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Age-related macular degeneration among the elderly: The 5th National Health and Nutrition Examination Survey, 2010 through 2012

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Abstract

Aim: This study was conducted to identify the prevalence and factors associated with age-related macular degeneration (AMD) in Korean elderly.

Methods: The study population of this cross-sectional survey was the Korean Health and Nutrition Examination Survey (KHANES) 2010 through 2012, the fifth population-based study.

Results: Analysis of 2,767 elderly (above age 65) from 23,376 participants showed the prevalence of any AMD to be 17.6% in the Korean elderly. Factors that were significantly positively associated with AMD included age, sex, occupation, low socioeconomic status, liver cirrhosis and physical activity ($p < .01$). Significantly negatively associated with AMD were cardiovascular disease, obesity, and beta-carotene intake ($p < .05$).

Conclusions: This study estimated the prevalence rate and assessed factors associated with AMD in the elderly. This can be used to build a strategy for elderly eye health, and provides valuable information for screening for putative risks in the elderly.

KEYWORDS
age-related macular degeneration, elderly, risk

1 | INTRODUCTION

Age-related macular degeneration (AMD) is a progressive blinding disease and the leading cause of visual impairment among the elderly population in developed countries (Congdon et al., 2004; Pascolini et al., 2004). AMD is known to be the leading cause of blindness among White populations older than 65 years (Wang, Foran, & Mitchell, 2000). It has long been hypothesized that Asians in general may have lower rates of AMD (W. L. Wong et al., 2014). However, recent research has suggested that the prevalence of AMD in Asian populations is similar to that of other ethnic groups (Miyazaki et al., 2005).

The prevalence of early AMD in the Blue Mountains Eye Study, a population study conducted west of Sydney, Australia, was reported to be 8.7% and that of late AMD was 1.1% (Tan et al., 2008). Large population-based studies usually find the prevalence of AMD at 0.2% in persons aged 55 to 64 years, rising to 13% in individuals 85 years of age or older. In a Japanese population, the prevalence of early AMD which was 11.8% in people aged 50 and over, similar to that for White populations (Kawasaki et al., 2008). The prevalence of AMD was 6.62% in a Korean population: 6.02% had early AMD and 0.60% had late AMD (Park et al., 2014). However, compared with Western data, Asian data are not sufficient to draw firm conclusions. Although the

prevalence of AMD in Korea is similar to that in other Asian countries, the prevalence of AMD is expected to increase.

The socioeconomic burden caused by AMD is expected to gradually intensify as a result of increased life expectancy, reduced birth rates, and increased elderly populations (Resnikoff et al., 2004). This burden seems to be even more serious in Korea, which is expected to become a "super-aged society" in 2026 because of sustained low birth rates and a rapid increase in life expectancy.

Over the past two decades, studies have been conducted in the United States, Australia, and developing countries to identify factors potentially affecting the prevalence of AMD. Related demographic characteristics include gender, age, and education level (Park et al., 2010), and related socioeconomic characteristics include household income level, economic level, residence, and occupation (An, Lee, & Lee, 2016; Kim, Park, & Park, 2013). Systemic chronic conditions including hypertension, cardiovascular disease, obesity, hypercholesterolemia, hyperlipidemia, and diabetes are associated with AMD (Olea & Tuñón, 2012; Song, Youm, Chang, & Yu, 2009), and personal habits influencing the risk of AMD include smoking, drinking, dietary supplementation, antioxidant vitamins and minerals intake, wearing sunglasses and exercise (Ngai et al., 2011; Park et al., 2014; Spencer et al., 2011).

Risk factors for AMD have been extensively studied in Western populations, whereas fewer studies have been published regarding Asians (Sasaki et al., 2018). Although many studies on risk factors have been carried out, most of them reflect results from small populations, and the results are inconsistent. Therefore, an entire population-based assessment using a nationwide database is needed to obtain more reliable results. Identifying the risk factors for AMD, which is associated with a high risk of blindness, is valuable because it can allow early interventions or preventive measures to inhibit the onset or progression of AMD.

We analyzed factors associated with AMD in a sample of the elderly (over age 65), evaluating demographic factors, socioeconomic factors, physical and eye health factors, health behavior, and nutritional habits. Our nationwide sample is drawn from data obtained from Korea National Health and Nutrition Examination Survey (KNHANES) from 2010–2012.

2 | METHODS

2.1 | Design and participants

For this descriptive study, targeting seniors aged 65 or older in the Republic of Korea, demographics, physical and eye health characteristics, health habits, obesity, dyslipidemia, and daily nutrition consumption were collected and the association of these factors with AMD was assessed.

2.2 | Data collection/ethical consideration

The fifth KNHANES, a population-based cross-sectional survey of a nationwide sample in the Republic of Korea was used for this study. The KNHANES began in 1998, with each survey collecting an independent rolling survey sample over a three-year survey period. The sample for the 5th Public Health Nutrition Survey comprised 8,958 participants in the first year (2010), 8,518 in the second year (2011), and 8,057 in the third year (2012).

The sampling frame of the fifth Survey was the registered residents in 2009. The sampling units were households from the date of the National Census Registry, and the households were selected using a stratified, multistage, clustered probability sampling of the non-institutionalized population. Randomly selected households received a letter from the KCDC (Korea Centers for Disease Control & Prevention) introducing the KNHANES (Korea Centers for Disease Control and Prevention, 2012).

In this study of AMD, 4,543 elderly (age 65 or older) were drawn from the frame of 23,376, then 3,860 elderly who had records of non-mydriatic fundus photography to test macular degeneration were identified. There were 1,093 with missing data of demographics, physical and eye health characteristics, health habits, daily nutrition consumption, who were excluded, leaving 2,767 for the final analysis.

2.3 | Ethical considerations

Ethics approval for this study was granted by the Institutional Review Board (IRB) of Chungbuk National University (IRB Approval No. CBNU-201607-ETC-318-01).

2.4 | Measurements

2.4.1 | AMD

AMD was diagnosed with non-mydriatic or mydriatic fundus photographs by an ophthalmologist at the examination bus. If the participants had diabetes mellitus or above 200 mg/dL random blood sugar levels, they were examined by mydriatic fundus photographs.

2.4.2 | Demographic characteristics

Age, sex, marital status, living arrangement, occupation, education level, types of medical security and economic status were investigated as the demographic characteristics. Age was grouped into 65–74 years old, 75–84 years old, and older than 85; marital status into married and unmarried

(bereaved, divorced, never-married); living arrangement into solitude, living with spouse, living with other family members; occupation into outdoors (agriculture, forestry and fishery, simple labor) and indoors (including housewives and students); education level into elementary school or lower, middle school, high school, and college or above. The types of medical security were health care insurance (region or occupation based insurance) and medical aid, and economic status was low, lower-middle, upper-middle, and high according to their income quartiles.

2.4.3 | Physical and eye health characteristics

Physical or eye health characteristics were chosen based on literature reports of association with AMD. Hypertension, diabetes, dyslipidemia, cardiovascular disease, renal failure, liver cirrhosis, perceived health status, perceived stress level, and blood pressure were physical health characteristics. Cardiovascular disease was designated positive by presence of any of cerebral infarction, myocardial infarction, or angina. Perceived health status was surveyed using the question "What do you think of your general health?" and the answer gauging from 1-very good, to 5-very bad. Perceived stress level was surveyed with the answer gauging from 1-feeling very much stress, 2-feeling moderate amount of stress, 3-feeling little stress, 4-feeling almost no stress. Respondents with the answer of 1 or 2 were considered positive for perceived stress, while 3 or 4 was negative. Blood pressure was measured at the examination bus three times in a series, and the systolic and diastolic blood pressure recorded as the average of the second and third measurements.

For the eye health-related characteristics, hours of sunlight exposure per day, ophthalmic examination within a year, family history of ophthalmic disease, prior ophthalmic operation, cataract and glaucoma, myopia, hyperopia, and astigmatism were included. Hours of daily sunlight exposure was classified to less than 2 hr, 2–5 hr, and over 5 hr of direct exposure to sunlight without sunglasses or hats. Subjects with family members who had records of cataract, glaucoma, strabismus, blepharoptosis, or retinal disease were considered to have a positive familial history of ophthalmic disease. Subjects were checked for history of cataract, glaucoma, strabismus, blepharoptosis, retina or refractive surgery. The presence of cataract and glaucoma was confirmed through ophthalmology inspection, and disease related to shortsightedness, farsightedness, and astigmatism were investigated via eyesight tests.

2.4.4 | Health behavior and obesity

Drinking, smoking, and physical activity were examined for health habit factors. Drinking frequency, drinking quantity per time, and high-risk drinking frequency were investigated for drinking. Drinking frequency was classified to less than once a month and more than once a month using the question "How frequently did you drink in the last year?" Drinking quantity was classified to less than or equal to two cups and more than or equal to three cups without consideration of the type of liquor using the question "How much do you drink at a time without differentiating the type of liquor?" A cup contains about 8 g of pure alcohol. High-risk drinking frequency was divided into less than once a week and more than once a week using the question "How many times do you drink more than or equal to seven cups (or five cans of beer) for male)/five cups (or three cans of beer) for female without differentiating the type of liquor at a time?" Smoking status and the daily average amount of smoking were measured for smoking. Subjects who answered the question "Do you smoke nowadays?" with "every day" and "occasionally" were considered smokers, and subjects who answered with "quit" and "never" non-smokers. Average smoking was calculated as the number of cigarettes smoked daily. Physical activity was considered positive if the participant responded to one or more out of these three items in the International Physical Activity Questionnaire: vigorous physical activity, moderate physical activity and walking. Vigorous physical activity was considered positive when the response to "How many days in the last week did you do more than 10 min of vigorous physical activity in which you were feeling exhausted or out of breath" was more than 3 days a week for over 20 min at a time. Similarly, moderate physical activity was considered positive when the response to "How many days in the last week did you do more than 10 min of moderate physical activity in which your body was feeling a little exhausted or a little bit out of breath" was more than 5 days a week for over 30 min at a time. Walking was considered positive if the response to "How many days in the last week did you walk for at least 10 min" was more than 5 days for over 30 min.

For obesity and dyslipidemia, anthropometry and blood sampling were done at the examination bus. Body mass index (BMI) was calculated after measuring height and weight using the formula of weight ÷ (height × height) (kg/m^2). BMI of more than 25 kg/m^2 is classified as obese according to the standard of the World Health Organization (WHO)'s Western Pacific Regional Office. For dyslipidemia, total cholesterol, triglyceride, high-density lipoprotein (HDL)-cholesterol were measured by the enzyme method after fasting for more than 8 hr. For participants with triglyceride concentration that was less than 200 mg/dL, low-density lipoprotein (LDL) was calculated with the Friedewald formula of "LDL-cholesterol = total cholesterol – HDL-cholesterol – triglyceride/5". The LDL-cholesterol of participants with triglyceride concentration over 200 mg/dL

was measured directly using the homogeneous assay. Dyslipidemia was defined as over 240 mg/dL of total cholesterol, LDL-cholesterol ≥160 mg/dL, triglyceride ≥200 mg/dL, HDL-cholesterol <40 mg/dL according to the Adult Treatment Panel III (ATP III) indicator of America's National Cholesterol Education Program (Jacobson et al., 2015; Jang & Lee, 2015).

2.4.5 | Daily nutrition consumption status

Daily nutrition consumption status data were collected by a professional national health nutrition investigation performance team via computer-aided personal interviews, visiting households. The food intake questionnaire calculated nutrition consumption using the volume/weight conversion code via two instruments: a personal 24 hr spodogram (food intake questionnaire I), and the household cooking record (food intake questionnaire II). These were open questionnaires in which the answers were recorded by research subjects' responses about the content and amount of food subjects consumed the day before the survey.

2.5 | Data analysis

The raw data of the fifth national health and nutrition survey is available to the public with anonymization to prevent individual identification. The data used for this study were downloaded after thorough approval process from the web site (https://knhanes.cdc.go.kr). Survey sample weights were used in all analyses. Collected data were analyzed by composite sampling data methods using SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). Weighted proportions, mean and standard errors of demographics, physical and eye health-related characteristics, health behavior, obesity, dyslipidemia, and daily nutritional consumption are presented in tables. The associations of demographics, physical and eye health-related characteristics, health behavior, obesity, dyslipidemia, and daily nutritional consumption with AMD were assessed by composite sample *t*-test and cross-analysis test. To identify covariates with AMD, multiple logistic regression for the composite sample was used. The full model was constructed using variables significantly associated with AMD by composite sample *t*-test and contingency table analysis. Backward elimination with *p* value .05 was used to find the final model. Null hypotheses of no difference were rejected if *p* values were less than .05, or equivalently, if the 95% CIs of risk point estimates excluded one. There were 15 variables in the final multiple logistic regression model for AMD: six demographic variables, two physical health-related characteristics, three health behavior variables, one obesity variable, and three daily nutritional consumption variables. Eleven of 15 variables were coded as dummy variables: sex, marital status, living arrangement, occupation, type of medical security, cardiovascular disease, liver cirrhosis, drinking frequency, drinking amount, physical activity, obesity. Four of 15 variables were used as continuous variables: age, daily ash, vitamin A, carotene consumptions. Odds ratios and 95% CIs were derived using composite sample multiple logistic regression. The logistic regression model of AMD was significant ($p < .001$). We used the odds ratio and its 95% confidence limits based on the Wald test from a multivariate model.

3 | RESULTS

3.1 | Comparison of general characteristics with and without AMD

Among the subjects aged 65 years or older, 472 had AMD, a prevalence of 17.1%. AMD was statistically significantly ($p < .05$) associated with age, sex, marital status, living together, type of occupation, and type of health insurance ($p < .05$). The mean age of the elderly with AMD was significantly higher than that of the elderly without AMD. Of the study subjects with AMD, 34.1% were aged 75 years or older, versus 27.1% of the subjects without AMD. AMD prevalence by gender was significantly higher in women. Subjects with AMD were significantly more likely to be unmarried and living alone. Other positive associations with AMD include outdoor occupations and being medical care recipients (Table 1).

3.2 | Comparison of physical and eye health-related characteristics with and without AMD

Among the physical health-related characteristics, cardiovascular disease and cirrhosis were significantly associated with AMD ($p < .05$). There was no statistically significant difference according to perceived subjective health status, perceived stress perception, blood pressure, hypertension, dyslipidemia, diabetes, and renal failure. AMD was negatively associated with cardiovascular disease, that is stroke, myocardial infarction, and angina. The prevalence of cardiovascular disease was 8.8% in those with AMD and 13.0% in those without. AMD was positively associated with liver cirrhosis; 4.3% of those with AMD had it versus 0.5% of subjects without AMD. There were no statistically significant differences in AMD risk by sun exposure time, eye examinations within 1 year, family history of ophthalmic diseases, past history of eye surgery, cataract, glaucoma, and myopia (Table 2).

TABLE 1 Weighted prevalence of age-related macular degeneration in subjects aged 65 years and over by baseline characteristics

		Age-related macular degeneration				
		Total (n = 2,767)	No (n = 2,295)	Yes (n = 472)		
Variables	Categories	n (%) or mean ± SE	n (%) or mean ± SE	n (%) or mean ± SE	X^2 / F	*p*
Age, years	65–74	2,017 (71.6)	1,699 (72.9)	318 (65.9)	7.71	.021
	75–84	724 (27.4)	579 (26.3)	145 (32.4)		
	≥ 85	26 (1.0)	17 (0.8)	9 (1.7)		
	Mean ± SE	72.4 ± 0.13	72.3 ± 0.14	73.0 ± 0.29	5.59	.018
Sex	Men	1,207 (42.3)	1,030 (43.8)	177 (35.3)	7.65	.005
	Women	1,560 (57.7)	1,265 (56.2)	295 (64.7)		
Marriage	Yes	1,945 (67.1)	1,639 (68.4)	306 (61.0)	6.52	.010
	No	822 (32.9)	656 (31.6)	166 (39.0)		
Living	Alone	475 (15.1)	388 (14.6)	87 (17.1)	8.18	.016
	With only spouse	1,298 (41.4)	1,107 (42.9)	191 (34.5)		
	With other family	994 (43.5)	800 (42.5)	194 (48.4)		
Occupation	Indoor worker	1,945 (70.5)	1,631 (71.9)	314 (64.6)	6.24	.012
	Outdoor worker	822 (29.5)	664 (28.1)	158 (35.4)		
Education	Elementary school or less	1,795 (68.7)	1,476 (67.9)	319 (71.8)	2.83	.417
	Middle school	347 (12.1)	300 (12.6)	47 (9.9)		
	High school	417 (12.9)	346 (13.0)	71 (12.3)		
	University or more	208 (6.3)	173 (6.4)	35 (5.7)		
Type of medical security	Health insurance	2,629 (94.6)	2,195 (95.6)	434 (90.0)	15.93	<.001
	Medical aid	138 (5.4)	100 (4.4)	38 (10.0)		
Basic livelihood security recipient	Yes	129 (5.1)	101 (4.5)	28 (7.8)	5.64	.017
	No	2,638 (94.9)	2,194 (95.5)	444 (92.2)		
Economic status	Low	1,394 (50.7)	1,148 (50.8)	246 (50.3)	2.83	.417
	Medium-low	698 (25.2)	584 (25.0)	114 (26.3)		
	Medium-high	394 (13.9)	319 (13.6)	75 (15.2)		
	High	281 (10.2)	244 (10.6)	37 (8.2)		
Monthly income	Mean ± SE	215.8 ± 16.83	221.9 ± 20.19	188.4 ± 13.00	2.06	.152

3.3 | Health behaviors, obesity and dyslipidemia according to presence of AMD, daily nutritional intake

Among health behaviors, AMD was statistically significantly associated with drinking frequency, one occasion drinking amount and physical activity ($p < .05$), but not with the frequency of high-risk drinking, and smoking. AMD is negatively associated with drinking more than once a month and drinking. AMD is positively associated with physical activity and with BMI less than 25 ($p < .05$).

Hypercholesterolemia, hypertriglyceridemia, low HDL-cholesterol and high LDL-cholesterol ratios were not associated with AMD (Table 3). AMD was negatively associated with daily intake of ash, vitamin A, and carotene ($p < .05$), while intake of protein, fat, carbohydrates, fibrin, retinol, thiamin, riboflavin, niacin, and vitamin C were not statistically associated with AMD (Table 3).

3.4 | AMD risk factors

Age, sex, occupation, type of health insurance, cardiovascular disease, cirrhosis, physical activity, obesity, and daily carotenoid intake were significantly associated with AMD ($p < 0.05$). Cirrhosis increased the risk of AMD by 4.25 times (odds ratio = 4.3, 95% CI = 1.54–11.75) compared with those who did not have cirrhosis. Elderly medical aid had an odds ratio of 2.42 (95% CI = 1.54–3.96) for AMD, the physical activity odds ratio was 1.45 (95% CI = 1.13–1.86) and that for female sex was 1.44 (95% CI = 1.12–1.86). Each 1-year increase in age raised AMD

TABLE 2 Weighted prevalence of age-related macular degeneration in subjects aged 65 years and over by physical & eye health-related characteristics

		Age-related macular degeneration				
		Total (n = 2767)	No (n = 2295)	Yes (n = 472)		
Variables	**Categories**	**n (%) or mean ± SE**	**n (%) or mean ± SE**	**n (%) or mean ± SE**	X^2 / F	*p*
Physical health-related characteristics						
Perceived health status		3.11 ± 0.02	3.11 ± 0.03	3.08 ± 0.05	0.33	.565
Systolic blood pressure		131.0 ± 0.50	130.7 ± 0.52	132.0 ± 1.12	1.18	.278
Diastolic blood pressure		74.8 ± 0.25	74.8 ± 0.27	74.9 ± 0.61	0.02	.901
Perceived stress	Yes	578 (21.7)	485 (22.1)	93 (19.6)	0.97	.323
	No	2188 (78.3)	1810 (77.9)	378 (80.4)		
Hypertension	Yes	1485 (55.9)	1230 (55.8)	255 (56.3)	0.02	.863
	No	1282 (44.1)	1065 (44.2)	217 (43.7)		
Cardiovascular disease	Yes	345 (12.2)	298 (13.0)	47 (8.8)	5.77	.016
	No	2422 (87.8)	1997 (87.0)	425 (91.2)		
Hyperlipidemia	Yes	567 (20.6)	488 (21.5)	79 (16.6)	3.43	.064
	No	2200 (79.4)	1807 (78.5)	393 (83.4)		
Diabetes mellitus	Yes	516 (18.6)	443 (19.3)	73 (15.7)	2.31	.128
	No	2251 (81.4)	1852 (80.7)	399 (84.3)		
Chronic renal failure	Yes	16 (0.5)	13 (0.5)	3 (0.8)	0.80	.369
	No	2751 (99.5)	2282(99.5)	469 (99.2)		
Liver cirrhosis	Yes	19 (0.8)	11 (0.5)	8 (2.3)	9.47	.002
	No	2748 (99.2)	2284 (99.5)	464 (97.7)		
Eye health-related characteristics						
Sun exposure	<2 hr/d	1461 (52.0)	1218 (52.5)	243 (49.7)	0.89	.638
	2 ~ 5 hr/d	652 (24.2)	543 (24.0)	109 (25.0)		
	≥5 hr/d	654 (23.8)	534 (23.5)	120 (25.3)		
Eye examination at ophthalmic clinic within 1 year	Yes	1165 (42.0)	984 (42.8)	181 (38.4)	1.91	.165
	No	1602 (58.0)	1311 (57.2)	291 (61.6)		
Family history of ophthalmic disease	Yes	294 (10.0)	248 (10.2)	46 (9.1)	0.39	.530
	No	2473 (90.0)	2047 (89.8)	426 (90.9)		
History of ophthalmic operation	Yes	825 (31.0)	683 (30.6)	142 (32.9)	0.51	.470
	No	1918 (69.0)	1593 (69.4)	325 (67.1)		
Cataract	Yes	867 (31.1)	732 (31.6)	135 (28.5)	1.07	.299
	No	1900 (68.9)	1563 (68.4)	337 (71.5)		
Glaucoma	Yes	63 (2.2)	56 (2.4)	7 (1.3)	2.26	.132
	No	2704 (97.8)	2239 (97.6)	465 (98.7)		
Myopia	Yes	683 (25.0)	579 (25.7)	104 (21.8)	2.04	.152
	No	2084 (75.0)	1716 (74.3)	368 (78.2)		
Hyperopia	Yes	1243 (43.9)	1019 (43.3)	224 (46.7)	1.49	.221
	No	1524 (56.1)	1276 (56.7)	248 (53.3)		
Astigmatism	Yes	2472 (89.6)	2054 (89.6)	418 (88.9)	0.20	.651
	No	295 (10.4)	241 (10.2)	54 (11.1)		

TABLE 3 Weighted prevalence of age-related macular degeneration in subjects aged 65 years and over by health behavior and nutritional habits

		Age-related Macular degeneration				
		Total (n = 2767)	No (n = 2295)	Yes (n = 472)		
Variables	**Categories**	**n (%) or mean ± SE**	**n (%) or mean ± SE**	**n (%) or mean ± SE**	X^2/t	*p*
Health behavior						
Drinking frequency	<1 month	1778 (64.5)	1456 (63.5)	322 (69.3)	5.02	.024
	≥1 month	989 (35.5)	839 (36.5)	150 (30.7)		
Drinking amount	≤2 cup	2143 (78.0)	1763 (77.0)	380 (82.4)	5.74	.016
	≥3 cup	624 (22.0)	532 (23.0)	92 (17.6)		
High-risk drinking frequency	<1 week	2526 (90.9)	2091 (90.4)	435 (92.8)	1.86	.172
	≥1 week	241 (9.1)	204 (9.6)	37 (7.2)		
Current smoking	No	2430 (87.5)	2018 (88.0)	412 (85.3)	1.45	.228
	Yes	337 (12.5)	277 (12.0)	60 (14.7)		
Smoking amount (cigarettes per day)		1.62 ± 0.11	1.59 ± 0.12	1.74 ± 0.29	0.32	.632
Physical activity	Yes	1296 (45.4)	1056 (44.2)	240 (50.7)	4.61	.031
	No	1471 (54.6)	1239 (55.8)	232 (49.3)		
Obesity and lipids						
Body mass index	<25	1830 (65.8)	1495 (64.5)	335 (71.5)	5.71	.016
	≥25	937 (34.2)	800 (35.5)	137 (28.5)		
	Mean ± SE	23.9 ± 0.08	24.0 ± 0.08	23.7 ± 0.20	2.51	.113
Hypercholesterolemia	Yes	600 (22.1)	513 (22.8)	87 (18.6)	2.98	.084
	No	2102 (77.9)	1728 (77.2)	374 (81.4)		
Serum cholesterol	Mean ± SE	190.4 ± 0.86	190.2 ± 0.98	190.9 ± 2.00	0.08	.780
Hypertriglyceridemia	Yes	408 (17.6)	346 (17.8)	62 (16.7)	0.20	.649
	No	2087 (82.4)	1729 (82.2)	358 (83.3)		
Serum triglyceride	Mean ± SE	142.4 ± 2.19	142.3 ± 2.17	143.1 ± 5.95	0.02	.891
Low high-density lipoprotein-cholesterolemia	Yes	744 (28.1)	631 (29.0)	113 (24.2)	3.07	.079
	No	1962 (71.9)	1613 (71.0)	349 (75.8)		
Serum high-density lipoprotein	Mean ± SE	47.0 ± 0.29	46.8 ± 0.29	48.0 ± 0.72	2.56	.110
Nutritional daily intake status						
Protein (g)		53.7 ± 0.73	54.0 ± 0.75	52.5 ± 1.69	0.71	.400
Fat (g)		23.0 ± 0.50	23.0 ± 0.56	22.8 ± 1.11	0.04	.849
Carbohydrate (g)		307.7 ± 3.38	307.8 ± 3.10	307.5 ± 9.28	0.00	.980
Fiber (g)		7.1 ± 0.21	7.0 ± 0.17	7.5 ± 0.82	0.25	.616
Ash (g)		16.3 ± 0.28	16.6 ± 0.29	15.1 ± 0.52	7.76	.005
Vitamin A (μgRE)		666.8 ± 40.53	695.9 ± 47.79	536.5 ± 33.96	8.68	.003
Carotene (mg)		3.64 ± 0.24	3.83 ± 0.28	2.79 ± 0.17	11.26	<.001
Retinol (μg)		46.3 ± 2.71	44.6 ± 2.19	54.0 ± 8.01	1.59	.207
Thiamin (mg)		1.1 ± 0.02	1.0 ± 0.02	1.1 ± 0.05	0.75	.387
Riboflavin (mg)		0.9 ± 0.02	0.9 ± 0.02	0.9 ± 0.08	0.29	.591
Niacin (mg)		13.1 ± 0.19	13.2 ± 0.20	12.8 ± 0.42	0.92	.336
Vitamin C (mg)		87.0 ± 2.77	87.8 ± 2.91	83.4 ± 5.49	0.59	.441

risk by 1.03 times (95% CI = 1.01–1.06), while the odds ratio for cardiovascular disease was protective at 0.67 (95% CI = 0.47–0.96). BMI over 25 was also protective with an odds ratio of 0.75 (95% CI = 0.57–0.99) (Table 4).

4 | DISCUSSION

This study identified the prevalence of and risk factors for AMD based on nationwide data from 2,767 participants over 65 years of age. The prevalence of AMD was 17.1%. This rate was higher than that found in a 2010 study of 388 Koreans aged 65 and over, in which the AMD prevalence was 11.6% (Kim et al., 2013). However, the prevalence of AMD in the fourth KNHANES 2008 was 25.8% (Korea Centers for Disease Control and Prevention, 2009). Differences in the prevalence may be due to sample size variation. The prevalence presented in this study reflects recent data and is thus thought to be close to the real prevalence of AMD among the elderly in Korea.

KNHANES data from 2008 to 2011, a period comparable to that of our study, show that the prevalence of AMD among Korean adults over 40 years of age is higher than that among our sample (Cho et al., 2014). The results of this study thus confirm that age is significantly positively associated with AMD. AMD prevalence varies across regions and ethnic groups (Jonas, 2014; T. Wong, Loon, & Saw, 2006).

The prevalence of AMD in the Korean elderly population was similar to that among people over 60 years of age in Iran (Rasoulinejad et al., 2015). A meta-analysis of studies published before 2013 found that the worldwide prevalence of AMD was 8.69%. The prevalence was highest in Europe (12.3%) and lowest in Asia (7.4%) (W. L. Wong et al., 2014). The study sample of W. L. Wong et al. (2014) was not restricted to those over 65, so the results are limited by the broad age range. In the Kawasaki study, the prevalence of AMD among the White population was 8.8%, compared to a 6.8% prevalence of early AMD in Asia (Kawasaki et al., 2010). AMD is less prevalent in Asia than in the West (Klein, Klein, Knudtson et al., 2006). The prevalence of AMD among Koreans aged 65 years or older was estimated in this study, and comparable data for each country were provided.

Age, gender (female), outdoor occupation, low socioeconomic status, cirrhosis disease, cardiovascular disease, physical activity, BMI, and daily beta-carotene intake were significantly associated with AMD in the elderly in this study. These are consistently identified as risk factors in previous studies (Age-Related Eye Disease Study Research Group, 2005; Chakravarthy et al., 2010; De Jong, 2006). However, smoking, which was a strong risk factor in most previous studies, was not significant in our study. This result may be attributable to the fact that average smoking amount of our subjects was very low, at 1.62 cigarettes per day.

In previous studies, the prevalence of AMD was higher in women than men (Smith, Mitchell, & Wang, 1997). Estrogen protects the retina from oxidative stress, and acts as an antioxidant in lipid peroxidation (Park et al., 2014).

TABLE 4 Weighted multivariate logistic regression analysis of factors associated with age-related macular degeneration in subjects aged 65 years and over

Variables		Odds ratio	95% CI		*p*
Age, years		1.03	1.01	1.06	.025
Sex	Men	1			
	Women	1.44	1.12	1.86	.004
Occupation	Indoor worker	1			
	Outdoor worker	1.54	1.18	2.02	.001
Type of medical security	Health insurance	1			
	Medical aid	2.43	1.49	3.96	<.001
Cardiovascular disease	No	1			
	Yes	0.67	0.47	0.96	.028
Liver cirrhosis	No	1			
	Yes	4.25	1.54	11.75	.005
Physical activity	No	1			
	Yes	1.45	1.13	1.86	.003
Body mass index	<25	1			
	≥25	0.75	0.57	0.99	.046
Daily intake amount of carotene (mg)		0.96	0.92	0.99	.012

Therefore, elderly women after menopause are a high-risk group for AMD.

In our study, we thought the strong association of AMD with outdoor occupations and physical activity was due to the increased sunlight exposure. Therefore, it is necessary to educate the elderly to protect their eyes from sunlight during outdoor activities. The prevalence of AMD was higher in low-income brackets, reflecting low socioeconomic status. Those with economic difficulties can neglect eye examinations and eye health, possibly accounting for the higher prevalence (Kim et al., 2013). Unlike normal presbyopia, AMD can get worse if left untreated and cause blindness, so regular eye examinations are needed. Financial support could therefore be helpful to support the poor elderly in receiving regular eye examinations.

We found that AMD was less common in subjects with cardiovascular disease. Cardiovascular disease was previously found to increase the risk of AMD. Both early and late AMD were associated with cardiovascular disease in a previous systematic review and meta-analysis (Wu, Uchino, Sastry, & Schaumberg, 2014). However, the relationship between cardiovascular disease and AMD has not been consistent across studies (Pennington & DeAngelis, 2016; Wieberdink et al., 2011). Previous studies have reported a relationship between hypertension and AMD, but the relationship between atherosclerosis and AMD is still unclear (Klein, Klein, Tomany, & Cruickshanks, 2003). The pathophysiology of AMD is not clear, so further research about the association of AMD and cardiovascular disease is warranted.

BMI was negatively associated with AMD in our study. Obesity is known to increase the risk of AMD (Olea & Tuñón, 2012), but a clear mechanism remains unknown. However, obese participants (BMI > 25) had 10% lower outdoor occupations and 811 μg higher carotene intake than non-obese participants. In other words, indoor occupation and high carotene intake might have some effect on lowering the risk of AMD in the obese elderly in this study.

The odds ratio of liver cirrhosis for AMD was over four, and it was identified as a risk factor in other studies (Cho et al., 2014; Haines et al., 2005). The mechanism of high AMD risk in cirrhotic subjects is unclear, but it may be due to increased complement factor H (CFH) which is produced primarily by the liver (Cho et al., 2014). Further studies are necessary to explore the association of liver cirrhosis with AMD. Meanwhile, prevention education and regular eye examination should be provided to the elderly with liver cirrhosis to prevent AMD.

The higher the daily intake of beta-carotene, the lower the risk of AMD. Intake of beta-carotene was significantly associated with AMD, unlike intake of vitamin A or retinol. Although the direct relationship between intake of beta-carotene and AMD risk remains unclear (Connell et al., 2009), lutein and zeaxanthin are known to reduce the risk of AMD in the elderly. These carotenoids exist commonly in vegetables and fruits. Higher intake of beta-carotene also may cause higher intake of lutein and zeaxanthin. Therefore, the association of beta-carotene and AMD found here may be a surrogate. The elderly should increase their intake of beta-carotene-rich foods such as carrot, sweet potato, spinach, and mango.

The results of this study described the prevalence of AMD in the Korean elderly, identified factors associated with the disease, helped to define possible risks, and provided basic data on the health of the elderly. The pathophysiology of AMD has not been established, and etiology is not well understood. However, it is necessary to inform people who have positive AMD risk factors, and to promote the importance of ophthalmologic care, especially for patients with liver cirrhosis. In particular, the elderly, women, and those of low socioeconomic status should be screened as risk groups and educated about the need for ophthalmologic care to prevent AMD. We encourage the consumption of beta-carotene for eye health and encourage sunglasses to be worn at all times for sun protection during outdoor activities.

Our study has some limitations and strengths. This paper is not enough to describe the cause and effect of AMD, as it is a cross-sectional study. In addition, it was not possible to include all nutritional intake statuses such as lutein, omega-3-fatty acid, and fruit and vegetables, because data were from a nationwide database and were collected by using a 24-hr recall method. However, it is meaningful in that this study provides basic data of elderly eye health by presenting the prevalence of AMD in the elderly in Korea using nationwide data. These findings are important to comprehensively assess the risk factors of AMD. For more reliable assessment, biochemical studies should be conducted to identify the causative mechanisms in the relationships between AMD and BMI, cardiovascular disease, and cirrhosis, including intake of some nutrients such as lutein and omega-3-fatty acid.

5 | CONCLUSIONS

This large population-based cross-sectional study among Korean elderly people found the AMD prevalence rate was 17.1% and there were associations between AMD and risk factors such as sex, socioeconomic status, liver cirrhosis, cardiovascular disease, beta-carotene intake and BMI.The mechanisms of the associations are yet controversial. Therefore, further investigations are warranted. However, these findings can be used to build a nutritional and educational strategy for elderly eye health, and to provide valuable

information for screening AMD risk groups who have outdoor occupations and liver cirrhosis in the elderly.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

C. G. K. and S. P. designed the study, analyzed the data and interpreted the findings, and drafted and submitted the manuscript; Y. K. supervised the study, conducted the survey, interpreted the findings, and provided guidance.

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