Graefe's Archive for Clinical and Experimental Ophthalmology (2020) 258:1427–1436
https://doi.org/10.1007/s00417-020-04682-z

MISCELLANEOUS

Sustainable practice of ophthalmology during COVID-19: challenges and solutions

Louis W. Lim[1] · Leonard W. Yip[1] · Hui Wen Tay[2] · Xue Ling Ang[2] · Llewellyn K. Lee[1] · Chee Fang Chin[1] · Vernon Yong[1]

Received: 23 March 2020 / Revised: 27 March 2020 / Accepted: 1 April 2020 / Published online: 21 April 2020

Abstract

Purpose The Coronavirus (COVID-19) outbreak is rapidly emerging as a global health threat. With no proven vaccination or treatment, infection control measures are paramount. In this article, we aim to describe the impact of COVID-19 on our practice and share our strategies and guidelines to maintain a sustainable ophthalmology practice.

Methods Tan Tock Seng Hospital (TTSH) Eye Centre is the only ophthalmology department supporting the National Centre for Infectious Diseases (NCID), which is the national screening center and the main center for management of COVID-19 patients in Singapore. Our guidelines during this outbreak are discussed.

Results Challenges in different care settings in our ophthalmology practice have been identified and analyzed with practical solutions and guidelines implemented in anticipation of these challenges. First, to minimize cross-infection of COVID-19, stringent infection control measures were set up. These include personal protective equipment (PPE) for healthcare workers and routine cleaning of "high-touch" surfaces. Second, for outpatient care, a stringent dual screening and triaging process were carried out to identify high-risk patients, with proper isolation for such patients. Administrative measures to lower patient attendance and reschedule appointments were carried out. Third, inpatient and outpatient care were separated to minimize interactions. Last but not least, logistics and manpower plans were drawn up in anticipation of resource demands and measures to improve the mental well-being of staff were implemented.

Conclusion We hope our measures during this COVID-19 pandemic can help ophthalmologists globally and serve to guide and maintain safe access in ophthalmology clinics when faced with similar disease outbreaks.

Keywords COVID-19 · SARS-CoV-2 · Clinic management · Singapore

Introduction

SARS-CoV-2, which causes COVID-19, is the third novel coronavirus in 17 years [1], first reported in Wuhan, China, on 31 December 2019 [2]. It has since spread globally, with the World Health Organization (WHO) declaring it a Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March 2020. With its basic reproduction number close to or higher than SARS-CoV [3, 4] and MERS-CoV [5], COVID-19 represents a potentially higher pandemic risk than the SARS outbreak in 2003 [6]. Initial cases of zoonotic transmission from bats [7] have since evolved into human-to-human transmission through droplets, fomites [8], fecal material [9], and tears [10]. Detection of SARS-CoV-2 in tears and conjunctival secretions of infected patients with conjunctivitis [10], similar to findings during the 2003 SARS outbreak [11], suggests a unique risk to the ophthalmology department.

Clinical progression of COVID-19 seems similar to that of SARS, with majority of cases (80%) having mild to moderate disease after an incubation period of 5–6 days (range, 1–14 days). Common symptoms include fever (87.9%), dry cough (67.7%), and fatigue (38.1%) [12]. Of note, 0.8% of patients presented with conjunctival congestion [12], presenting new challenges to ophthalmologists. Interestingly, the first medical professional to sound the alarm on a possible

Louis W. Lim and Leonard W. Yip contributed equally to this work.

✉ Leonard W. Yip
leonard_yip@ttsh.com.sg

[1] National Healthcare Group Eye Institute, Tan Tock Seng Hospital, 11 Jalan Tan Tock Seng, Singapore 308433, Singapore

[2] Yong Loo Lin School of Medicine, National University of Singapore, 21 Lower Kent Ridge Rd, Singapore, Singapore

outbreak was a late Chinese ophthalmologist from Wuhan, Hubei, China [13].

Singapore reported our first imported case on 23 January 2020. We have since enforced strict border control through travel advisories and entry restrictions from high-risk countries like China and South Korea raised our "Disease Outbreak Response System Condition" (DORSCON) level from yellow to orange and implemented measures to minimize community spread through cancelation or deferment of large-scale events, daily health checks at workplaces, and restricting doctors from travelling between different healthcare institutions [14].

As of 26 March 2020, there were 462,684 confirmed cases and 20,834 deaths globally, with 81,961 of the confirmed cases and 3293 of the deaths occurring in China [15]. One hundred and ninety-nine countries and territories have been affected [15], with numbers continuing to climb. Singapore has had a total of 683 COVID-19 cases, with 172 discharged and 2 fatalities [16]. High incidence rates were also seen in Italy (74,386 cases), USA (63,570 cases), Spain (47,610 cases), Germany (36,508 cases), and Iran (27,017 cases) [15].

Being the only ophthalmology department supporting the National Centre for Infectious Diseases (NCID), the national screening center and the main center for management of COVID-19 patients in Singapore, we would like to discuss the impact COVID-19 has had on our practice, detail our past experiences with infection control in ophthalmology, and apply these concepts to develop a sustainable practice of ophthalmology at Tan Tock Seng Hospital (TTSH) Eye Centre. We hope to serve as a model to guide future management in ophthalmology clinics when faced with the current and similar disease outbreaks.

Challenges affecting ophthalmic practice

Infection control

TTSH Eye Centre is one of the busiest outpatient clinics in TTSH. With a usual patient load of 600 patients per day, the risk of COVID-19 transmission is imminent and catastrophic. Furthermore, ophthalmology is a unique practice requiring routine use of reusable equipment in close contact with patients and with many high-risk high-touch surfaces [17], thereby increasing the risk of disease transmission among ophthalmology patients. Examples include the Goldmann applanation tonometer (GAT) heads, slit lamp, contact lenses, eye drops, chin-rests, and table surfaces of ophthalmic diagnostic and laser devices such as the Humphrey visual field and optical coherence tomography. This, coupled with the fact that Coronaviruses can survive up to 96 h in biological fluids and in high relative humidity and low temperature [18], thus makes contaminated surfaces key sources of iatrogenic transmission of infections [19–22] between patients [11, 23].

Outpatient care

During this COVID-19 outbreak, our department's weekly outpatient visits' no-show rate has increased significantly from 13 to 33%. Possible reasons include patients postponing follow-up visits to avoid hospitals, or departments postponing visits to keep outpatient attendance low to reduce risks of cross-infection [24]. Uncertainty in the duration of the outbreak [25] makes choosing a new appointment date difficult. Hence, patients who miss appointments, especially glaucoma patients, are predisposed to sight-threatening complications [26].

Inpatient care

The TTSH ophthalmology department only accepts inpatient referrals from NCID or TTSH general wards. Movement of inpatients and ophthalmologists to and from different wards and the eye center poses significant means of cross-infection between different wards, as well as between outpatient and inpatient services.

Surgery

In ophthalmology, surgical turnover and caseload are high, with a daily average of 40 to 50 ambulatory day surgeries at the TTSH Eye Centre. Hence, surgical procedures serve as a means for cross-infection between surgical patients from different wards, as well as between patients and healthcare workers from different departments.

Healthcare worker

As SARS-CoV-2 can cause conjunctivitis [27, 28], precautions should be taken against transmission through aerosol contact with the conjunctiva. Moreover, patients may be infectious even before symptom manifestation [29]. Hence, ophthalmologists are at increased risks for COVID-19 because of their proximity to a patient's nose and mouth and potential exposure to tears which may contain the virus [30]. As such, the American Academy of Ophthalmology has recommended protection for the mouth, nose, and eyes when caring for patients potentially infected with COVID-19 [28].

Sustainable ophthalmic practice guidelines

With no effective antiviral treatment available [31] and an effective vaccine unlikely to be widely available for up to 6 months [32], the COVID-19 outbreak continues to challenge the healthcare ecosystem. Thus, healthcare infrastructure should be directed at enhancing detection of cases and minimizing transmission risks at all frontiers.

In addition, the added physical, mental, and social stressors to ophthalmologists from both patient and personal safety concerns should be addressed [33].

General infection control

Ophthalmic equipment can be contaminated with respiratory droplets, tears, and conjunctival secretions of infected patients [10]. Unattended to, ophthalmic equipment may serve as hotbeds for virus contamination as patients often come in close contact with them.

Routine cleaning significantly reduces environmental contamination [34]. However appropriate cleaning agents should be used. A review of studies on antiseptics-disinfectants for human coronaviruses (HCoVs) recommended the use of a povidone-iodine or combination of chlorhexidine with ethanol and cetrimide for infection control against HCoV [18]. Most alcohol-based solutions, such as isopropanol or ethanol, also significantly reduced viral titers [35] and are recommended. Surprisingly, some commonly used antiseptics-disinfectants formulated with only quaternary ammonium compounds or phenolic compounds, or a combination formulation of chlorhexidine with cetrimide, were found to be ineffective against HCoV [36] and thus may be ineffective against COVID-19 as well.

Hence, we recommend that healthcare workers wash their hands with combination chlorhexidine with ethanol and cetrimide, or hand-rub with alcohol-based solutions, and routinely clean "high-touch" surfaces after each patient. To ensure proper decontamination of ophthalmic devices and optical surfaces, we suggest reviewing product inserts of each device for the most appropriate cleaning method and ensure that the recommended cleaning agent is effective in disinfecting COVID-19. In addition, we recommend avoiding the use of the air puff to measure intraocular pressure to prevent the generation of aerosols from infected conjunctival secretions that risk transmission to healthcare workers [37].

Outpatient care

Proper triaging of patients is imperative in a busy clinic to reduce the spread of possible disease and for contact tracing purposes. TTSH employs a stringent dual screening and triaging process to classify patients and all accompanying persons based on their COVID-19 status.

Firstly, at all entry points of the hospital, their temperatures are checked by thermal image cameras, while stationed staff screen them for the following:

1. Travel or close contact with recent travelers to affected countries (Mainland China, Republic of Korea, Japan, Iran, Northern Italy);
2. Close contact with a case of COVID-19;
3. Acute respiratory infection (ARI) (cough, fever, and shortness of breath).

Those negative for all of the above are given a round triage sticker, while those with no travel or contact risk factors but have acute respiratory symptoms are given a hexagonal triage sticker. Those who are positive for all three will be denied entry and sent to the NCID screening center instead (Table 1). To prevent the reuse of stickers, the color of the stickers is changed daily. At the electronic registration counter of the eye center, patients and accompanying persons are again screened to pick out suspected COVID-19 cases based on the criteria listed in Figs. 1 and 2, in particular noting patients with acute respiratory symptoms.

Patients and accompanying persons negative for the COVID-19 suspect criteria are given a green triage sticker. Otherwise, the attending doctor is informed about the suspect patient to assess the need for a same-day consultation. Any suspect accompanying persons will be denied entry into the clinic and informed to leave the hospital premises.

Suspect patients in need of a same-day consult are given a surgical mask and an orange triage sticker for identification, before being escorted to the isolation "pink" room. Thereafter, the treatment room nurse will check the patient's visual acuity as well as reassure and advise the patient on the isolation protocols. Guidelines on the clinic triage protocol (Figs. 1 and 2) have been affixed within the eye center to ensure that all triage personnel and medical staff are familiar.

General patients

With a stringent and robust triaging and screening system in place, most routine eye consults would thus be with patients without respiratory symptoms and at low risk for COVID-19. Current recommendations from the WHO and the Centers for Disease Control and Prevention would be personal protective equipment (PPE) according to standard precautions. In our hospital, standard precautions for all staff include surgical masks in all clinical areas, mitigating the risk of inadvertent exposure of a health care worker to an unidentified COVID-19 patient.

In addition, since subclinical patients are capable of transmitting the virus [29], to prevent and limit cross-infection, reducing outpatient attendance is important. To this end, senior ophthalmologists screen through clinical notes to determine patients with stable conditions whose appointments can be safely rescheduled, while the eye center administrative team contacts patients at least 1 week prior to their scheduled appointments to update them on their new appointments. These patients will also have their prescriptions refilled. This has resulted in a 30% reduction of the 13,000 monthly patients.

Table 1 Questionnaire for screening of outpatients

Acute respiratory illness (ARI) (Cough, fever and shortness of breath)	Travel or close contact with recent travellers to affected countries (mainland China, Republic of Korea, Japan, Iran, Northern Italy)	Close contact with a case of COVID-19	Action
			Allow entry and give ROUND sticker
✖			Allow entry, give HEXAGONAL sticker and issue surgical mask
	✖		
		✖	
✖	✖	✖	Deny entry

Patients who defaulted their follow-up were also not neglected. After each subspecialty clinic, senior ophthalmologists screen through a defaulter name-list from their clinic and give an appropriate time frame for rescheduling their appointments. The administrative team will then contact patients and update them on their new appointments.

High-risk patients

For high-risk patients fulfilling the above criteria, full PPE is worn at all times by all involved healthcare workers, with the patient placed and examined in dedicated isolation "pink" rooms. Single-use consumables such as eye drops are used to reduce the risk of transmission to the next patient, with non-disposable equipment cleaned with appropriate disinfectants as discussed above.

The importance and enforcement of PPE should also extend to the hospital's janitorial service. Studies have shown the presence of SARS-CoV-2 in an infected patient's biological products and waste [9, 11, 12]. Yet, past experience from SARS suggested that cleaners in affected hospitals viewed their risk of exposure to SARS as low, at only 0.50 times that of doctors [38]. This is concerning as these misconceptions from cleaners, who play an essential role in the hospital's cleanliness and hygiene, may lead to non-compliance of infection control measures. Hence, it is imperative that new understanding and updates on COVID-19 are communicated down the entire organization.

Inpatient care

Separating inpatient and outpatient ophthalmology care is the cornerstone of our practice to curtail the risk of cross-infection. As far as possible, inpatients should be seen at the bedside. If specific equipment or investigations only available outpatient are required, the inpatient is then seen at an outpatient clinic that has been specifically allocated for inpatient use, with minimal to no interaction with other outpatients. These cases are vetted to ensure they are non-suspect cases and afebrile. In addition, to avoid the congregation of inpatients from different wards, separate time slots have been allotted for each group—ophthalmology inpatients are seen at 8 am, while inpatient interdisciplinary referrals to ophthalmology are only seen after 9:30 am (Fig. 3).

To further minimize interaction between these different groups of patients, inpatients are under constant supervision by clinic staff, with diagnostic investigations minimized. This

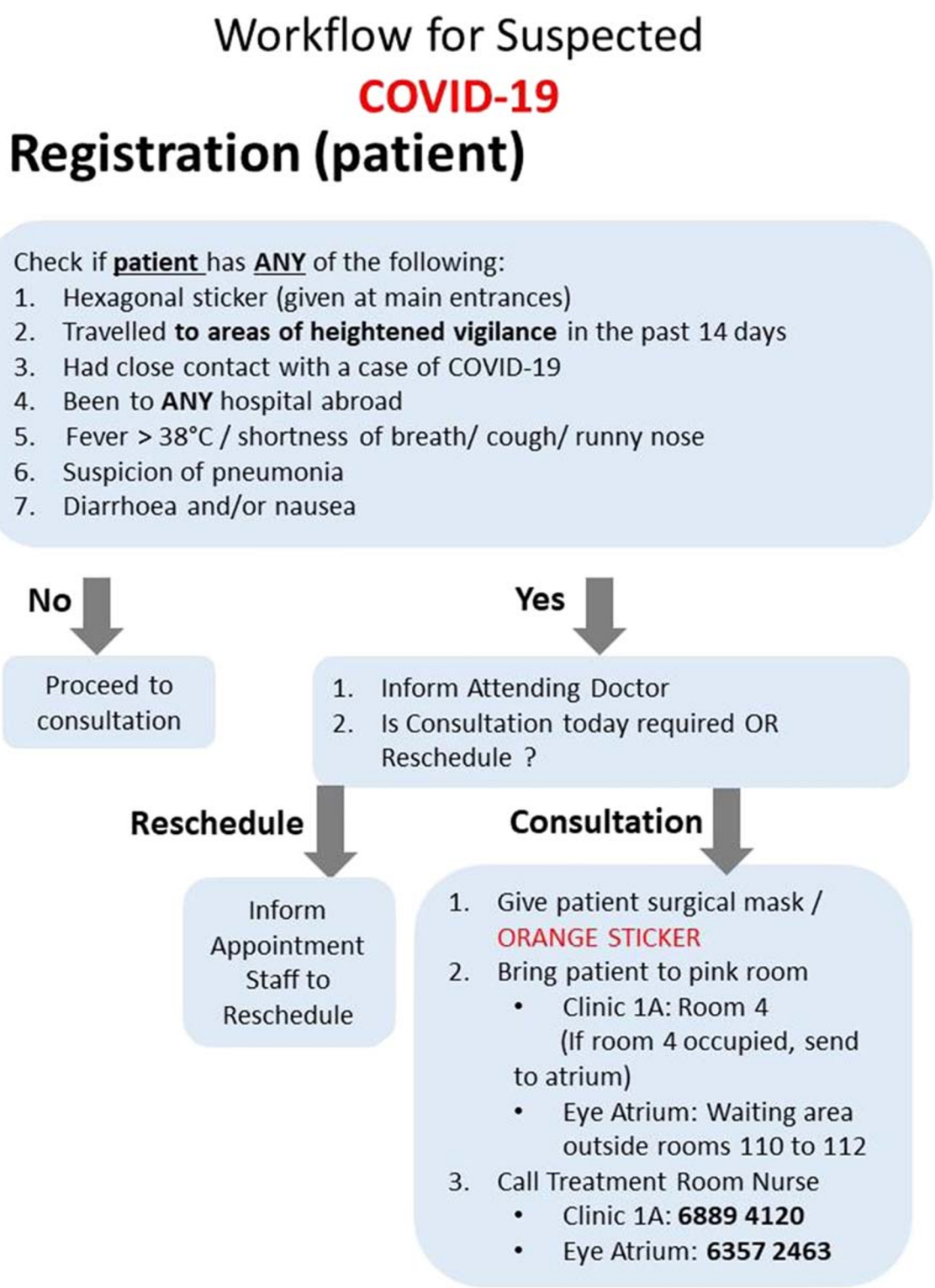

Fig. 1 Registration workflow for outpatients

is in concordance with the practice in Hong Kong during the SARS outbreak, where inpatients were seen by the bedside with portable equipment, and transfer of inpatients to the outpatient department was contraindicated due to their high risk of cross-infection [23].

Surgery

Aerosol-generating procedures such as tracheal intubation and manual ventilation before intubation increase the risk of transmission of acute respiratory infections to healthcare workers

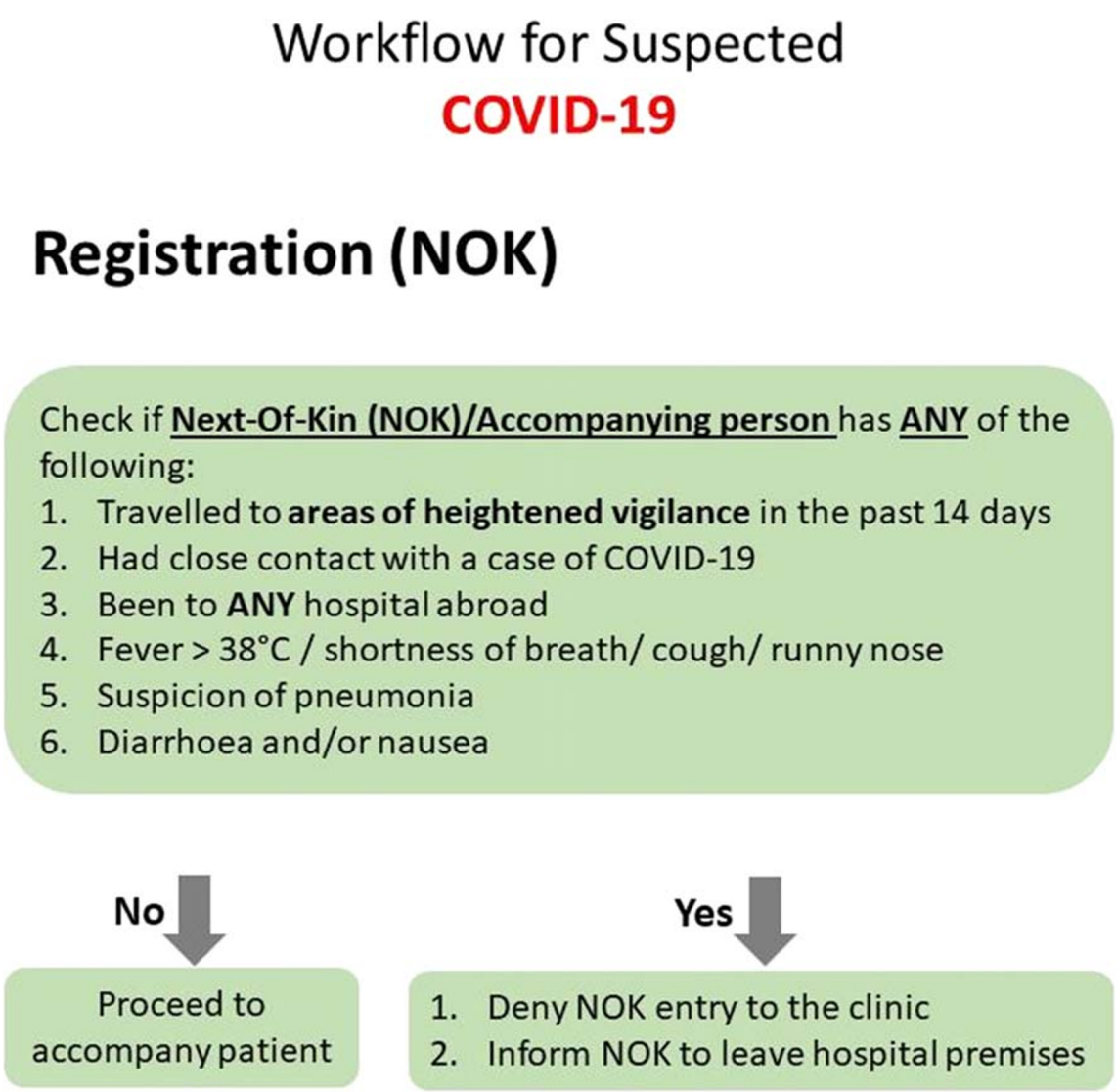

Fig. 2 Registration workflow for accompanying persons

by 3 to 7 times [37]. With ventilatory support required during surgery, yet posing a risk to healthcare workers, we have postponed non-emergency elective cases to reduce caseload and potential infection risks to both patients and healthcare workers alike and reinforced screening for cough and fever during our pre-operative assessment if surgery is necessary. This has reduced our ambulatory day surgeries by about 50%.

Where surgery is needed, proper PPE is worn when intubating patients who are undergoing general anesthesia. If manipulation of the nasopharynx is involved, such as dacryocystorhinostomy, donning of appropriate PPE with the N95 mask is required for all operating theater staff.

Protective eyewear was found to reduce transmission risk in SARS [39]. We recommend the use of visor masks or coverspecs over the use of goggles, as although both increase the working distance from the operating microscope and affects visualization during surgery, the latter further impairs vision due to condensation.

Should emergency surgery be necessitated for confirmed COVID-19 cases, the operating theater is regarded as at high-risk and universal precaution measures will be taken, with the use of goggles and N95 masks for all staff within the operating theater. Similar measures for ophthalmic surgeries were used in other institutions during outbreaks [23, 40].

Healthcare workers

Preparedness plans

Using lessons learned from the 2003 SARS and 2009 H1N1 outbreak, Singapore has continuously expanded and upgraded its capacity to better manage emerging infectious disease outbreaks like COVID-19. Steps taken include infrastructural reform through the construction of the National Centre for Infectious Diseases (NCID) and National Public Health

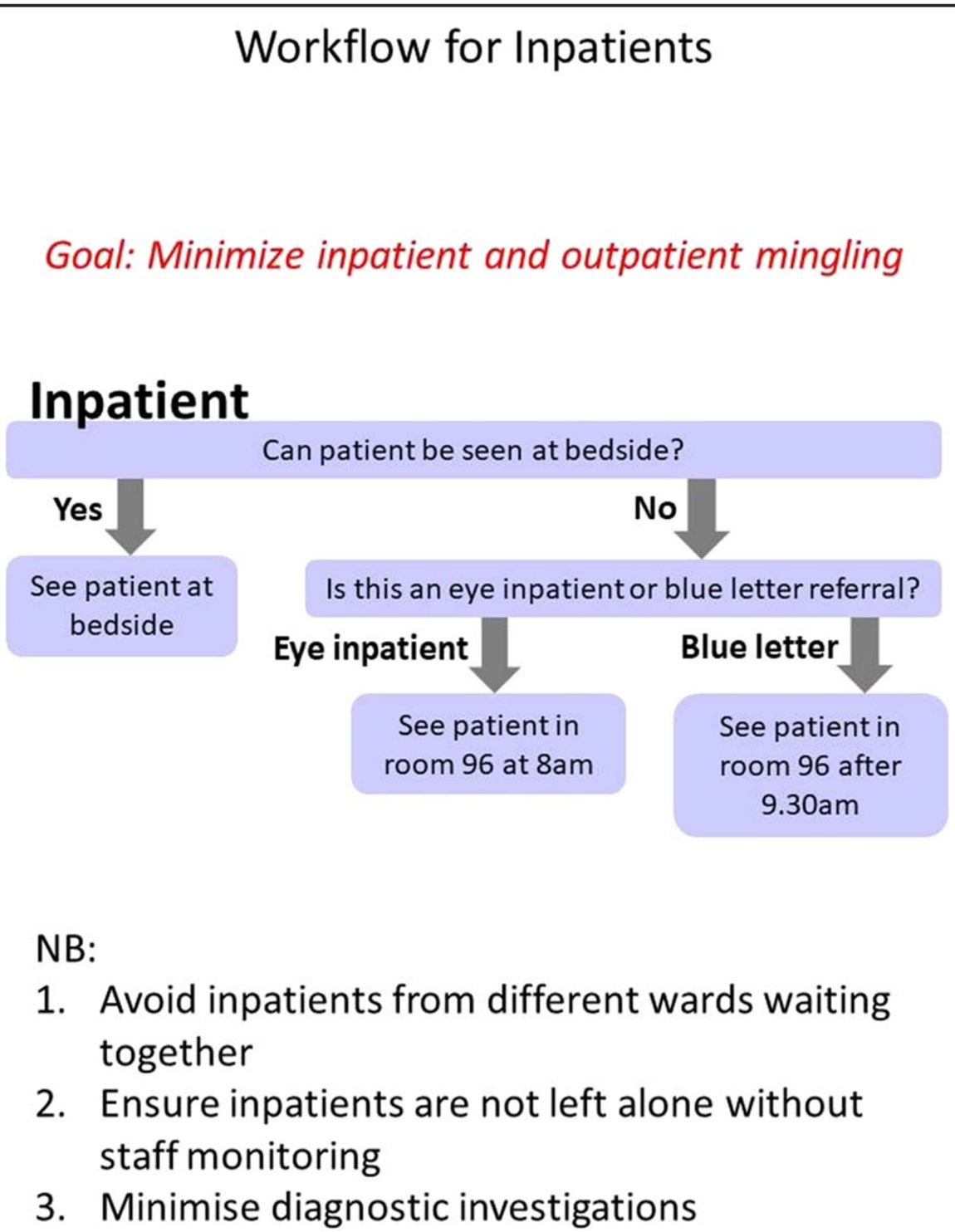

Fig. 3 Workflow for inpatients

Laboratory and equipping all public hospitals with isolation facilities ready to accept COVID-19 patients, as opposed to centralized treatment of all SARS patients at TTSH in 2003. At an organizational level, formal platforms for collaboration have been established, with protocols ready for implementation and training provided to healthcare professionals [33] as it has been shown to reduce transmission rates [39].

Logistics

Currently, there is a high worldwide demand for PPE with many countries running low on supplies for their healthcare workers [41]. At the national level, although the Singapore government has maintained a 6-month national stockpile of PPE and masks in preparation for crises since SARS in 2003

[42], with available stockpiles prioritized for healthcare institutions [43], clinic managers should take stock of their current supplies and devise sustainable usage strategies for staff until resupply. For example, in our clinic, each healthcare worker is allotted 2 surgical masks per day, which must be signed out from a centralized location to facilitate usage tracking, minimize wastage, and ensure proper use of resources.

Manpower

Additional hospital and clinic screening efforts, as detailed above, may draw staff away from their normal duties. In addition, ophthalmologists may have to augment and support departments such as the emergency department and inpatient units that are under tremendous strain from the influx of patients. Unprecedented community cluster outbreaks may lead to sudden surges of patients and place further strain on the hospital. Thus, these contingency requirements, though previously unthinkable, may require planning and forethought. To achieve this, our department has undertaken superfluous staffing to cater to the differing elasticities of manpower demand during this crisis [44] by restricting all leave and conference attendances.

Personnel protection and training

In addition to providing PPE, refresher training on how to don and remove PPE should be provided to all healthcare staff to decrease infection risk [39]. Repeat N95 mask fitting should also be carried out if done more than 1 year ago as the lack of training is associated with greater transmission risks [39]. In lieu of live PPE demonstrations, online training material and videos could be circulated to avoid mass gathering of staff. Education on the rationale and importance of PPE should also be continually emphasized as the physical discomfort and time-consuming nature can lead to lapses in compliance during a long-drawn outbreak.

To enhance the protection of all healthcare staff, updating influenza vaccination to the prevailing seasonal strain can be considered. Though the influenza vaccine confers no protection against COVID-19, it may help avoid false alarms of clusters of fevers due to circulating strains transmitting among staff, avoiding unnecessary quarantine measures [45].

Personnel communication and social distancing

Methods to reduce workplace transmission of influenza may be adapted for COVID-19. Workplace social distancing measures have been previously studied as a means to prevent influenza transmission [46]. Practical measures to reduce non-clinical work contact without affecting manpower requirements include stopping large group gatherings beyond 10 people and replacing department meetings and teachings with video conferencing. Mealtimes can also be staggered and distanced seating (2 m apart) implemented in common staff areas.

With social distancing in place, dissemination of critical information through traditional means such as department or hospital meetings will be inefficient and be a potential source of disease spread. In a rapidly evolving or complex healthcare crisis, in addition to e-mails, communication can be supplemented with widely used smartphone messaging applications such as WhatsApp and Telegram. The benefit is that unlike short message service (SMS), which only allows single person interactions, modern messaging apps allow large group chats. This facilitates fast large group dissemination of information, consultation, coordination, and action. Many functional social-level group chats may already exist and should be tapped on, for example administrative, resident, nursing, or ophthalmic technician groups. A situational crisis group for COVID-19 may comprise key stakeholders for decision-making in a clinic or department and leaders from different functional groups. Such chats also serve as a temporary resource of relevant information, where documents and protocols can be attached. Larger organizations may even have approved secure instant messaging applications like the TigerConnect, and organizational policies may dictate that only these be used.

Resilience and mental well-being

The 2003 SARS outbreak taught us the significant psychosocial impact a highly infectious disease outbreak can have on hospital staff [47, 48]. Inexperience in dealing with such an outbreak among young healthcare workers, coupled with increased workload and risk perceptions, compounds the physical and psychological stresses that healthcare workers have to deal with daily [38]. Hence, the psychological welfare of staff must not be neglected. Assistance in this regard could be sought from affiliated psychiatry or psychology departments or colleagues. Staff could be taught self-help methods on coping with stress and increasing resilience. Avenues for seeking help should be made known to all staff so that those experiencing an acute stress reaction can seek help. A 3S (Staff Support Staff) framework could also be instituted where fellow staff members help look out for signs in colleagues and are trained to provide informal psychological support. These efforts should persevere beyond the resolution of COVID-19.

Due to the uncertainty and prolonged period of stress during this COVID-19 outbreak, it is crucial to support healthcare workers through planning well-being initiatives (both within and beyond the hospital) and understanding the practical issues faced by staff [49]. In this aspect, an anonymized TTSH-NCID workplace well-being survey was conducted to aid in understanding the difficulties faced by staff while at work during the COVID-19 outbreak. Other similar avenues should

be explored to understand how hospital management can better support their staff during this trying period. The concept of a department or clinic welfare officer can also be considered, where he/she works toward the well-being of all staff at the behest of the department or clinic. Ground-level stresses and grievances can then be safely surfaced, and wellness activities planned and executed.

Conclusion

In an emergent healthcare crisis caused by COVID-19, we discuss important considerations for healthcare leaders in ophthalmology and examples of how they have been applied. The initial emphasis is certainly on rigorous infection control to ensure that healthcare workers and patients are protected. In the longer term, we also suggest that strategies be developed to conduct standard eye care and surgery safely to maintain a sustainable practice. The aim, ultimately, is to maintain public confidence and safe access to both routine and emergency eye care while balancing the additional needs in a disease outbreak.

Authors' contributions All authors contributed to the study conception and design. Material preparations were performed by Hui Wen Tay, Xue Ling Ang, Leonard W. Yip, and Louis W. Lim. The first draft of the manuscript was written by Louis W. Lim and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Availability of data and material Nil

Code availability Nil

References

1. Young BE, Ong SWX, Kalimuddin S et al (2020) Epidemiologic features and clinical course of patients infected with SARS-CoV-2 in Singapore. Jama. https://doi.org/10.1001/jama.2020.3204
2. Huang C, Wang Y, Li X et al (2020) Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 395(10223):497–506. https://doi.org/10.1016/s0140-6736(20)30183-5
3. Lipsitch M, Cohen T, Cooper B et al (2003) Transmission dynamics and control of severe acute respiratory syndrome. Science. 300(5627):1966–1970. https://doi.org/10.1126/science.1086616
4. Wallinga J, Teunis P (2004) Different epidemic curves for severe acute respiratory syndrome reveal similar impacts of control measures. Am J Epidemiol 160(6):509–516. https://doi.org/10.1093/aje/kwh255
5. Lin Q, Chiu AP, Zhao S et al (2018) Modeling the spread of Middle East respiratory syndrome coronavirus in Saudi Arabia. Stat Methods Med Res 27(7):1968–1978. https://doi.org/10.1177/0962280217746442
6. Tao Liu JH, Min Kang, Lifeng Lin, Haojie Zhong, Jianpeng Xiao, Guanhao He, Tie Song, Qiong Huang, Zuhua Rong, Aiping Deng, Weilin Zeng, Xiaohua Tan, Siqing Zeng, Zhihua Zhu, Jiansen Li, Donghua Wan, Jing Lu, Huihong Deng, Jianfeng He, Wenjun Ma. Transmission dynamics of 2019 novel coronavirus (2019-nCoV). 2020. p. 27
7. Wuhan Municipal Health Commission (2019) Report of clustering pneumonia of unknown etiology in Wuhan City. China; 31 December 2019
8. Perlman S (2020) Another decade, another coronavirus. N Engl J Med 382(8):760–762. https://doi.org/10.1056/NEJMe2001126
9. Gao QY, Chen YX, Fang JY (2020) 2019 novel coronavirus infection and gastrointestinal tract. J Dig Dis. https://doi.org/10.1111/1751-2980.12851
10. Xia J, Tong J, Liu M et al (2020) Evaluation of coronavirus in tears and conjunctival secretions of patients with SARS-CoV-2 infection. J Med Virol. https://doi.org/10.1002/jmv.25725
11. Loon SC, Teoh SC, Oon LL et al (2004) The severe acute respiratory syndrome coronavirus in tears. Br J Ophthalmol 88(7):861–863. https://doi.org/10.1136/bjo.2003.035931
12. World Health Organization (2020) Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19), Geneva
13. Green A (2020) Li Wenliang The Lancet 395(10225):1. https://doi.org/10.1016/S0140-6736(20)30382-2
14. Ministry of Health (MOH) Singapore (2020) Additional measures introduced with DORSCON Orange. https://www.gov.sg/article/additional-measures-introduced-with-dorscon-orange.
15. World Health Organization (2020) Coronavirus disease 2019 (COVID-19) situation report – 66. Geneva (27 March 2020)
16. Ministry of Health (MOH) Singapore (2020) Official update of COVID-19 situation in Singapore Singapore. https://experience.arcgis.com/experience/7e30edc490a5441a874f9efe67bd8b89.
17. Ministry of Health (MOH) Singapore (2013) Environmental cleaning guidelines for healthcare settings Singapore. https://www.moh.gov.sg/docs/librariesprovider5/licensing-terms-and-conditions/environmental-cleaning-guidelines-for-healthcare-settings.pdf.
18. Geller C, Varbanov M, Duval RE (2012) Human coronaviruses: insights into environmental resistance and its influence on the development of new antiseptic strategies. Viruses. 4(11):3044–3068. https://doi.org/10.3390/v4113044
19. Dancer SJ (1999) Mopping up hospital infection. J Hosp Infect 43(2):85–100. https://doi.org/10.1053/jhin.1999.0616
20. Boyce JM, Havill NL, Lipka A et al (2010) Variations in hospital daily cleaning practices. Infect Control Hosp Epidemiol 31(1):99–101. https://doi.org/10.1086/649225
21. Bhalla A, Pultz NJ, Gries DM et al (2004) Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. Infect Control Hosp Epidemiol 25(2):164–167. https://doi.org/10.1086/502369
22. Hayden MK, Blom DW, Lyle EA et al (2008) Risk of hand or glove contamination after contact with patients colonized with vancomycin-resistant enterococcus or the colonized patients' environment. Infect Control Hosp Epidemiol 29(2):149–154. https://doi.org/10.1086/524331
23. Chan WM, Liu DT, Lam DS (2007) Precautions in ophthalmic practice in a hospital with a major acute SARS outbreak: an experience from Hong Kong. Eye (Lond) 21(2):305–306. https://doi.org/10.1038/sj.eye.6702580
24. Lai THT, Tang EWH, Chau SKY et al (2020) Stepping up infection control measures in ophthalmology during the novel coronavirus

outbreak: an experience from Hong Kong. Graefes Arch Clin Exp Ophthalmol. https://doi.org/10.1007/s00417-020-04641-8
25. Fulton P, Brownlee IG, Messonnier NE (2020) Transcript for CDC media telebriefing: update on COVID-19: press briefing transcript: Friday. February 21:2020
26. Davis A, Baldwin A, Hingorani M et al (2017) A review of 145 234 ophthalmic patient episodes lost to follow-up. Eye (Lond) 31(3): 422–429. https://doi.org/10.1038/eye.2016.225
27. Lu CW, Liu XF, Jia ZF (2020) 2019-nCoV transmission through the ocular surface must not be ignored. Lancet. 395(10224):e39. https://doi.org/10.1016/s0140-6736(20)30313-5
28. American Academy of Ophthalmology (AAO) (2020) Alert: important coronavirus updates for ophthalmologists. https://www.aao.org/headline/alert-important-coronavirus-context. Accessed 7 March 2020
29. Nishiura H, Linton NM, Akhmetzhanov AR (2020) Serial interval of novel coronavirus (COVID-19) infections. Int J Infect Dis. https://doi.org/10.1016/j.ijid.2020.02.060
30. Li JO, Lam DSC, Chen Y et al (2020) Novel Coronavirus disease 2019 (COVID-19): the importance of recognising possible early ocular manifestation and using protective eyewear. Br J Ophthalmol 104(3):297–298. https://doi.org/10.1136/bjophthalmol-2020-315994
31. de Wit E, van Doremalen N, Falzarano D et al (2016) SARS and MERS: recent insights into emerging coronaviruses. Nat Rev Microbiol 14(8):523–534. https://doi.org/10.1038/nrmicro.2016.81
32. Qualls N, Levitt A, Kanade N et al (2017) Community mitigation guidelines to prevent pandemic influenza - United States, 2017. MMWR Recomm Rep 66(1):1–34. https://doi.org/10.15585/mmwr.rr6601a1
33. Wong JEL, Leo YS, Tan CC (2020) COVID-19 in Singapore-current experience: critical global issues that require attention and action. Jama. https://doi.org/10.1001/jama.2020.2467
34. Ong SWX, Tan YK, Chia PY et al (2020) Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. Jama. https://doi.org/10.1001/jama.2020.3227
35. Rabenau HF, Cinatl J, Morgenstern B et al (2005) Stability and inactivation of SARS coronavirus. Med Microbiol Immunol 194(1–2):1–6. https://doi.org/10.1007/s00430-004-0219-0
36. Sattar SA, Springthorpe VS, Karim Y et al (1989) Chemical disinfection of non-porous inanimate surfaces experimentally contaminated with four human pathogenic viruses. Epidemiol Infect 102(3): 493–505. https://doi.org/10.1017/s0950268800030211
37. Tran K, Cimon K, Severn M et al (2012) Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One 7(4):e35797. https://doi.org/10.1371/journal.pone.0035797
38. Koh D, Lim MK, Chia SE et al (2005) Risk perception and impact of severe acute respiratory syndrome (SARS) on work and personal lives of healthcare workers in Singapore: what can we learn? Med Care 43(7):676–682. https://doi.org/10.1097/01.mlr.0000167181.36730.cc
39. Liu W, Tang F, Fang L-Q, De Vlas SJ, Ma H-J, Zhou J-P, Looman CWN, Richardus JH, Cao W-C (2009) Risk factors for SARS infection among hospital healthcare workers in Beijing: a case control study. Tropical Med Int Health 14:8. https://doi.org/10.1111/j.1365-3156.2009.02255.x
40. Tien HC, Chughtai T, Jogeklar A et al (2005) Elective and emergency surgery in patients with severe acute respiratory syndrome (SARS). Can J Surg 48(1):71–74
41. World Health Organization (2020). Shortage of personal protective equipment endangering health workers worldwide. 3 March 2020
42. Goh KT, Cutter J, Heng BH et al (2006) Epidemiology and control of SARS in Singapore. Ann Acad Med Singap 35(5):301–316
43. Zhaki Abdullah AHM (2020). Supply of masks in Singapore 'enough' if managed properly: Chan Chun Sing. Channel news Asia. 30 January 2020
44. Tsao HM, Sun YC, Liou DM (2015) A rational approach to estimating the surgical demand elasticity needed to guide manpower reallocation during contagious outbreaks. PLoS One 10(4): e0122625. https://doi.org/10.1371/journal.pone.0122625
45. Huh K, Shin HS, Peck KR (2020) Emergent strategies for the next phase of COVID-19. Infect Chemother
46. Ahmed F, Zviedrite N, Uzicanin A (2018) Effectiveness of workplace social distancing measures in reducing influenza transmission: a systematic review. BMC Public Health 18(1):518. https://doi.org/10.1186/s12889-018-5446-1
47. Wu P, Fang Y, Guan Z et al (2009) The psychological impact of the SARS epidemic on hospital employees in China: exposure, risk perception, and altruistic acceptance of risk. Can J Psychiatr 54(5):302–311. https://doi.org/10.1177/070674370905400504
48. Nickell LA, Crighton EJ, Tracy CS et al (2004) Psychosocial effects of SARS on hospital staff: survey of a large tertiary care institution. Cmaj. 170(5):793–798. https://doi.org/10.1503/cmaj.1031077
49. Teo WL, Lee M, Lim W-S (2017) The relational activation of resilience model: how leadership activates resilience in an organizational crisis. J Conting Crisis Manag 25(3):136–147. https://doi.org/10.1111/1468-5973.12179