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The Impact of Fish and Shellfish Consumption on Age-Related Macular Degeneration

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Abstract

Purpose—To determine the relationship between fish and shellfish consumption and age-related macular degeneration (AMD) status in the Salisbury Eye Evaluation (SEE) Study participants.

Design—A cross-sectional study of dietary and ophthalmologic data.

Participants—A random sample of 2520 Salisbury, Maryland, residents aged 65 to 84 years.

Methods—A food frequency questionnaire was used to estimate weekly fish/shellfish consumption for each participant. Age-related macular degeneration status was determined from fundus photographs obtained at baseline and graded by 2 masked readers for drusen size, retinal pigment epithelium abnormalities, geographic atrophy (GA), and choroidal neovascularization (CNV). The association between weekly fish/shellfish intake and risk of AMD was investigated using logistic regression while adjusting for risk factors and correlation between eyes.

Main Outcome Measures—Status of AMD.

Results—The distribution of weekly fish/shellfish consumption was not different between specific AMD categories compared with controls ($P = 0.6$, 0.7 , and 0.7 for large drusen, pigment abnormalities, and advanced AMD compared with controls, respectively). Those with advanced AMD (CNV or GA) were significantly less likely to consume fish/shellfish high in omega-3 fatty acids (odds ratio 0.4 ; confidence interval, 0.2 – 0.8). There was no relationship of AMD with intake of crab and oysters combined, each of which has high levels of zinc.

Conclusions—These data support a protective effect of fish/shellfish intake against advanced AMD.

Approximately 1.75 million Americans have been diagnosed with advanced age-related macular degeneration (AMD), making it the leading cause of blindness in the United States among whites.^{1,2} By 2020, the number of people affected with AMD-related choroidal neovascularization or geographic atrophy in the United States is expected to increase by 50% to 2.95 million cases.²

It has been postulated that high intakes of dietary omega-3 fatty acids can reduce the risk of AMD development or progression.³⁻⁹ Consumption of fatty fish, such as salmon and tuna, has been reported to increase serum omega-3 fatty acid concentrations.¹⁰ In addition, populations with habitual consumption of shellfish and lean fish reportedly have elevated omega-3 fatty acid levels.^{11,12} Recent epidemiologic research has suggested an inverse association between high levels of fish consumption and risk of AMD.^{4,6,13,14} These results in conjunction with studies in animals and other model systems, which have reported high concentrations of omega-3 fatty acids in the retina, have led some to propose that omega-3 fatty acids are necessary for eye health.⁵

This study's aim is to determine whether consumption of fish and shellfish is associated with a decreased risk of AMD within the Salisbury Eye Evaluation (SEE) Study, a population of elderly participants living on Maryland's Eastern Shore.

Materials and Methods

Design and Population

The SEE Study design and population selection have been described in detail.¹⁵ In essence, potential participants were randomly selected from the Health Care Financing Administration Medicare Database. The eligibility criteria of the cohort included non-institutionalized persons aged 65 to 84 years who were residents of Salisbury, Maryland, as of July 1, 1993, and who scored 17 or greater on a Mini-Mental State Examination. A total of 3906 residents were eligible for the study, of whom 2520 participated in the study. Recruitment of participants began September 1, 1993, and ended September 15, 1995.

The Johns Hopkins University School of Medicine Institutional Review Board approved all procedures used in this study. Written informed consent was obtained from all participants before participation in the study.

Age-Related Macular Degeneration Assessment

Stereoscopic 30-degree color fundus film photographs (Topcon TRC-FET fundus camera, Topcon, Tokyo, Japan) were taken of each dilated eye, centering on the disc and macula, and graded for signs of AMD, as previously described.¹⁶ Two readers from the Johns Hopkins University Wilmer Reading Center graded the photographs and were masked to demographic and companion eye data for each participant. To grade the photographs, eye pairs were separated onto 2 sheets, to grade the eyes independently, and a circular grid consisting of 3 circles was overlaid on 1 photograph of the macula pair. The interior circle radius is 500 μm and was used to align the grid onto the foveal avascular zone center of the fundus image. The middle circle (1500 μm) was used to define the central macular zone, and the area between the middle and outer circle (3000 μm) corresponds to the pericentriolar macular zone. Drusen size was estimated using a circular template containing diameter marks at 64, 125, and 250 μm . Inconsistencies between readers were rectified with a joint diagnosis between readers, and an ophthalmologist (SB) decided any unresolved differences. This ophthalmologist also randomly reviewed a sample of all photographs (10%) and all photographs graded to have neovascular AMD, geographic atrophy, and ophthalmologic diseases other than AMD.

On the basis of the readers' results, each participant was classified by subtype of AMD. Advanced AMD was classified as the presence of neovascularization or geographic atrophy. Neovascularization was defined as choroidal neovascularization, disciform scarring, or evidence of laser photocoagulation, and geographic atrophy was defined as focal well-demarcated confluent areas of retinal pigment epithelial atrophy in any location within the grid. Early-stage AMD was graded as having drusen $\geq 125 \mu\text{m}$ or retinal pigment epithelial

abnormalities in the central or pericentral macular zones. The classification of “no AMD” (controls) was defined as the absence of abnormalities in the retinal pigment, the absence of drusen $\geq 125 \mu\text{m}$, and the absence of advanced AMD.

For the analyses presented in this article, categories of AMD were defined as neovascular or geographic atrophy (AMD3); eyes with pigment abnormalities (AMD2) but not classified as AMD3; and eyes with drusen $\geq 125 \mu\text{m}$ not classified as AMD3 or AMD2 (AMD1). All eyes with pigment abnormalities had drusen at least $>64 \mu\text{m}$ in size. Images were missing or ungradable from both eyes for 112 participants, and 23 participants had photographs, but no features were gradable.

The age of each participant was defined as age at clinical evaluation. Body mass index (BMI) was calculated from weight (kilograms) divided by height squared (meters), and data were obtained at baseline. Race and smoking status were self-reported on the baseline questionnaire. Smoking status was classified as a never, current, or past smoker; and race was categorized as black or white.

Dietary Assessment

A 91-item food frequency questionnaire (FFQ) section of the Health Habits and History Questionnaire distributed by the National Cancer Institute (NCI) was administered to participants. After formative research, the questionnaire was modified by the senior nutritionist investigator (LC) to include oysters, crab, and other fish dishes commonly found in Salisbury, Maryland. Trained interviewers administered the FFQ, which collected dietary data over the year before the interview. Data regarding the average serving size (small, medium, or large), frequency of food consumption (daily, weekly, monthly, yearly, never, or “do not know”), and average number of times the food was consumed within the frequency were specified. These data were transformed into nutrient data using the NCI Dietary Analysis System (version 3.7c, 1994, NCI, Bethesda, MD). Respondents were contacted regarding any questionable responses.

Fish/shellfish consumption was categorized into 6 groups based on the categories used in the FFQ: fried fish (fried fish/fish sandwich), oysters (oyster fritters/fried oysters), tuna (tuna fish/tuna salad/tuna casserole), shellfish (shrimp or lobster), crab (crab/crab cakes/crab salad), and “other fish” (other fish baked or fried). For each participant, the average number of times a food was consumed was multiplied by the frequency the food item was consumed (as derived from the participant’s responses to the FFQ) and a seasonality factor (seasonality factor = the number of months the food item is in season/12 months; seasonality factor = 1 for tuna, and fried fish). This value was then standardized to the average consumption per week of that food item. The weekly consumption of all fish and shellfish categories was then summed for analyses. Categories of weekly fish/shellfish consumption were created: <1 , 1 to <2 , and 2+ servings/week.

A category of fish/shellfish with high omega-3 fatty acid content was created on the basis of each food item’s content of eicosapentaenoic acid and docosahexaenoic acid determined from the United States Department of Agriculture National Nutritional Database Standard Reference.¹⁷ By selecting the database fish/shellfish food items most similar to those on the FFQ, the total content of eicosapentaenoic acid and docosahexaenoic acid for each food item was determined per 100-g serving: crab (0.58 g/100 g), other fish (0.542 g/100 g), oysters (0.42 g/100 g), fried fish (0.49 g/100 g), shellfish (0.32 g/100 g for shrimp and 0.37 g/100 g for lobster), and tuna (0.24 g/100 g for canned tuna and 0.07 g/100 g for tuna salad).¹⁷ Because salmon is considered the fish with the highest omega-3 fatty acid content (~ 2.1 g/100 g serving),¹⁷ we arbitrarily chose the cut point of high fatty acid fish/shellfish to be those food items with 20% of this value. Therefore, those food items with omega-3 fatty

acid content greater than 0.4 g/100 g serving were included in the high omega-3 fatty acid group: crab, other fish, oysters, and fried fish.¹⁷ We then summed the weekly consumption of crab, oysters, fried fish, and other fish categories. Comparison of less than 1 serving per week was made with 1 or more serving per week, because most of the intake was highly seasonal and thus averaged over a year was modest.

Oysters and crab have high zinc content compared with other food items. Crab has approximately 4 mg of zinc per 100 g serving, and oysters have approximately 182 mg of zinc per 100 g serving.¹⁷ We created a category of the sum of the weekly intake of these 2 food items, and compared those whose intake was above the combined mean with those whose intake was below the mean (combined mean = 0.07 servings/week).

Statistical Analyses

Data were analyzed using STATA 10 (STATA Statistical Software: Release 10, STATA Corp., College Station, TX) and SAS (SAS Inc., Cary, NC). Lowess graphs were generated for all continuous covariates to check for non-linearity. The association of AMD with weekly fish/shellfish consumption (servings/week), omega-3 fatty acid rich fish (servings/week), and zinc from crab and oysters (servings/week) was determined using univariate and multivariate models. Potential confounders considered were gender (male or female), race (black or white), smoking status (never, past, or current), age at clinic visit (years), education (years), BMI (kilograms/meters squared), and average daily energy consumption (kilocalories). The distribution of each of these variables by AMD status was analyzed, and *P* values from chi-square or *t* tests comparing each category with controls were obtained. The distribution of weekly intakes of types of fish/shellfish was also examined between AMD categories. Because of skewed distributions, log transformation was used when performing *t* tests to compare these group means.

In addition, both stepwise and Akaike information criterion (AIC) values resulting from likelihood tests comparing null and extended models determined the most parsimonious statistical model. Average daily energy consumption was first included in the statistical models, but then removed because removal did not affect results, and the AIC values for both models were not statistically different from each other. Statistical models using log-transformed weekly fish/shellfish consumption were examined because of the skewed distribution of this variable. However, the log-transformed models had similar AIC values compared with those that did not use log-transformed variables, and therefore an untransformed covariate was used in all subsequent statistical models. All analyses were run excluding 1 outlier data point (weekly total fish/shellfish consumption > 10.0 servings/week). The analyses were also run removing those with intermediate drusen from controls (>63 and <125), but the results did not differ.

A Hosmer–Lemeshow goodness-of-fit test was used to assess the fit of the final fully adjusted model (including age, gender, race, and smoking status) and indicated a good fit (*P* = 0.8). For multivariate models, eye-specific models were run, adjusting confidence intervals (CIs) for the correlation between eyes using the methods of Zeger and Liang.¹⁸ Odds ratios (OR) and 95% CIs for these analyses are reported for all analyses.

Results

After all exclusions, 2391 participants (94.9%) were eligible for analyses. Among these participants, 1943 (77.1%) were classified as persons without AMD signs (controls), 227 (9.0%) were classified as AMD1, 153 (6.1%) were classified as AMD2, and 68 (2.7%) were classified as AMD3 (Table 1). Mean BMI, average daily energy consumption (kilocalories), years of education, and gender were not statistically different between the categories of

AMD. However, there was a statistically significant difference among the age, race, and smoking status distributions in the AMD categories (Table 1). The mean age of those without AMD (controls) was 73.1 years (95% CI, 72.9–73.3), compared with those with neovascular or geographic atrophy (AMD3), which was 76.6 years (95% CI, 75.3–78.0) (Table 1). The proportion of whites in each of the AMD categories was higher compared with the proportion in the control group. Weekly fish/shellfish consumption was not statistically different between categories of AMD; all participants consumed on average 1.1 serving per week. Blacks and current smokers were more likely to have higher fish/shellfish consumption, suggesting the possibility of confounding by these variables.

There was no significant difference in the distribution of fish/shellfish consumption among any of the AMD groups after adjustment for multiple confounders and adjusting for the correlation between eyes (Table 2). Total weekly fish/shellfish consumption may mask associations with specific types of fish or shellfish, although with multiple categories, associations must be deemed exploratory. The distribution of each type of fish and shellfish was examined. However, the only significant difference was the intake of “other fish” between cases of large drusen (AMD1) (mean = 0.09 servings/week) compared with controls (mean = 0.07 servings/week) ($P = 0.04$) (Table 3).

Because some types of fish and shellfish are higher in omega-3 fatty acids than others, categories of the total consumption of fish/shellfish with high levels of omega-3 fatty acid were analyzed (Table 4). A significant protective effect between intake of fish high in omega-3 and advanced AMD (AMD3) was observed once adjusted for other factors. However, no protective effect was observed for large drusen (AMD1) or pigment abnormalities (AMD2).

Crab and oysters have significantly higher zinc content compared with other foods. Because zinc has been shown to be protective in the Age-Related Eye Disease Study (AREDS), we examined the relationship between crab and oyster intake and AMD (Table 5).¹⁹ There was no significant protective effect for any category of AMD with intake of crab and oyster.

Discussion

Our study of older participants found a protective effect for advanced AMD with intake of fish and shellfish high in omega-3 fatty acids. However, this protective effect was not observed for large drusen or pigment abnormalities, fundus features that frequently precede the development of AMD.

Other studies have found that increasing levels of fish consumption decrease the risk of AMD.^{4,6} For example, the Blue Mountains Eye Study found a protective effect among those who reported eating more than 1 serving of fish per week compared with those who consumed less than 1 serving per month.¹⁴ A study conducted in Europe reported a statistically significant protective effect against neovascular AMD among those who consumed more than 1 serving of oily fish per week compared with those who consumed less than 1 serving per week, similar to our findings of a protective effect for consumption of fish high in omega-3 and advanced AMD.¹³ The AREDS study also found a protective effect of intake of omega-3 fatty acid for the 12-year incidence of advanced AMD.⁹ We observed a nonsignificant protective effect for advanced AMD with higher fish/shellfish intake, which became significant when confined to fish/shellfish high in omega-3 fatty acids. This finding supports a growing body of evidence that suggests omega-3 fatty acids are protective against AMD.

We did not find a protective effect for higher consumption of crab and oysters, seafood high in zinc content, and risk of large drusen, pigment abnormalities, or advanced AMD. These foods are high in zinc but have a lower concentration than dietary supplements.²⁰ Our data were collected in 1993, before reports of a protective effect of zinc, and the supplements on the market in Salisbury at that time did not contain zinc. The protective effect of zinc-containing supplements in the AREDS study was observed with a daily dose of 80 mg per day, or 560 mg per week. On average, 100 g of crab and 100 g of oysters provide 186 mg of zinc,¹⁹ and our average zinc intake from these foods is 13 mg per week or 1.9 mg per day. This dietary level of zinc intake is clearly much less than the 80 mg per day that was administered in the AREDS and does not seem to provide a protective effect. Although data were collected on supplement use in the SEE Study, we did not code for specific mineral intake and would have missed persons taking specific zinc supplements.

A significant difference in the mean intake of the “other fish” category between those with large drusen (AMD1) (mean = 0.09 servings/week) and controls (mean = 0.07 servings/week) was observed ($P = 0.04$) (Table 3). No other fish categories were related to large drusen, and no protective effect or risk effect was observed with total intake. In the absence of any consistent finding with other categories of fish, it is more likely this association represents a chance finding from multiple comparisons.

Study Limitations

The small sample size of the advanced AMD category should be considered when interpreting the results of this study, because the overall significance levels of total fish intake may have been different with larger numbers. The fact that dietary data have many sources of error, including possible recall bias, cannot be excluded. However, the SEE Study was conducted before published associations between fish consumption (or other nutrients) and AMD; therefore, bias due to differential misclassification is unlikely. Arguments are made that other factors associated with those who have healthy diets, including high fish and shellfish consumption, may be the protective factors. However, fish and shellfish eating in Salisbury is not perceived as a “healthy” lifestyle, but rather a consequence of easy access to this ready source of protein. In fact, both smoking and BMI increase with increasing consumption of fish/shellfish in this population, suggesting if anything an inverse relation of healthy living with fish consumption in this cohort.

The FFQ was administered before ocular assessment, and administrators were not aware of the photograph findings, so interviewer bias is unlikely. The participation rate of the SEE Study is characteristic of other population studies within the same age group, but concern may be raised for differential participation. However, dietary data were collected during an at-home interview, and a comparison between those who participated in the subsequent clinic examination and those who did not found no difference in total fish intake between these 2 groups. This suggests that differential participation does not explain our null findings.

In conclusion, our results suggest a protective effect of selective fish and shellfish intake against the risk of advanced AMD, most likely because of their omega-3 fatty acid content. Some shellfish (crab and oysters, in particular) are also rich sources of zinc, but intake of crab and oyster was not related to risk. However, zinc intake, even from these food sources, is low compared with supplements, given the average consumption of these foods in this population. Future studies, as suggested by a recent systematic review, are needed to further elucidate the association between the consumption of fish, shellfish, zinc, and omega-3 fatty acids and the risk of AMD.²¹

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Table 1

Baseline Characteristics of Salisbury Eye Evaluation Study Participants Based on Age-Related Macular Degeneration Status

	Controls*	AMD1*	AMD2*	AMD3*
	1943 (77.1)	227 (9.0)	153 (6.1)	68 (2.7)
	N (%)	N (%)	N (%)	N (%)
Gender (%)				
Male	831 (42.8)	88 (38.8)	72 (47.1)	32 (47.1)
Female	1112 (57.2)	139 (61.2)	81 (52.9)	36 (52.9)
χ^2 P value [†]	0.4			
Race (%)				
White	1416 (72.9)	177 (78.0)	124 (81.1)	59 (86.8)
Black	527 (27.3)	50 (22.3)	29 (19.0)	9 (13.2)
χ^2 P value [†]	0.005			
Smoking status (%)				
Never	785 (40.6)	96 (42.3)	45 (29.4)	18 (26.45)
Past	870 (44.9)	106 (46.7)	76 (49.7)	40 (58.8)
Current	281 (14.5)	25 (11.0)	31 (20.3)	9 (13.2)
χ^2 P value [†]	0.01			
Age at clinic visit (yrs)				
N	1943	227	153	68
Mean (SD)	73.1 (5.0)	75.3 (5.2)	74.3 (5.0)	76.6 (5.6)
t test P value [‡]		<0.001	0.004	<0.001
BMI (kg/m ²)				
N	1901	224	150	67
Mean (SD)	27.9 (5.6)	28.2 (6.0)	28.0 (5.0)	27.0 (5.1)
t test P value [‡]		0.6	0.8	0.2
Education (yrs)				
N	1940	227	153	68
Mean (SD)	11.1 (3.4)	11.1 (3.4)	11.2 (3.3)	11.4 (3.4)
t test P value [‡]		0.2	0.8	0.5
Average daily energy intake (Kcal)				
N	1800	211	136	65
Mean (SD)	1478.8 (535.5)	1449.5 (526.0)	1524.0 (610.5)	1557.9 (499.6)
t test P value [‡]		0.5	0.3	0.2
Weekly consumption of fish/shellfish (servings/week)				
N	1915	223	152	68
Mean (SD)	1.1 (1.0)	1.2 (1.2)	1.1 (1.2)	1.1 (1.0)
t test P value [‡]		0.6	0.7	0.7

AMD = age-related macular degeneration; BMI = body mass index; SD = standard deviation.

* Control = those eyes without AMD disease (not classified as AMD1, AMD2, AMD3, or missing or ungradable photos in both eyes); AMD1 = drusen ≥ 125 μm but not classified as AMD2 or AMD3; AMD2 = pigment abnormalities but not classified as AMD3; AMD3 = geographic atrophy or exudative AMD.

[†] Based on chi-square test.

[‡] Based on *t* test comparing group mean with control group mean.

Table 2

Comparison of Weekly Fish/Shellfish (Servings/Week) Consumption between Controls and Categories of Age-Related Macular Degeneration

	Cases/No. at Risk	<1 Serving/Week	1 to <2 Servings/Week OR (95% CI)	2+ Servings/Week OR (95% CI)
AMD1 *				
Crude	327/3041	Ref	0.8 (0.6–1.1)	0.7 (0.5–1.1)
Age-adjusted	327/3041	Ref	0.9 (0.6–1.2)	0.8 (0.5–1.1)
Adjusted [†]	327/3030	Ref	0.9 (0.6–1.2)	0.8 (0.5–1.1)
AMD2 *				
Crude	188/2902	Ref	0.8 (0.5–1.1)	0.9 (0.5–1.5)
Age-adjusted	188/2902	Ref	0.8 (0.5–1.2)	0.9 (0.5–1.4)
Adjusted [†]	186/2889	Ref	0.8 (0.6–1.2)	1.0 (0.6–1.6)
AMD3 *				
Crude	102/2816	Ref	0.8 (0.5–1.4)	0.4 (0.2–1.0)
Age-adjusted	102/2816	Ref	0.9 (0.5–1.6)	0.4 (0.2–1.0)
Adjusted [†]	100/2803	Ref	0.9 (0.5–1.6)	0.5 (0.2–1.2)

AMD = age-related macular degeneration; CI = confidence interval; OR = odds ratio.

* Control eyes = those eyes without AMD disease (not classified as AMD1, AMD2, AMD3, or missing or ungradable photos in both eyes); AMD1 = drusen $\geq 125 \mu\text{m}$ and not classified as AMD2 or AMD3; AMD2 = pigment abnormalities and not classified as AMD3; AMD3 = geographic atrophy or neovascular AMD.

[†] Adjusted for gender (male or female), age (years), race (black or white), smoking status (current, former, or never), and correlation between eyes using multiple logistic regression analyses.

Table 3

Distribution Fish/Shellfish Categories by Age-Related Macular Degeneration Disease Status

	Controls*	AMD1*	AMD2*	AMD3*
	1943 (77.1)	227 (9.0)	153 (6.1)	68 (2.7)
	N (%)	N (%)	N (%)	N (%)
Weekly shellfish consumption (servings/wk)				
N	1942	226	153	68
Mean (SD)	0.03 (0.07)	0.03 (0.05)	0.04 (0.07)	0.03 (0.04)
Median	0.01	0.006	0.02	0.01
IQR	0.04	0.04	0.04	0.04
<i>t</i> test <i>P</i> value [†]		0.4	0.1	0.7
Weekly crab consumption (servings/wk)				
N	1941	225	152	68
Mean (SD)	0.05 (0.09)	0.05 (0.07)	0.05 (0.06)	0.05 (0.06)
Median	0.02	0.02	0.04	0.02
IQR	0.05	0.05	0.05	0.05
<i>t</i> test <i>P</i> value [†]		0.7	0.9	0.4
Weekly oyster consumption (servings/wk)				
N	1936	227	153	68
Mean (SD)	0.02 (0.06)	0.02 (0.05)	0.02 (0.04)	0.02 (0.03)
Median	0.006	0.003	0.006	0.006
IQR	0.02	0.02	0.02	0.02
<i>t</i> test <i>P</i> value [†]		10.5	0.9	0.6
Weekly "other fish" [‡] consumption (servings/wk)				
N	1932	226	153	68
Mean (SD)	0.07 (0.1)	0.09 (0.1)	0.08 (0.1)	0.07 (0.1)
Median	0.04	0.04	0.04	0.04
IQR	0.07	0.09	0.07	0.07
<i>t</i> test <i>P</i> value [†]		0.04	0.6	0.8
Weekly fried fish consumption (servings/wk)				
N	1933	226	153	68
Mean (SD)	0.3 (0.6)	0.4 (0.7)	0.4 (0.8)	0.4 (0.9)
Median	0.2	0.04	0.08	0.1
IQR	0.4	0.4	0.4	0.4
<i>t</i> test <i>P</i> value [†]		0.2	0.5	0.5
Weekly tuna consumption (servings/wk)				
N	1938	227	153	68
Mean (SD)	0.6 (0.8)	0.6 (1.0)	0.5 (0.8)	0.5 (0.6)
Median	0.06	0.2	0.2	0.06
IQR	0.6	0.6	0.5	0.5

	Controls [*]	AMD1 [*]	AMD2 [*]	AMD3 [*]
	1943 (77.1)	227 (9.0)	153 (6.1)	68 (2.7)
	<i>N (%)</i>	<i>N (%)</i>	<i>N (%)</i>	<i>N (%)</i>
<i>t</i> test <i>P</i> value [†]		0.5	0.2	0.9

AMD = age-related macular degeneration; IQR = interquartile range; SD = standard deviation.

^{*} Control = those eyes without AMD disease (not classified as AMD1, AMD2, AMD3, or missing or ungradable photos in both eyes); AMD1 = drusen ≥ 125 μm but not classified as AMD2 or AMD3; AMD2 = pigment abnormalities but not classified as AMD3; AMD3 = geographic atrophy or exudative AMD.

[†] Based on *t* test comparing log-transformed group means with log-transformed control group mean.

[‡] “Other fish” means other types of baked fish.

Table 4

Comparison of Fish/Shellfish* Consumption (Servings/Week) High in Omega-3 Fatty Acids between Controls and Categories of Age-Related Macular Degeneration

	Cases/No. at Risk	<1 Serving/Week	1+ Servings/ Week OR (95% CI)
AMD1 [†]			
Crude	327/3041	Ref	0.9 (0.7–1.3)
Age-adjusted	327/3041	Ref	0.9 (0.6–1.2)
Adjusted [‡]	327/3030	Ref	0.9 (0.6–1.3)
AMD2*			
Crude	188/2902	Ref	1.0 (0.6–1.5)
Age-adjusted	188/2902	Ref	0.9 (0.6–1.4)
Adjusted [‡]	186/2889	Ref	1.0 (0.6–1.6)
AMD3 [†]			
Crude	102/2816	Ref	0.4 (0.2–0.8)
Age-adjusted	102/2816	Ref	0.3 (0.1–0.7)
Adjusted [‡]	100/2803	Ref	0.4 (0.2–0.8)

AMD = age-related macular degeneration; CI = confidence interval; OR = odds ratio.

* High omega-3 fatty acid weekly fish/shellfish = crab +oysters +fried fish + “other fish”.

[†] Control eyes = those eyes without AMD disease (not classified as AMD1, AMD2, AMD3, or missing or ungradable photos in both eyes); AMD1 = drusen ≥ 125 μm and not classified as AMD2 or AMD3; AMD2 = pigment abnormalities and not classified as AMD3 (AMD3); (AMD3) = geographic atrophy or neovascular AMD.

[‡] Adjusted for gender (male or female), age (years), race (black or white), smoking status (current, former, or never) and correlation between eyes using multiple logistic regression analyses.

Table 5

Comparison of Fish/Shellfish Consumption (Servings/Week) High in Zinc^{*} between Controls and Categories of Age-Related Macular Degeneration

	Cases/No. at Risk	<0.07 Servings/Week	0.07 + Servings/Week OR (95% CI)
AMD1 [†]			
Crude	327/3043	Ref	0.9 (0.7–1.2)
Age adjusted	327/3043	Ref	0.9 (0.7–1.2)
Adjusted [‡]	327/3032	Ref	0.9 (0.7–1.2)
AMD2 [†]			
Crude	188/2904	Ref	1.2 (0.8–1.6)
Age adjusted	188/2904	Ref	1.2 (0.8–1.7)
Adjusted [‡]	186/2891	Ref	1.2 (0.8–1.6)
AMD3 [†]			
Crude	102/2818	Ref	1.1 (0.7–1.9)
Age adjusted	102/2818	Ref	1.1 (0.7–1.9)
Adjusted [‡]	100/2805	Ref	1.0 (0.6–1.7)

AMD = age-related macular degeneration; CI = confidence interval; OR = odds ratio.

^{*} High zinc = crab + oysters.

[†] Control eyes = those eyes without AMD disease (not classified as AMD1, AMD2, AMD3, or missing or ungradable photos in both eyes); AMD1 = drusen ≥ 125 μm and not classified as AMD2 or AMD3; AMD2 = pigment abnormalities and not classified as AMD3 (AMD3); (AMD3) = geographic atrophy or neovascular AMD.

[‡] Adjusted for gender (male or female), age (years), race (black or white), smoking status (current, former, or never), and correlation between eyes using multiple logistic regression analyses.