Are Mercury Advisories Effective?
Information, Education, and Fish Consumption

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ABSTRACT

This paper examines responses to a national FDA advisory urging at-risk individuals to limit store-bought fish consumption due to the dangers of methyl-mercury. We address this issue using parametric and nonparametric methods, including recently developed tests of stochastic dominance. Both education and newspaper readership were important determinants of consumption response, suggesting that information acquisition and assimilation are key factors for risk avoidance. While the advisory was effective for some groups, we do not find a response among the relatively large group of at-risk households which met neither the education nor readership criteria.

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I. Introduction

Many state and federal programs include information provision as an integral part of their strategy to mitigate environmental and public health dangers. Examples include the toxics release inventory, lead paint disclosures, drinking water quality notices, food nutritional labeling, and product safety warnings. This paper examines the determinants of consumer response to one such information policy, the 2001 FDA methyl-mercury fish advisory.

Mercury exposure from environmental pollution is a prominent public health risk. A 2001 Center for Disease Control (CDC) study found that one in ten American women of childbearing age has elevated levels of mercury in her blood. At current reference doses and margins of safety, the CDC findings suggest that every year at least 85,000 U.S. children are born at risk of neurological damage from mercury exposure. Yet, mercury is a health risk that households could readily limit. The consumption of contaminated fish is the primary source of environmental exposure to mercury. Young children, nursing mothers, and pregnant women are the most susceptible to mercury toxicity.

Because mercury persists in the environment, even completely eliminating emissions would not eliminate mercury risks in the near term.[1] Reducing mercury exposure by avoiding excess fish consumption among at-risk groups is therefore vital. In January 2001, the Food and Drug Administration (FDA) issued a commercial fish consumption advisory that warned of the health hazards from mercury and urged at-risk

[1] Domestic emissions controls alone are unlikely to eliminate the risk, even in the long term, because many fish are imported. Further, mercury emissions from foreign sources may be deposited into U.S. waters.

individuals to limit fish consumption. Changes in consumption patterns following this first major national mercury advisory are the focus of our study.

To what extent did the FDA advisory reduce exposure to at-risk groups? We address the question by examining household-level fish consumption from the U.S. Consumer Expenditure Survey (CEX). Specifically, we analyze how certain groups' consumption of canned fish products changed in response to the advisory. An advisory can only be effective if consumers are aware of it and are willing and able to translate awareness into behavior. We therefore focus on proxies for access to information, ability to assimilate information, and risk preferences as response predictors. For example, since news readership is a proxy for information acquisition, we investigate differential responses among readers and non-readers. Education may serve as a proxy for both information acquisition and assimilation, so we investigate differential responses among educated and less educated consumers. We also investigate health consciousness since the literature suggests it serves as a proxy for risk preferences.

We address consumption response empirically through a battery of parametric and bootstrapped non-parametric tests, including a novel combination of the classical double-difference (difference-in-difference) and stochastic dominance approaches. Our simplest non-parametric analysis is a comparison of means before and after the advisory for various groups. We also use a double-difference comparison of means approach to sweep out overall consumption shocks not directly attributable to the advisory. A limitation of these standard mean tests is that they focus only on measures of central tendency. The mean is of course important, but it does not fully characterize distributions. To provide a broader view of consumer response, we apply recently developed tests of second-order stochastic dominance. We also extend the stochastic-dominance test to the double-difference framework in order to provide robustness to common shocks.

We find four main results. Most notably, a large group of at-risk consumers did not respond to the advisory. Specifically, non-reading, non-college educated households did not significantly reduce consumption. In contrast, news readers reduced consumption significantly as compared to non-readers. This held for all consumer categories, not just those targeted as at-risk. Access to information thus appears to be an important factor limiting response. Educated consumers also significantly reduced consumption compared to the less-educated. In this case, the response was limited to targeted at-risk groups. While readers responded broadly, the educated responded in a manner more consistent with advisory language. While education and news readership importantly affected advisory response, health consciousness did not.

This is the first economic study of consumer responses to advisories for store-bought fish, the primary source of mercury exposure to the public. The most closely related research measured responses of recreational anglers to localized safety advisories. See, for example, Belton *et al.* (1986) and May and Berger (1996). Using assumptions based on such recreational demand studies, Jakus, McGuinness, and Krupnick (2002) developed health and welfare benefit estimates of a striped bass advisory to Chesapeake Bay anglers.

This study extends a broader literature on public advisories as a policy tool. Adler & Pittle (1984) have a pessimistic view of the efficacy of advisories in practice. It is debated whether even the surgeon general's warning for tobacco was in and of itself a "watershed event" (Fenn *et al.* (2001) and Sloan *et al.* (2002)). Our findings indicate that advisories can be effective, but the short-run response is nuanced. Some sectors of the at-risk population strongly respond, while others respond minimally, if at all. Readership and education are the primary response predictors.

This research also makes a contribution to the product and food safety literature. Experimental work by Viscusi *et al.* (1986) shows that, given information about product hazards, subjects undertake precautionary behavior generally consistent with basic economic theory. Our research confirms these experimental findings in a revealed preference setting. In previous empirical work, Foster and Just (1989) (milk), Brown and Shrader (1990) (eggs), and Kinnucan *et al.* (1997) (meat) all show that adverse health information is correlated with reductions in overall consumption. These studies were based on aggregate data. Our data allow us to disentangle information-related response determinants at the household level.

The paper proceeds as follows. Section II reviews the sources of mercury exposure, health consequences, and key policy milestones. Section III summarizes our consumer expenditure data. Section IV examines several methodological approaches, each with their own strength. Graphical analyses, non-parametric statistical tests, and a standard parametric analysis are included. Section V presents our results by answering a series of key questions. Finally, section VI concludes by interpreting our results for economics and policy.

II. Mercury Science & Policy
A. Sources and Consequences of Mercury Exposure

Levels of mercury circulating in the environment have increased dramatically over the last century. Coal-fired electrical plants are currently the largest source of anthropogenic mercury. Mercury binds with sulfuric compounds in coal, and burning releases the mercury into the atmosphere. When atmospheric mercury is deposited into surface water, bacteria convert the mercury into organic methylmercury. It then readily enters a fish's bloodstream from water passing over gills and accumulates in the tissues. Methylmercury bio-accumulates up the food chain. Even in water where ambient mercury levels are extremely low, mercury concentrations may reach high levels in predatory species like shark, mackerel, and tuna.

For the general public, fish consumption is the primary source of exposure to mercury. Cooking and other forms of preparation do not mitigate the risk. Once consumed, mercury is a potent neurotoxin, which is absorbed into the bloodstream. In adults, abnormally high concentrations can contribute to brain damage, heart disease, blurred vision, slurred speech, and other neurological ailments. Such concentrations in adults are rare. However, even modest mercury concentrations can cause significant harm to the developing neurological systems of fetuses, infants, and children. Consequences may include learning and attention disorders, or generally slow intellectual and behavioral development, as well as severe neurological illnesses such as cerebral palsy. Fetuses and nursing infants are at risk because mercury readily passes through the placenta, concentrates in umbilical tissues, and leaches into breast milk.

B. Mercury & Public Policy

Mercury has recently drawn considerable regulatory scrutiny. For example, the Clear Skies Initiative was touted as "the first ever national cap on mercury emissions." Similarly, the EPA has established power plant mercury emissions standards as a top national priority. Unfortunately, even very strict standards cannot eliminate the hazard because mercury persists in the environment. Further, most large fish consumed domestically are caught abroad. For these reasons, demand-side consumer policy is, and will remain, essential for the protection of public health.

Major milestones in consumer policy are reported in Table 1.[2] There was a period in which mercury consumption risks were thought to be minimal. Indeed, FDA scientists counseled in 1994 that "normal patterns of consumption" do not pose a health threat. This official stance persisted until mid-2000, when the FDA became alarmed by the cumulative findings of an EPA report (1997) and a National Academy of Sciences (June 2000) study that highlighted the dangers of consuming contaminated fish. In August of 2000, the FDA announced it was considering a new methyl-mercury advisory and solicited comment.

The FDA formally released the new mercury advisory on January 12, 2001. The advisory singled out infants, small children, pregnant or nursing mothers, and women who may become pregnant. It states in part, "While it is true that the primary danger from methylmercury in fish is to the developing nervous system of the unborn child, it is prudent for nursing mothers and young children not to eat these fish as well." The

[2] Table 1 and the accompanying discussion emphasize consumption advisories for fish commercially caught and marketed. EPA and state advisories for methylmercury contamination in locally, recreationally caught fish have been periodically issued as well. Due to their relatively limited scope and scale, we

advisory named several large fish that these targeted consumers should avoid entirely. More generally, it stated that consumers should limit their consumption of all fish, including canned fish, to no more than 12 ounces per week (less than two average meals). This advisory was an unusual response by the FDA; while agency inspections, approvals, and sanctions are common, this type of broad and direct consumer campaign was, and remains, very rare.[3]

Table 1. Consumer Policy Milestones

Time Period	Consumer Advisory Policy Event
Sept. 1994	FDA Releases 'FDA Consumer' … "Eating commercially available fish should not be a problem."
Dec. 1997	EPA Releases 'Mercury Study Report to Congress' … "A snapshot of our current understanding of mercury."
1998-2000	Interest groups and the EPA debate the appropriate reference dose for mercury exposure and policy decisions.
June 2000	National Academy of Sciences (NAS) Releases 'Toxicological Effects of Methylmercury' … "60,000 U.S. children may be at risk."
Aug-Dec 2000	FDA debates existence and language of new consumer advisory, soliciting comments from consumer advocates, public health professionals, environmental groups, and industry organizations. Focus groups conducted.
Jan 2001	FDA issues new consumption advisory. Pregnant women, women of childbearing age, and young children should limit consumption of all fish, and should not eat fish known to contain high levels of mercury.
Jan-Mar 2001	Phase I of FDA Mercury Advisory Education Plan.
Jan-Dec 2002	Phase II of FDA Mercury Advisory Education Plan.

The FDA's outreach program consisted of a two-phase information campaign. Over the course of three months following the advisory, the FDA communicated its message by releasing pre-prepared newsprint and television press releases. Similar media kits were sent to weekly print news sources, parenting magazines, and women's health periodicals. Phase I of the information campaign also included letters to physicians and health organizations. Phase II was a methodologically similar, but less intense, "reminder" campaign conducted in 2002.

consider these recreational advisories of secondary importance. The interested observer may wish to check the EPA's 'Local Fish Advisory Programs' page at http://www.epa.gov/waterscience/fish/states.htm .

[3] FDA inspections can identify localized public health threats, and product- or location- specific consumption advisories are not infrequent. For example, the FDA recently publicized a number of branded almond recalls due to the possibility of *salmonella enteriditis* contamination. Advisories specifically advocating the reduction or elimination of certain foods are rare.

III. Data

A. CEX Diary Surveys

Our research assesses the impact of the FDA advisory on consumption of canned fish. We analyze data from the Bureau of Labor Statistics' Consumer Expenditure Survey (CEX). This annual survey asks a cross-section of households to record all expenditures over a two-week period in daily diaries. We sum these data to reflect total household purchases of each item over the sample period.

Using the CEX diaries offers a number of advantages. First, CEX data are widely used for economic and statistical analyses. Second, the unit of observation is the household, allowing us to account for a diverse set of demographic and expenditure variables.[4] Third, CEX households are geographically diverse, and weighting allows the dataset to approximate a nationally representative sample. Finally, purchase snapshots provide unbiased estimates of consumption.

B. Sample & Definitions

Our sample covers the period 1999-2002; two years before and after the FDA advisory. Since the focus of the warning is on pregnancy and children, we restrict our analysis to households with a young child or with an adult no older than 45 years. To concentrate on a relatively homogenous sample, we exclude households with more than twelve members total, households with three or more adults, and households with multiple unmarried adults. Further, to avoid outliers or data entry errors, we eliminate households with incomplete diaries, those that report no in-home food purchases for the diary period, and the 17 observations with per-capita quantities more than 4 standard

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[4] Datasets tracking landings and exports are available, but these contain no household-level data. Further, these aggregate statistics reflect institutional as well as household consumption and do not account for possible warehousing.

deviations above the mean for households with positive fish expenditures.

Much of our analysis focuses on identifying differential responses between groups targeted by the advisory and not directly targeted by the advisory. In effect, this latter category may serve as a control group. We study the response of households with young or nursing children relative to this control. The warning also targets women who are pregnant or may become pregnant. We would ideally separately analyze this group as well, but our data do not allow us to identify these individuals directly. In order to avoid contaminating our control group with these individuals, we set aside the control demographic most likely to include them: childless married women less than 46 years of age.[5]

The resulting dataset consists of 10,537 households. Observations are approximately evenly distributed over the sample period. There are 5297 observations in the two years prior to the advisory and 5240 observations in the two years after the advisory.

The most direct measure of fish consumption in the CEX is expenditure on canned fish. We choose canned fish because it is widely consumed, it was specified in the advisory language, and data are readily available. To translate expenditures into quantities, we divide by price. Since the CEX does not contain price information, we use the BLS regional average price for canned tuna by month.[6] We construct an adult-equivalence scaling factor for tuna consumption by regressing total in-home meat consumption on the number of adults, babies, young children, medium-aged children, and

[5] Of course, women who already have young children may also be likely to have more children. They are, however, already categorized as targeted.

[6] Tuna has consistently comprised over 80% of canned fish consumption over the last decade. The ratio of canned tuna consumption to other canned fish has remained quite stable (NMFS).

old children living in the household. Adults are normalized to one, and children are scaled accordingly. Since the mercury advisory may induce changes in the decision to consume and the quantity conditional on consuming, our analysis considers three separate indicators: total consumption, a consumption decision dummy, and consumption conditional on non-zero expenditures.

Beyond identifying broad consumption responses, we analyze how specific groups reacted to the advisory. We analyze the responses of readers relative to non-readers. Similarly, we compare educated households to less educated households. Finally, we compare health conscious consumers relative to other consumers. Thus, we include a dummy for newspaper or magazine purchases, a dummy for college graduates, and an ad-hoc proxy index for health consciousness. We consider households 'health conscious' if their food expenditure share of fresh fruits of and vegetables is larger than 70 percent of demographically similar households, and have no tobacco expenditures.[7]

C. Summary Statistics

Summary statistics and variable definitions are presented in Table 2. The table illustrates the stability of household demographic composition over time. All nine variables reflecting households' physical composition, news purchases, education, and health consciousness have similar means before and after the warning. Average changes are an order of magnitude smaller than their standard deviations. This suggests that variability in consumption behavior over time is unlikely to be attributable to variability in sample composition.

[7] We later check that our results are robust to the definition of the educated and health-conscious groups.

Table 2. Summary Statistics [8]

Variable	Description	ENTIRE SAMPLE Mean	ENTIRE SAMPLE Std. Dev.	PRE-ADVISORY Mean	PRE-ADVISORY Std. Dev.	POST-ADVISORY Mean	POST-ADVISORY Std. Dev.
PURCHASED?	Dummy; '1' if canned fish purchased in 2-week diary period, '0' otherwise	0.168	0.374	0.169	0.375	0.167	0.373
QUANTITY	Canned Fish Quantity (lbs.)	0.264	0.758	0.252	0.724	0.275	0.789
	Quantity Conditional on Purchase (lbs.)	1.57	1.17	1.49	1.12	1.64	1.21
SHARE	Canned Fish Expenditure Share	.004	0.017	.004	0.016	.004	0.017
	Share Conditional on Purchase	.026	0.033	.025	0.032	.027	0.034
PRICE	Real Regional Price (per lb.)	1.94	0.155	2.02	0.139	1.86	0.133
SUB PRICE	Index of Substitute Prices – Base Period Normalized to 1	1.09	0.057	1.04	0.030	1.14	0.034
FOOD	Real In-home Food Expenditures ($100s)	1.15	0.967	1.15	0.974	1.14	0.961
AGE	Age of Respondent	38.8	13.4	38.6	13.4	38.9	13.3
CHILDREN	Dummy; HH with Young/Nursing Child?	0.303	0.458	0.306	0.461	0.300	0.458
READER	Dummy; Newspaper or Magazine Purchase?	0.242	0.428	0.249	0.432	0.235	0.424
EDUCATED	Dummy; Respondent College Graduate?	0.299	0.458	0.290	0.454	0.308	0.462
HEALTHY	Dummy; Particularly Healthy Household?	0.225	0.418	0.225	0.418	0.225	0.418
RCHILD	Reader/Children Interaction	0.078	0.268	0.081	0.273	0.074	0.262
ECHILD	Educated/Children Interaction	0.097	0.296	0.093	0.290	0.101	0.301
HCHILD	Healthy/Children Interaction	0.076	0.266	0.079	0.270	0.074	0.262
PERSONS	Number of Equivalent Adults	1.90	0.906	1.91	0.908	1.90	0.905

The statistics in Table 2 also show that average aggregate canned fish quantity was approximately 8.5 percent higher after the advisory than before. Specifically, quantities conditional on consuming rose by approximately 10 percent while the percentage of consumers purchasing canned fish fell by 1.2 percent. Shares, which incorporate both prices and quantities, remained relatively constant over time. Of course, additional factors beyond the advisory may have induced consumption changes. On average, the real price of canned fish fell and substitute prices rose. Awareness of the benefits of fish consumption (such as omega-3 fatty acids) may also have changed. Unless otherwise specified, the ensuing analyses difference out these and other potential common shocks. Our main identification strategy emphasizes changing expenditure patterns for relevant sub-populations *relative to* expenditure changes for control sub-populations.

[8] Summary Statistics Weighted in Standard Manner. 'Persons' is not directly a variable in the model, but is used for demographic scaling.

IV. Empirical Methods

Our empirical analysis addresses the following questions: After the FDA mercury advisory, did the groups directly targeted by advisory language respond? Did news readership influence consumption choices? Did education levels influence consumption choices? Did health consciousness influence consumption choices?

We answer these questions in three ways. First, we graphically illustrate changes in the empirical distribution of pre- and post-advisory consumption. Second, we formalize the results of the graphical analysis with non-parametric comparisons of means. A double difference approach controls for common shocks. A limitation of the mean tests, however, is that they focus only on measures of central tendency. To provide a more complete view of consumption responses, we apply tests of second-order stochastic dominance.[9] We also extend the stochastic dominance test to the double-difference framework to provide robustness to unobserved common shocks. Third, we supplement the non-parametric approach with standard regression analyses. Regression essentially runs the comparison of means simultaneously accounting for potential unobserved correlation.

A. Distribution and Mean Comparisons

Comparing Cumulative Distribution Functions

Our analysis of each question begins with a graphical presentation of fish expenditure shares. We compare post-advisory empirical cumulative distribution functions (cdfs) with pre-advisory cdfs. If, on average, households meaningfully altered their behavior after the advisory, the post-advisory cdf will differ from the pre-advisory

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[9] See McFadden (1989), Anderson (1996), and Massoumi & Heshmati (2000).

cdf *ceteris paribus*.[10] To illustrate, Figure 1 plots the empirical cdf of overall shares in the two periods. The vertical axis represents the proportion of households consuming less than the amount represented on the horizontal axis. Since the area to the left of the cdf, to the right of the vertical axis, and below probability 1 can be interpreted as a mean (here, mean fish expenditure shares), a broad shift to the northwest indicates that consumers reduced their consumption. Alternatively, a shift to the southeast would signify increased consumption. In Figure 1, the two cdfs are virtually identical, so aggregate consumption patterns after the advisory are similar to aggregate consumption patterns before the advisory.

Figure 1. Empirical cdfs: Overall

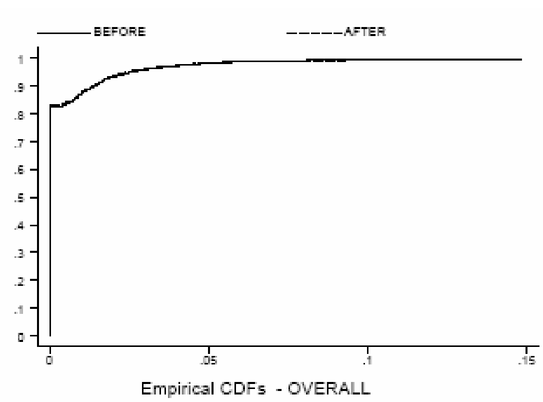
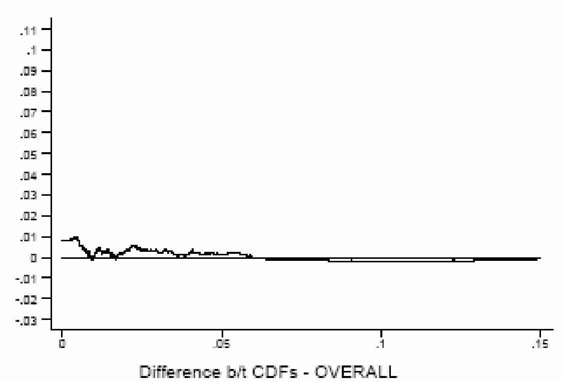


Figure 2. Difference Graph: Overall



Given the scaling of our figures, changes can be difficult to identify visually in absolute cdf graphs such as Figure 1. For this reason, we present graphs such as Figure 2, which plot the vertical difference between post- and pre- consumption. For these difference graphs, the integrated area between the horizontal zero-axis and the cdf difference curve can be interpreted as the change in mean consumption between the pre- and post- advisory periods. The areas above the axis contribute towards a reduction in

[10] To be precise, the weighted empirical cdfs will differ. Throughout our analyses, all graphical data include

mean consumption after the advisory, and the areas below the axis contribute towards an increase. In Figure 2, areas both above and below the horizontal axis are small and approximately equal to one another. It therefore appears that average fish expenditure shares over all demographic groups did not change significantly after the advisory.

Statistical Tests: Mean Comparisons

Since the information in the graphs represents differences in means, we use simple statistical methods to formally test graphical insights. For example, we could test the mean reduction in the overall share of food expenditures allocated to fish. For subscript 0 indicating 'pre-advisory', subscript 1 indicating 'post-advisory,' and $\bar{X}$ indicating mean fish expenditure share, this test statistic would be $\bar{X}_0 - \bar{X}_1$, and its value corresponds to the net sum of the integrated areas in Figure 2.

Of course, changes in fish consumption over time may not be fully attributable to the mercury advisory. For example, canned fish and substitute prices changed. Information about the potential benefits of fish consumption for cardiovascular health and protein attainment may also have changed. As a consequence, we sweep out shocks common to groups by computing the double difference in means (DDM), also referred to as the difference in differences. For example, we will examine consumption responses of demographic groups directly targeted by the advisory language, after netting out consumption changes for demographic groups untargeted by the advisory.

Formally, we examine the *inter*-group difference of the *intra*-group changes in mean consumption. The DDM test statistic for a group's mean change in consumption, after sweeping out common shocks based on a control group, is:

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probability weights.

$(\bar{X}_0 - \bar{X}_1) - (\bar{Y}_0 - \bar{Y}_1)$, where X is the mean for the group of interest, Y is the mean for the control group, and the subscripts represent time periods.[11] We use bootstrap methods to provide finite sample test statistics and confidence intervals. All reported non-parametric test statistics reflect 10,000 bootstrap replications.

We apply comparison tests in three ways. First, we compare unconditional double-differenced means as discussed above. These statistics intuitively parallel the difference between the integrated area in the presented graph for the group of interest and the integrated area in the presented graph for the control group. Second, we apply these same comparisons to means conditional on consuming canned fish. Third, we apply analogous comparisons to the number of consumers purchasing any canned fish. For the three cases, relative to a control group the null hypotheses are: (1) No change in mean consumption, (2) No change in mean consumption, conditional on purchase, and (3) No change in the percent of the group purchasing any canned fish.

Statistical Tests: Second-Order Stochastic Dominance

The methods described in the previous section emphasized changes in mean consumption. While the mean is of course important, comparisons only account for shifts in the central tendency of a distribution. Consequently, we also employ tests of stochastic dominance to get a more complete non-parametric view of pre- versus post-advisory consumption changes.

[11] The graphical analog to this test, not presented in the interest of space but potentially useful for a reader's intuition, is a "double-difference" graph. The generated curve would indicate differences in the target group's pre- and post- advisory consumption after 'sweeping out' common shocks measured by changes in non-target (control) consumers' expenditure shares. In practice, the graph would entail subtracting the non-target group's (cdf) difference graph from the target group's (cdf) difference graph.

We use the notion of second order stochastic dominance as an indicator of a broad-based reduction in consumption.[12] Formally, if G0 second order dominates G1, then $\int_0^q (G1(x) - G0(x))dx > 0$ for all q. For the limiting case of q at the upper bound of the support, this integral is simply the difference in means. More generally, at any q, the integral represents the difference across distributions in expected consumption by those consuming less than q. In our case, for a given group, if the pre-advisory consumption distribution second-order dominates the post-advisory consumption distribution, then at every point analyzed empirically the expected share of fish by those consuming less than this share is greater after the advisory than before. In other words, the response must have been broad-based, impacting all portions of the consumption cdf.

Our test statistic for second-order dominance follows McFadden (1989): $q^* = \arg\min \int_0^q (G1(x) - G0(x))dx$. We evaluate the integral and take the argmin over a set of integration limits corresponding to 250 evenly spaced expenditure shares between 0 and 25 percent. Effectively, the statistic identifies the maximal empirical violation of second order stochastic dominance, if one exists. If no violation exists, the statistic identifies the single q that most nearly produces an empirical violation.

We test the significance of this statistic using a bootstrap procedure, as suggested by Maasoumi and Heshmati (2000); see Millimet and List (2003) for an application. In a more formal analysis, Barrett and Donald (2003) show that these procedures behave well both asymptotically and in finite samples. Using 10,000 bootstrap replications, we

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[12] The most commonly utilized stochastic dominance evaluation is the first-order comparison between distributions. This condition requires that the two cdf's never cross. Since this is not the case for the

produce an estimate of the empirical variability of the test statistic around its true value. To produce p-values, we measure the probability of the sample statistic being equal to or greater than that observed (under the null hypothesis of no dominance). We take the value of q* under the null to be zero, to reflect the smallest possible violation of strict stochastic dominance.

While standard dominance test provides a robust check for a broad shift in consumption patterns, it only captures absolute changes, rather than changes relative to a reference group. Thus, it does not control for potential common shocks. We adapt the classical double-difference approach to provide the necessary correction. This pairing of two well-established methodologies provides a broad test for shifts in consumption patterns that is robust to the possibility of common shocks.

One way to account for common shocks in the stochastic dominance framework is to make an adjustment based upon the vertical differences between cdf's. Thus, at each point analyzed, we net out the changes in the control group's cdf when testing for stochastic dominance in the group of interest. This approach is an intuitive analog of the scalar double difference in means (DDM) emphasized in the previous section, and in fact nests the DDM. We regard this comparison as a reasonable way to examine broad shifts in consumption patterns when incorporating common shocks is desirable.[13]

Formally, our double-difference stochastic dominance test is as follows. After correcting for common shocks measured by control distribution F, G0 second order

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majority of our data, we focus on the somewhat less restrictive notion of second-order stochastic dominance.

[13] There are of course other possible ways to model a common shock. For example, there might be a common multiplicative rather than additive shock. Or, one could investigate changes in the horizontal rather than vertical difference of cdf's. However, such alternatives do not nest the familiar scalar double difference in means.

stochastic dominates G1 when $\int_0^q ((G1(x)-G0(x))-(F1(x)-F0(x)))dx > 0$ for all q. For the limiting case of q at the upper bound of the support, this integral is simply the traditional double difference in means test. Stochastic dominance requires that the shift in G is generally greater than a corresponding shift in F. The underlying assumption of this approach is that the shift in the cdf of interest (G) due to the common shock is the same as that the shift actually observed in the control cdf (F). Intuitively, this parallels the basic structure of a standard double difference in means test.[14]

Our double difference stochastic dominance test statistic is:

$q^* = \arg\min \int_0^q ((G1(x)-G0(x))-(F1(x)-F0(x)))dx$, evaluated at 250 evenly spaced shares between 0 and 25 percent. As before, G and F are empirical cdfs indexed by time period subscripts. Paralleling the standard dominance test, this statistic picks out the single q that most nearly produces an empirical violation of shock corrected dominance (if no violation exists), or the maximal violation (if one exists).

Again, we employ 10,000 bootstrap replications to produce an estimate of the empirical variability of the test statistic around its known sample value. Since the bootstrap treats our sample data as the population, the true value of the statistic for the bootstrap replications is simply the corresponding statistic from the original sample. The bootstrap replications then approximate the sampling variability around this known

[14] In the double difference in means, $\overline{X}_1 - (\overline{Y}_0 - \overline{Y}_1)$ is sometimes interpreted as the predicted mean based only upon the common shock. One difficulty with this interpretation is that it is logically possible to produce negative mean consumption. We have deliberately constructed our robust test of stochastic dominance to nest the double difference in means, because this test is the most common approach to net out common shocks. So, the same issue must arise here. In this broader context, it is possible that G1-(F1-F0) may not be a proper cumulative distribution function. Thus, one must be careful not to over-interpret the underlying structure.

parameter. We confirm that the statistic is approximately pivotal using a double bootstrap approach, thus the bootstrap provides a valid approximation of the true underlying variability (Davison and Hinkley (1997)). Under the null hypothesis that the true statistic is zero, the p-value then works out to be the proportion of the bootstrapped replications that are greater than two times the original sample statistic.[15]

B. Regression Methods

We supplement the previous non-parametric methods with a standard regression analysis, consistent with the bulk of the mainstream demand literature. More structured empirics provide efficiency gains and correlation controls. Moreover, to ensure the robustness of our results to indicators of consumption, we run a regression with quantity purchased as the dependant variable to supplement the previous analyses based on expenditure shares.[16]

The choice of explanatory variables is motivated by basic demand theory; price, substitute prices, total food expenditure, region, and household demographics influence consumption decisions. As in the double-difference graphical and comparison of means analyses, we control for both price and non-price shocks (like changes in information on the benefits of omega-3 fatty acids). Here, we include time dummies for the pre- and

[15] The bootstrap procedure provides an estimate of the sampling density of the vector of replicate statistics, B, around the true value of the statistic. For the replicate statistics, the true value is by construction the observed sample statistic, $\hat{b}$. Subtracting this known value from each replicate statistic then produces a centered replicate vector, B-$\hat{b}$, that approximates the sampling density under the null hypothesis that the underlying value of the statistic is 0. The p-value is then the proportion of these centered bootstrap statistics that are greater than the observed statistic: B-$\hat{b} > \hat{b}$, or B > 2$\hat{b}$.

[16] We perform complementary analyses with two different consumption indicators. Regressions use absolute quantities as the dependent variable. Non-parametric analyses use expenditure shares as the dependent variable. Since demand for canned fish is inelastic and price was lower after the advisory, one would expect expenditure shares to fall while quantities rise. While this may be a source of concern, the

post-advisory periods. We later perform a more structured parallel analysis which includes canned fish prices and an index of substitute prices as covariates. In all cases, since households vary in size, we demographically scale household composition covariates multiplicatively by the adult-equivalent measure discussed in Section 2 (Pollack and Wales (1981)).

As with many household expenditure datasets, we observe a large number of zero purchases. Here, zeros may arise in two ways. One possibility is infrequency of purchase, since a diary survey represents only a snapshot of a given household's canned fish expenditure. A second possibility is abstention from the good entirely. To capture the dichotomous purchase choice, we begin the analysis with a standard probit regression. Of course, conditional on purchasing canned fish, we are also interested in the impact of the FDA warning on the quantity purchased. Therefore, we run a second stage continuous regression. We allow the same covariates to influence both the discrete purchase and the continuous quantity decision, but we do not impose cross-equation restrictions on the covariates of interest.

The error term in this conditional demand equation is potentially correlated with the error term in the probit equation. In this case, our model is exactly that suggested by Blundell and Meghir (1987) for the case of a good with non-negative desired demand.[17] Mathematically, this is equivalent to Heckman's (1976) selectivity model. See Deaton and Irish (1982) for a discussion, and Fry and Pashardes (1994) for an application. To summarize, our empirical model can be represented by:

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primary non-parametric double-difference tests and the regression differences are both designed exactly to sweep out this type of common shock. Further, results across consumption indicators are similar.

$$C = X\beta + \varepsilon_C$$
$$D = X\Gamma + \varepsilon_D$$
$$Q = \begin{cases} C & if \quad D > 0 \\ 0 & otherwise. \end{cases}$$

for observed quantity Q, binary purchase decision D, continuous quantity choice C, and explanatory variables X.

To quantify the impact of the FDA advisory, we test whether pre-advisory parameters are significantly different from post-advisory parameters. To assess significance, we use standard χ^2 tests for null hypotheses of the form $\gamma_{k0}=\gamma_{k1}$ (for coefficients γ, explanatory variables k, pre-advisory period 0, and post-advisory period 1). Rejection of the null is indicative of a change in expenditure for the subgroup indicated by variable k.

We estimate two primary specifications. The first specification examines the entire sample, whereas the second specification highlights pre- versus post-advisory changes by removing the year immediately prior to and immediately after the advisory. We employ this latter specification to allow for potential lags in consumer responses.

[17] Another possible source of zero expenditures is the standard Tobit-style censoring where observation error may drive consumption to zero. We believe that this is not a major concern in our analysis. However, in the sensitivity section, we confirm that results are robust to this assumption.

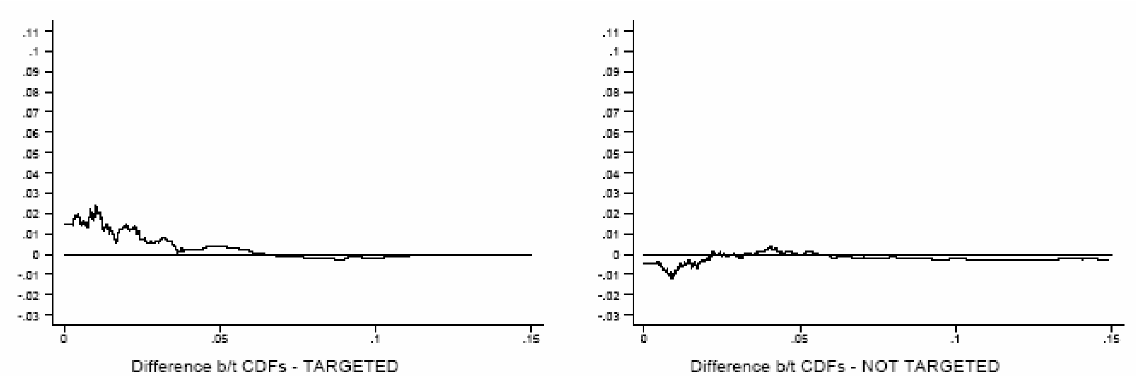
V. Empirical Results

Graphical results are presented in Figures 3-6, and statistical test results are summarized in accompanying tables 3-6. Regression results are summarized in Table 8.[18] In this section, we motivate our discussion of the results by asking a series of policy relevant questions. Sensitivity analysis follows.

Did the target group respond to the FDA advisory?

Taken as a whole, it appears that households with young or nursing children responded to the advisory relative to non-target households, but the statistical evidence is modest. Panel A of Figure 3 shows a general reduction for the target group at most expenditure share levels. Recall that the integrated area between the difference curve and the horizontal axis is equal to the mean. Here, the net integrated area is positive; the sample mean clearly fell after the advisory for this group. In contrast, Panel B shows little change for the non-target control group. Comparing Panel B to Panel A, we see that mean expenditure share for the target group fell relative to the non-target group.

Figure 3. Difference Graphs: Target and Non-Target Groups



Panel A **Panel B**

[18] Full regression results are presented in Appendices A and B.

Table 3. Non-Parametric Tests Summary: Target and Non-Target Groups[19] [20]

	Percent Drop in Mean Expenditure Share Allocated to Fish	Percent Drop in Mean Share, Conditional on Positive Quantities	Percent Drop in the Proportion of Consumers with Positive Quantities	Second-Order Stochastic Dominance at α=0.10?
Target, Net of Changes to Non-Target Group	21.8 (0.08)	13.0 (0.17)	9.7 (0.13)	Yes (0.08)

p-values in parentheses

The DDM statistic is simply the normalized numerical value of the difference in means for the target group, net of mean changes for the non-target group (here, a control). The net drop in the overall mean expenditure share allocated to fish for the target group was 21.8 percent. The corresponding DDM statistic is statistically different from zero at the 8 percent significance level. We also find evidence of second order stochastic dominance at the 8 percent level. Thus, after accounting for common shocks to non-target groups, target consumers' total expenditure of fish by those purchasing less than each share analyzed was greater before the advisory than after the advisory. In other words, target groups' post-advisory expenditure fell broadly across the entire distribution, not just at the mean.

While the overall mean fell, the disaggregated components of this mean did not fall significantly when considered individually. Neither the percent drop in net share conditional on purchase nor the percent drop in the net proportion of households purchasing is significant at conventional levels. Similarly, the regression results summarized in Table 8 show no statistically significant expenditure response by target households relative to the non-target control group. Looking at the row labeled 'Children

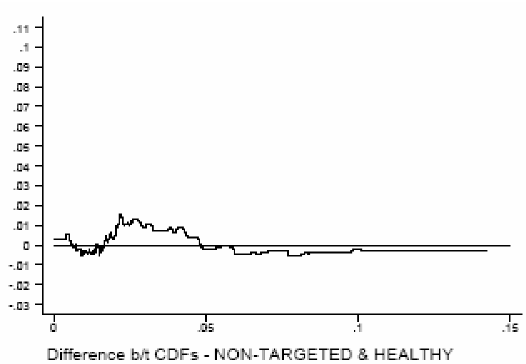
[19] To enhance the economic interpretation, Tables 3-6 report percent changes for mean expenditure share, mean expenditure share conditional on consuming, and proportion of group purchasing any fish. The actual test statistics, however, are based upon absolute differences rather than percents.
[20] The calculated stochastic dominance p-value from the bootstrap was 0.07, slightly less than the mean share p-value of 0.08. Technically, stochastic dominance can not be more significant than the mean, because it nests the mean test. The slight discrepancy arises because of numerical differences in the

(Targeted)' in Table 8, the pre- and post- advisory coefficients are not significantly different from one another in either the binary purchase decisions or the quantity conditional on purchasing decisions.

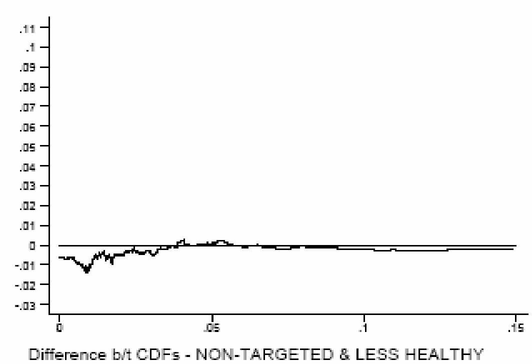
Did health-conscious consumers respond to the advisory?

No. We find no evidence that health-conscious households, as a group, responded to the advisory. Recall that we define healthy households by a function of good diet and tobacco abstinence. Panel A of Figure 4 illustrates the change in expenditure patterns for healthy households in the non-target group, while Panel B represents less healthy households in the non-target group. In neither panel do we observe much net integrated area; there is little change in mean expenditure behavior. Panels C and D of Figure 4 represent expenditure changes by healthy and less healthy target groups, respectively. While both panels show a reduction in mean expenditure, a clear differential response among healthy and less healthy target consumers is not apparent.

Figure 4. Difference Graphs: Healthy and Less Healthy Groups

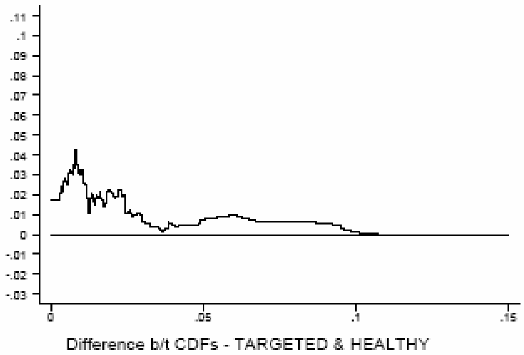


Panel A

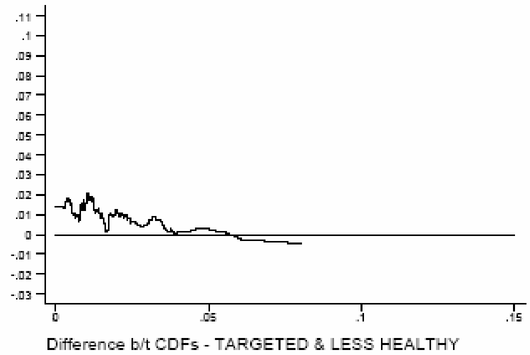


Panel B

calculations. In this and subsequent cases where the issue appears, we report the more conservative p-value associated with the mean.



Panel C



Panel D

Table 4. Non-Parametric Tests Summary: Healthy and Less Healthy Groups

	Percent Drop in Mean Expenditure Share Allocated to Fish	Percent Drop in Mean Share, Conditional on Positive Quantities	Percent Drop in the Proportion of Consumers with Positive Quantities	Second-Order Stochastic Dominance at α=0.10?
Non-Target: Healthy, Net of	13.2	6.4	7.2	No
Changes to Less Healthy	(0.27)	(0.36)	(0.30)	(0.27)
Target: Healthy, Net of	16.8	14.6	1.8	No
Changes to Less Healthy	(0.22)	(0.20)	(0.44)	(0.31)
Healthy: Target, Net of	18.8	14.6	6.5	No
Changes to Non-Target	(0.26)	(0.29)	(0.36)	(0.26)
Less Healthy: Target, Net of	21.7	11.5	10.5	No
Changes to Non-Target	(0.12)	(0.24)	(0.15)	(0.12)

p-values in parentheses

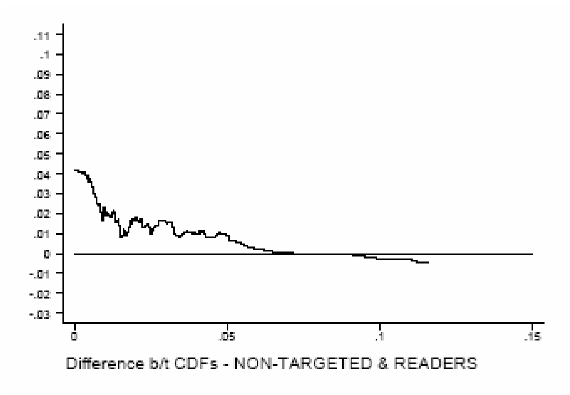
Non-parametric statistical tests confirm the visual insights. Among non-targeted consumers, the DDM statistic for the percent change in the overall mean expenditure share for the healthy subgroup (after accounting for mean changes for the less healthy subgroup) is not significant at conventional levels (p-value of 0.27). The corresponding overall DDM statistic is also not statistically significant for the target group (p-value of 0.22). All other non-parametric DDM statistics are similar. Neither the healthy group's net mean share conditional on purchase nor the healthy group's net proportion of consumers purchasing any fish changes significantly, regardless of whether the particular households are targeted or non-targeted. These findings are not restricted to the mean; we find no evidence of second-order stochastic dominance for all relevant comparisons.

Regression results are consistent with these findings. In Table 8, the row labeled 'Healthy' summarizes sign patterns and significance levels for the various specifications. We do not find a significant change from the pre- to post-advisory periods in the coefficient on the health-consciousness dummy. Similarly, we find no significant changes in the *incremental* impact of health-consciousness for the target group, summarized in the interaction row labeled 'Healthy & Child.'

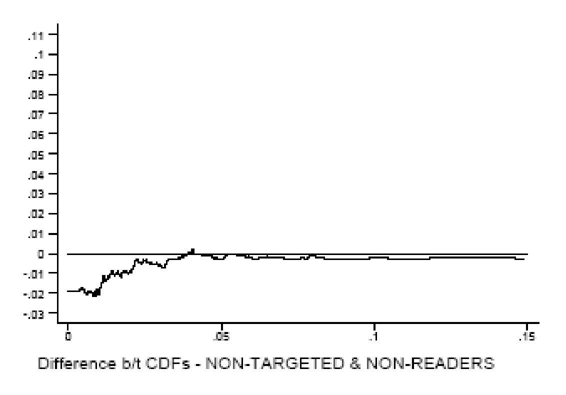
Did readers respond to the advisory?

Yes. Households purchasing newspapers or magazines reduced fish expenditure shares after the advisory. Panel A of Figure 5 indicates that shares fell after the advisory among readers in the non-target group. In contrast, Panel B shows that expenditure shares rose slightly among non-targeted non-readers. Thus, non-target readers' share fell considerably after netting out changes to non-target non-readers. Panels C and D of Figure 5 represent changes in share by reading and non-reading target consumers, respectively. While both panels indicate a reduction in post-advisory expenditure shares, it appears that targeted readers responded somewhat more than targeted non-readers. Collectively, the figures suggest a fall in post-advisory shares for readers and a differential response among readers and non-readers.

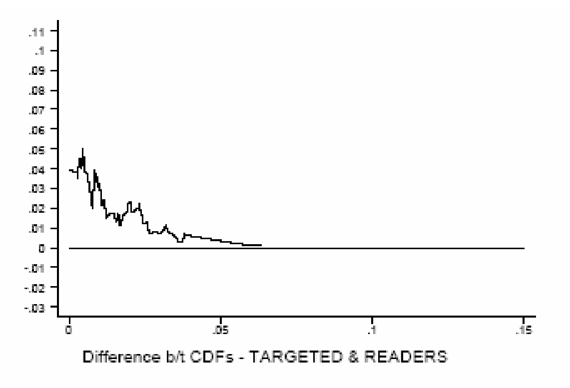
Figure 5. Difference Graphs: Reading and Non-Reading Groups



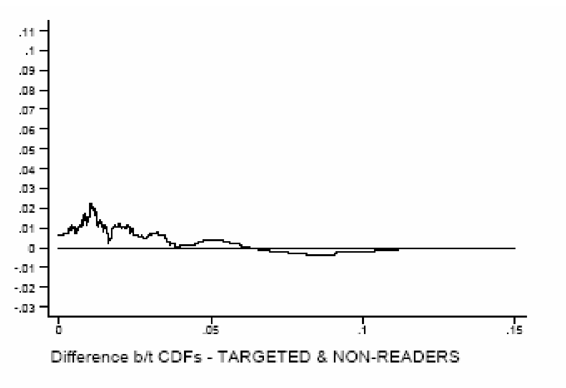
Panel A



Panel B



Panel C



Panel D

Table 5. Non-Parametric Tests Summary: Reading and Non-Reading Groups

	Percent Drop in Mean Expenditure Share Allocated to Fish	Percent Drop in Mean Share, Conditional on Positive Quantities	Percent Drop in the Proportion of Consumers with Positive Quantities	Second-Order Stochastic Dominance at α=0.10?
Non-Target: Readers, Net of Changes to Non-Readers	28.6	-5.9	30.7	Yes
	(0.06)	(0.64)	(0.01)	(0.06)
Target: Readers, Net of Changes to Non-Readers	19.1	5.6	15.9	No
	(0.19)	(0.36)	(0.15)	(0.19)
Reading: Target, Net of Changes to Non-Target	7.6	25.2	-0.9	No
	(0.39)	(0.13)	(0.51)	(0.49)
Non-Reading: Target, Net of Changes to Non-Target	25.4	8.3	12.9	Yes
	(0.08)	(0.30)	(0.09)	(0.08)

p-values in parentheses

The non-parametric tests confirm the visual evidence. Among non-targeted consumers, the drop in the overall mean expenditure share allocated to fish for the reading group (net of mean changes for the non-reading group) was 28.6 percent. The corresponding DDM statistic is statistically different from zero at the 6 percent level.

Most of the change is attributable to changes in the number of consumers; the net proportion of non-target readers consuming any fish fell more than 30 percent (p-value of 0.01), while the net share conditional on purchase remained relatively constant. Results are not restricted to the means of the expenditure share distributions; we find evidence of second-order stochastic dominance at the 6 percent level. Results for the smaller target subgroup are less pronounced; all DDM statistics are not statistically different from zero. However, among readers, we also cannot reject the hypothesis that target and non-target groups respond in the same way.

Regression coefficients support this analysis. Looking at Table 8, we see that the 'Reader' row shows a coefficient drop in each specification for both the binary and continuous expenditure decisions. The row labeled 'Reader & Child' reflects changes in the *additional* impact of membership in the target group on readers. In no case is this significant. Therefore, we find that readers, as a group, reduced expenditure after the advisory relative to non-readers. However, there is no detected difference among readers across the target and non-target groups.[21]

Did educated households respond to the advisory?

Yes. Educated households responded strongly, but only if they are in the target group. First, consider Panels A and B of Figure 6. Neither educated nor less educated non-target households seem to change expenditure shares. In contrast, Panel C shows a sharp drop in shares among educated households with young or nursing children. Panel D

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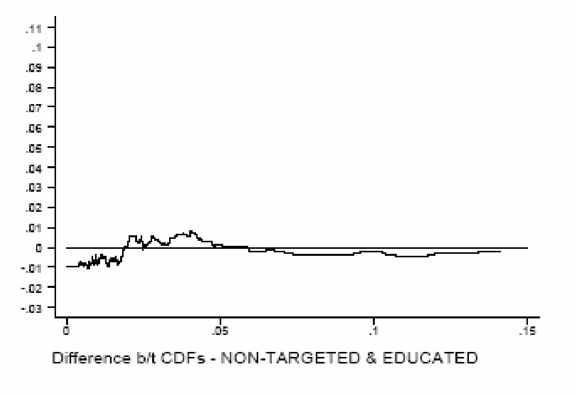
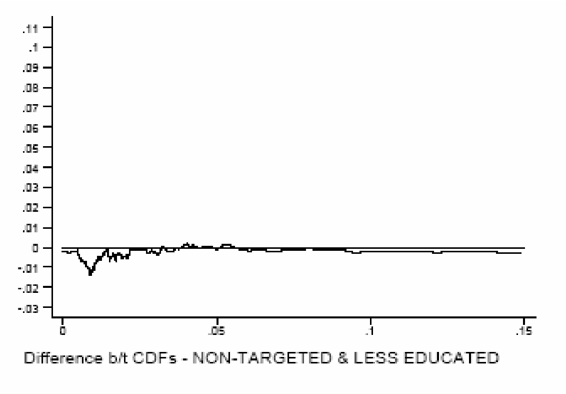
[21] Both parametric and non-parametric results may be biased if readership and fish consumption are joint consumption decisions in an economically meaningful way. For example, suppose households purchase newspapers and magazines primarily to find out about food safety. Our working assumption is that such joint decisions represent, at most, a small portion of readership and should not bias results. Further, our data

shows little change for less-educated households with young or nursing children. Comparing Panel C to D suggests a very strong impact of education for the response of the target group relative to the non-target group.

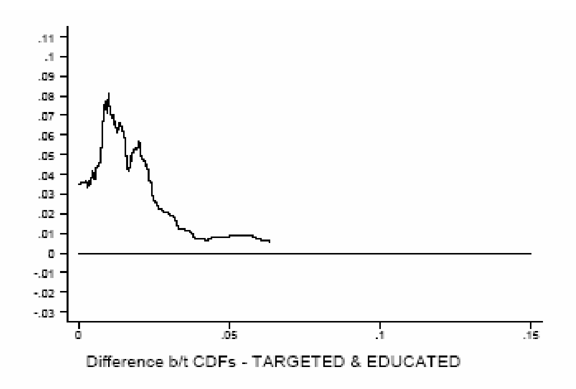
Figure 6. Difference Graphs: Educated and Less Educated Groups



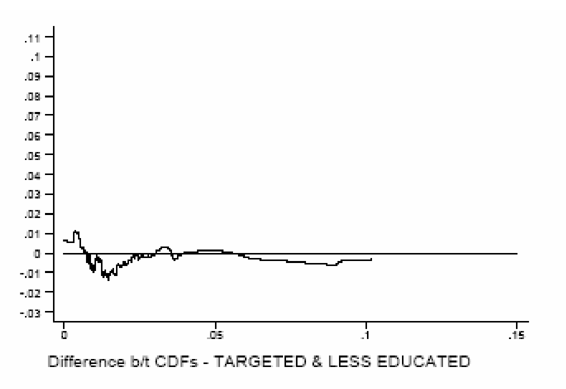
Panel A



Panel B



Panel C



Panel D

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suggests this concern is perhaps not practically important here; for both target and non-target consumers, news readership remains relatively constant across periods.

Table 6. Non-Parametric Tests Summary: Educated and Less Educated Groups

	Percent Drop in Mean Expenditure Share Allocated to Fish	Percent Drop in Mean Share, Conditional on Positive Quantities	Percent Drop in the Proportion of Consumers with Positive Quantities	Second-Order Stochastic Dominance at α=0.10?
Non-Target: Educated, Net of	1.5	6.2	-4.2	No
Changes to Less Educated	(0.49)	(0.35)	(0.64)	(0.49)
Target: Educated, Net of	50.2	43.2	13.5	Yes
Changes to Less Educated	(0.01)	(0.01)	(0.17)	(0.06)
Educated: Target, Net of	51.2	34.3	20.4	Yes
Changes to Non-Target	(0.02)	(0.06)	(0.07)	(0.03)
Less Educated: Target, Net of	3.4	0.5	4.3	No
Changes to Non-Target	(0.43)	(0.49)	(0.34)	(0.45)

p-values in parentheses

Statistical tests once again support the graphical analyses. Among non-targeted consumers, the DDM statistic for the percent change in the overall mean expenditure share for the educated subgroup (net of mean changes for the less educated subgroup) is not significant at conventional levels (p-value of 0.49). Further, none of the non-parametric tests indicate any differential response among educated non-target consumers and less educated non-target consumers. In contrast, among target consumers, the drop in overall mean expenditure share allocated to fish in the educated group (net of changes for the less educated group) was more than 50 percent (p-value of 0.01). The fall is attributable to changes in both the proportion of at-risk educated consumers that purchase at all and shares conditional on consuming. Results appear robust across the distributions; we find evidence of second order stochastic dominance at the 6 percent significance level.

Regression results tell a similar story. In Table 8, the interaction row labeled 'Educated and Child' summarizes evidence about the impact of education on response patterns of targeted households, *beyond* any general impact of education. For both specifications, we find a statistically significant effect for both the number of consumers and the mean quantity. Educated households with young or nursing children strongly reduced quantity after the advisory, relative to the control group. Contrast these results to the row labeled 'Educated,' which reflects the overall impact of education across all consumers. We generally do not observe a statistically significant change in coefficients.

Sensitivity Analysis: Single Differences

The primary non-parametric and parametric results in the previous section emphasize differential consumption changes between two groups. For example, we find a differential response between target and non-target consumers, readers and non-readers (whether targeted or not), and educated and less educated consumers (if targeted). The motivation for differential responses is robustness to common shocks.

However, sharper results can be obtained by assuming the unobserved common shocks are small on average. An additional benefit of this assumption is that estimated response magnitudes are absolute and more readily interpretable. In practice, imposing this restriction amounts to performing single difference non-parametric tests, without reference to a control group. The corresponding single difference parametric regressions include observable potential time variant shocks like prices and substitute prices, but omit time-varying constants.[22]

Single difference statistical test (SDM) results are presented in Table 7, and single difference regression results are presented in Table 9. The most important feature is that the single difference results closely resemble the double difference results, so unobserved shocks are likely small on average. For responding groups, post-advisory consumption fell, both absolutely and relative to control groups. Non-target readers' mean expenditure share fell by approximately one-fourth (DDM 28.6%, SDM 13.7%), target readers' mean

[22] Our working hypothesis is that prices are exogenous world prices. This seems plausible since canned fish is mostly caught and packaged abroad, and included substitute prices appear as an index of major meats.

share fell on the order of one-fifth (DDM 19.1%, SDM 27.7%), and the target educated groups' mean share fell by approximately one-half (DDM 50.2%, SDM 43.6%).

The similarity between single and double difference results also suggests that there is no meaningful advisory response among those groups with statistically undetected consumption changes. Of course, this depends upon the power of the tests. For those least likely to be knowledgeable about the advisory (the non-reading, less educated group examined the in last rows of Table 7), we find an insignificant response. Tests of power at the 90 percent confidence level reveal that this group's overall mean expenditure share decrease is less than 13 percent, their mean share decrease conditional on fish purchase is less than 12 percent, and their mean fall in the proportion of consumers purchasing any fish is less than 8 percent.[23] In other words, changes for this uninformed group are relatively small, if not precisely zero.

[23] Double Difference results and analyses, not reported in the interest of space, are similar.

Table 7. Non-Parametric Tests Summary: Single Differences

	Percent Drop in Mean Expenditure Share Allocated to Fish	Percent Drop in Mean Share, Conditional on Positive Quantities	Percent Drop in the Proportion of Consumers with Positive Quantities	Second-Order Stochastic Dominance?
Target and Non-Target				
Target Group	11.3	4.1	7.5	No
	(0.14)	(0.31)	(0.15)	(0.14)
Non-Target Group	-8.8	-5.9	-2.8	No
	(0.82)	(0.78)	(0.68)	(0.82)
Healthy and Less Healthy				
Non-Target Group: Healthy	2.6	-0.3	2.9	No
	(0.46)	(0.52)	(0.40)	(0.46)
Non-Target Group: Less Healthy	-12.4	-7.6	-4.4	No
	(0.87)	(0.81)	(0.75)	(0.87)
Target Group: Healthy	21.7	14.1	8.9	No
	(0.14)	(0.19)	(0.26)	(0.16)
Target Group: Less Healthy	6.5	-0.6	7.0	No
	(0.31)	(0.53)	(0.21)	(0.18)
Reading and Non-Reading				
Non-Target Group: Readers	13.7	-9.4	21.1	No
	(0.18)	(0.77)	(0.02)	(0.18)
Non-Target Group: Non-Readers	-16.4	-2.8	-13.2	No
	(0.91)	(0.63)	(0.96)	(0.91)
Target Group: Readers	27.7	10.7	19.0	Yes
	(0.05)	(0.17)	(0.08)	(0.07)
Target Group: Non-Readers	7.2	4.0	3.3	No
	(0.29)	(0.34)	(0.34)	(0.29)
Educated and Less Educated				
Non-Target Group: Educated	-6.7	-1.1	-5.6	No
	(0.65)	(0.54)	(0.70)	(0.65)
Non-Target Group: Less Educated	-9.6	-8.0	-1.5	No
	(0.80)	(0.82)	(0.58)	(0.80)
Target Group: Educated	43.6	32.7	16.2	Yes
	(0.01)	(0.01)	(0.09)	(0.02)
Non-Target Group: Less Educated	-8.4	-11.8	3.1	No
	(0.72)	(0.86)	(0.36)	(0.72)
Non-Reading and Less Educated				
Non-Target Group: Less Educated Non-Readers	-16.0	-3.0	-12.6	No
	(0.87)	(0.62)	(0.92)	(0.88)
Target Group: Less Educated Non-Readers	-14.2	-10.1	-3.7	No
	(0.78)	(0.79)	(0.63)	(0.78)

p-values in parentheses

Sensitivity Analysis: Other Assumptions

The results of the preceding sections are consistent across both single- and double- difference graphical, non-parametric, and regression analyses. Below, we provide evidence these results are robust to choices of proxy-variable definitions, model structure, error specification, and the precise nature of the 'event'.

When the threshold for "educated" is defined as a college degree, we found a strong differential response compared to less educated target consumers. Increasing the threshold to some graduate education amplifies this difference. However, upon decreasing the threshold to high school graduation, the difference with the less educated group is no longer statistically significant.

Our definition of 'health conscious' is *ad hoc.* However, results are not sensitive to the construction of the proxy variable. A wide variety of plausible indices and thresholds were considered without finding any differential response between healthy and unhealthy consumers.

Our regression model assumes a mean-zero error, implying that the sample average is a consistent estimate of true market demand. If zero-censoring of the dependent variable due to observation error is a concern, a Tobit correction would be in order. Therefore, we tested a supplementary Cragg (1971) correlated double-hurdle model to address this concern. The results for this specification were quite similar to those reported.

Another possible concern is that our study's 'event' (the January 2001 advisory) is poorly defined. For example, perhaps consumers were broadly aware of the dangers of mercury prior to the announcement, since a number of states had issued advisories for recreational fish before the FDA action. One might also be concerned that the possibility of a FDA advisory was widely publicized long before its actual release. However, experiments indicate that these concerns are unsupported. For example, we do not find differential responses between those in the eight states that issued their own commercial advisories and those in other states. Further, target groups' expenditures remained unchanged or increased between each of pre-advisory years (1997/1998, 1998/1999, 1999/2000). We also detected no systematically differential response among educated and uneducated target consumers prior to the advisory itself.

There are other sound reasons to believe the event is properly defined. First, the FDA issued the advisory within months of initially considering action. Second, FDA focus groups conducted in October 2000 (two months before the advisory) indicated, "None of the [focus] groups showed much interest or concern about mercury as a hazard in fish before seeing the information pieces….There was little or no awareness in any group of a hazard due to low level mercury exposure from fish consumption that was not due to a specific [localized] pollution problem." (FDA 2000) Finally, if consumers had already reacted to the mercury hazard, it would be difficult to reconcile the observed differential responses after the advisory between educated and less educated consumers.

VI. Discussion & Conclusion

We find that some targeted consumers significantly reduced canned fish purchases as a result of the FDA mercury advisory of January 2001. In particular, college educated consumers in the target group responded strongly. Among households with young and nursing children, mean canned fish expenditure share fell by 29 percent after the advisory, accounting for common shocks. In contrast, we detected no statistically significant response among those with less education.

We also found that newspaper or magazine purchases were associated with a significant reduction in post-advisory consumption. Among households that purchased newspapers or magazines in the diary period, mean fish expenditure fell by 19 percent after the advisory, accounting for common shocks. However, we found no differential response among targeted readers and non-targeted readers.

Access to information and the ability to assimilate information were important limiting factors in the advisory response. We view newspaper readership as a reasonable proxy for exposure to information about the dangers of mercury in fish, and readers responded. We also view college education as a reasonable proxy for the ability to assimilate information appropriately, and educated individuals responded only if targeted by the advisory.

Differential responses among educated and less educated target consumers might also be explained by systematic differences in risk preferences. This seems less plausible. First, there is no empirical connection between risk preferences and education. See, for example, Halek and Eisenhauer (2001). Second, while healthy behaviors are believed to be correlated with risk preferences, we find no differential advisory responses between healthy and unhealthy households.[24]

Can the observed changes in consumption be attributed to the FDA policy? The responses are consistent with increased information about mercury hazards. Further, FDA focus groups found no public awareness of the relevant risks two months prior to the advisory. Although we do not know whether individual responding consumers were aware of the advisory *per se*, there is no doubt that the advisory resulted in much greater general public awareness of mercury risk. In this sense, an advisory can be effective through promoting awareness, even if indirectly.

Targeted consumers likely to be aware of and understand the advisory tend to reduce fish consumption. Mercury advisories and education programs can therefore be an effective policy tool for reducing the contaminant exposure of nursing and young children. However, those at-risk consumers least likely to be knowledgeable about the advisory do not significantly reduce consumption. Unfortunately, this large group of non-college educated, non-readers is also likely to be poorly equipped to withstand negative health shocks from mercury. At a minimum, these latter results suggest that a broader and more targeted educational outreach program is necessary to reach many vulnerable members of society. Possible enhanced outreach methods include health-advertising campaigns (on public transportation, for example) and in-store advisory signs. Perhaps alternative methods, like mandatory product labeling, should even be explored. Mathios (2000) showed that labeling induces important consumption responses, and Teisl *et al.* (2002) showed that point of consumption labeling is particularly effective for canned fish.[25]

More broadly, we find that well-informed consumers do actively respond to environmental risk warnings. Prominent advisories may therefore be an effective and low-cost method of reducing public health damages, but particular attention must be paid to less educated and less informed consumers. On another cautionary note, our results also indicate that informed individuals may respond more broadly than intended, as non-targeted readers reduced fish consumption after the mercury advisory. While this may be a rational or even optimal response, it is not consistent with the stated intent of the advisory. Therefore, advisories and outreach programs should be carefully crafted with such spillovers in mind.

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[24] Viscusi *et al.* (1999) found that smokers had systematically different risk preferences than non-smokers. Our health measure incorporates this; households with tobacco purchases are automatically classified as 'unhealthy.'

[25] Teisl *et al.* (2002) examined the impact of "dolphin-safe" eco-labeling on tuna consumption.

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Table 8. Tests for Equivalence of Pre-Advisory and Post-Advisory Coefficients, Regression Specifications with Time Dummies (Double Difference)

	BINARY CONSUMPTION DECISION		QUANTITY CONDITIONAL ON CONSUMING DECISION	
Variable	Entire Sample ’99,’00 vs. ’01,’02	Cored Sample ’99 vs. ‘02	Entire Sample ’99,’00 vs. ’01,’02	Cored Sample ’99 vs. ‘02
CHILDREN (TARGETED)	-	+	-	-
	.38	.79	.59	.95
READER	-	-	-	-
	.03**	.07*	.07*	.08*
EDUCATED	+	+	+	+
	.26	.39	.21	.74
HEALTHY	-	-	-	-
	.43	.48	.87	.81
READER & CHILD	+	+	+	+
	.55	.72	.56	.51
EDUCATED & CHILD	-	-	-	-
	.10*	.03**	.05**	.02**
HEALTHY & CHILD	+	+	-	+
	.60	.14	.78	.49

+ indicates that post-advisory increased relative to pre-advisory coefficients, - indicates the reverse.
The 1st column for each decision examines the entire sample. The 2nd columns highlight pre- vs. post- advisory changes by examining the sample with the year immediately before the advisory and the year immediately following the advisory removed.
Numbers are p-values for change in pre- vs. post- advisory coefficient.
** - Significant at α = .05, * - Significant at α = .10.

Table 9. Tests for Equivalence of Pre-Advisory and Post-Advisory Coefficients, Specifications Without Time Dummies (Single Difference)

	BINARY CONSUMPTION DECISION		QUANTITY CONDITIONAL ON CONSUMING DECISION	
Variable	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**
CHILDREN (TARGETED)	+	+	-	+
	.59	.51	.99	.72
READER	-	-	-	-
	.15	.09*	.24	.26
EDUCATED	+	+	+	+
	.06*	.34	.08*	.28
HEALTHY	-	-	-	-
	.88	.58	.98	.46
READER & CHILD	+	+	+	-
	.98	.94	.99	.90
EDUCATED & CHILD	-	-	-	-
	.01**	.01**	.02**	.01**
HEALTHY & CHILD	+	+	-	+
	.93	.17	.96	.14

+ indicates that post-advisory increased relative to pre-advisory coefficients, - indicates the reverse.
The 1st column for each decision examines the entire sample. The 2nd columns highlight pre- vs. post- advisory changes by examining the sample with the year immediately before the advisory and the year immediately following the advisory removed.
Numbers are p-values for change in pre- vs. post- advisory coefficient.
** - Significant at α = .05, * - Significant at α = .10.

Appendix A. Complete Regression Results, Specifications with Time Dummies

	BINARY CONSUMPTION DECISION		QUANTITY CONDITIONAL ON CONSUMING DECISION	
Variable	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**
FOOD	0.390**	0.431**	0.660**	0.738**
	(0.020)	(0.028)	(0.040)	(0.063)
AGE OF RESPONDENT	0.001	0.001	0.002	0.001
	(0.001)	(0.001)	(0.002)	(0.002)
CHILDREN (TARGETED) 0	0.065*	-0.000	0.099*	0.057
	(0.033)	(0.046)	(0.059)	(0.081)
CHILDREN (TARGETED) 1	0.025	0.016	0.056	0.049
	(0.033)	(0.046)	(0.057)	(0.076)
READER 0	0.060*	0.047	0.084	0.099
	(0.032)	(0.044)	(0.055)	(0.077)
READER 1	-0.042	-0.069	-0.067	-0.099
	(0.035)	(0.049)	(0.062)	(0.082)
EDUCATED 0	-0.029	-0.039	-0.020	-0.023
	(0.035)	(0.046	(0.061)	(0.080)
EDUCATED 1	0.025	0.016	0.084	0.014
	(0.033)	(0.045	(0.057)	(0.077)
HEALTHY 0	0.010	-0.007	0.003	-0.030
	(0.039)	(0.055)	(0.070)	(0.100)
HEALTHY 1	-0.032	-0.060	-0.012	-0.062
	(0.038)	(0.054)	(0.067)	(0.093)
READER & CHILD 0	-0.079*	-0.056	-0.132*	-0.153
	(0.046)	(0.064)	(0.078)	(0.109)
READER & CHILD 1	-0.038	-0.023	-0.063	-0.045
	(0.051)	(0.071)	(0.088)	(0.123)
EDUCATED & CHILD 0	0.034	0.089	0.052	0.138
	(0.048)	(0.067)	(0.082)	(0.114)
EDUCATED & CHILD 1	-0.077*	-0.122*	-0.177**	-0.240**
	(0.047)	(0.068)	(0.082)	(0.121)
HEALTHY & CHILD 0	0.015	-0.023	0.068	0.026
	(0.052)	(0.077)	(0.092)	(0.141)
HEALTHY & CHILD 1	0.054	0.136*	0.031	0.164
	(0.054)	(0.077)	(0.094)	(0.137)
CONSTANT 0	-0.437**	-0.399**	-0.889**	-0.884**
	(0.065)	(0.087)	(0.117)	(0.150)
CONSTANT 1	-0.397**	-0.394**	-0.803**	-0.798**
	(0.063)	(0.087)	(0.113)	(0.148)
TIME INVARIANT CONSTANT	-0.633**	-0.615**	-	-
	(0.058)	(0.093)		

Figures in parentheses are robust standard errors.
** - Significant at $\alpha = .05$, * - Significant at $\alpha = .10$.

Notes:
a. 0 in the variable name indicates ‘pre-advisory’ and 1 indicates ‘post-advisory’
b. Both regression specifications use a maximum likelihood procedure mathematically identical to Heckman’s Selectivity model.
c. Both specifications include 4-1 regional dummies and 4-1 race dummies. We omit these control results to conserve space.
d. Wald tests for all coefficients being 0 generate χ^2 statistics of 310, 442, 183, and 375.

Appendix B. Complete Regression Results, Specifications without Time Dummies

	BINARY CONSUMPTION DECISION		QUANTITY CONDITIONAL ON CONSUMING DECISION	
Variable	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**	**Entire Sample ’99,’00 vs. ’01,’02**	**Cored Sample ’99 vs. ‘02**
FOOD	0.038**	0.420**	0.889**	1.01**
	(0.018)	(0.025)	(0.047)	(0.061)
PRICE	-0.010	-0.011	-0.141	-0.121
	(0.043)	(0.064)	(0.093)	(0.142)
SUB PRICE INDEX	-0.088	-0.048	-0.074	-0.037
	(0.084)	(0.117)	(0.178)	(0.258)
AGE OF RESPONDENT	0.002	0.001	0.004	0.003
	(0.001)	(0.001)	(0.002)	(0.003)
CHILDREN (TARGETED) 0	-0.012	-0.058	-0.011	-0.094
	(0.027)	(0.038)	(0.056)	(0.083)
CHILDREN (TARGETED) 1	0.005	-0.026	-0.012	-0.056
	(0.027)	(0.037)	(0.056)	(0.079)
READER 0	0.003	-0.009	-0.023	-0.043
	(0.026)	(0.036)	(0.054)	(0.078)
READER 1	-0.049*	-0.094**	-0.112*	-0.166**
	(0.029)	(0.039)	(0.060)	(0.085)
EDUCATED 0	-0.034	-0.029	-0.032	-0.049
	(0.042)	(0.038)	(0.060)	(0.081)
EDUCATED 1	0.036	0.019	0.109*	0.068
	(0.041)	(0.037)	(0.057)	(0.079)
HEALTHY 0	-0.012	-0.012	0.003	0.029
	(0.032)	(0.045)	(0.068)	(0.099)
HEALTHY 1	-0.019	-0.047	-0.000	-0.076
	(0.032)	(0.045)	(0.068)	0.100
READER & CHILD 0	-0.037	-0.011	-0.068	0.007
	(0.041)	(0.055)	(0.085)	(0.123)
READER & CHILD 1	-0.035	-0.004	-0.067	-0.016
	(0.045)	(0.062)	(0.094)	(0.135)
EDUCATED & CHILD 0	0.056	0.087	0.061	0.130
	(0.042)	(0.058)	(0.088)	(0.127)
EDUCATED & CHILD 1	-0.095**	-0.134**	-0.235**	-0.342**
	(0.041)	(0.059)	(0.089)	(0.129)
HEALTHY & CHILD 0	0.029	-0.014	0.044	-0.094
	(0.045)	(0.067)	(0.096)	(0.147)
HEALTHY & CHILD 1	0.034	0.117	0.037	0.218
	(0.048)	(0.067)	(0.103)	(0.148)
TIME INVARIANT CONSTANT	-1.39**	-1.41**	-2.40**	-2.64**
	(0.039)	(0.054)	(0.177)	(0.189)

Figures in parentheses are robust standard errors.
** - Significant at $\alpha = .05$, * - Significant at $\alpha = .10$.

Notes:
a. 0 in the variable name indicates ‘pre-advisory’ and 1 indicates ‘post-advisory’
b. Both regression specifications use a maximum likelihood procedure mathematically identical to Heckman’s Selectivity model.
c. Both specifications include 4-1 regional dummies and 4-1 race dummies. We omit these control results to conserve space.
d. Wald tests for all coefficients being 0 generate χ^2 statistics of 442 and 375.