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supervision were all concerns raised by patients. We suggest these findings be used to inform ophthalmology training programs on the importance of malpractice education, effective communication, and careful supervision methods. As performed in this study, we also encourage clinicians to evaluate malpractice cases themselves and understand the clinical decisions and outcomes that precipitate lawsuits. Although further research is needed to identify optimal methods to mitigate malpractice risk in trainees, we recommend attending physicians to maintain an open communication line with trainees and to review complicated or over-the-phone cases with both the trainee and patient. In addition to providing a smooth transition into a physician's career, preventing medical malpractice lawsuits has benefits in terms of physician wellness and burnout, the healthcare system, and, most importantly, the patient.

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Effectiveness of an Ophthalmic Hospital-Based Virtual Service during the COVID-19 Pandemic



The coronavirus disease 2019 (COVID-19) pandemic has posed challenges for healthcare providers,¹ while also bringing about new opportunities for telehealth services worldwide. Although media publicity for telehealth and virtual consultations has been widespread,² few peer-reviewed studies have been conducted to describe the characteristics and effectiveness of hospital-based telehealth virtual practice in response to the COVID-19 pandemic. In China, the Zhongshan Ophthalmic Center (ZOC) of Sun Yat-sen University established a virtual clinical service using several digital technologies³ (5G telecommunication networks, big data analytics, artificial intelligence,⁴ and blockchain technology⁵) to deliver online ophthalmic diagnosis and treatment services. This study analyzed the characteristics and effectiveness of a virtual service run by the tertiary ophthalmic center in China to construct a pragmatic paradigm for telehealth eye care services during and beyond the pandemic.

With lockdown regulations for the COVID-19 epidemic being implemented, from February 1 to 7, 2020, ZOC on-site registration was open for emergencies only. Comprehensive and specialist clinics were reopened gradually beginning on February 15, 2020. The ZOC internet hospital was launched on February 1 to provide patients with diagnosis and treatment options. Three interlinked modules constituted the main body of the ZOC internet hospital: artificial intelligence prescreening by chatbot and image recognition,⁶ virtual live consultation with ophthalmologists, and online pharmacy for prescription renewals and remote drug delivery (details in [Fig S1A](#), available at www.aaojournal.org).

We extracted clinical services records from virtual 2020, face-to-face 2020, and face-to-face 2019 encounters from February 1 through March 13 for analysis, including patient age, gender, address, date and hour for consultation, transcript records of online communications, diagnosis of on-site clinic visits, and so forth. We used the Shapiro-Wilk test to evaluate for normal distribution of each sample. The median and interquartile range (IQR) were used for the description of continuous variables that did not conform to a normal distribution. The Kruskal-Wallis test (among the 3 groups) and the Wilcoxon rank-sum test (between 2 groups) were used for comparisons. The frequency and proportion were used for descriptions of categorical variables, and the chi-square test was used for comparisons between groups. *P* values of less than 0.05 were considered statistically significant for all tests. This study followed the principles outlined in the Declaration of Helsinki. The study protocol was approved by the ethical board committee of the Zhongshan Ophthalmic Center, Sun Yat-sen University. The requirement for informed consent was waived because of the retrospective nature of the study.

During the 6-week study period, a total of 38 038 visits online (virtual 2020) and offline (face-to-face 2020) were observed in this study, including 10 641 visits with the artificial intelligence chatbot, 9850 virtual live consultations by 127 doctors, and 17 547 on-site face-to-face clinic visits. Along with the gradual opening of the on-site outpatient and emergency services by the ZOC, the number of on-site patients showed a steep rise. Simultaneously, online service numbers steadily increased because of the increased awareness of the service, optimization of the patient-user experience, and the availability of online pharmacy service and delivery (Fig S1B). Thus, we were able to offer an end-to-end solution based on a fully virtual diagnosis and treatment.

The median age of virtual 2020 patients was 32 years, significantly younger than that of the face-to-face 2019 (35 years) and face-to-face 2020 (45 years) groups. The proportions of youth (18–34 years [35.9%]) and middle-aged (35–54 years [26.8%]) patients increased in the virtual 2020 group after the COVID-19 outbreak compared with the face-to-face 2019 group. Women were more likely to use virtual live consultations (53.3% of 9850 visits) than face-to-face 2020 (47.7% of 17 547 visits) or face-to-face 2019 (51.1% of 98 225 visits) encounters.

Retinopathy was one of the most common reasons for the encounter in the virtual 2020 (22.6% [1644/7273]), face-to-face 2020 (26.5% [1203/4532]), and face-to-face 2019 (20.1% [10 740/53 308]) groups. Nevertheless, more visits were for ocular surface diseases (24.2% [1761/7273]) and glaucoma (19.4% [1411/7273]) in patients who undertook a virtual live consultation. Trauma (26.3% [1194/4532]) accounted for the second-largest proportion of face-to-face 2020 encounters. Refraction problems (26.1% [13 895/53 308]) were the most common reason for face-to-face 2019 consultations.

Compared with face-to-face 2019 encounters, which represented the normal state before the COVID-19 outbreak, face-to-face 2020 visits in the corresponding period involved patients more geographically concentrated around ZOC clinics from Guangdong Province (85.6% [14 050/16 405] of China) and

Guangzhou City (72.9% [10 112/13 876] of Guangdong Province) because of the travel restrictions during the national lockdown. By contrast, virtual 2020 visits were significantly more dispersed, with a median geographical distance of 340 km (IQR, 64.0–677 km), significantly farther than face-to-face 2020 (2.66 km [IQR, 0.01–128 km]) and face-to-face 2019 (2.65 km [IQR, 0.00–219 km]; Table S1, available at www.aaojournal.org) encounters.

We further analyzed the indications of virtual live consultations in 2020. Specific disease consultation was the most commonly cited reason for virtual live consultation and accounted for 67.0% of the total 9850 visits, followed by symptomatic conditions (56.0%), prescription renewal (54.6%), other consultations (2.2%; including drug use, procedures for attending clinics during the lockdown period, eye health consultation, etc.), and repeated consultation (1.6%). Among the symptoms addressed, ocular discomfort or appearance abnormalities constituted the overwhelming majority (87.2%). In terms of specific disease consultations, 38.7% and 26.9% of the total 6597 visits concerned follow-up and queries about surgery-related information, respectively. The top 3 most referred diseases were ocular surface diseases (26.7%), retinopathy (24.9%), and glaucoma (21.4%; Fig S2A, available at www.aaojournal.org). When stratified by age, specific disease consultation was the most common reason across all age groups, and the demand increased with age from 64.7% in children (<18 years; 1339/2069) to 70.7% in older adults (>55 years; 1131/1599). Youth (18–34 years) were the most eager to seek virtual consultation for symptoms (60.4% [2036/3539]) and other consultations (2.6% [92/3539]). Older adults (>55 years) were most likely to use virtual consultation for prescription renewal, with up to 10% more older adults requesting prescription renewal than the other age groups. Repeated consultation was the only category that children or their guardians (1.8% [37/2039]) were more likely to use (Fig S2B).

The study has several limitations. First, during the 6-week study period, the ZOC online and on-site services were running separately and thus were analyzed as independent parts. We could not trace the flow of visits for a patient from online to on-site, or vice versa. Subsequently, the online and on-site healthcare interactions were integrated and incorporated in the ZOC internet hospital design. Second, the direct reproducibility of the virtual clinical services may be limited by the licensing requirements from different countries and regions. Nevertheless, we have offered lessons and collaborate with other ophthalmology services providers during and after the COVID-19 pandemic.

Our results indicate that online medical services could be fully used for telehealth advantages, including time savings, bridging geographical barriers, and additional functionalities such as remote assessment, in a complementary manner to on-site face-to-face clinical services. Interestingly, we observed from the spectrum of diseases that ocular surface diseases were most cited in the virtual live consultations in 2020, which differs significantly from the most common reasons for the face-to-face 2020 (retinopathy) and face-to-face 2019 (refraction) consultations. This finding may reflect that COVID-19 may have ocular surface symptoms, although we did not record COVID-19-positive patients in our service. Alternatively, ocular surface

disorders could be related to physical or psychological factors (break from regular life, overuse of digital screens, stress, anxiety during the pandemic).⁷

Even as countries and systems adapt to the new normal after the COVID-19 pandemic, many of the virtual systems that were established to meet short-term needs eventually will evolve into long-term trends and solutions. The virtual clinical practice described herein was beneficial especially for patients with ocular surface symptoms or for those in need of follow-up medications. Furthermore, virtual evaluation could provide effective forward triage to specific on-site specialists as a useful complement. The virtual service also offered an alternative for patients with less time or those whose geographic locations made our services less accessible. The guidance and lessons from this study are a reference for other ophthalmology services in different countries during and after the COVID-19 pandemic.

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themselves are not a major source of transmission,¹ the upper respiratory tract may harbor high concentrations of severe acute respiratory syndrome coronavirus 2.² Because concern exists that routine ophthalmic procedures may potentiate the spread of respiratory droplets onto operating room personnel, some centers mandate masks for all operative patients.³ Herein, a series of simulations of a coughing patient during ophthalmic surgery were conducted to identify the potential spread of respiratory droplets and to evaluate interventions aimed at mitigating droplet spread from patients to operating room personnel. No human subjects were included in this study. Individual patient-level consent was not required.

In a series of simulations, a manikin was placed on a surgical bed in an operating room. For each simulation, a standard cataract surgical drape with a transparent adhesive quadrangle (level 4 eye surgical drape, 70 × 65 inches; Association for the Advancement of Medical Instrumentation PB70, MEDLINE) was placed over the surgical site, the adhesive drape was cut, and a speculum was inserted. The surgeon donned a clean surgical gown and gloves and sat with his hands adjacent to the surgical field (Fig 1A; Video 1, available at www.aojournal.org). Three simulations were conducted as follows: (1) no surgical mask for the patient and a complete seal of the drape around the surgical field, (2) an ear loop surgical mask (American Society for Testing Materials level 2; 3M, Ontario, Canada) for the patient and an incomplete seal of the surgical drape intentionally applied by leaving a gap near the medial canthus, and (3) an ear loop surgical mask for the patient and a complete surgical seal with the adhesive of the drape. In scenarios 2 and 3, the superior edge of the mask was taped so that it adhered to the face. Methods previously validated for visualization of cough droplets were used^{3–5} and are described in more detail elsewhere (Supplementary Appendix, available at www.aojournal.org).

In the first simulation (no mask, complete seal), no visible droplet contamination of the surgical field or the surgeon was seen (Fig 1B). However, diffuse droplets appeared on the underside of the drape and on the manikin’s body (Fig 2A, available at www.aojournal.org). In the second simulation (mask, incomplete seal), droplets were seen on the surgical field (Fig 1C) and the surgeon’s gloves, with minimal contamination of the underside of the drape. In the third simulation (mask, complete seal), no droplets were seen on the surgical field or the surgeon (Fig 1D), and minimal contamination occurred on the underside of the drape. During drape removal, droplets spread from beneath the mask onto the manikin’s lower eyelid in all 3 simulations (Fig 2B, available at www.aojournal.org).

These simulations demonstrate that a complete surgical seal and masked patient minimize droplet spread and that an incomplete seal may allow respiratory droplets to travel onto the surgical field. Incomplete seals are not uncommon, the reasons for which include a prominent nose, deep-set orbits, reflex blepharospasm, blepharitis, insufficient drying of the skin after prepping, progressive loss of the adhesion of the drape as the case progresses, or a combination thereof. In addition to drying the area adequately before application of the drape, a transparent adhesive film dressing can be used to reinforce adhesion of the draping further. An aerosol box⁵ and additional plastic drapes⁶ have been used in other medical disciplines to minimize risk of droplet spread during surgery, but these methods are not adapted as easily in ophthalmic surgery, where access to the eyes and adnexa in close proximity to the airways is required.

Spread of Respiratory Droplets in a Simulated Ophthalmic Surgery



Performing ophthalmic surgery safely during the coronavirus 2019 pandemic is important to ophthalmologists, anesthesiologists, nurses, patients, and health policy analysts. Although ophthalmic procedures