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Original Research Article

Nationwide trends in the prevalence of cataract, glaucoma, and macular degeneration among Korean adults amid the COVID-19 pandemic, 2015-2021: A representative study in South Korea

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Abstract

Objective: Understanding the impact of the COVID-19 pandemic on the prevalence of key ocular diseases—cataracts, glaucoma, and macular degeneration—in the general population remains a critical yet understudied area. This study aimed to assess the long-term national prevalence of cataract, glaucoma, and macular degeneration in South Korea, considering various sociodemographic factors, health-related lifestyles, and the impact of the COVID-19 pandemic.

Methods: We analyzed the Korea National Health and Nutrition Examination Survey data from 2015 to 2021, focusing on these ocular diseases' prevalence and risk factors. The study included data from 51,682 participants aged 20 and above from the Korea National Health and Nutrition Examination Survey. Socioeconomic and behavioral factors, including age, sex, region of residence, educational background, marital status, BMI, smoking status, and alcohol consumption, were considered, alongside the influence of the COVID-19 pandemic. The prevalence of cataracts, glaucoma, and macular degeneration was analyzed using weighted multivariate regression models. Weighted odds ratios (wORs) and beta differences (β_{diff}) were calculated to evaluate changes in prevalence during the pre-and-pandemic periods.

Results: The study revealed a general decline in cataract prevalence (3.27% [95% CI, 2.94-3.60] in 2015-2016; 3.22 [2.73-3.72] in 2021), contrasted by an increase in glaucoma (0.70% [95% CI,0.57-0.84] in 2015-2016; 1.15 [0.85-1.45] in 2021) and macular degeneration (0.21% [95% CI, 0.14-0.29] in 2015-2016; 0.45 [0.30-0.61] in 2021). Specific demographic groups, particularly those with higher economic status and urban residents, showed an increased prevalence of cataracts. The ratio of odds ratio analysis indicated varied impacts of the pandemic on different socioeconomic and behavioral factors.

Conclusions: The study highlights a nuanced understanding of the prevalence and risk factors of key ocular diseases in South Korea during the COVID-19 pandemic. The findings emphasize the need for targeted healthcare strategies and regular screenings, particularly for high-risk groups, to manage ocular health in the evolving socioeconomic landscape effectively.

Keywords: ocular diseases, cataract, glaucoma, macular degeneration, COVID-19 pandemic, socioeconomic factors, epidemiology, South Korea

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1. Introduction

The COVID-19 pandemic has profoundly impacted socioeconomic conditions worldwide.[1] Yet, it remains uncertain whether this has influenced the prevalence of ocular fundus diseases, specifically cataracts, glaucoma, and macular, in the general population.[2] A significant concern during the pandemic has been the perception that clinic visits could exacerbate the spread of COVID-19, leading to a decline in the number of such visits among the general population.[3] As the COVID-19 pandemic continues to shape healthcare systems worldwide, it is crucial to identify disadvantaged populations in terms of accessing optimal medical treatment, particularly for ocular health.[4]

In this context, health issues detectable in the ocular fundus, particularly cataracts, glaucoma, and macular degeneration, or key ocular diseases, represent chronic conditions associated with a heightened risk of continuous deprivation of eyesight, and it possibly can even cause one to lose eyesight.[5] Such health outcomes also lead to increased healthcare expenditures, especially in advanced stages, necessitating interventions such as phacoemulsification, ongoing use of eyedrops, and photodynamic therapy. A significant challenge with these three types of ocular fundus is their typically silent and asymptomatic nature during the initial stages. Often, patients are unaware until the conditions have reached an advanced stage, when symptoms become more apparent, such as limited eyesight or worsened blurriness. As a result, early detection through optimal screening in hospitals or workplaces, coupled with data-based management, is essential to mitigate these health issues.

Despite the critical nature of these conditions, there is a notable gap in research regarding the prevalence of cataracts, glaucoma, and macular degeneration during the COVID-19 pandemic and the risk factors of these conditions.[3] Therefore, conducting a long-term trend analysis to understand the variations in the prevalence of these conditions, both before and during the COVID-19 pandemic, is vital; this analysis will provide insights into the impact of the pandemic on ocular health and help strategize effective healthcare responses.[4]

To maintain this goal, the primary objective of this study is to assess the long-term national prevalence of cataracts, glaucoma, and macular degeneration across various subgroups, especially incorporating age, sociodemographic factors, and health-related lifestyles. This evaluation was based on the Korea National Health and Nutrition Examination Survey (KNHANES). Furthermore, the study aimed to analyze changes in such three health outcomes (cataract, glaucoma, and macular degeneration) during the COVID-19 pandemic; this involved comparing the estimated prevalence of these ocular fundus-related health outcomes between the pre-COVID-19 pandemic period with COVID-19 pandemic period.

2. Methods

2.1 Patient selection and data collection

This study utilized data from KNHANES, conducted by the Korea Disease Control and Prevention Agency. KNHANES has been a critical source of data since 1998, aimed at understanding the health and nutritional status of the South Korean population. Conducted under the National Health Promotion Act, it provides a nationally representative cross-sectional survey of roughly 10,000 individuals annually[6]; our study utilized data from this dataset, spanning from 2015 to 2021. The final dataset of our study included 51,682 individuals aged between 20 to over 60 years across the study timeframe. The distribution of these participants

throughout the study period was as follows: 14,781 from 2015 to 2016, 15,358 from 2017 to 2018, 7,716 in 2019, 7,096 in 2020, and 6,731 in 2021 (Table 1). The research protocol, approved by the Institutional Review Board of Kyung Hee University and the Korea Disease Control and Prevention Agency, ensured informed written consent was obtained from all participants involved in the survey. Throughout the study, the Declaration of Helsinki was strictly abided by.

Table 1. General characteristics of Korean adults, in the data obtained from the KNHANES from 2015 to 2021 (total N = 51,682)

Variables	Total	Years				
		2015-2016	2017-2018	2019	2020	2021
Overall, n (%)	51,682 (100.00)	14,781 (28.60)	15,358 (29.72)	7,716 (14.93)	7,096 (13.73)	6,731 (13.02)
Crude rate, n (%)						
Age						
20-39 years	9,981 (19.31)	2,913 (19.71)	2,984 (19.43)	1,512 (19.60)	1,396 (19.67)	1,176 (17.47)
40-59 years	14,549 (28.15)	4,180 (28.28)	4,408 (28.70)	2,185 (28.32)	1,904 (26.83)	1,872 (27.81)
≥ 60 years	15,519 (30.03)	4,105 (27.77)	4,423 (28.80)	2,303 (29.85)	2,314 (32.61)	2,374 (35.27)
Unknown	11,633 (22.51)	3,583 (24.24)	3,543 (23.07)	1,716 (22.24)	1,482 (20.89)	1,309 (19.45)
Sex						
Male	23,511 (45.49)	6,668 (45.11)	6,993 (45.53)	3,530 (45.75)	3,282 (46.25)	3,038 (45.13)
Female	28,171 (54.51)	8,113 (54.89)	8,365 (54.47)	4,186 (54.25)	3,814 (53.75)	3,693 (54.87)
Region of residence						
Urban	25,308 (48.97)	8,469 (57.30)	7,226 (47.05)	3,440 (44.58)	3,074 (43.32)	3,099 (46.04)
Rural	26,374 (51.03)	6,312 (42.70)	8,132 (52.95)	4,276 (55.42)	4,022 (56.68)	3,632 (53.96)
BMI group[a]						
Underweight to normal	25,539 (49.42)	7,494 (50.70)	7,782 (50.67)	3,896 (50.49)	3,251 (45.81)	3,116 (46.29)
Overweight to obese	25,755 (49.83)	7,252 (49.06)	7,493 (48.79)	3,774 (48.91)	3,738 (52.68)	3,498 (51.97)
Unknown	388 (0.75)	35 (0.24)	83 (0.54)	46 (0.60)	107 (1.51)	117 (1.74)
Educational background						
High school or lower	25,020 (48.41)	7,362 (49.81)	7,463 (48.59)	3,661 (47.45)	3,235 (45.59)	3,299 (49.01)
College or higher	17,681 (34.21)	4,597 (31.10)	5,314 (34.60)	2,748 (35.61)	2,599 (36.63)	2,423 (36.00)

Table 1. Continued

Variables	Total	Years				
		2015-2016	2017-2018	2019	2020	2021
Unknown	8,981 (17.38)	2,822 (19.09)	2,581 (16.81)	1,307 (16.94)	1,262 (17.78)	1,009 (14.99)
Smoking status						
Smoker	7,269 (14.06)	2,088 (14.13)	2,226 (14.49)	1,082 (14.02)	981 (13.82)	892 (13.25)
Ex-smoker	9,251 (17.90)	2,433 (16.46)	2,687 (17.50)	1,433 (18.57)	1,353 (19.07)	1,345 (19.98)
Non-smoker	35,162 (68.04)	10,260 (69.41)	10,445 (68.01)	5,201 (67.41)	4,762 (67.11)	4,494 (66.77)
Alcohol consumption frequency						
Non-drinker	29,588 (57.25)	8,553 (57.86)	8,603 (56.02)	4,353 (56.42)	4,089 (57.62)	3,990 (59.28)
1–5 days/month	13,314 (25.76)	3,759 (25.43)	3,973 (25.87)	2,055 (26.63)	1,827 (25.75)	1,700 (25.26)
6–30 days/month	8,780 (16.99)	2,469 (16.70)	2,782 (18.11)	1,308 (16.95)	1,180 (16.63)	1,041 (15.47)
Economic level of the family						
Low	22,137 (42.83)	6,318 (42.74)	6,506 (42.36)	3,451 (44.73)	2,968 (41.83)	2,894 (43.00)
High	29,545 (57.17)	8,463 (57.26)	8,852 (57.64)	4,265 (55.27)	4,128 (58.17)	3,837 (57.00)
Weighted rate % (95% CI)						
Age						
20-39 years	26.44 (25.76 to 27.13)	27.24 (25.96 to 28.52)	26.65 (25.39 to 27.90)	26.45 (24.60 to 28.29)	25.67 (23.77 to 27.57)	25.18 (23.30 to 27.05)
40-59 years	31.36 (30.83 to 31.90)	31.78 (30.72 to 32.83)	31.46 (30.47 to 32.45)	31.28 (29.96 to 32.60)	31.01 (29.37 to 32.65)	30.77 (29.49 to 32.05)
≥ 60 years	21.21 (20.52 to 21.91)	18.93 (17.80 to 20.07)	20.54 (19.13 to 21.95)	22.02 (19.82 to 24.22)	23.19 (20.89 to 25.50)	24.45 (22.19 to 26.71)
Unknown	20.98 (20.47 to 21.48)	22.05 (21.15 to 22.95)	21.36 (20.32 to 22.40)	20.25 (18.88 to 21.63)	20.13 (18.61 to 21.65)	19.60 (18.03 to 21.18)
Sex						
Male	50.09 (49.66 to 50.52)	50.05 (49.26 to 50.84)	50.11 (49.26 to 50.97)	50.11 (49.02 to 51.19)	50.10 (49.09 to 51.11)	50.09 (48.87 to 51.32)
Female	49.91 (49.48 to 50.34)	49.95 (49.16 to 50.74)	49.89 (49.03 to 50.74)	49.89 (48.81 to 50.98)	49.90 (48.89 to 50.91)	49.91 (48.68 to 51.13)
Region of residence						
Urban	49.39 (47.85 to 50.92)	58.53 (54.80 to 62.25)	46.69 (42.87 to 50.50)	45.05 (38.22 to 51.88)	44.75 (37.53 to 51.97)	45.57 (38.57 to 52.57)
Rural	50.61 (49.08 to 52.15)	41.47 (37.75 to 45.20)	53.31 (49.50 to 57.13)	54.95 (48.12 to 61.78)	55.25 (48.03 to 62.47)	54.43 (47.43 to 61.43)
BMI group[a]						

Table 1. Continued

Variables	Total	Years				
		2015-2016	2017-2018	2019	2020	2021
Underweight to normal	48.44 (47.85 to 49.02)	49.58 (48.51 to 50.65)	49.77 (48.70 to 50.84)	49.12 (47.44 to 50.80)	44.69 (43.07 to 46.31)	46.50 (44.73 to 48.28)
Overweight to obese	50.87 (50.29 to 51.45)	50.14 (49.08 to 51.21)	49.72 (48.66 to 50.77)	50.27 (48.58 to 51.97)	54.02 (52.45 to 55.58)	52.08 (50.33 to 53.83)
Unknown	0.70 (0.60 to 0.79)	0.28 (0.16 to 0.39)	0.52 (0.37 to 0.66)	0.61 (0.39 to 0.83)	1.30 (0.98 to 1.61)	1.41 (1.01 to 1.82)
Educational background						
High school or lower	44.11 (43.23 to 44.98)	45.77 (44.18 to 47.35)	44.48 (42.71 to 46.26)	43.35 (40.68 to 46.03)	41.57 (38.90 to 44.24)	43.33 (40.81 to 45.85)
College or higher	40.80 (39.96 to 41.64)	37.48 (35.95 to 39.02)	41.28 (39.64 to 42.91)	42.18 (39.69 to 44.66)	42.74 (40.11 to 45.36)	43.21 (40.75 to 45.66)
Unknown	15.09 (14.60 to 15.58)	16.75 (15.81 to 17.69)	14.24 (13.24 to 15.24)	14.47 (13.28 to 15.65)	15.69 (14.24 to 17.13)	13.46 (12.20 to 14.72)
Smoking status						
Smoker	17.01 (16.54 to 17.48)	17.77 (16.88 to 18.66)	17.49 (16.57 to 18.41)	16.72 (15.47 to 17.97)	16.20 (14.91 to 17.49)	15.56 (14.30 to 16.83)
Ex-smoker	18.55 (18.16 to 18.94)	16.93 (16.23 to 17.64)	18.03 (17.34 to 18.72)	19.09 (18.04 to 20.13)	19.91 (18.88 to 20.95)	21.03 (19.87 to 22.19)
Non-smoker	64.44 (63.93 to 64.95)	65.30 (64.37 to 66.23)	64.48 (63.51 to 65.46)	64.19 (62.80 to 65.58)	63.89 (62.50 to 65.29)	63.41 (61.85 to 64.96)
Alcohol consumption frequency						
Non-drinker	52.21 (51.63 to 52.80)	52.02 (50.93 to 53.11)	51.04 (50.00 to 52.09)	51.78 (50.39 to 53.17)	53.28 (51.59 to 54.97)	54.43 (52.61 to 56.26)
1–5 days/month	28.98 (28.46 to 29.50)	29.00 (28.03 to 29.98)	28.92 (27.98 to 29.86)	30.18 (28.83 to 31.53)	28.13 (26.66 to 29.61)	28.65 (27.10 to 30.20)
6–30days/month	18.81 (18.39 to 19.23)	18.98 (18.18 to 19.78)	20.04 (19.28 to 20.79)	18.04 (16.81 to 19.26)	18.59 (17.44 to 19.73)	16.91 (15.77 to 18.06)
Economic level of family						
Low	38.96 (37.83 to 40.09)	39.38 (37.13 to 41.62)	39.44 (37.27 to 41.61)	40.89 (37.74 to 44.04)	36.98 (33.48 to 40.48)	37.12 (33.74 to 40.51)
High	61.04 (59.91 to 62.17)	60.62 (58.38 to 62.87)	60.56 (58.39 to 62.73)	59.11 (55.96 to 62.26)	63.02 (59.52 to 66.52)	62.88 (59.49 to 66.26)

BMI, body mass index; CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.
[a]BMI is divided into two groups: underweight to normal (<23.0 kg/m^2), overweight to obese (≥ 23.0 kg/m^2)

2.2 Ascertainment of cataracts, glaucoma, and macular degeneration

The primary aim of our study was to ascertain the occurrence of cataracts, glaucoma, and macular degeneration over seven years, from 2015 to 2021. Participants were asked a targeted question regarding their history of diagnosed cataracts, glaucoma, and macular degeneration,

explicitly inquiring, "Have you ever received a clinical diagnosis of cataracts?" "Have you ever received a clinical diagnosis of glaucoma?" and "Have you ever received a clinical diagnosis of macular degeneration?" . [7,8]

2.3 Covariate definitions

According to previous studies, covariates known to influence ocular fundus diseases were selected. Covariates included age (20–39, 40–59, and ≥ 60 years), sex, region of residence (urban and rural), BMI group[9], education background (high school or lower), smoking status (non-smoker, ex-smoker, and smoker)[10], alcohol consumption (1–5 days/month, 6–30 days/month, and non-drinker), and household income (low and high). Utilizing the self-reported height and body weight, BMI was calculated; the calculated BMI was separated into two categories: normal (<23.0 kg/m^2) and overweight to obese (≥23.0 kg/m^2).

2.4 Statistical analyses

This study's outcomes were presented after examining survey-reported data, which were expressed as proportions or percentages. Weighted multivariate regression models were employed to analyze and compare the prevalence of cataracts, glaucoma, and macular degeneration before and during the pandemic. The estimates were reported using weighted odds ratios (wORs) and 95% confidence intervals (CIs).[11] The prevalence of cataract, glaucoma, and macular degeneration was calculated by analyzing data from the KNHANES, covering the period from 2015 to 2021, and stratifying the data into different year groups. The weighted complex sampling analysis was conducted to ensure accurate estimation. The study employed a binomial logistic model to compute the wORs with 95% CIs and linear logistic regression models for calculating β-coefficients with 95% CIs; these statistical methods facilitated the analysis of the prevalence of cataract, glaucoma, and macular degeneration. Furthermore, the β difference (β_{diff}) was calculated to evaluate the change in prevalence of cataract, glaucoma, and macular degeneration before and during the pandemic. ORs were calculated for each year group to assess the prevalence of cataracts, glaucoma, and macular degeneration. The SAS software (version 9.4; SAS Institute, Cary, NC, USA) was used for statistical analyses, employing a two-sided test, with a p-value ≤ 0.05 considered statistically significant.[12]

3. Results

In this study, we encompassed data from 51,682 participants aged 20 and above who fully engaged in the KNHANES from 2015 to 2021, qualifying them as eligible participants. The participant allocation across these years was as follows: 14,781 individuals for 2015-2016, 15,358 for 2017-2018, 7,716 in 2019, 7,096 in 2020, and 6,731 in 2021. Additionally, to investigate the differences in the prevalence of key ocular diseases during pre- and COVID-19 pandemic periods, we established two comparison epochs: 2020 against 2019, with 2019 serving as the reference year, and 2021 against 2020, with 2020 as the reference. Additionally,

for assessing the risk factors of cataract, glaucoma, and macular degeneration, the cohort was divided into two temporal segments to evaluate risk factors: the pre-pandemic period (2015 to 2019) and the pandemic period (2020 to 2021). Notably, a significant proportion of the participants were aged 60 years or older, comprising 30.03% of the sample. There was also a higher representation of females in the survey, accounting for 54.51% of the participants, indicating a higher female participation rate, as shown in Table 1.

Fig. 1 and Table 2 delineate the estimated prevalence of key ocular diseases from 2015 to 2021, including age, sex, region of residence, educational background, marital status, BMI group, smoking status, and alcohol consumption. From the inception of the pre-pandemic period until 2021, a general decrease in cataracts was noted, whereas an upsurge was observed in the prevalence of macular degeneration. Between the pre- and pandemic periods, cataract (βdiff, 0.04; 95% CI, -0.40 to 0.48) and glaucoma (βdiff, 0.12; 95% CI, -0.10 to 0.35) exhibited a slight but insignificant increase in prevalence, whereas macular degeneration (β_{diff}, -0.26; 95% CI, -0.42 to 0.10) showed a slight but insignificant decrease in prevalence during the same timeframe (Table 2). Contrary to these overarching trends, subgroups including males, urban residents, individuals with high economic levels of family, individuals with an underweight to normal BMI group, and ex-smokers demonstrated an escalated prevalence of the cataract. Additionally, age cohorts of 20-39 and 40-59 years exhibited a general increase in the prevalence. Remarkably, these demographic groups, along with urban residents and individuals, showed a slight decline in the prevalence of all key ocular diseases in the comparison of pre- and during-pandemic periods. (Table 2).

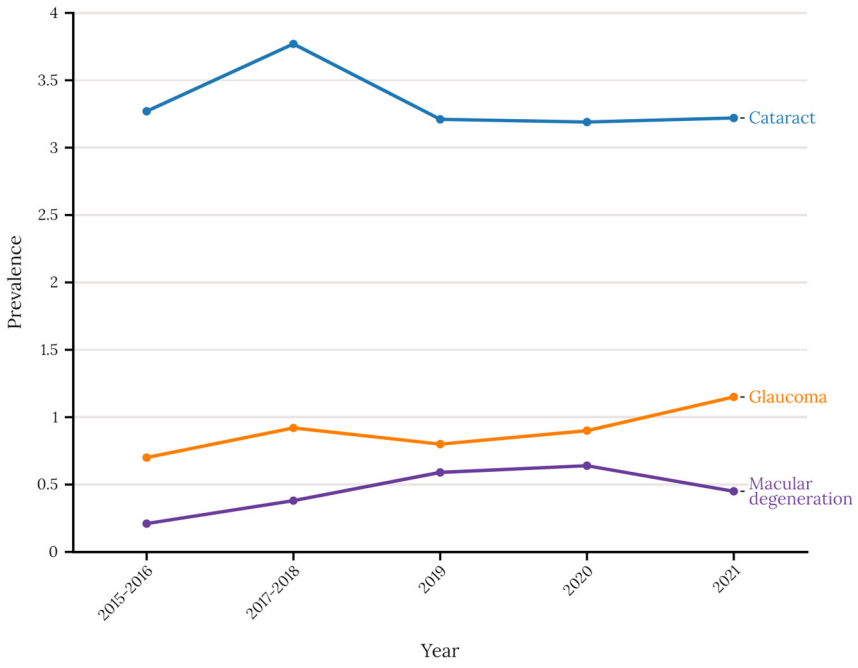

Fig. 1. Nationwide trends in the overall prevalence of cataract, glaucoma, and macular degeneration among Korean adults in the KNHANES, 2015–2021.

Table 2. National trends of the prevalence of cataract, glaucoma, and macular degeneration and β-coefficients of odds ratios before and during the COVID-19 pandemic, weighted % (95% CI), in the data obtained from the KNHANES

Year	Category	Pre-pandemic			During the pandemic		Trends in the pre-pandemic era, β (95% CI)	Trends in during the pandemic era, β (95% CI)	β_{diff} between pre-pandemic and during the pandemic (95% CI)
		2015-2016	2017-2018	2019	2020	2021			
Overall	Cataract	3.27 (2.94 to 3.60)	3.77 (3.42 to 4.13)	3.21 (2.77 to 3.66)	3.19 (2.69 to 3.68)	3.22 (2.73 to 3.72)	-0.03 (-0.32 to 0.25)	0.01 (-0.34 to 0.35)	0.04 (-0.40 to 0.48)
	Glaucoma	0.70 (0.57 to 0.84)	0.92 (0.76 to 1.09)	0.80 (0.59 to 1.02)	0.90 (0.65 to 1.15)	1.15 (0.85 to 1.45)	0.05 (-0.08 to 0.18)	0.17 (-0.01 to 0.36)	0.12 (-0.10 to 0.35)
	Macular degeneration	0.21 (0.14 to 0.29)	0.38 (0.28 to 0.47)	0.59 (0.40 to 0.78)	0.64 (0.43 to 0.86)	0.45 (0.30 to 0.61)	**0.19 (0.09 to 0.29)**	-0.07 (-0.19 to 0.06)	-0.26 (-0.42 to -0.10)
Age									
20-39 years	Cataract	0.29 (0.08 to 0.51)	0.30 (0.06 to 0.54)	0.21 (0.00 to 0.44)	N/A	0.05 (0.00 to 0.13)	-0.04 (-0.20 to 0.11)	-0.08 (-0.20 to 0.04)	-0.04 (-0.24 to 0.16)
	Glaucoma	0.19 (0.03 to 0.35)	0.16 (0.03 to 0.29)	0.15 (0.00 to 0.36)	0.04 (0.00 to 0.12)	N/A	-0.02 (-0.15 to 0.11)	-0.08 (-0.18 to 0.03)	-0.06 (-0.22 to 0.11)
	Macular degeneration	0.06 (0.00 to 0.15)	0.09 (0.00 to 0.20)	0.19 (0.00 to 0.45)	0.15 (0.00 to 0.43)	0.05 (0.00 to 0.14)	0.07 (-0.07 to 0.20)	-0.07 (-0.21 to 0.06)	-0.14 (-0.33 to 0.05)
40-59 years	Cataract	1.37 (0.90 to 1.84)	1.40 (1.00 to 1.80)	1.52 (1.00 to 2.05)	1.70 (1.01 to 2.39)	1.30 (0.78 to 1.83)	0.08 (-0.27 to 0.43)	-0.11 (-0.48 to 0.26)	-0.19 (-0.69 to 0.32)
	Glaucoma	0.43 (0.22 to 0.65)	0.74 (0.46 to 1.02)	0.65 (0.27 to 1.02)	1.11 (0.49 to 1.74)	0.78 (0.33 to 1.22)	0.11 (-0.11 to 0.32)	0.07 (-0.23 to 0.36)	-0.04 (-0.40 to 0.32)
	Macular degeneration	0.05 (0.00 to 0.13)	0.08 (0.00 to 0.17)	0.16 (0.00 to 0.38)	0.12 (0.00 to 0.36)	0.04 (0.00 to 0.11)	0.06 (-0.06 to 0.17)	-0.06 (-0.18 to 0.05)	-0.12 (-0.28 to 0.04)
≥ 60 years	Cataract	14.20 (12.95 to 15.45)	15.41 (14.11 to 16.71)	11.93 (10.44 to 13.43)	11.16 (9.50 to 12.82)	11.22 (9.63 to 12.80)	**-1.20 (-2.18 to -0.22)**	-0.35 (-1.47 to 0.77)	0.85 (-0.64 to 2.34)
	Glaucoma	2.44 (1.92 to 2.95)	2.97 (2.39 to 3.56)	2.48 (1.76 to 3.19)	2.11 (1.44 to 2.78)	3.68 (2.69 to 4.68)	0.01 (-0.44 to 0.45)	0.62 (0.00 to 1.25)	0.62 (-0.15 to 1.38)
	Macular degeneration	0.62 (0.34 to 0.89)	1.16 (0.82 to 1.50)	1.61 (0.94 to 2.28)	1.54 (0.95 to 2.12)	1.49 (0.94 to 2.05)	**0.50 (0.13 to 0.87)**	-0.06 (-0.50 to 0.38)	-0.56 (-1.13 to 0.02)
Sex									
Male	Cataract	2.10 (1.73 to 2.47)	2.46 (2.10 to 2.82)	2.30 (1.80 to 2.79)	2.24 (1.74 to 2.74)	2.36 (1.78 to 2.94)	0.10 (-0.21 to 0.41)	0.03 (-0.35 to 0.42)	-0.06 (-0.56 to 0.43)
	Glaucoma	0.67 (0.48 to 0.86)	1.01 (0.76 to 1.25)	0.83 (0.52 to 1.14)	0.97 (0.61 to 1.33)	1.05 (0.65 to 1.45)	0.08 (-0.10 to 0.26)	0.11 (-0.14 to 0.37)	0.03 (-0.28 to 0.35)
	Macular degeneration	0.24 (0.12 to 0.36)	0.36 (0.22 to 0.51)	0.47 (0.25 to 0.69)	0.71 (0.37 to 1.06)	0.38 (0.19 to 0.56)	0.12 (-0.01 to 0.24)	-0.05 (-0.19 to 0.10)	-0.16 (-0.36 to 0.03)
Female	Cataract	4.45 (3.93 to 4.96)	5.09 (4.52 to 5.66)	4.13 (3.42 to 4.84)	4.13 (3.39 to 4.88)	1.25 (0.81 to 1.68)	-0.16 (-0.60 to 0.28)	-0.02 (-0.55 to 0.51)	0.14 (-0.55 to 0.83)
	Glaucoma	0.74 (0.54 to 0.93)	0.84 (0.61 to 1.07)	0.78 (0.49 to 1.07)	0.83 (0.50 to 1.17)	0.53 (0.30 to 0.76)	0.02 (-0.15 to 0.19)	0.23 (-0.02 to 0.49)	0.21 (-0.10 to 0.52)
	Macular degeneration	0.18 (0.09 to 0.27)	0.39 (0.25 to 0.52)	0.71 (0.39 to 1.02)	0.57 (0.29 to 0.85)	3.68 (2.85 to 4.51)	**0.26 (0.10 to 0.43)**	-0.09 (-0.28 to 0.11)	-0.35 (-0.61 to -0.09)

Table 2. Continued

Year	Category	Pre-pandemic			During the pandemic		Trends in the pre-pandemic era, β (95% CI)	Trends in during the pandemic era, β (95% CI)	β_{diff} between pre-pandemic and during the pandemic (95% CI)
		2015-2016	2017-2018	2019	2020	2021			
Region of residence									
Urban	Cataract	3.02 (2.60 to 3.44)	3.95 (3.41 to 4.49)	3.61 (2.91 to 4.32)	3.67 (2.86 to 4.49)	3.68 (2.85 to 4.51)	0.32 (-0.09 to 0.73)	0.03 (-0.51 to 0.58)	-0.29 (-0.97 to 0.40)
	Glaucoma	0.54 (0.40 to 0.68)	1.10 (0.83 to 1.37)	1.05 (0.66 to 1.45)	0.92 (0.54 to 1.29)	1.11 (0.61 to 1.61)	**0.27 (0.06 to 0.47)**	0.03 (-0.28 to 0.34)	-0.24 (-0.61 to 0.14)
	Macular degeneration	0.22 (0.11 to 0.33)	0.41 (0.26 to 0.56)	0.67 (0.36 to 0.99)	0.78 (0.40 to 1.16)	0.36 (0.14 to 0.58)	**0.22 (0.06 to 0.39)**	-0.16 (-0.35 to 0.04)	**-0.38 (-0.63 to -0.13)**
Rural	Cataract	3.63 (3.10 to 4.17)	3.62 (3.13 to 4.11)	2.88 (2.29 to 3.48)	2.79 (2.18 to 3.40)	2.84 (2.26 to 3.43)	-0.39 (-0.80 to 0.02)	-0.02 (-0.44 to 0.40)	0.37 (-0.21 to 0.96)
	Glaucoma	0.93 (0.66 to 1.20)	0.77 (0.56 to 0.97)	0.60 (0.37 to 0.84)	0.89 (0.55 to 1.23)	1.18 (0.82 to 1.54)	-0.17 (-0.34 to 0.01)	**0.29 (0.08 to 0.50)**	**0.46 (0.18 to 0.73)**
	Macular degeneration	0.20 (0.10 to 0.29)	0.34 (0.21 to 0.48)	0.52 (0.29 to 0.75)	0.53 (0.29 to 0.78)	0.53 (0.31 to 0.75)	**0.16 (0.03 to 0.29)**	0.00 (-0.16 to 0.16)	-0.16 (-0.36 to 0.05)
Educational background									
High school or lower	Cataract	6.08 (5.49 to 6.66)	6.92 (6.24 to 7.60)	6.00 (5.16 to 6.84)	6.15 (5.06 to 7.24)	5.51 (4.69 to 6.32)	-0.03 (-0.55 to 0.48)	-0.25 (-0.85 to 0.35)	-0.21 (-1.00 to 0.57)
	Glaucoma	1.15 (0.91 to 1.39)	1.49 (1.17 to 1.80)	1.38 (0.96 to 1.80)	1.51 (1.01 to 2.00)	1.86 (1.38 to 2.35)	0.12 (-0.12 to 0.36)	0.24 (-0.07 to 0.56)	0.13 (-0.27 to 0.52)
	Macular degeneration	0.37 (0.22 to 0.52)	0.62 (0.43 to 0.81)	0.92 (0.53 to 1.31)	1.02 (0.62 to 1.42)	0.82 (0.50 to 1.14)	**0.28 (0.07 to 0.48)**	-0.05 (-0.30 to 0.20)	-0.33 (-0.65 to 0.00)
College or higher	Cataract	1.21 (0.86 to 1.55)	1.64 (1.30 to 1.98)	1.41 (1.01 to 1.81)	1.29 (0.89 to 1.70)	1.93 (1.36 to 2.50)	0.09 (-0.17 to 0.36)	0.26 (-0.09 to 0.61)	0.17 (-0.27 to 0.61)
	Glaucoma	0.45 (0.26 to 0.64)	0.58 (0.38 to 0.79)	0.49 (0.24 to 0.74)	0.65 (0.31 to 0.99)	0.78 (0.33 to 1.24)	0.02 (-0.14 to 0.17)	0.15 (-0.12 to 0.41)	0.13 (-0.18 to 0.43)
	Macular degeneration	0.11 (0.03 to 0.19)	0.24 (0.13 to 0.36)	0.43 (0.20 to 0.66)	0.51 (0.20 to 0.82)	0.21 (0.05 to 0.37)	**0.16 (0.04 to 0.28)**	-0.11 (-0.25 to 0.03)	**-0.27 (-0.46 to -0.08)**
Economic level of family									
Low	Cataract	5.78 (5.12 to 6.44)	6.51 (5.84 to 7.19)	5.28 (4.43 to 6.13)	4.84 (4.01 to 5.67)	5.02 (4.09 to 5.95)	-0.26 (-0.81 to 0.29)	-0.13 (-0.78 to 0.51)	0.13 (-0.72 to 0.97)
	Glaucoma	1.01 (0.76 to 1.26)	1.44 (1.11 to 1.78)	1.15 (0.76 to 1.54)	1.02 (0.63 to 1.40)	1.91 (1.34 to 2.47)	0.07 (-0.16 to 0.30)	**0.37 (0.03 to 0.71)**	0.30 (-0.10 to 0.71)
	Macular degeneration	0.25 (0.13 to 0.36)	0.47 (0.31 to 0.64)	0.81 (0.47 to 1.14)	0.75 (0.39 to 1.11)	0.82 (0.47 to 1.16)	**0.28 (0.10 to 0.46)**	0.00 (-0.24 to 0.24)	-0.28 (-0.57 to 0.02)

Table 2. Continued

Year	Category	Pre-pandemic			During the pandemic		Trends in the pre-pandemic era, β (95% CI)	Trends in during the pandemic era, β (95% CI)	β_{diff} between pre-pandemic and during the pandemic (95% CI)
		2015-2016	2017-2018	2019	2020	2021			
High	Cataract	1.64 (1.34 to 1.94)	1.99 (1.70 to 2.28)	1.78 (1.35 to 2.21)	2.21 (1.68 to 2.75)	2.16 (1.67 to 2.65)	0.07 (-0.20 to 0.33)	0.19 (-0.14 to 0.52)	0.12 (-0.30 to 0.54)
	Glaucoma	0.51 (0.34 to 0.67)	0.58 (0.42 to 0.75)	0.57 (0.34 to 0.80)	0.83 (0.49 to 1.18)	0.70 (0.31 to 1.09)	0.03 (-0.11 to 0.17)	0.07 (-0.16 to 0.29)	0.04 (-0.23 to 0.30)
	Macular degeneration	0.19 (0.10 to 0.28)	0.31 (0.19 to 0.43)	0.44 (0.22 to 0.65)	0.58 (0.31 to 0.85)	0.24 (0.09 to 0.38)	**0.12 (0.01 to 0.24)**	-0.10 (-0.23 to 0.03)	-0.23 (-0.40 to -0.05)
BMI group[a]									
Under weight to normal	Cataract	2.23 (1.88 to 2.58)	2.93 (2.55 to 3.32)	2.34 (1.84 to 2.84)	2.55 (1.90 to 3.20)	2.48 (1.86 to 3.11)	0.05 (-0.26 to 0.36)	0.07 (-0.33 to 0.47)	0.02 (-0.49 to 0.52)
	Glaucoma	0.60 (0.43 to 0.77)	0.77 (0.55 to 1.00)	0.63 (0.37 to 0.88)	0.77 (0.43 to 1.10)	1.06 (0.66 to 1.47)	0.01 (-0.14 to 0.16)	0.22 (-0.02 to 0.46)	0.21 (-0.08 to 0.49)
	Macular degeneration	0.18 (0.08 to 0.28)	0.23 (0.14 to 0.33)	0.56 (0.30 to 0.83)	0.62 (0.31 to 0.93)	0.31 (0.12 to 0.51)	**0.19 (0.05 to 0.33)**	-0.12 (-0.29 to 0.04)	**-0.31 (-0.53 to -0.10)**
Over-weight to obese	Cataract	4.31 (3.78 to 4.83)	4.60 (4.09 to 5.10)	4.06 (3.35 to 4.76)	3.60 (2.98 to 4.22)	3.82 (3.12 to 4.52)	-0.13 (-0.57 to 0.32)	-0.12 (-0.63 to 0.40)	0.01 (-0.67 to 0.69)
	Glaucoma	0.81 (0.58 to 1.04)	1.07 (0.84 to 1.31)	0.99 (0.64 to 1.33)	1.02 (0.67 to 1.37)	1.22 (0.80 to 1.64)	0.09 (-0.12 to 0.30)	0.12 (-0.15 to 0.39)	0.03 (-0.31 to 0.37)
	Macular degeneration	0.24 (0.14 to 0.35)	0.52 (0.35 to 0.69)	0.62 (0.36 to 0.88)	0.65 (0.35 to 0.95)	0.50 (0.27 to 0.72)	**0.19 (0.05 to 0.33)**	-0.06 (-0.23 to 0.11)	**-0.25 (-0.47 to -0.03)**
Smoking status									
Smoker	Cataract	2.24 (1.43 to 3.05)	1.62 (1.16 to 2.08)	2.21 (1.37 to 3.05)	2.03 (1.10 to 2.96)	1.51 (0.74 to 2.28)	-0.02 (-0.60 to 0.57)	-0.35 (-0.92 to 0.23)	-0.33 (-1.15 to 0.49)
	Glaucoma	0.77 (0.41 to 1.14)	0.82 (0.44 to 1.20)	0.91 (0.34 to 1.49)	1.00 (0.31 to 1.70)	1.16 (0.20 to 2.12)	0.07 (-0.27 to 0.41)	0.13 (-0.43 to 0.68)	0.06 (-0.59 to 0.70)
	Macular degeneration	0.29 (0.05 to 0.53)	0.27 (0.03 to 0.50)	0.32 (0.03 to 0.61)	0.37 (0.00 to 0.79)	0.25 (0.00 to 0.54)	0.01 (-0.17 to 0.20)	-0.03 (-0.24 to 0.17)	-0.05 (-0.33 to 0.23)
Ex-smoker	Cataract	3.80 (3.05 to 4.56)	4.31 (3.59 to 5.02)	4.05 (3.07 to 5.03)	3.72 (2.83 to 4.62)	4.41 (3.23 to 5.58)	0.12 (-0.51 to 0.74)	0.19 (-0.57 to 0.95)	0.07 (-0.91 to 1.05)
	Glaucoma	1.01 (0.64 to 1.37)	1.45 (0.97 to 1.93)	1.20 (0.63 to 1.77)	1.51 (0.76 to 2.25)	1.73 (0.95 to 2.50)	0.09 (-0.25 to 0.43)	0.26 (-0.22 to 0.75)	0.17 (-0.42 to 0.77)
	Macular degeneration	0.32 (0.11 to 0.54)	0.79 (0.44 to 1.14)	0.85 (0.35 to 1.36)	1.33 (0.57 to 2.10)	0.47 (0.16 to 0.78)	0.26 (-0.02 to 0.54)	-0.20 (-0.50 to 0.10)	**-0.46 (-0.87 to -0.05)**
Non-smoker	Cataract	3.42 (3.04 to 3.79)	4.21 (3.74 to 4.68)	3.22 (2.65 to 3.80)	3.31 (2.73 to 3.90)	3.25 (2.61 to 3.90)	-0.10 (-0.45 to 0.25)	0.01 (-0.43 to 0.46)	0.11 (-0.45 to 0.67)
	Glaucoma	0.61 (0.45 to 0.77)	0.80 (0.61 to 0.99)	0.66 (0.43 to 0.89)	0.69 (0.42 to 0.96)	0.95 (0.62 to 1.29)	0.03 (-0.11 to 0.17)	0.15 (-0.05 to 0.35)	0.12 (-0.12 to 0.36)
	Macular degeneration	0.16 (0.09 to 0.24)	0.29 (0.19 to 0.39)	0.58 (0.32 to 0.84)	0.50 (0.28 to 0.72)	0.50 (0.29 to 0.70)	**0.21 (0.08 to 0.34)**	-0.04 (-0.21 to 0.12)	**-0.25 (-0.46 to -0.04)**

Table 2. Continued

Year	Category	Pre-pandemic			During the pandemic		Trends in the pre-pandemic era, β (95% CI)	Trends in during the pandemic era, β (95% CI)	β_{diff} between pre-pandemic and during the pandemic (95% CI)
		2015-2016	2017-2018	2019	2020	2021			
Alcohol consum -ption									
Non-drinker	Cataract	4.37 (3.86 to 4.87)	4.77 (4.21 to 5.34)	3.86 (3.20 to 4.53)	4.07 (3.38 to 4.75)	3.92 (3.19 to 4.64)	-0.26 (-0.68 to 0.17)	0.03 (-0.48 to 0.53)	0.28 (-0.38 to 0.94)
	Glaucoma	0.77 (0.58 to 0.95)	0.93 (0.71 to 1.15)	0.90 (0.61 to 1.20)	1.00 (0.66 to 1.34)	1.13 (0.73 to 1.53)	0.07 (-0.11 to 0.24)	0.12 (-0.13 to 0.36)	0.05 (-0.26 to 0.35)
	Macular degenera-tion	0.26 (0.15 to 0.36)	0.50 (0.33 to 0.66)	0.73 (0.42 to 1.04)	0.76 (0.44 to 1.08)	0.58 (0.36 to 0.81)	**0.24 (0.07 to 0.40)**	-0.08 (-0.27 to 0.12)	**-0.31 (-0.56 to -0.06)**
1–5 days/ month	Cataract	2.00 (1.60 to 2.40)	2.66 (2.19 to 3.14)	2.44 (1.73 to 3.15)	1.99 (1.37 to 2.60)	2.31 (1.59 to 3.04)	0.22 (-0.19 to 0.63)	-0.07 (-0.57 to 0.44)	-0.28 (-0.93 to 0.36)
	Glaucoma	0.60 (0.37 to 0.84)	0.84 (0.55 to 1.13)	0.71 (0.32 to 1.10)	0.86 (0.27 to 1.44)	1.18 (0.65 to 1.71)	0.05 (-0.18 to 0.28)	0.24 (-0.09 to 0.57)	0.19 (-0.22 to 0.59)
	Macular degenera-tion	0.09 (0.01 to 0.17)	0.15 (0.03 to 0.27)	0.40 (0.08 to 0.73)	0.63 (0.27 to 0.99)	0.31 (0.06 to 0.56)	0.16 (-0.01 to 0.33)	-0.04 (-0.25 to 0.16)	-0.20 (-0.47 to 0.06)
6–30 days/ month	Cataract	2.22 (1.57 to 2.87)	2.83 (2.18 to 3.48)	2.64 (1.85 to 3.43)	2.47 (1.54 to 3.40)	2.54 (1.62 to 3.45)	0.21 (-0.30 to 0.73)	-0.05 (-0.66 to 0.55)	-0.27 (-1.06 to 0.53)
	Glaucoma	0.68 (0.36 to 1.01)	1.02 (0.61 to 1.42)	0.68 (0.20 to 1.16)	0.68 (0.25 to 1.12)	1.14 (0.43 to 1.85)	0.00 (-0.29 to 0.29)	0.23 (-0.20 to 0.65)	0.23 (-0.29 to 0.74)
	Macular degenera-tion	0.28 (0.04 to 0.52)	0.39 (0.18 to 0.59)	0.48 (0.15 to 0.82)	0.32 (0.00 to 0.74)	0.26 (0.00 to 0.55)	0.10 (-0.10 to 0.31)	-0.11 (-0.33 to 0.11)	-0.21 (-0.51 to 0.09)

BMI, body mass index; CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.

[a]BMI is divided into two groups: underweight to normal (<23.0 kg/m^2) or overweight to obese (≥ 23.0 kg/m^2).

The numbers in bold indicate a significant difference (p<0.05).

The analysis of the ratio of odds ratio (ROR) on key ocular diseases between the pre-and during-pandemic periods is depicted in Table 3.

Furthermore, the study investigated the ratio of odds ratio to discern the difference between the prevalence and each socioeconomic and behavioral factor, as shown in Table 4. While RORs of most subgroups were around the reference ROR of 1 (indicating no significant difference in the strength of association), certain groups displayed more pronounced effects. Urban residents (ROR, 1.31; 95% CI, 1.02 to 1.70), individuals with college or higher educational background (ROR, 1.24; 95% CI, 0.92 to 1.67), individuals with a high economic level of family (ROR, 1.49; 95% CI, 1.17 to 1.90), and smokers (ROR, 1.13; 95% CI, 0.88 to 1.46) exhibited RORs exceeding 1 for cataract, suggesting a more substantial impact of the COVID-19 pandemic on the interplay between cataract and these socioeconomic and behavioral dimensions. Similar trends were observed in individuals with high economic level of family (ROR, 1.17; 95% CI, 0.72 to 1.91), ex-smokers (ROR, 1.12; 95% CI, 0.58 to 2.20), smokers (ROR, 1.13; 95% CI, 0.67 to 1.88) and individuals who consume alcohol 1-5 days per

Table 3. Difference between pre- and during the COVID-19 pandemic by the ratio of ORs on cataract or glaucoma or macular degeneration, weighted % (95% CI), in the data obtained from the KNHANES.

Variables	Cataract		Glaucoma		Macular degeneration	
	2020 versus 2019 (reference)	2021 versus 2020 (reference)	2020 versus 2019 (reference)	2021 versus 2020 (reference)	2020 versus 2019 (reference)	2021 versus 2020 (reference)
	wOR (95% CI)[a]	wOR (95% CI)[b]	wOR (95% CI)[a]	wOR (95% CI)[b]	wOR (95% CI)[a]	wOR (95% CI)[b]
Age						
20-39 years	N/A	N/A	0.27 (0.03 to 2.96)	N/A	0.75 (0.07 to 7.97)	0.31 (0.02 to 5.20)
40-59 years	1.12 (0.66 to 1.90)	0.76 (0.43 to 1.37)	1.73 (0.77 to 3.91)	0.70 (0.32 to 1.53)	0.74 (0.07 to 7.94)	0.31 (0.02 to 5.18)
≥60 years	0.93 (0.74 to 1.16)	1.01 (0.79 to 1.28)	0.85 (0.55 to 1.32)	1.77 (1.15 to 2.73)	0.95 (0.54 to 1.69)	0.97 (0.57 to 1.65)
Sex						
Male	0.98 (0.71 to 1.34)	1.05 (0.75 to 1.48)	1.17 (0.69 to 2.00)	1.09 (0.63 to 1.87)	1.52 (0.78 to 2.98)	0.53 (0.27 to 1.04)
Female	1.00 (0.76 to 1.31)	0.99 (0.75 to 1.30)	1.07 (0.62 to 1.85)	1.50 (0.88 to 2.55)	0.81 (0.41 to 1.59)	0.93 (0.48 to 1.79)
Region of residence						
Urban	1.02 (0.75 to 1.39)	1.00 (0.72 to 1.40)	0.87 (0.51 to 1.50)	1.22 (0.67 to 2.22)	1.17 (0.60 to 2.27)	0.46 (0.21 to 0.99)
Rural	0.97 (0.71 to 1.32)	1.02 (0.75 to 1.38)	1.48 (0.86 to 2.57)	1.33 (0.81 to 2.17)	1.02 (0.54 to 1.93)	1.00 (0.54 to 1.83)
Education background						
High school or lower	1.03 (0.81 to 1.30)	0.89 (0.70 to 1.13)	1.09 (0.70 to 1.71)	1.24 (0.81 to 1.90)	1.11 (0.63 to 1.97)	0.80 (0.46 to 1.39)
College or higher	0.92 (0.59 to 1.42)	1.50 (0.95 to 2.36)	1.32 (0.64 to 2.73)	1.21 (0.55 to 2.68)	1.18 (0.53 to 2.67)	0.41 (0.16 to 1.08)
Economic level of family						
Low	0.91 (0.71 to 1.18)	1.04 (0.79 to 1.36)	0.88 (0.53 to 1.47)	1.89 (1.17 to 3.07)	0.93 (0.49 to 1.75)	1.09 (0.57 to 2.07)
High	1.25 (0.88 to 1.77)	0.98 (0.70 to 1.37)	1.48 (0.82 to 2.64)	0.84 (0.42 to 1.68)	1.33 (0.68 to 2.61)	0.41 (0.19 to 0.87)
BMI group[c]						
Underweight to normal	1.09 (0.78 to 1.54)	0.97 (0.68 to 1.40)	1.22 (0.68 to 2.20)	1.40 (0.79 to 2.48)	1.10 (0.55 to 2.21)	0.51 (0.23 to 1.13)

Table 3. Continued

Variables	Cataract		Glaucoma		Macular degeneration	
	2020 versus 2019 (reference)	2021 versus 2020 (reference)	2020 versus 2019 (reference)	2021 versus 2020 (reference)	2020 versus 2019 (reference)	2021 versus 2020 (reference)
	wOR (95% CI)[a]	wOR (95% CI)[b]	wOR (95% CI)[a]	wOR (95% CI)[b]	wOR (95% CI)[a]	wOR (95% CI)[b]
Overweight to obese	0.88 (0.68 to 1.15)	1.06 (0.81 to 1.39)	1.03 (0.63 to 1.68)	1.20 (0.73 to 1.96)	1.05 (0.57 to 1.93)	0.76 (0.40 to 1.43)
Smoking status						
Non-smoker	0.91 (0.50 to 1.66)	0.74 (0.37 to 1.48)	1.10 (0.43 to 2.84)	1.16 (0.40 to 3.40)	1.15 (0.26 to 5.10)	0.68 (0.13 to 3.57)
Ex-smoker	0.92 (0.65 to 1.30)	1.19 (0.82 to 1.73)	1.26 (0.63 to 2.54)	1.15 (0.58 to 2.25)	1.57 (0.69 to 3.58)	0.35 (0.15 to 0.85)
Smoker	1.03 (0.78 to 1.35)	0.98 (0.74 to 1.30)	1.04 (0.62 to 1.76)	1.39 (0.83 to 2.35)	0.86 (0.46 to 1.61)	0.99 (0.54 to 1.83)
Alcohol consumption frequency	0.91 (0.50 to 1.66)	0.74 (0.37 to 1.48)	1.10 (0.43 to 2.84)	1.16 (0.40 to 3.40)	1.15 (0.26 to 5.10)	0.68 (0.13 to 3.57)
Non-drinker	1.06 (0.81 to 1.37)	0.96 (0.73 to 1.26)	1.11 (0.69 to 1.78)	1.13 (0.69 to 1.86)	1.04 (0.58 to 1.88)	0.77 (0.44 to1.35)
1–5days/ month	0.81 (0.52 to 1.26)	1.17 (0.75 to 1.82)	1.21 (0.50 to 2.90)	1.39 (0.61 to 3.14)	1.57 (0.59 to 4.17)	0.50 (0.19 to 1.31)
6-30 days/ month	0.93 (0.58 to 1.51)	1.03 (0.61 to 1.75)	1.00 (0.39 to 2.61)	1.68 (0.69 to 4.06)	0.67 (0.16 to 2.87)	0.82 (0.15 to 4.40)

CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey; wOR, weighted odds ratio.
[a]Derived using weighted logistic regression; this model included the KNHANES (2020 [COVID-19 pandemic] vs 2019 [reference]) as categorical variable
[b]Derived using weighted logistic regression; this model included the KNHANES (2021 [COVID-19 pandemic] vs 2020 [reference]) as a categorical variable
[c]BMI is divided into two groups: underweight to normal (<23.0 kg/m^2) or underweight to obese (≥ 23.0 kg/m^2).
Bolded data indicate significant differences in the regression model (p<0.05).

month (ROR, 1.14; 95% CI, 0.67 to 1.95) for glaucoma as well as individuals who consume alcohol 1-5 days per month (ROR, 1.77; 95% CI, 0.82 to 3.82) for macular degeneration.

4. Discussion

4.1 Key findings

The study revealed a general decline in cataract prevalence (3.27% [95% CI, 2.94-3.60] in

Table 4. Ratio of ORs for association between the prevalence of diabetes and each socioeconomic and behavioral factor.

Variables		Overall (2015 to 2021)	Pre-pandemic era (2015 to 2019)	During pandemic era (2020 to 2021)		
		Weighted OR (95% CI)	Weighted OR (95% CI)	Weighted OR (95% CI)	Ratio of ORs (95% CI), during pandemic versus pre-pandemic (reference)	*P*-value
Cataract						
Age	40-59 years (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	20-39 years	**0.14 (0.09 to 0.24)**	**0.19 (0.12 to 0.33)**	**0.01 (0.00 to 0.10)**	**0.07 (0.01 to 0.56)**	0.012
	≥ 60 years	**10.47 (8.83 to 12.41)**	**11.56 (9.45 to 14.15)**	**8.23 (6.02 to 11.25)**	0.71 (0.49 to 1.03)	0.074
Sex	Male (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Female	2.01 (1.81 to 2.22)	2.08 (1.84 to 2.35)	1.82 (1.49 to 2.23)	0.88 (0.69 to 1.11)	0.269
Region of residence	Rural (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Urban	1.08 (0.97 to 1.21)	1.00 (0.88 to 1.14)	**1.32 (1.06 to 1.64)**	**1.31 (1.02 to 1.70)**	**0.037**
Education back-ground	High school or lower (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	College or higher	**0.23 (0.20 to 0.26)**	**0.21 (0.18 to 0.25)**	**0.26 (0.21 to 0.34)**	**1.24 (0.92 to 1.67)**	**0.152**
Economic level of family	Low (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	High	**0.32 (0.29 to 0.36)**	**0.29 (0.26 to 0.33)**	**0.43 (0.35 to 0.53)**	**1.49 (1.17 to 1.90)**	**0.001**
BMI group[a]	Underweight to normal (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Overweight to obese	**1.68 (1.52 to 1.86)**	**1.76 (1.57 to 1.97)**	**1.49 (1.21 to 1.84)**	0.85 (0.67 to 1.08)	0.175
Smoking status	Non-smoker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Ex-smoker	**0.53 (0.44 to 0.64)**	**0.53 (0.42 to 0.66)**	**0.54 (0.37 to 0.77)**	1.01 (0.66 to 1.55)	0.953
	Smoker	**1.14 (1.02 to 1.28)**	1.10 (0.97 to 1.26)	1.25 (1.00 to 1.55)	1.13 (0.88 to 1.46)	0.346
Alcohol consump-tion frequency	Non-drinker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	1–5 days/month	**0.52 (0.46 to 0.59)**	**0.52 (0.45 to 0.60)**	**0.53 (0.41 to 0.68)**	1.01 (0.76 to 1.35)	0.935
	6–30days/ month	**0.58 (0.50 to 0.68)**	**0.57 (0.47 to 0.68)**	**0.62 (0.46 to 0.82)**	1.09 (0.78 to 1.52)	0.623
Glaucoma						
Age	40-59 years (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	20-39 years	**0.19 (0.11 to 0.33)**	**0.29 (0.16 to 0.52)**	**0.02 (0.00 to 0.17)**	**0.08 (0.01 to 0.63)**	**0.017**

Table 4. Continued

Variables		Overall (2015 to 2021)	Pre-pandemic era (2015 to 2019)	During pandemic era (2020 to 2021)		
		Weighted OR (95% CI)	Weighted OR (95% CI)	Weighted OR (95% CI)	Ratio of ORs (95% CI), during pandemic versus pre-pandemic (reference)	*P*-value
	≥ 60 years	**4.01 (3.13 to 5.14)**	**4.55 (3.40 to 6.08)**	**3.11 (1.97 to 4.90)**	0.68 (0.40 to 1.17)	0.167
Sex	Men (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Women	0.97 (0.79 to 1.18)	0.94 (0.74 to 1.20)	1.03 (0.71 to 1.48)	1.09 (0.70 to 1.69)	0.700
Region of residence	Rural (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Urban	1.03 (0.84 to 1.26)	1.07 (0.84 to 1.36)	0.98 (0.67 to 1.45)	0.92 (0.58 to 1.45)	0.718
Education back-ground	High school or lower (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	College or higher	**0.40 (0.32 to 0.50)**	**0.38 (0.29 to 0.50)**	**0.42 (0.27 to 0.65)**	1.09 (0.65 to 1.83)	0.740
Economic level of family	Low (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	High	**0.48 (0.39 to 0.59)**	**0.45 (0.36 to 0.57)**	**0.53 (0.35 to 0.81)**	1.17 (0.72 to 1.91)	0.528
BMI group[a]	Underweight to normal (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Overweight to obese	**1.35 (1.11 to 1.66)**	**1.41 (1.11 to 1.79)**	1.22 (0.85 to 1.76)	0.87 (0.56 to 1.34)	0.522
Smoking status	Non-smoker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Ex-smoker	1.22 (0.91 to 1.63)	1.18 (0.85 to 1.64)	1.33 (0.74 to 2.38)	1.12 (0.58 to 2.20)	0.733
	Smoker	**1.86 (1.47 to 2.35)**	**1.77 (1.35 to 2.32)**	**2.00 (1.29 to 3.10)**	1.13 (0.67 to 1.88)	0.651
Alcohol consump-tion frequency	Non-drinker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	1–5 days/month	0.87 (0.68 to 1.11)	0.84 (0.63 to 1.11)	0.95 (0.60 to 1.51)	1.14 (0.67 to 1.95)	0.636
	6–30 days/month	0.92 (0.70 to 1.20)	0.96 (0.70 to 1.32)	0.84 (0.50 to 1.39)	0.87 (0.48 to 1.59)	0.660
Macular degenera-tion						
Age	40-59 years (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	20-39 years	**0.19 (0.11 to 0.33)**	**0.35 (0.15 to 0.80)**	0.21 (0.04 to 1.12)	0.61 (0.09 to 3.91)	0.599
	≥ 60 years	**4.01 (3.13 to 5.14)**	**3.67 (2.35 to 5.74)**	**3.32 (1.80 to 6.14)**	0.90 (0.42 to 1.93)	0.794
Sex	Men (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Women	1.06 (0.79 to 1.42)	1.10 (0.77 to 1.57)	1.00 (0.61 to 1.63)	0.91 (0.50 to 1.66)	0.754

Table 4. Continued

Variables		Overall (2015 to 2021)	Pre-pandemic era (2015 to 2019)	During pandemic era (2020 to 2021)		
		Weighted OR (95% CI)	Weighted OR (95% CI)	Weighted OR (95% CI)	Ratio of ORs (95% CI), during pandemic versus pre-pandemic (reference)	*P*-value
Region of residence	Rural (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Urban	1.08 (0.81 to 1.43)	1.11 (0.78 to 1.58)	1.09 (0.67 to 1.77)	0.98 (0.54 to 1.79)	0.950
Education back-ground	High school or lower (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	College or higher	**0.41 (0.30 to 0.56)**	**0.41 (0.28 to 0.60)**	**0.39 (0.23 to 0.69)**	0.97 (0.49 to 1.91)	0.925
Economic level of family	Low (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	High	**0.60 (0.45 to 0.79)**	**0.63 (0.45 to 0.89)**	**0.53 (0.32 to 0.87)**	0.83 (0.46 to 1.53)	0.556
BMI group[a]	Underweight to normal (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Overweight to obese	**1.45 (1.09 to 1.94)**	**1.56 (1.10 to 2.21)**	1.24 (0.75 to 2.06)	0.80 (0.43 to 1.48)	0.469
Smoking status	Non-smoker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	Ex-smoker	0.83 (0.51 to 1.34)	0.96 (0.54 to 1.71)	0.62 (0.25 to 1.55)	0.64 (0.22 to 1.89)	0.423
	Smoker	**2.03 (1.46 to 2.81)**	**2.12 (1.43 to 3.15)**	**1.83 (1.05 to 3.19)**	0.86 (0.44 to 1.71)	0.673
Alcohol consump-tion frequency	Non-drinker (ref)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	
	1–5 days/month	**0.51 (0.35 to 0.74)**	**0.40 (0.23 to 0.69)**	0.70 (0.41 to 1.21)	1.77 (0.82 to 3.82)	0.143
	6–30 days/month	0.67 (0.45 to 1.00)	0.81 (0.51 to 1.27)	0.44 (0.18 to 1.09)	0.54 (0.20 to 1.50)	0.236

BMI, body mass index; CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey; ORs, Odds Ratios.

[a]BMI is divided into two groups: underweight to normal (<23.0 kg/m^2), overweight to obese (≥ 23.0 kg/m^2)

The numbers in bold indicate a significant difference (p <0.05).

2015-2016; 3.22 [2.73-3.72] in 2021), contrasted by an increase in glaucoma (0.70% [95% CI,0.57-0.84] in 2015-2016; 1.15 [0.85-1.45] in 2021) and macular degeneration (0.21% [95% CI, 0.14-0.29] in 2015-2016; 0.45 [0.30-0.61] in 2021). Specific demographic groups, particularly those with higher economic status and urban residents, showed an increased prevalence of cataracts. The ROR analysis indicated varied impacts of the pandemic on different socioeconomic and behavioral factors. This correlation underscores a potential linkage between high economic status within South Korean society and an increased vulnerability to key ocular diseases. These findings suggest that lifestyle or environmental factors, inherently associated with socioeconomic standing, may contribute to heightened risk.

4.2 Possible mechanisms

Leveraging a comprehensive national population dataset, our study tracked changes in the prevalence and incidence of key ocular diseases, which are cataracts, glaucoma, and macular degeneration. Our analysis identified a constellation of cultural, environmental, and social factors that correlate with key ocular diseases, necessitating ongoing evaluation.[13] During the study period, the prevalence of cataracts exhibited a statistically insignificant, but slight decrease in the pre-pandemic period, followed by a slight increase in the pandemic period. Glaucoma showed a slight increase in both pre- and during-pandemic periods. Conversely, macular degeneration increased slightly pre-pandemic but slightly decreased during the pandemic period, potentially influenced by lockdown and social distancing measures. The advent of COVID-19 in South Korea prompted the government to implement stringent lockdown policies,[14] mirroring global trends, necessitating the temporary closure of most establishments, except essential institutions such as schools and hospitals. This reduction in social engagement may have possibly led to the heightened prevalence of key ocular disease, discernible both overall and specifically during the pandemic period.

Out of various factors that might have contributed to such a trend of key ocular diseases, one potential driver of this trend could be increased screen time followed by decreased physical activity during the COVID-19 pandemic period. Similar to its established association with other eye-related diseases,[15-20] reduced physical activity and augmented screen time might have directly influenced the incidence of cataracts, glaucoma, and macular degeneration.

Moreover, our risk factor analysis, encompassing diverse socioeconomic and behavioral factors, indicated that individuals with high economic status are more likely to experience key ocular diseases. Notably, cataracts, glaucoma, and macular degeneration often remain undiagnosed in early stages due to their asymptomatic nature until significant vision impairment occurs.[21,22] Consequently, the general population may struggle to receive timely diagnoses and treatment. However, individuals with high economic status often have access to superior medical resources, including regular, high-quality health check-ups,[23,24] potentially leading to increased detection of these conditions during the clinically silent stages, which may explain the higher prevalence rate compared to those with a low economic status.

4.3 Policy implications

Our study has elucidated that there has been either a general increase or a specific increase in the prevalence of key ocular diseases among the South Korean population during the COVID-19 pandemic. Additionally, our risk factor analysis highlights those individuals of high economic status as well as those aged 40-59 years, have demonstrated a heightened likelihood of experiencing all key ocular diseases. Moreover, individuals who have quit smoking or are current smokers are shown to have an elevated occurrence for more than half of these key diseases.

Given these findings, it becomes imperative for the government to prioritize these identified groups in its healthcare strategies.[11] The South Korean government can possibly set a required regular health check-up through people's jobs under these sociodemographic features, using the insurance system of South Korea.[25] However, it is also crucial for the government and companies that can provide extra healthcare support to acknowledge that this trend may be partly attributable to more frequent health check-ups in these groups, leading to a higher

diagnosis rate of key ocular diseases.[26] Consequently, the government should be cognizant of the potential risks among other demographic groups.[27] To address this, similar to the policy recommendation suggested above, the government could implement a national screening program for key ocular diseases at local public health centers,[28] with targeted outreach efforts toward groups that do not engage in health services. The outreach should be careful not to overlook groups that appear to have a low prevalence of these diseases, since the prevalence may be a matter of inadequate access to services, which can result in under-detection.

4.4 Limitations and strengths

When considering the outcomes of this study, it is crucial to recognize several inherent limitations. First, the data utilized in the study was derived from the KNHANES, which restricts the extrapolation of our findings exclusively to South Korean populations. Furthermore, within this dataset, certain data points, such as the WOR of cataracts in the 20-29 age group, were classified as non-applicable; this resulted in informational gaps, consequently impacting the uniformity of analysis across the entire study duration. Second, the absence of data pertaining to the child and adolescents constrains the generalizability of our results to this particular demographic segment. This limitation is significant as it potentially omits crucial insights into the prevalence and evolving patterns of the key ocular diseases under study within this younger population. Third, the reliance of our study on self-reported data introduces potential biases. Specifically, the risks of recall bias, where participants may not accurately remember past events or conditions, and social desirability bias, where responses might be influenced by the desire to present oneself in a favorable light, cannot be discounted.6 These factors may skew the authenticity of the reported data, thus affecting the accuracy and reliability of our study findings.

Despite the acknowledged limitations, the significance of this study remains robust. It represents a comprehensive, nationwide, population-based exploration, delineating the longitudinal trends of critical ocular diseases—cataracts, glaucoma, and macular degeneration. Furthermore, it delves into an in-depth investigation of risk factors, with a particular focus on sociodemographic characteristics, through the analysis of seven consecutive years of data from the KNHANES; this method enables our study to provide a detailed portrayal of the prevalence of these key ocular diseases spanning both pre- and during-COVID-19 pandemic periods. Additionally, it provides a thorough analysis of the OR corresponding to various risk factors. Thus, our research contributes a significant perspective on the evolving landscape of ocular health issues in the context of ongoing global health challenges, serving as a valuable resource for future studies and public health policy formulation.

5. Conclusion

The comprehensive analysis of data from the KNHANES spanning 2015 to 2021 has provided pivotal insights into the prevalence of key ocular diseases—cataract, glaucoma, and macular degeneration—among the adult population in South Korea, especially within the milieu of the COVID-19 pandemic. The study revealed a general decline in cataract prevalence, contrasted with an increase in glaucoma and macular degeneration. The study has significantly highlighted how socioeconomic and behavioral factors profoundly impact ocular health, with urban residents and higher economic status notable risk contributors, underscoring the necessity

for healthcare strategies that are acutely aware of and responsive to socioeconomic disparities. It brings to the fore the imperative for health policies to be inclusive and equitable, particularly in addressing ocular health concerns. Our findings advocate for integrating regular ocular screenings and preventive care into public health initiatives, taking advantage of South Korea's healthcare infrastructure. Implementing such proactive healthcare measures, for example, in workplaces, could be instrumental in the early identification and management of ocular diseases, potentially preventing severe visual impairment. As the world progresses through and beyond these challenging times, the insights from this study could be crucial in shaping comprehensive strategies to preserve ocular health and, consequently, enhance the overall quality of life for communities globally.

Capsule Summary

The study has significantly highlighted how socioeconomic and behavioral factors profoundly impact ocular health, with urban residents and higher economic status notable risk contributors, underscoring the necessity for healthcare strategies that are acutely aware of and responsive to socioeconomic disparities.

Ethical statement

The research protocol, approved by the Institutional Review Board of Kyung Hee University and the Korea Disease Control and Prevention Agency, ensured informed written consent was obtained from all participants involved in the survey. Throughout the study, the Declaration of Helsinki was strictly abided by.

Patient and public involvement

No patients were directly involved in designing the research question or conducting the research. No patients were asked to interpret or write up the results. However, we plan on disseminating the results of this study to any of the study participants or wider relevant communities on request.

Data Availability Statement

Data are available on reasonable request.

Transparency statement

The leading authors (Dr. YS) are an honest, accurate, and transparent account of the study being reported.

Author Contribution

Dr. YS had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final version before submission. Study concept and design: HL, JHL, and YS; Acquisition, analysis, or interpretation of data: HL, JHL, and YS; Drafting of the manuscript: HL, JHL, and YS; validation and methodological revision: HL, JHL, and YS; critical revision of the manuscript for important intellectual content and language review & editing: all authors; Statistical analysis: HL, JHL, and YS; Study supervision: YS. YS is the guarantor for this study. HL and JHL

contributed equally. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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