treatment. Supportive, nonsurgical therapy was provided to one third of the patients (Table S4, available at www.aaojournal.org). The final visual acuity was not available for most injuries because of a lack of follow-up, but 10 patients (33%) had no light perception vision after the injury was addressed.

Our survey identified serious ocular sequelae associated with rubber bullets and other nonlethal projectiles, including ruptured globes, retinal detachments, and macular holes. Approximately one third of injuries resulted in near immediate and complete loss of vision in the involved eye. This is consistent with prior reports in the peer-reviewed literature.

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Ocular Symptoms among Nonhospitalized Patients Who Underwent COVID-19 Testing

The novel severe acute respiratory syndrome coronavirus 2, which causes a syndrome known as coronavirus 2019 (COVID-19), has been designated a global pandemic by the World Health Organization.[1] The vast majority of patients with COVID-19 are advised to isolate and recuperate at home. The stay-at-home restrictions and limited access to ambulatory ophthalmology care inadvertently may delay the recognition of ocular signs and symptoms associated with COVID-19.

Currently, we have minimal data on the incidence and severity of ocular manifestations of nonhospitalized COVID-19–positive patients. Characterizing ocular manifestations in this cohort will help ophthalmologists learn how, if at all, this virus affects the eye in an ambulatory population. To answer these questions, an electronic Research Electronic Data Capture (REDCap)[2,3] survey was developed (Appendix 1, available at www.aaojournal.org), and distributed to participants of the COVID Volunteer Research database, which was created by the Vanderbilt Institute for Clinical and Translational Research. Every adult who underwent testing for COVID-19 at one of Vanderbilt University Medical Center's walk-in locations was provided the opportunity to volunteer to participate in future research studies. Patients were tested either because of COVID-19–like symptoms or because they were at risk for occupational reasons or after exposure to an affected person. The database is maintained at a central secure location, and the survey was approved exempt by the institutional review board/ethics committee of Vanderbilt University Medical Center. The study was performed in accordance with the tenets of the Declaration of Helsinki. Study data were collected and managed using REDCap[2,3] tools hosted at Vanderbilt University Medical Center. The survey questionnaire was sent to participants independent of their COVID-19 test results. Basic demographic questions as well as underlying medical and ocular history were investigated. Allergy questions were added to tease out seasonal ocular and systemic symptoms that are common in the middle Tennessee region and may be mistaken for COVID-19 during the pandemic. Descriptive statistics were performed for this analysis.

The survey was distributed to approximately 1100 eligible persons who had provided written informed consent. Participants responded to the survey 1 to 4 weeks after receiving the results of their COVID-19 testing. A total of 458 surveys were completed during the study period. Eight surveys were removed from the analysis because of incomplete or missing data. Of the remaining 450 surveys, 144 (32.0%) were completed by persons showing positive results for COVID-19, and 306 (68.0%) were completed by persons showing negative results for COVID-19 (Table S1, available at www.aaojournal.org).

Table 1. Ocular Symptoms Experienced by Patients Showing Positive and Negative Results for Coronavirus 2019

Symptom	Positive Results, No. (%)	Negative Results, No. (%)	Odds Ratio	*P* Value
Red eyes	15 (10.4)	67 (21.9)	0.41	0.0024
Eye pain	28 (19.4)	56 (18.3)	1.08	0.8186
Epiphora	10 (6.9)	54 (17.6)	0.35	0.0016
Photophobia	20 (13.9)	60 (19.6)	0.66	0.147
Blurry vision	16 (11.1)	39 (12.7)	0.86	0.7287
Diplopia	2 (1.4)	5 (1.6)	0.85	0.8264
Flashes or floaters	17 (11.8)	33 (10.8)	1.11	0.7017
Scotoma	2 (1.4)	7 (2.3)	0.60	0.5189
Tunnel vision	5 (3.5)	7 (2.3)	1.54	0.4765
Flickering lights	3 (2.1)	5 (1.6)	1.28	0.7505
Other	8 (5.6)	29 (9.5)	0.56	0.1524

Among COVID-19–positive patients, the most common nonocular symptoms experienced were muscle aches or weakness (77.1%), cough (74.3%), headache (73.6%), loss of smell or taste (69.4%), and fever (68.1%). Other than the loss of smell or taste, these symptoms were experienced at a similar rate in respondents showing negative results for COVID-19, which is not surprising because they underwent testing as a result of the presence of flu-like symptoms (Table S2, available at www.aaojournal.org).

Approximately 47% (68/144) of COVID-19–positive patients reported at least 1 overlapping eye-related symptom. The most commonly reported ocular symptoms in survey respondents showing positive results for COVID-19 were eye pain (19.4%), photophobia (13.9%), flashes or floaters (11.8%), blurry vision (11.1%), and red eyes (10.4%). Only 20.6% (14/68) noted ocular symptoms before systemic symptoms, with 26.5% (18/68) of respondents still experiencing persistent eye symptoms despite recovery from systemic illness. Notably, 54% (164/306) of COVID-19–negative patients reported at least 1 ocular symptom. No statistically significant differences were found favoring these symptoms in COVID-19–positive patients compared with COVID-19–negative patients in our cohort. Red eye (21.9%) and excessive tearing (17.6%) were found at a significantly higher rate in COVID-19–negative survey respondents (Table 1). Similarly, 15.2% (25/164) noted ocular symptoms before systemic symptoms, with 23.2% of respondents (38/164) still experiencing persistent eye symptoms despite recovery from systemic illness, which was not statistically different from the COVID-19–positive cohort. Although more than 50% of the entire surveyed cohort reported some history of environmental allergy, no statistically significant difference was found between COVID-19–positive patients (53.5%) and COVID-19–negative patients (54.9%; Table S3, available at www.aaojournal.org).

To date, the reports on ocular findings have been limited. Conjunctivitis[4] has been reported; however, recent reports show a low prevalence of conjunctivitis and chemosis in COVID-19–hospitalized patients.[5,6] OCT and retinal findings of 12 adult patients from São Paulo, Brazil, described cotton-wool spots and microhemorrhages, suggesting ischemic changes in the papillomacular bundle with no signs of intraocular inflammation.[7] As clinics start to reopen, we must anticipate the ocular conditions that could represent either direct end-organ damage resulting from COVID-19 infection or sequelae after cytokine release, thromboembolic phenomena, or secondary ischemic events.

In our cohort, the most common symptoms experienced were red eye, photophobia, epiphora, and eye pain. Interestingly, some of these symptoms were more likely to be noted among COVID-19–negative patients rather than COVID-19–positive patients. Although it is important to take all necessary precautions, we hope these data will reassure patients and physicians that every red eye is not necessarily a sign of COVID-19. To elucidate further why several patients may have red eyes and seemingly allergic ocular symptoms, we explored the history of drug and environmental allergies among cohorts. The COVID-19–negative patients showed higher rates of self-reported drug allergies; this is of unclear clinical significance.

This analysis has several limitations. The analysis is based on patient reports, and therefore is subject to recall bias and selection bias. We received responses from 458 of more than 1000 participants, which may suggest patients with ocular symptoms were more likely to respond to a study about ocular associations with COVID-19. The study was conducted in an urban setting where the prevalence of COVID-19 was higher than in surrounding counties, and our respondents were predominantly white. The strengths of the study are the large number of responses from patients who were not hospitalized, which is more than 80% of affected COVID-19 patients.

In conclusion, this retrospective patient survey found no association between ocular symptoms and COVID-19 positivity in an outpatient population.

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Do Slit-Lamp Shields and Face Masks Protect Ophthalmologists amidst COVID-19?

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is transmitted primarily via respiratory droplets, contact with contaminated surfaces, or free-floating aerosols.[1,2] The American Academy of Ophthalmology recommends the use of surgical masks and commercially available slit-lamp shields (Breath Shields; Carl Zeiss AG, Oberkochen, Germany).[3] However, a lack of evidence exists regarding the true efficacy of slit-lamp shields. We attempted to replicate the spread of infected aerosols and large droplets in the clinical setting of a slit-lamp examination to evaluate the efficacy of protective equipment in reducing the risk of viral transmission.

This study adhered to the Declaration of Helsinki and institutional review board approval was not required. Aerosols were defined as smaller light particles that remain suspended in the air because of slowly settling velocity, whereas large droplets were defined as heavier particles that fall rapidly after a downward trajectory.[4] The experimental setup (Fig S1, available at www.aaojournal.org) consisted of a slit lamp (B900 Slit Lamp; Haag-Streit Holding AG, Köniz, Switzerland), a mannequin face that represented the ophthalmologist, and a spray bottle at the chin rest that represented respiratory particle production from the patient. A particle produced by the spray bottle had a peak velocity of 4.0 meters/second and a maximum horizontal distance of 2.35 m, which was comparable to particle behavior by coughing or sneezing. A high-speed camera capturing 1000 frames/second (Chronis 1.4; Kron Technologies, Inc., Burnaby, Canada) was used for video recordings (Fig 1). This process was repeated for 3 simulations: (1) no protective equipment; (2) commercially available slit-lamp breath shield installed; and (3) mask placed in front of the spray bottle (Fig S1). For simulation 3, 5 types of masks were used: an N95 respirator (N95 particulate respiratory 8210; 3M, Alexandria, MN), 3 surgical masks of different brands and bacterial filtration efficiencies ranging from 95% to 99%, and a cloth mask (bacterial filtration efficiency, 55%).

The outcome measure for aerosol transmission was the number of aerosol particles in a predefined region (Fig 1, rectangle area bordered in red [31.2 × 19.6 mm]). In total, we included 26 consecutive frames (6 ms apart) from the video recordings of each simulation. Two trained graders (Y.J.X., T.T.Y.F.) independently counted the number of aerosol particles within this region, with the mean of the 2 used as the final count. A 1-way analysis of covariance test was used to compare the number of particles in this region for each simulation. To determine the risk of large droplet transmission, identical simulations were repeated with Glo Germ liquid (Glo Germ Company, Moab, UT). The slit lamp, table, and mannequin were examined under ultraviolet A light for fluorescent droplets.

In simulation 1 (Fig 1A), aerosols remained suspended in the air, with the highest density anterior to the mannequin's mouth and nose. This density was reduced in simulation 2 (Fig 1B). In simulation 3 (Fig 1C), no particles could be observed for all 5 types of masks. The mean ± standard deviation number of particles in the region of interest was 42.7 ± 34.5 for simulation 1, 12.3 ± 5.7 for simulation 2, and 0.0 ± 0.0 for simulation 3 ($P < 0.001$; Fig S2, available at www.aaojournal.org). Post hoc analysis showed that simulation 3 had a statistically significantly lower aerosol count than simulation 2, which in turn had a lower aerosol count than simulation 1 ($P < 0.05$). Hyperfluorescent areas were found on the lower half of the mannequin, slit lamp, and table for simulation 1. In simulation 2, hyperfluorescent areas were seen on the mannequin's neck, the shield, the slit lamp, and the table. In simulation 3, the hyperfluorescent area was observed only on the inner surface of the masks (Fig 1).

The close proximity between the ophthalmologist and the patient increases risk of respiratory transmission of virus.[4] With or without the slit-lamp shield, aerosols congregated at the highest density in the region of the ophthalmologist's nose and mouth. Because SARS-CoV-2 remains viable in aerosols for hours,[2] a high concentration