668***	0.214
RBADB	0.188	0.259
AGE	0.032*	0.017
ED	-0.031	0.039
COUPLE	0.021	0.222
FIRSTPREG	-0.086	0.163

a * denotes significant at the 10% level; ** denotes significant at the 5% level; *** denotes significant at the 1% level