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LETTER TO THE EDITOR

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Eyeglasses in the wonderland of COVID-19

To the Editor,

A recent cohort study[1] at Suizhou in China identified that the proportion of subjects who wore eyeglasses was lower in hospitalized patients with coronavirus disease 2019 (COVID-19) than in the general population. The study, however, enrolled a small number of patients with COVID-19 (276 patients) including those with myopia (16 patients) in a single center. In the present study, the association of myopia with COVID-19 in US states was investigated applying inverse-variance weighted regression.

For each US state, the cumulative number of COVID-19 confirmed cases, deaths, and tested subjects on September 20, 2020 were available on the "Johns Hopkins Coronavirus Resource Center (https://github.com/CSSEGISandData/COVID-19/blob/master/csse_covid_19_data/csse_covid_19_daily_reports_us/09-20-2020.csv)." Estimated prevalence rates (per Census 2010 populations) of myopia were procurable in the "Vision Problems in the United States, 2012 edition (http://www.visionproblemsus.org/vpus-search.html)." Cumulative incidence rates of COVID-19 were calculated as cumulative cases per populations in 2018 (available on the "2014–2018 ACS 5-Year Data Profile [https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2018/]"), test-positive rates were defined as cumulative cases per cumulative tested subjects, mortality rates were calculated as cumulative deaths per populations, and fatality rates were defined as cumulative deaths per cumulative cases. The random-effects inverse-variance weighted regression (i.e., meta-regression considering a state as a study in a meta-analysis) was performed using OpenMetaAnalyst (http://www.cebm.brown.edu/openmeta/index.html). In the inverse-variance weighted regression which is quite different from simple regression, association of explanatory variables with an outcome variable is more influenced by larger samples (states in the case of the present study) than by smaller samples because samples are weighted by the precision of their respective estimate (https://training.cochrane.org/handbook/current/chapter-10#section-10-11-4). A regression graph depicted COVID-19 cumulative incidence, test-positive, mortality, and fatality rates (plotted as the logarithm-transformed data on the *y*-axis) as a function of myopia prevalence rates (plotted on the *x*-axis). To adjust for potential confounders, the multivariable regression was performed when a coefficient of myopia prevalence was statistically significant ($p < .05$) in the univariable regression. The multivariable regression entered demographic and socioeconomic characteristics (including age and race distribution) (Table 1) together with myopia prevalence as covariates.

In the entire United States, myopia prevalence was 23.92%, the COVID-19 cumulative incidence was 2093 cases per 0.1-million population, the test-positive rate was 7.14%, the mortality was 61.58 deaths per 0.1-million population, and the fatality was 2.94% (Table 1). The myopia prevalence was significantly and negatively associated with the COVID-19 incidence (coefficient [slope of the meta-regression line], −0.144 of logarithmic cases [per population] per 1% increase in myopia prevalence; 95% confidence interval [CI], −0.228 to −0.060; $p < .001$; Figure 1, upper panel), the test-positive rate (coefficient, −0.111 of logarithmic percent per 1% increase in myopia prevalence; 95% CI, −0.211 to −0.011; $p = .030$; Figure 1, lower panel), and mortality (coefficient, −0.204 of logarithmic percent per 1% increase in myopia prevalence; 95% CI, −0.324 to −0.083; $p < .001$; Figure 2, upper panel). Myopia prevalence, however, was not correlated to fatality (coefficient, −0.073 of logarithmic percent per 1% increase in myopia prevalence; 95% CI, −0.176 to 0.031; $p = .169$; Figure 2, lower panel). In multivariable regression, myopia prevalence was still significantly and negatively associated with the COVID-19 incidence and the test-positive rate, whereas it was not correlated to mortality (Table 2). Similar analyses were performed for hyperopia and cataract. The hyperopia prevalence was associated with none of the COVID-19 incidence ($p = .065$), test-positive rate ($p = .543$), mortality ($p = .055$), and fatality ($p = .357$). The cataract prevalence was also correlated to none of the COVID-19 incidence ($p = .819$), test-positive rate ($p = .445$), mortality ($p = .712$), and fatality ($p = .672$).

The present study indicated the significant, independent, and negative association of the myopia prevalence with the COVID-19 cumulative incidence and the test-positive rate (neither the mortality nor the fatality) in US states, which suggests a probably negative correlation of wearing eyeglasses to COVID-19 infection because eyeglasses are the primary choice for optical correction in most myopia patients (https://www.aoa.org/healthy-eyes/eye-and-vision-conditions/myopia?sso=y). Wider view fields and clearer vision, however, may be offered by contact lenses than eyeglasses for some subjects, and laser procedures (e.g., laser in situ keratomileusis or photorefractive keratectomy) are also potential options for adult myopia (https://www.aoa.org/healthy-eyes/eye-and-vision-conditions/myopia?sso=y). According to the "Vision Council of America (https://www.thevisioncouncil.org)," 75% of adults need vision correction, and 64% and 11% of them wear eyeglasses and contact lenses, respectively. In accordance to "Jobson Optical Research (https://jobsonresearch.com)," 61% of the population in the United States use some sort of vision correction, and 61% of them need eyewear due to myopia. Due to the community-level (not patient-level) study design, the present findings simply denote that COVID-19 infection was less frequent in states where myopia patients (who probably wore eyeglasses) were more present, and never directly import that a myopia patient is at low risk of COVID-19 infection. Zeng et al.[1] also suggested the association of

TABLE 1 Data on myopia/COVID-19 and demographic/socioeconomic characteristics

State	Myopia (in 2012) Case	Myopia (in 2012) Prevalence (%)	Population (2018)	COVID-19 (on 20 September 2020) Case	Death	Tested people	Incidence (per 0.1-million population)	Test positive (%)	Mortality (per 0.1-million population)	Fatality (%)
Alabama	525,188	23.33	4,864,680	144,962	2437	1,054,017	2980	13.75	50.10	1.68
Alaska	77,104	25.79	738,516	6822	45	426,925	924	1.60	6.09	0.66
Arizona	671,647	23.51	6,946,685	214,021	5477	1,383,924	3081	15.46	78.84	2.56
Arkansas	329,724	24.23	2,990,671	75,723	1181	883,984	2532	8.57	39.49	1.56
California	3,633,510	22.51	39,148,760	786,168	15,016	13,523,158	2008	5.81	38.36	1.91
Colorado	565,597	25.29	5,531,141	64,837	2014	1,195,379	1172	5.42	36.41	3.11
Connecticut	444,664	24.87	3,581,504	55,527	4492	1,422,148	1550	3.90	125.42	8.09
Delaware	102,162	23.51	949,495	19,566	621	271,421	2061	7.21	65.40	3.17
District of Columbia	45,516	18.49	684,498	14,955	620	355,144	2185	4.21	90.58	4.15
Florida	2,148,126	22.4	20,598,139	683,754	13,296	5,095,089	3319	13.42	64.55	1.94
Georgia	974,697	23.25	10,297,484	306,155	6602	2,750,822	2973	11.13	64.11	2.16
Hawaii	137,072	20.96	1,422,029	11,403	120	279,849	802	4.07	8.44	1.05
Idaho	175,085	25.81	1,687,809	37,491	443	286,830	2221	13.07	26.25	1.18
Illinois	1,397,613	24	12,821,497	276,443	8686	5,107,351	2156	5.41	67.75	3.14
Indiana	760,045	25.5	6,637,426	111,505	3506	1,301,940	1680	8.56	52.82	3.14
Iowa	374,337	25.77	3,132,499	80,410	1265	718,279	2567	11.19	40.38	1.57
Kansas	324,803	25.22	2,908,776	52,700	595	474,749	1812	11.10	20.46	1.13
Kentucky	529,587	25.81	4,440,204	61,542	1111	1,047,995	1386	5.87	25.02	1.81
Louisiana	463,804	22.78	4,663,616	161,219	5368	2,178,999	3457	7.40	115.10	3.33
Maine	187,004	26.22	1,332,813	5077	139	374,138	381	1.36	10.43	2.74
Maryland	620,202	22.77	6,003,435	120,156	3879	1,529,476	2001	7.86	64.61	3.23
Massachusetts	809,926	25.41	6,830,193	127,540	9310	3,399,512	1867	3.75	136.31	7.30
Michigan	1,186,260	24.77	9,957,488	128,087	6969	3,318,469	1286	3.86	69.99	5.44
Minnesota	647,051	26.16	5,527,358	90,017	2017	1,838,392	1629	4.90	36.49	2.24
Mississippi	297,347	22.32	2,988,762	93,364	2810	703,163	3124	13.28	94.02	3.01
Missouri	708,384	25.03	6,090,062	114,170	1826	1,212,508	1875	9.42	29.98	1.60
Montana	125,588	25.48	1,041,732	10,299	157	302,813	989	3.40	15.07	1.52
Nebraska	211,366	25.49	1,904,760	41,083	442	423,360	2157	9.70	23.21	1.08
Nevada	284,753	23.58	2,922,849	75,804	1531	665,184	2593	11.40	52.38	2.02
New Hampshire	182,558	26.87	1,343,622	7947	438	401,689	591	1.98	32.60	5.51
New Jersey	1,010,209	23.71	8,881,845	199,762	16,067	3,352,791	2249	5.96	180.90	8.04
New Mexico	205,761	21.74	2,092,434	27,579	849	857,456	1318	3.22	40.57	3.08
New York	2,126,071	23.22	19,618,453	449,900	33,087	9,922,446	2293	4.53	168.65	7.35
North Carolina	1,048,568	23.78	10,155,624	193,547	3243	2,804,818	1906	6.90	31.93	1.68
North Dakota	80,851	25.74	752,201	17,958	192	562,599	2387	3.19	25.53	1.07
Ohio	1,397,664	25.06	11,641,879	144,309	4615	2,825,297	1240	5.11	39.64	3.20

(Continues)

TABLE 1 (Continued)

State	Myopia (in 2012) Case	Prevalence (%)	Population (2018)	COVID-19 (on 20 September 2020) Case	Death	Tested people	Incidence (per 0.1-million population)	Test positive (%)	Mortality (per 0.1-million population)	Fatality (%)
Oklahoma	415,135	24.41	3,918,137	76,807	946	1,072,504	1960	7.16	24.14	1.23
Oregon	461,765	25.23	4,081,943	30,801	526	636,069	755	4.84	12.89	1.71
Pennsylvania	1,582,240	24.83	12,791,181	154,867	7960	1,908,910	1211	8.11	62.23	5.14
Rhode Island	131,074	25.31	1,056,611	23,620	1088	675,108	2235	3.50	102.97	4.61
South Carolina	500,664	22.97	4,955,925	137,708	3199	1,132,595	2779	12.16	64.55	2.32
South Dakota	97,047	25.63	864,289	18,696	202	176,353	2163	10.60	23.37	1.08
Tennessee	738,545	24.65	6,651,089	183,514	2218	2,667,126	2759	6.88	33.35	1.21
Texas	2,348,771	22.74	27,885,195	713,007	15,088	5,593,488	2557	12.75	54.11	2.12
Utah	248,779	26.17	3,045,350	63,772	440	758,165	2094	8.41	14.45	0.69
Vermont	85,947	26.39	624,977	1715	58	155,895	274	1.10	9.28	3.38
Virginia	891,617	24	8,413,774	140,395	3013	1,882,028	1669	7.46	35.81	2.15
Washington	789,447	25.38	7,294,336	82,548	2037	1,723,040	1132	4.79	27.93	2.47
West Virginia	245,313	25.59	1,829,054	14,062	314	514,304	769	2.73	17.17	2.23
Wisconsin	706,079	25.85	5,778,394	101,227	1242	1,439,394	1752	7.03	21.49	1.23
Wyoming	67,008	25.74	581,836	4872	49	92,431	837	5.27	8.42	1.01

State	Demographic and socioeconomic characteristics Sex ratio (males per 100 females)	35 years and over (%)	Black or African American (%)	Bachelor's degree or higher (%)	Civilian unemployment (%)	No health insurance (%)	Poverty people (%)
Alabama	93.90	54.83	26.58	24.93	6.6	9.98	17.5
Alaska	109.25	48.64	3.27	29.23	7.4	14.42	7.5
Arizona	98.86	53.09	4.39	28.88	6.5	10.94	16.1
Arkansas	96.46	53.83	15.41	22.59	5.5	9.04	17.6
California	98.78	51.89	5.79	33.25	6.7	8.49	14.3
Colorado	101.11	52.42	4.12	40.15	4.7	8.12	10.9
Connecticut	95.24	56.93	10.56	38.94	6.5	5.58	10
Delaware	93.80	56.20	22.11	31.40	5.9	6.04	11.9
District of Columbia	90.34	47.81	46.94	57.57	7.4	4.02	16.8
Florida	95.68	58.36	16.10	29.17	6.3	13.53	14.8
Georgia	94.83	52.12	31.46	30.65	6.4	13.75	16
Hawaii	100.78	55.08	1.85	32.48	4.5	4.06	9.9
Idaho	100.39	51.49	0.68	26.92	4.7	11.03	13.8
Illinois	96.48	53.84	14.23	34.07	6.6	7.34	13.1
Indiana	97.17	53.38	9.33	25.91	5.4	9.12	14.1
Iowa	98.51	53.88	3.51	28.20	3.9	4.94	11.7
Kansas	99.32	51.96	5.84	32.89	4.4	9.00	12.4
Kentucky	97.04	54.71	7.98	23.62	6.1	6.09	17.9

TABLE 1 (Continued)

State	Demographic and socioeconomic characteristics						
	Sex ratio (males per 100 females)	35 years and over (%)	Black or African American (%)	Bachelor's degree or higher (%)	Civilian unemployment (%)	No health insurance (%)	Poverty people (%)
Louisiana	95.65	52.28	32.23	23.73	6.9	10.68	19.4
Maine	95.85	60.93	1.34	30.92	4.6	8.32	12.5
Maryland	94.09	54.75	29.78	39.63	5.6	6.47	9.4
Massachusetts	94.25	55.42	7.48	42.91	5.4	2.80	10.8
Michigan	96.85	55.50	13.81	28.60	6.5	6.06	15
Minnesota	99.14	53.89	6.19	35.45	3.9	4.66	10.1
Mississippi	94.28	52.82	37.67	21.82	8.2	12.67	20.8
Missouri	96.37	54.45	11.57	28.63	5.1	9.72	14.2
Montana	101.30	55.90	0.44	31.20	4.2	10.22	13.7
Nebraska	99.48	51.87	4.77	31.33	3.5	8.42	11.6
Nevada	100.79	53.95	8.93	24.25	6.9	11.92	13.7
New Hampshire	97.99	58.84	1.53	36.49	4	6.51	7.9
New Jersey	95.38	56.23	13.47	38.89	6.1	8.47	10.4
New Mexico	98.04	53.22	2.06	27.12	7.2	10.71	20
New York	94.26	54.77	15.64	35.93	6	6.48	14.6
North Carolina	94.89	54.57	21.46	30.50	6.3	11.06	15.4
North Dakota	105.51	50.08	2.72	29.45	2.8	7.40	10.9
Ohio	96.06	55.25	12.35	27.79	5.8	6.48	14.5
Oklahoma	98.23	51.87	7.35	25.18	5.3	14.22	16
Oregon	98.26	55.81	1.91	32.90	6	7.27	14.1
Pennsylvania	95.94	56.71	11.13	30.77	5.8	6.24	12.8
Rhode Island	94.49	55.87	6.55	33.27	6.1	5.21	13.1
South Carolina	94.33	55.20	27.03	27.41	6.4	11.02	16
South Dakota	101.69	52.39	1.88	28.48	3.5	9.39	13.6
Tennessee	95.19	54.69	16.80	26.62	5.9	10.09	16.1
Texas	98.68	49.21	12.07	29.30	5.4	17.38	15.5
Utah	101.33	43.75	1.18	33.26	3.9	9.99	10.3
Vermont	97.15	58.70	1.29	37.32	4.1	4.10	11.2
Virginia	96.80	54.20	19.17	38.16	5	9.22	10.9
Washington	99.92	53.68	3.70	35.25	5.3	6.79	11.5
West Virginia	97.77	58.82	3.65	20.26	6.7	6.49	17.8
Wisconsin	98.84	55.40	6.38	29.52	4	5.77	11.9
Wyoming	104.26	53.09	0.95	26.89	4.5	11.35	11.1

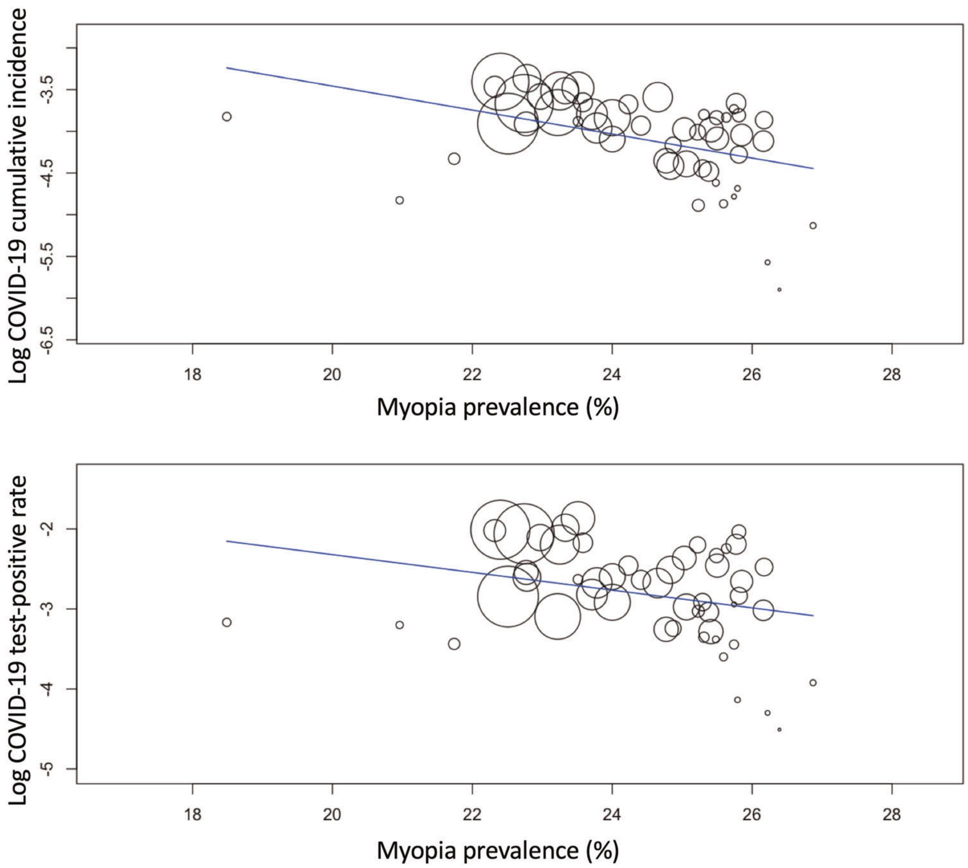

FIGURE 1 Inverse-variance weighted regression graphs depicting COVID-19 cumulative incidence (upper panel) and test-positive (lower panel) rates (plotted as the logarithm-transformed data on the *y*-axis) as a function of myopia prevalence rates (plotted on the *x*-axis). Each circle represents a state with an area proportional to the inverse of the variance of COVID-19 incidence/test-positive rates

wearing eyeglasses with less frequent COVID-19 infection. Similar to their study, which compared the proportion of COVID-19 patients who wore "eyeglasses" (all of them suffered "myopia") with that of "myopia" patients (not subjects who wore "eyeglasses") in the general population, the present study investigated the proportion of "myopia" patients (not subjects who wore "eyeglasses") because of unavailable data on wearing "eyeglasses." The sample size, however, was far greater in the present study (approximately 6.8-million COVID-19 patients and 34-million myopia ones in the entire United States) than in the study by Zeng et al.[1] (merely 276 COVID-19 patients and 16 myopia ones at a city in China).

Angiotensin-converting enzyme 2 (which is known as a SARS-CoV-2 receptor) has been identified in the human retinal as well as non-retinal ocular structure.[2] One-third of COVID-19 patients suffered conjunctivitis (including conjunctival hyperemia, chemosis, epiphora, or increased secretion) which is more frequent in patients with more severe COVID-19.[3] Eyeglasses may evade hand-to-eye transfer of the virus by means of restraint and dissuasion of feeling eyes.[1] The "COVID-19 advice for the public" by the World Health Organization (WHO) (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public) also recommends to avoid touching eyes.

Several issues should be noted as limitations of the present study. First, although the myopia prevalence was provided in merely ≥40-year subjects, the COVID-19 cumulative incidence was reported in all-age subjects. Second, the myopia prevalence is 1.8-fold greater in Whites (26.4%) than in Blacks (14.5%) (http://www.visionproblemsus.org/vpus-search.html), whereas the COVID-19 incidence is 2.6-time higher in Blacks than in White (https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-race-ethnicity.html). Hence, in states with greater proportion of Whites, myopia prevalence and COVID-19 incidence would be higher and lower, respectively. Zeng et al,[1] however, did not address these confounders. In the present study, the proportions of Black (or African American) and ≥35-year subjects (because of unavailable proportions of ≥40-year subjects) were entered into the multivariable regression as potential confounders, which indicated still a significant and negative association of the myopia prevalence with the COVID-19 incidence and the test-positive rate. Third, although the myopia prevalence in 2012 was calculated using the Census 2010 populations, COVID-19 incidence was defined using the populations in 2018 from the "2014–2018 ACS 5-Year Data Profile." More recent data on myopia prevalence, however, have not been procurable to date. Fourth, as aforementioned, the proportion of "myopia" patients instead of subjects who wore "eyeglasses" was analyzed in the present study, which may bias the suggested negative association of wearing eyeglasses with COVID-19 infection.

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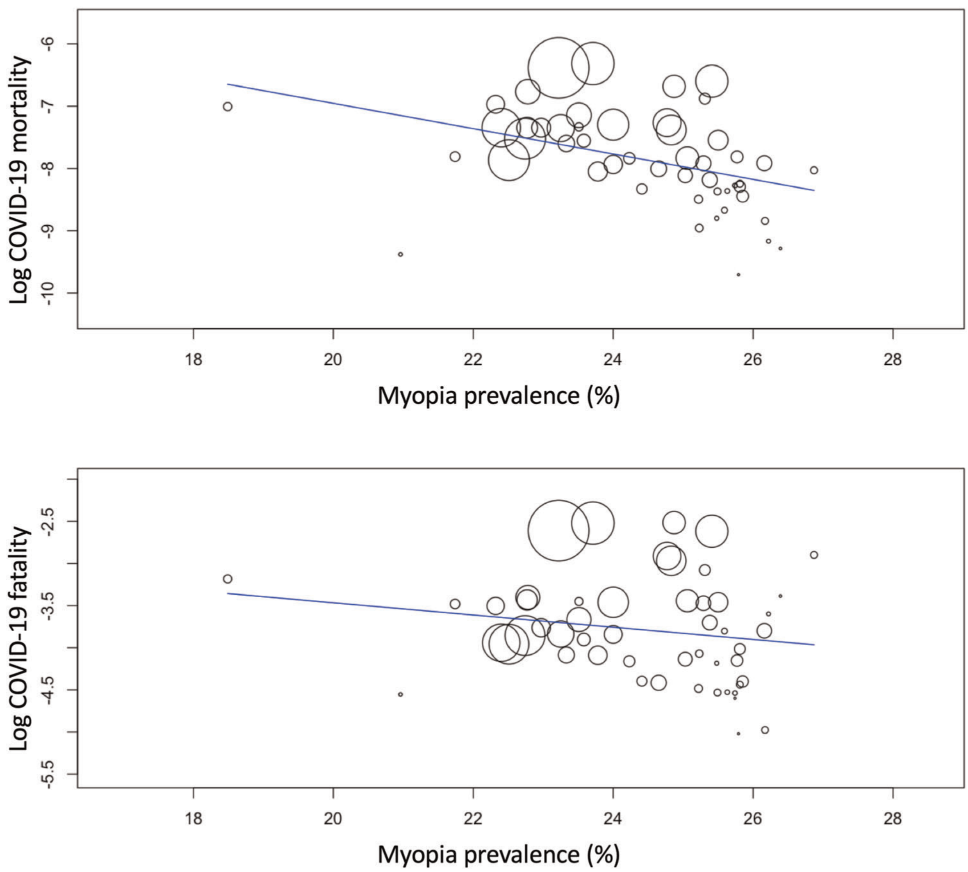

FIGURE 2 Inverse-variance weighted regression graphs depicting COVID-19 mortality (upper panel) and fatality (lower panel) rates (plotted as the logarithm-transformed data on the *y*-axis) as a function of myopia prevalence rates (plotted on the *x*-axis). Each circle represents a state with an area proportional to the inverse of the variance of COVID-19 mortality/fatality rates

TABLE 2 Results of the multivariable regression

	Prevalence (per population)				Test positive (%)				Mortality (per population)			
Covariate	Coefficient	LLCI	ULCI	*p* value	Coefficient	LLCI	ULCI	*p* value	Coefficient	LLCI	ULCI	*p* value
Myopia prevalence (%)	**−0.123**	**−0.235**	**−0.011**	**.031***	**−0.120**	**−0.236**	**−0.005**	**.042***	**−0.007**	**−0.163**	**0.148**	**.926**
Sex ratio (males per 100 females)	−0.106	−0.172	−0.040	.002*	−0.142	−0.219	−0.065	<.001*	−0.175	−0.281	−0.070	.001*
35 years and over (%)	−0.117	−0.166	−0.068	<.001*	−0.107	−0.164	−0.050	<.001*	−0.059	−0.136	0.017	.129
Black or African American (%)	0.006	−0.012	0.024	.506	−0.001	−0.022	0.019	.902	−0.001	−0.029	0.027	.950
Bachelor's degree or higher (%)	−0.047	−0.076	−0.019	<.001*	−0.066	−0.099	−0.033	<.001*	−0.008	−0.052	0.036	.712
Civilian unemployment (%)	−0.043	−0.159	0.074	.471	−0.166	−0.302	−0.030	.017*	0.181	−0.002	0.364	.053
No health insurance (%)	0.017	−0.026	0.060	.436	0.053	0.002	0.103	.040*	0.003	−0.065	0.070	.940
Poverty people (%)	−0.057	−0.119	0.006	.075	−0.072	−0.145	0.001	.053	−0.061	−0.158	0.037	.223

Abbreviations: LLCI, lower limit of 95% confidence interval; ULCI, upper limit of 95% confidence interval.

*Statistically significant.

Finally, during the COVID-19 pandemic period, some people may have worn a face shield as a preventive behavior against COVID-19. The combination of a face mask and a face shield could crucially retard the COVID 19 spread.[4]

In conclusion, on the basis of data from US states, myopia prevalence was independently and negatively associated with the COVID-19 cumulative incidence and the test-positive rate (neither the mortality nor the fatality), which suggests that wearing eyeglasses may be negatively correlated to COVID-19 infection but doesn't import that a myopia patient is at low risk of COVID-19 infection.

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Abbreviations: LLCI, lower limit of 95% confidence interval; ULCI, upper limit of 95% confidence interval.*Statistically significant.

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