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ORIGINAL ARTICLE

Impact of social distancing policy on pediatric emergency ophthalmic severity during the coronavirus disease 2019 pandemic

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Abstract

Background: We investigated the impact of social distancing policies (SDPs) on ophthalmic severity in children who underwent emergency ophthalmic referrals during the coronavirus disease 2019 pandemic period.

Methods: We reviewed all children with ophthalmic referrals in a single academic hospital emergency department during the period from February 2017 to December 2019 (prepandemic) or February 2020 to December 2022 (pandemic). Baseline features, diagnosis-based severity, and outcomes were compared between the two periods. The Government Response Stringency Index (GRSI), which ranges from 0 to 100, was used as a surrogate for the intensity of SDPs during the pandemic. Poisson regression was used to quantify the association of the GRSI with the severity.

Results: Among 1074 children with ophthalmic referrals, 437 (40.7%) visited during the pandemic. This was 31.4% lower than that during the prepandemic period. In numbers, pandemic-related declines were more modest in high severity than in medium-to-low severity (35.1% vs. 55.0%), and for injury than for illness (28.5% vs. 36.1%). In percentages, high severity increased from 63.3% to 71.3% ($p=0.016$). The hospitalization rate increased from 1.7% to 3.9% ($p=0.029$). For every 10-point increase in GRSI, there was a 20.0% decrease in high severity (95% confidence interval, 5%–30%).

Conclusions: This study shows an inverse association of SDPs with ophthalmic severity and an increase in severe cases along with consistent flow of injury cases, amid the overall decline in eye-related visits to the emergency department during the pandemic period.

KEYWORDS
COVID-19, eye diseases, eye injuries, ophthalmology, physical distancing

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic strengthened compulsory viral testing and isolation processes in emergency departments (EDs), social distancing policies (SDPs), and guardians' concerns for nosocomial infection, leading to a 56.7% to 63.8% decrease in overall pediatric ED visits.[1–4] This downtrend would have been reproduced in children's eye-related ED visits in developed countries. Specifically, pediatric eye-related visits to or ophthalmic referrals in EDs decreased by 51.0%–89.5% in the USA,[5,6] 51.6% in Israel,[7] 47.1%–50.6% in Türkiye,[8,9] 46.1% in France,[10] and 42.8% in Spain.[11] Previous studies reflect government policies in a qualitative fashion—for example, lockdown versus post-lockdown. Furthermore, they used diagnoses based

on the International Classification of Diseases codes or broad terms that were not confirmed by pediatric ophthalmologists.

Although the COVID-19 pandemic is over, for future pandemics, pediatricians and emergency physicians need to allocate pediatric emergency resources properly for specific needs, such as ophthalmologist practices. Hence, we analyzed the pandemic-related changes in pediatric ophthalmic referrals, and tested a possible association of the governmental stringency of SDPs, such as school closure, with ophthalmic severity (hereafter, "severity") in children who visited an ED in Korea. For this purpose, we used quantitative data on the intensity of SDPs during the pandemic and detailed diagnoses provided by pediatric ophthalmologists.

METHODS

Study design, setting, and population

This retrospective study is a planned secondary analysis of a single academic hospital ED-based study on pediatric ophthalmic referrals.[12] The hospital is situated in Gyeonggi-do Province, Korea, which has an under-18 population of approximately 2,200,000. Before the COVID-19 pandemic, the ED attended to roughly 21,000 children annually, which adjusted to 12,000–19,000 during the pandemic. The ED is staffed by board-certified emergency physicians or pediatricians, or emergency medicine residents in postgraduate years 4–5 (ie, senior residents in Korea), and maintains a 24/7 on-call ophthalmologist practice. Children presenting with ocular symptoms are initially evaluated by the professionals and, if it is deemed necessary, are referred to the ophthalmologists. The criteria for referral did not change throughout the pandemic. Routine ophthalmic examinations are conducted in order of visual acuity, intraocular pressure, slit lamp, pupil, ocular movement, and fundus, using age-appropriate methods.[13,14]

We included children (<18 years) with ocular injury or illness, who visited the ED from February 1, 2017 through December 31, 2019 (prepandemic) or from February 1, 2020 through December 31, 2022 (pandemic). In the case of multiple visits, the index visit was analyzed to ensure the independence of each visit. Exclusion criteria were visits for procedural complications and discharges before thorough ophthalmic examinations. This study was approved by the institutional review board with a waiver for informed consent (IRB no. AJOUIRB-DB-2024-066).

Coronavirus disease 2019 situation in Korea

The pandemic period was defined based on the World Health Organization's declaration of "public health emergency of international concern," which was valid from January 30, 2020 through May 5, 2023. In Korea, the first adult case of COVID-19 was confirmed on January 20, 2020, and the epidemic started in the following month. During the period from March 2020 to April 2022, Korean government implemented a set of SDPs, such as mask mandates, without issuing a stay-at-home order. The school closure phase was defined as February to May 2020 (cf., school attendance, June 2020 to December 2022). The decision was based on the fact that after the winter break (late December to early February), school reopening was postponed until mid-February, and the schools reopened gradually from May 13 through June 1, 2020.[15]

Government Response Stringency Index

The Government Response Stringency Index (GRSI) is a quantitative, country-based, composite measure based on nine indicators of SDPs, including school closure, workplace closure, cancellation of public events, restrictions on gatherings, public transportation, stay-at-home order, restrictions on internal movement, international travel controls, and public information campaigns.[16] The index, which ranges from 0 to 100, was reported daily during 2020 and 2022 on the Oxford COVID-19 Government Response Tracker.[16] The GRSI quantified how Korean governmetal SDPs were stringent.[3,16] Among the six developed countries cited in the introduction, the mean GRSI was lowest in Korea (Supporting Information, Table S1).

Data collection

The following data were collected: age, age groups (0–3, 4–6, 7–12, and 13–17 years), sex, injury, transfer form another hospital, at night, and on weekend/holiday, ED-assigned high acuity (Korean Triage and Acuity Scale level 1–2),[12,17] arrival-referral time (minutes from arrival at the ED to the first referral), referral-answer time (minutes from the first referral to posting ophthalmologist's diagnosis), diagnosis-based severity (see details in below section), emergency surgery or hospitalization to Department of Ophthalmology. We analyzed the mechanism and place of injury, and chief illness complaint.[12]

Diagnosis-based severity

Diagnoses entered by the ophthalmologists in the medical records were rated by the following levels of severity: "high," requiring emergency surgery or hospitalization (eg, corneal penetrating laceration), "medium," requiring only on-call ophthalmologist practice (eg, uveitis), and "low," requiring follow ups or medication (eg, conjunctivitis). This rating was primarily based on a table from a 2006–2011 US Nationwide ED sample-based

study, which classified ophthalmic diagnoses as "likely emergent," "unlikely emergent," and "could not determine," corresponding to the "high," "medium," and "low" severities, respectively.[18] Unrated diagnoses were evaluated by a pediatric ophthalmologist (SA Chung). In the case of multiple diagnoses, a representative one was chosen based on the severity and clinical context. Diagnoses that did not require ophthalmic referrals, such as eyelid injury repaired by an emergency physician, were not considered.

Statistical analysis

Data were presented as medians with interquartile ranges or means ± standard deviations and as percentages and numbers for continuous and categorical variables, respectively. They were compared using the Mann–Whitney *U*-tests, analyses of variance, χ^2 tests, or Fisher's exact tests. Given the expected nature of the pandemic-related decrease in number of visits, we primarily compared percentages, unless specified as "in number (s)." To quantify a possible association of the stringency of SDPs with severity as a dependent variable, Poisson regression models were constructed with month, year, and GRSI as fixed effects. Regression discontinuity in time was used to estimate a pandemic effect on high severity. Statistical significance was defined as $p<0.05$. We used R Statistical Software, version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS Statistics for Windows, version 25.0 (IBM Corp, Armonk, NY).

RESULTS

Study population

During the prepandemic period, 84,401 children visited the ED. Of these, 1695 had ocular symptoms, of whom 660 were referred to the ophthalmologists. During the pandemic, 40,649 children (down by 51.8% in numbers from the prepandemic period) visited the ED. Of these, 918 had ocular symptoms, of whom 446 were referred to the ophthalmologists. After excluding 32 children, we analyzed 1074, which consisted of 637 prepandemic cases and 437 cases during the pandemic; down by 31.4% in number, from the prepandemic period; Figure 1).

Baseline characteristics

From the pre-pandemic to pandemic periods, increases were noted in the age of 7–12 years, high severity, and

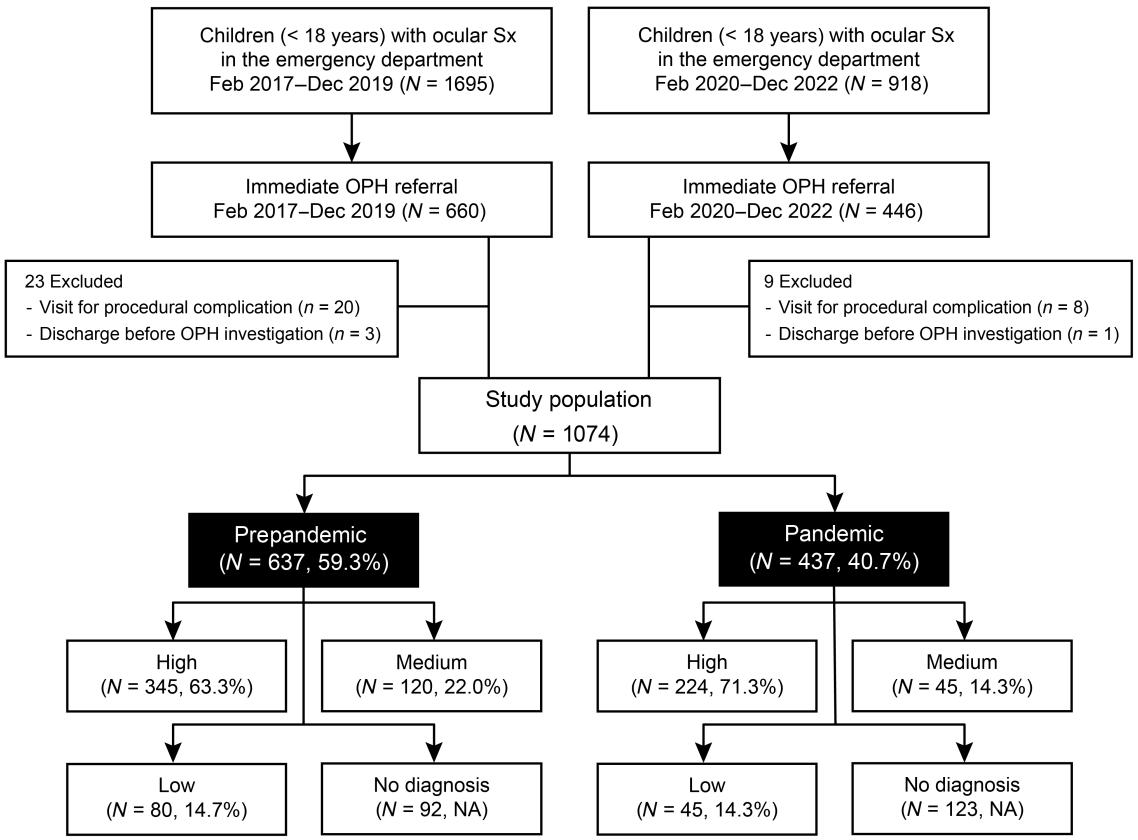

FIGURE 1 Flowchart for selection of the study population. "High," "Medium," and "Low" denote OPH severity. OPH, ophthalmic; Sx, symptom.

hospitalization, while decreases were noted in the age of 13–17 years, visits via transfers, and medium severity (Table 1). In terms of numbers, high severity cases were down by 35.1% (from 345 to 224), whereas medium-to-low severity cases were down by 55.0% (from 200 to 90). Injury showed no change in percentages, and a smaller decrease in numbers compared to illness (injury, down by 28.5% from 393 to 281 vs. illness, down by 36.1% from 244 to 156). As for the mechanism or place of injury, or chief complaint of illness, both in percentages and numbers, cases of falls, home, and foreign body sensation/mass increased, whereas motor vehicle accidents and swelling/erythema decreased (Table 2).

Trends in ophthalmic referrals, high severity cases, and effect of SDPs

As Figure 2a shows, during the early pandemic period, numbers of injury- and illness-induced referrals reached their nadirs. This overlapped with the school closure phase, with subsequent rebounds. Meanwhile, a decline in high severity cases lagged behind such declines in the referrals. A trade-off was observed between high severity and GRSI. To further analyze the trade-off, we compared the school closure and attendance phases. High severity was more frequently observed in the school closure phase (closure, 92.0% [23/25] vs. attendance, 69.6% [201/289]; $p=0.017$). In contrast, medium severity cases showed no difference (8.0% [2/25] vs. 14.9% [43/289]; $p=0.551$), and low severity cases were more common in the school attendance phase (0% [0/25] vs. 15.6% [45/289]; $p=0.033$).

In the Poisson regression, after controlling for year and month, GRSI was negatively associated with the frequency of high severity (coefficient, −0.02; 95% confidence interval, −0.03 to −0.005), while not with medium or low severity (Table 3). The monthly number of children with high severity cases decreased by 7.49 during the pandemic period (Figure 2b).

Diagnosis-based severity

The diagnoses are listed in Supporting Information, Table S2. Among the top five diagnoses, all injuries were rated as high severity without an overall difference (prepandemic, 42.7% vs. pandemic, 39.8%; $p=0.346$; Table 4). In contrast, the illnesses showed heterogeneous severities with an overall decrease (23.2% vs. 17.8%; $p=0.033$). In detail, hyphema and cellulitis decreased,

TABLE 1 Baseline characteristics of the study population.

Variable	Total ($N=1074$)	Prepandemic ($N=637$)	Pandemic ($N=437$)	p
Age, years	8.0 (3.0–14.0)	9.0 (3.0–14.0)	8.0 (3.0–13.0)	0.229
Age group, years				
0–3	277 (25.8)[a]	162 (25.4)[a]	115 (26.3)	0.018
4–6	164 (15.3)[a]	99 (15.5)[a]	65 (14.9)	
7–12	280 (26.1)[a]	147 (23.1)[a]	133 (30.4)	
13–17	353 (32.9)[a]	229 (35.9)[a]	124 (28.4)	
Girls	357 (33.2)	206 (32.3)	151 (34.6)	0.449
Injury	674 (62.8)	393 (61.7)	281 (64.3)	0.385
Visit via transfer	343 (31.9)	219 (34.4)	124 (28.4)	0.038
Visit at night	536 (49.9)	311 (48.8)	225 (51.5)	0.391
Visit on weekend/holiday	397 (37.0)	225 (35.3)	172 (39.4)	0.178
ED-assigned high acuity[b]	43 (4.0)	29 (4.6)	14 (3.2)	0.268
Arrival-referral time, min	59.0 (31.0–108.0)	58.0 (29.0–108.0)	61.0 (37.0–103.0)	0.097
Referral-answer, min	21.0 (6.0–56.3)	15.0 (4.0–42.5)	30.0 (11.0–80.0)	<0.001
High severity[c]	569 (66.2)	345 (63.3)	224 (71.3)[a]	0.016
Medium severity[c]	165 (19.2)	120 (22.0)	45 (14.3)[a]	0.006
Low severity[c]	125 (14.6)	80 (14.7)	45 (14.3)[a]	0.889
Emergency surgery	30 (2.8)	14 (2.2)	16 (3.7)	0.153
Hospitalization[c,d]	28 (2.6)	11 (1.7)	17 (3.9)	0.029

Note: Values are expressed as medians (interquartile ranges) or numbers (with percentages in parentheses).

Abbreviation: ED, emergency department.

[a] The sums of proportions are not equal to 100% due to rounding.

[b] Korean Triage and Acuity Scale 1–2.

[c] Given the absence of ophthalmic diagnoses, the denominators are 859, 545, and 314 in the order of column.

[d] To Department of Ophthalmology.

TABLE 2 Mechanism and place of injury, or chief complaint of illness.

Variable	Total ($N=1074$)	Prepandemic ($N=637$)	Pandemic ($N=437$)	p
Mechanism of injury				
Sports	160 (14.9)	102 (16.0)	58 (13.3)	0.215
Impact/compression	112 (10.4)	74 (11.6)	38 (8.7)	0.124
Poke	67 (6.2)	36 (5.7)	31 (7.1)	0.337
Fall	86 (8.0)	39 (6.1)	47 (10.8)	0.006
Assault	74 (6.9)	42 (6.6)	32 (7.3)	0.643
Cut/scratch/pierce	76 (7.1)	40 (6.3)	36 (8.2)	0.219
Chemical/burn	57 (5.3)	28 (4.4)	29 (6.6)	0.108
Motor vehicle accident	23 (2.1)	19 (3.0)	4 (0.9)	0.021
Foreign body	19 (1.8)	13 (2.0)	6 (1.4)	0.415
Places of injury				
Home	273 (25.4)	136 (21.4)	137 (31.4)	<0.001
Playground	186 (17.3)	119 (18.7)	67 (15.3)	0.154
Road	109 (10.1)	74 (11.6)	35 (8.0)	0.054
Educational facility	73 (6.8)	43 (6.8)	30 (6.9)	0.942
Public	30 (2.8)	19 (3.0)	11 (2.5)	0.649
Others	3 (0.3)	2 (0.3)	1 (0.2)	>0.999
Chief complaint of illness				
Swelling/erythema	86 (8.0)	67 (10.5)	19 (4.3)	<0.001
Red eye	47 (4.4)	31 (4.9)	16 (3.7)	0.343
Eye pain	36 (3.4)	16 (2.5)	20 (4.6)	0.065
Itching sensation	29 (2.7)	21 (3.3)	8 (1.8)	0.145
Visual loss/blur				
Painless	36 (3.4)	16 (2.5)	20 (4.6)	0.065
Painful	29 (2.7)	18 (2.8)	11 (2.5)	0.759
Other visual	29 (2.7)	17 (2.7)	12 (2.7)	0.939
Foreign body sense/mass	24 (2.2)	9 (1.4)	15 (3.4)	0.028
Rash/vesicle	25 (2.3)	18 (2.8)	7 (1.6)	0.191
Eye discharge	14 (1.3)	10 (1.6)	4 (0.9)	0.353
Diplopia	23 (2.1)	12 (1.9)	11 (2.5)	0.481
Other symptoms	22 (2.0)	9 (1.4)	13 (3.0)	0.076

Note: Values are expressed as numbers (with percentages in parentheses).

whereas chemical burns and corneal abrasions due to illness increased in both percentages and numbers. Among the categories of cellulitis, periorbital cellulitis (the sole medium severity case) decreased by 6.4%, whereas the other categories showed a 0.2% to 0.4% change. During the pandemic period, among the top five diagnoses, injury was more common in the school-closure phase (Figure 3).

DISCUSSION

This study has the following implications arisen from the long-term changes in ophthalmologist practice in the ED due to the COVID-19 pandemic period. During the pandemic, the stringency of SDPs imposed by Korean government was inversely associated with high severity cases. From the prepandemic period to the pandemic period, the reductions in numbers were more modest in high-severity cases than in medium-to-low severity cases, and in injury cases than in illness cases.

This study is comparable to the relevant studies in terms of the age, diagnosis, and long-term pandemic-related changes. The median age of our study population approximates to the mean age reported in US and Turkish studies (8.0 vs. 7.9–9.7 years).[6,8] Many studies consistently cited trauma, conjunctivitis, and hordeolum as frequent diagnoses,[5–7,10] as well as foreign bodies, corneal abrasions, and cellulitis in some studies.[8,11] These are encompassed by our top five diagnoses (Table 4). However, the decrease in the number of ophthalmic referrals was smaller than the previously reported (31.4% vs. 42.8%–89.5%).[5–11] The

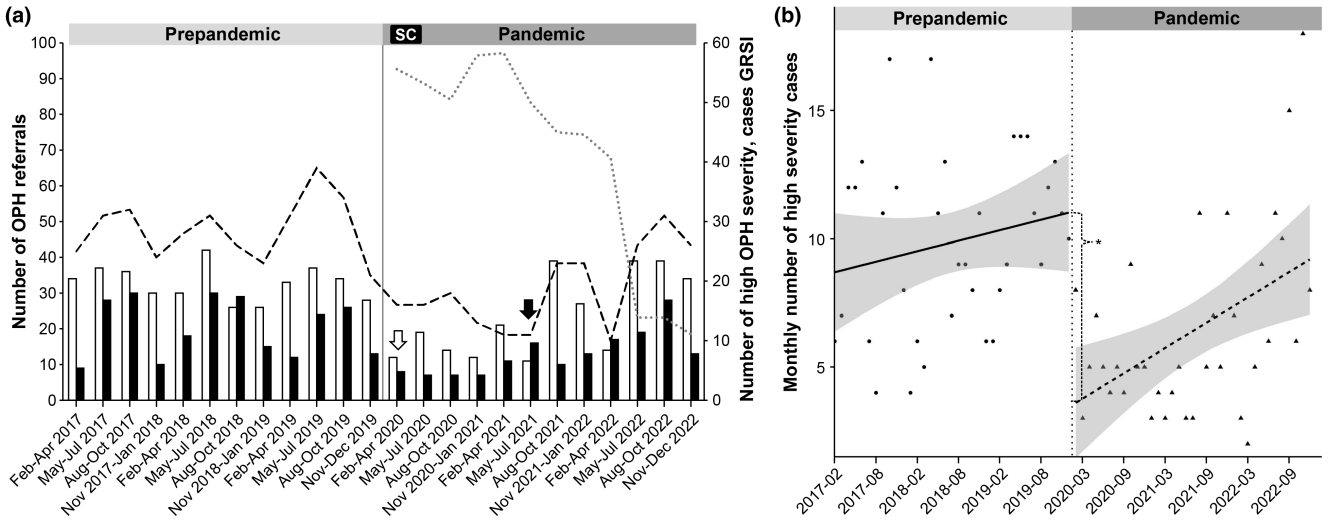

FIGURE 2 Trends in OPH referrals, high severity, and effects of social distancing policies. Vertical lines indicate the starting point of the coronavirus disease 2019 pandemic. (a) Quarterly trend of the referrals, high severity, and GRSI. Open and shaded bars indicate the numbers of the injury- and illness-induced referrals, respectively, during each 3 month interval. "SC" denotes the school closure phase, coinciding with a nadir of referrals (open arrow; February–April 2020), and preceding a nadir of high severity (shaded arrow; May–July 2021). A trade-off is shown between high severity (dashed line) and GRSI (dotted line). (b) Regression discontinuity in time analysis. Each circle and triangle indicates the monthly numbers of high severity. Shades indicate 95% CIs of slopes. A slope during the prepandemic (solid line) is 0.07 (95% CI, −0.04 to 0.18; $p=0.221$), whereas a slope during the pandemic (dash line) is 0.10 (95% CI, −0.06 to 0.25; $p=0.226$). An asterisk indicates an estimated change in monthly number of high severity (−7.49; 95% CI, −10.65 to −4.32; $p<0.001$). CI, confidence interval; GRSI, Government Response Stringency Index; OPH, ophthalmic.

TABLE 3 Poisson regression models.

Independent variable	Coefficient (95% confidence interval)	Standardized coefficient	Standard error	*Z* value	*p*
High severity[a]					
Intercept	144.21 (−424.24 to 687.43)	—	282.98	0.51	0.610
Year	−0.07 (−0.34 to 0.21)	0.93	0.14	−0.50	0.615
Month	0.05 (0.01 to 0.09)	1.05	0.02	2.21	0.027
GRSI	−0.02 (−0.03 to −0.005)	0.98	0.01	−2.71	0.007
Medium severity[b]					
Intercept	−625.60 (−2112.57 to 646.94)	—	696.60	−0.90	0.369
Year	0.31 (−0.32 to 1.04)	1.36	0.34	0.90	0.368
Month	0.02 (−0.08 to 0.13)	1.02	0.05	0.45	0.651
GRSI	−0.02 (−0.05 to 0.01)	0.98	0.02	−1.19	0.235
Low severity[c]					
Intercept	−2155.66 (−4044.89 to −639.27)	—	865.68	−2.49	0.013
Year	1.07 (0.32 to 2.00)	2.91	0.43	2.49	0.013
Month	0.00 (−0.12 to 0.13)	1.00	0.06	0.00	0.996
GRSI	0.00 (−0.03 to 0.04)	1.00	0.02	0.10	0.921

Abbreviation: GRSI, Government Response Stringency Index.

[a]Akaike information criterion = 164.5; Hosmer-Lemeshow goodness-of-fit test, $p=0.571$.

[b]Akaike information criterion = 104.2; Hosmer-Lemeshow goodness-of-fit test, $p=0.829$.

[c]Akaike information criterion = 102.3; Hosmer-Lemeshow goodness-of-fit test, $p=0.906$.

disparity might be partly explained by our longer study period compared with that of previous studies (35 months in our study vs. 2–13 months in previous studies).[5–8,10] The nadir during the early pandemic followed by the rebound of referrals in our study (Figure 2a) is in agreement with a Spanish study that showed a 57.4% decrease in annual eye-related ED visits in 2019–2020, followed by a 68.5% increase in 2020–2021.[11]

TABLE 4 Top five diagnoses.

Diagnosis	Total ($N=1074$)	Prepandemic ($N=637$)	Pandemic ($N=437$)	p
Injury	446 (41.5)	272 (42.7)	174 (39.8)	0.346
Hyphema (H)	144 (13.4)	101 (15.9)	43 (9.8)	0.004
Orbital fracture (H)	141 (13.1)	86 (13.5)	55 (12.6)	0.663
Corneal abrasion (H)	76 (7.1)	42 (6.6)	34 (7.8)	0.456
Laceration (H)	45 (4.2)	26 (4.1)	19 (4.3)	0.831
Chemical burn (H)	40 (3.7)	17 (2.7)	23 (5.3)	0.027
Illness	226 (21.0)	148 (23.2)	78 (17.8)	0.033
Keratoconjunctivitis (H-L)	119 (11.1)	74 (11.6)	45 (10.3)	0.499
Herpes zoster (H)	26 (2.4)	24 (3.8)	2 (0.5)	
Herpes simplex (H)	8 (0.7)	5 (0.8)	3 (0.7)	
Glaucomatocyclitic crisis (H)	2 (0.2)	0 (0)	2 (0.5)	
Bacterial (M)	8 (0.7)	4 (0.6)	4 (0.9)	
Viral/idiopathic (M)	21 (2.0)	4 (0.6)	17 (3.9)	
Keratoconjunctivitis sicca (L)	2 (0.2)	2 (0.3)	0 (0)	
Epidemic (L)	22 (2.0)	20 (3.1)	2 (0.5)	
Allergic (L)	29 (2.7)	15 (2.4)	14 (3.2)	
Phlyctenular (L)	1 (0.1)	0 (0)	1 (0.2)	
Cellulitis (H-M)	68 (6.3)	57 (8.9)	11 (2.5)	<0.001
Orbital (H)	7 (0.7)	3 (0.5)	4 (0.9)	
Dacrocystitis (H)	4 (0.4)	3 (0.5)	1 (0.2)	
Dacryoadenitis (H)	1 (0.1)	1 (0.2)	0 (0)	
Periorbital (M)	56 (5.2)	50 (7.8)	6 (1.4)	
Hordeolum/chalazion (L)	15 (1.4)	8 (1.3)	7 (1.6)	0.635
Corneal abrasion (H)	14 (1.3)	4 (0.6)	10 (2.3)	0.018
Optic neuritis (M)	10 (0.9)	5 (0.8)	5 (1.1)	0.539

Note: Values are expressed as numbers (with percentages in parentheses). Severity is parenthesized. H, High; M, Medium; L, Low.

As shown by the regression model, the negative association of GRSI with severity means that for every 10-point decrease in GRSI, there was a 20.0% increase on average in high severity cases (95% confidence interval, 5%–30%). In that model, the positive association of "month" with high severity is parallel to the time-related increase in that severity during the pandemic period (Figure 2b). Korea's lowest GRSI among the developed countries (Table S1) proves low-key SDPs in Korea, consistent with the absence of a stay-at-home order. High-severity cases increased in studies performed in France and Türkiye, where the mean GRSIs were similar to that of Korea (Supporting Information, Table S1).[8,10] In contrast, studies in the USA and Spain, in which GRSIs were higher than that of Korea, showed decreases in injury and high severity.[5,11]

We speculate that in Korea, the low-key SDPs maintained children's outdoor activities to some level, thereby leading to the slight rise in high-severity cases and the steady flow of injury during the pandemic period. A US nationwide study shows pandemic-related decreases in injuries related to sports (from 6.5% to 3.9%) and school activities (from 3.5% to 1.5%).[19] In contrast, we observed no such decreases in "playground" and "educational facility" injuries (Table 2). This discrepancy might be due to the less stringent SDPs in Korea than in the USA (Supporting Information, Table S1). The low-key SDPs in Korea likely allowed children to engage in injury-prone activities, such as sports, more frequently than their US counterparts.

We need to discuss the background of the rise in high severity along with steady flow of injury, amid an overall decrease in eye-related ED visits. First, an ocular injury inherently indicates a higher severity than an illness affecting the eyes. For example, laceration or foreign body is considered more urgent than conjunctivitis or hordeolum.[5,18] An injury like a corneal penetrating laceration or a chemical burn may directly jeopardize visual acuity. From the perspective of guardians, such injuries drive them to bring their children to EDs even during a pandemic period. This contrasts with conjunctivitis, which can be treated temporarily at home.

Second, hand washing or mask mandates primarily reduce the spread of viruses,[20–22] as shown by a decrease in conjunctivitis.[5,11,23] This phenomenon was exemplified by the fact that the injury's predominance over illness

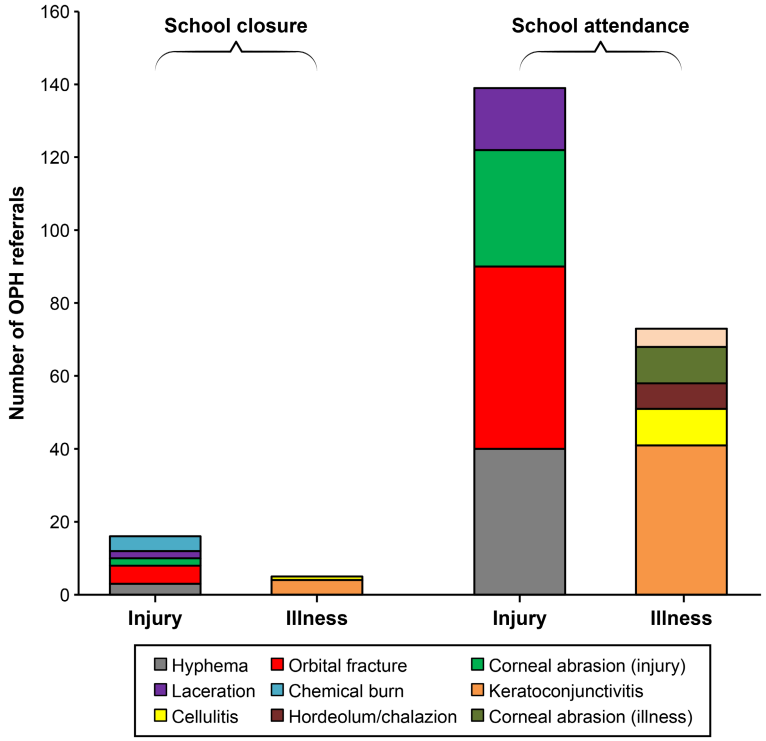

FIGURE 3 Top five diagnoses during the pandemic period. Injury was more common in the school closure phase than in the school attendance phase (76.2% vs. 65.6%). A gap between the percentages of injury and illness was larger in the former phase (52.4%=76.2% [16/21]–23.8% [5/21]) than in the latter phase (31.2%=65.6% [139/212]–34.4% [73/212]).

was greater in the school closure phase than in the school attendance phase (Figure 3). As shown in Figure 2a, the school closure overlapped with the nadir of overall referrals (i.e., injury plus illness). Thus, the SDP-induced prevention of viral infection may explain why the nadir of referrals preceded that of high severity. In contrast with the illnesses, which declined sharply, injury showed conflicting changes (Supporting Information, Table S1). We noted increases in numbers of domestic injury (Table 2) and chemical burns caused by hand sanitizers or disinfectants (Table 4) (prepandemic, one case vs. pandemic, five cases; data not shown). Such increases likely reflected pandemic-related behavioral changes, and counterbalanced the school-closure-induced decline in injury.[7,24–26]

Third, the low-key SDPs and relatively high activity level in Korea might have led to the steady occurrence of injury (Table 1). This feature may be related to a 22.4% gap in high severity between the school closure and attendance phases (92.0% vs. 69.6%, respectively), which is larger than the 8.0% gap in the severity between the prepandemic and pandemic periods (63.3% vs. 71.3%; Table 1).

This study has several limitations. First, being based in a single ED, the results may not be widely generalizable. Medical and social responses to a pandemic vary based on local circumstances. Thus, the implications of this study should be carefully applied to similar academic hospitals with the capability of providing a 24/7 on-call ophthalmologist practice. Second, the lack of standardized severity criteria for pediatric ophthalmic diagnoses suggests a potential for classification bias, despite our efforts to rate severity as rigorously as possible. Third, there might be another factor confounding the association of the SDPs with severity. We attempted to minimize this issue by controlling for month, year, and GRSI in the regression models. Social factors were probably controlled to some degree by the use of GRSI, which encompasses many social factors.

In conclusion, Korean government stringency with regard to SDPs was inversely associated with high severity cases during the COVID-19 pandemic period. During the period, children with high severity cases or injuries were referred to the ophthalmologists at a similar or higher frequency than those with medium-to-low severity or illness. This tendency could be related to the low-key SDPs in Korea and the fact that outdoor activity levels of children were maintained during the pandemic. During future pandemics, allowing for some outdoor activity may require preparing pediatric emergency resources for ophthalmologist practice, focusing on vision-threatening injuries. Targeted education on the prevention of ocular injury should also be implemented and adapted to the intensity of SDPs. During periods of high stringency (e.g., high GRSI or lockdown), guardians should be vigilant about domestic injuries, particularly from falls or hand sanitizers. As the restrictions reduce, outdoor activity can be a major source

of ocular injury. Thus, the focus of education should shift towards awareness of injury-prone activities, along with relevant preventive measures (e.g., use of protective eyewear for ball sports).

AUTHOR CONTRIBUTIONS

Hyung Kyoo Woo, Seung Ah Chung, and Jung Heon Kim designed the study. Hyung Kyoo Woo, Seung Ah Chung, and Jung Heon Kim collected and analyzed the data. Hyelynn Jeon, Bumhee Park, and Jung Heon Kim performed the statistical analyses. Hyung Kyoo Woo, Seung Ah Chung, and Jung Heon Kim drafted the manuscript. All authors read and approved the final manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ETHICAL APPROVAL

This study was approved by the institutional review board with a waiver for informed consent (IRB no. AJOUIRB-DB-2024-066).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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