







Screening and testing for COVID-19 before surgery

Joshua G. Kovoov ,* David R. Tivey ,†‡ Penny Williamson,† Lorwai Tan ,† Helena S. Kopunic,† Wendy J. Babidge ,†‡ Trevor G. Collinson,§ Peter J. Hewett,‡ Thomas J. Hugh ,¶|| Robert T. A. Padbury,**†† Mark Frydenberg,‡‡§§ Richard G. Douglas,¶¶|| Jen Kok||| and Guy J. Maddern †‡

*University of Adelaide, Adelaide, South Australia, Australia

†Research Audit and Academic Surgery, Royal Australasian College of Surgeons, Adelaide, South Australia, Australia

‡University of Adelaide Discipline of Surgery, The Queen Elizabeth Hospital, Adelaide, South Australia, Australia

§General Surgeons Australia, Adelaide, South Australia, Australia

¶Northern Clinical School, University of Sydney, Sydney, New South Wales, Australia

||Surgical Education, Research and Training Institute, Royal North Shore Hospital, Sydney, New South Wales, Australia

**Flinders University, Adelaide, South Australia, Australia

††Division of Surgery and Perioperative Medicine, Flinders Medical Centre, Adelaide, South Australia, Australia

‡‡Department of Urology, Cabrini Institute, Cabrini Health, Melbourne, Victoria, Australia

§§Department of Surgery, Central Clinical School, Monash University, Melbourne, Victoria, Australia

¶¶Department of Surgery, The University of Auckland, Auckland, New Zealand and

|||Centre for Infectious Diseases and Microbiology Laboratory Services, NSW Health Pathology – Institute of Clinical Pathology and Medical Research, Westmead Hospital, Westmead, New South Wales, Australia

Key words

COVID-19, imaging, screening, surgery, testing.

Correspondence

Professor Guy J. Maddern, Discipline of Surgery, The Queen Elizabeth Hospital, The University of Adelaide, 28 Woodville Road, Woodville, South Australia, 5011, Australia.

Email: guy.maddern@adelaide.edu.au

D. R. Tivey BSc (Hons), PhD; **P. Williamson** BHlth Sci (Hons), PhD; **L. Tan** BSc (Hons), PhD; **H. S. Kopunic** MRes, PhD; **W. J. Babidge** BAApp Sci (Hons), PhD; **T. G. Collinson** MS, FRACS; **P. J. Hewett** MBBS, FRACS; **T. J. Hugh** MD, FRACS; **R. T. A. Padbury** PhD, FRACS; **M. Frydenberg** MBBS, FRACS; **R. G. Douglas** MD, FRACS; **J. Kok** PhD, FRCPA; **G. J. Maddern** PhD, FRACS.

CT, computed tomography; RT-PCR, reverse transcription-polymerase chain reaction.

Accepted for publication 4 August 2020.

doi: 10.1111/ans.16260

Introduction

Coronavirus disease 2019 (COVID-19) has disrupted surgical care worldwide. Infection with the causative virus, severe acute respiratory

Abstract

Background: Preoperative screening for coronavirus disease 2019 (COVID-19) aims to preserve surgical safety for both patients and surgical teams. This rapid review provides an evaluation of current evidence with input from clinical experts to produce guidance for screening for active COVID-19 in a low prevalence setting.

Methods: An initial search of PubMed (until 6 May 2020) was combined with targeted searches of both PubMed and Google Scholar until 1 July 2020. Findings were streamlined for clinical relevance through the advice of an expert working group that included seven senior surgeons and a senior medical virologist.

Results: Patient history should be examined for potential exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Hyposmia and hypogeusia may present as early symptoms of COVID-19, and can potentially discriminate from other influenza-like illnesses. Reverse transcription-polymerase chain reaction is the gold standard diagnostic test to confirm SARS-CoV-2 infection, and although sensitivity can be improved with repeated testing, the decision to retest should incorporate clinical history and the local supply of diagnostic resources. At present, routine serological testing has little utility for diagnosing acute infection. To appropriately conduct preoperative testing, the temporal dynamics of SARS-CoV-2 must be considered. Relative to other thoracic imaging modalities, computed tomography has the greatest utility for characterizing pulmonary involvement in COVID-19 patients who have been diagnosed by reverse transcription-polymerase chain reaction.

Conclusion: Through a rapid review of the literature and advice from a clinical expert working group, evidence-based recommendations have been produced for the preoperative screening of surgical patients with suspected COVID-19.

syndrome coronavirus 2 (SARS-CoV-2), has been associated with considerable postoperative mortality and morbidity for surgical patients.^{1–3} The global backlog of operations resulting from the temporary suspension of elective surgery could take close to a year to resolve.⁴

Although both Australia and New Zealand have experienced a relatively low COVID-19 caseload on an international scale,⁵ surgical systems within both countries have still been affected. During the initial phase of COVID-19, evidence-based guidance was required⁶ from organizations such as the Royal Australasian College of Surgeons (RACS) and other specialty surgical societies and associations for safe intraoperative practice,^{7,8} appropriate personal protective equipment (PPE), management of surgical departments^{9,10} and effective surgical triage^{11,12} in order to preserve the safety of surgical patients and staff. With the recommencement of elective surgery, clarity is required regarding the most appropriate methods of screening for active SARS-CoV-2 infection before surgery.¹³

We aimed to evaluate the literature and produce evidence-based guidance regarding screening methods for active SARS-CoV-2 infection before surgery in a setting of low COVID-19 prevalence.

Methods

A rapid review of the literature was combined with the advice of a working group comprising clinical experts across Australia and New Zealand, including seven senior surgeons (five general surgeons, one urologist and one otorhinolaryngologist) and a senior medical virologist. Input was also provided by five representatives from other areas of medicine, surgery and healthcare management.

A rapid review methodology¹⁴ was utilized for an extensive search of the peer-reviewed literature using the PubMed database (Appendix I). The search was date-limited to articles published between 31 December 2019 and 6 May 2020 (search date) in order to correspond with the World Health Organization's identification of the novel coronavirus.¹⁵ This was supplemented with targeted searches of the peer-reviewed literature until 1 July 2020, using both the PubMed and Google Scholar databases, which were informed by the working group.

Study selection was performed by JGK and DRT, and was expedited using the web application, Rayyan.¹⁶ Data extraction from each study was performed by a single reviewer (JGK, PW, LT, HSK) using a standard template, and a sample of the extractions was checked by JGK and DRT. Inclusion was not limited by language as any relevant non-English articles were translated using Artificial Intelligence translation tools where necessary. Case series with a sample size under 40 were excluded, apart from articles deemed important by the reviewers.^{17,18} Median values and interquartile ranges of the datapoints on the demographics and symptoms associated with COVID-19 were calculated from the retrieved studies.

Results and Discussion

Search results

The literature search yielded an initial pool of 5762 citations, from which 1395 human studies were identified (Appendix I). After screening of title and abstract, this pool was refined to 255 relevant articles, for which full-text versions were retrieved. Information

deemed pertinent from this pool of 255 articles were synthesized along with findings from the targeted searches.

Balancing the diagnostic workup of COVID-19 with surgical urgency

Given the considerable postoperative morbidity and mortality associated with operating on COVID-19 patients,¹⁻³ it is imperative that all surgical patients with suspected SARS-CoV-2 infection undergo appropriate screening prior to surgery. However, this must be balanced with the urgency of surgery to ensure optimal outcomes for the patient, and surgery should not be delayed unnecessarily. Non-elective surgery should not be delayed for confirmation of COVID-19 diagnosis in suspected patients,¹² rather it should proceed with surgical staff wearing full PPE¹⁰ and undertaking appropriate intraoperative precautions, especially during aerosol-generating procedures.⁷ If turnaround times of reverse transcription-polymerase chain reaction (RT-PCR) testing are within 24 h, results of patients with suspected COVID-19 should be awaited prior to surgery provided that the delays do not adversely affect patient outcomes.

Patients that receive a positive result in preoperative RT-PCR testing should be managed on a case-by-case basis by the treating clinical team.¹² Surgical decision-making should incorporate the urgency of the patient's condition, local supply of hospital resources, and potential postoperative outcomes if the operation is postponed for repeat testing or symptom resolution.

Evidence-based recommendations have been produced (Table 1) along with a proposed schema for the preoperative screening of surgical patients suspected of having COVID-19 (Table 2). A printable questionnaire has also been developed for verbally screening patients for both symptoms of COVID-19 and a history of potential SARS-CoV-2 exposure, either during face-to-face or telemedicine consultations at any point in the preoperative setting (Appendix II). The proportion of patients responding positively to the questionnaire (Appendix II) or requiring diagnostic workup (Table 2) will vary significantly depending on the local prevalence of COVID-19. The use of existing preoperative screening checklists should also be considered,¹⁹ particularly if recommended by local institutions.

Importance of exposure history

Due to the high level of SARS-CoV-2 shedding in the upper respiratory tract which is estimated to begin 2–3 days prior to the onset of symptoms,^{20,21} asymptomatic or presymptomatic persons with COVID-19 are capable of transmitting the virus to others during this period²² and at other times during the disease course.^{23,24} It has been estimated that up to 17.9% of COVID-19 cases could be asymptomatic,²⁵ and that approximately 44% of secondary cases in a given cohort could have been infected during the presymptomatic stage of index cases.²¹

As SARS-CoV-2 can spread rapidly even when clinically undetectable, patient history must be screened for potential sources of exposure to the virus (Table 1). Surgical patients from population groups at high risk of contracting COVID-19^{21,26} should be

Table 1 Recommendations from the working group on screening for COVID-19 before surgery (1 July 2020)¹³

<p>Patient history should be thoroughly examined for potential sources of SARS-CoV-2 exposure (especially close contact with groups at high risk of contracting the disease), and equal weight should be given to these findings as to clinical presentation. Preoperative testing for COVID-19 is not recommended in patients with no risk factors</p> <p>Assessment of patient symptoms is insufficient as a sole method of diagnosing COVID-19, although it can inform necessary adjunctive investigations</p> <p>Hyposmia (loss of smell) or hypogeusia (loss of taste) should be considered important in evaluating potential SARS-CoV-2 infection</p> <p>Although crucial to the optimal management of patients with COVID-19, non-SARS-CoV-2 specific laboratory tests (such as haematology and biochemistry tests) have limited utility on their own within the diagnostic workup of potential SARS-CoV-2 infection</p> <p>Reverse Transcription-Polymerase Chain Reaction (RT-PCR) is the gold standard laboratory test for diagnosing SARS-CoV-2 infection, and within Australia and New Zealand there is good concordance in analytical performance between in-house developed and commercial tests. False negatives can decrease with repeated testing, however, the decision to repeat test should be made based on clinical history and the local supply of laboratory testing resources. Local microbiology services should be consulted regarding testing capability, particularly with regard to the availability of rapid RT-PCR testing</p> <p>Turnaround times for RT-PCR results detecting SARS-CoV-2 infection may be within 24 hours in Australia and New Zealand. There is considerable postoperative morbidity and mortality associated with operating on COVID-19 patients. Thus, any surgical operation that can be delayed for 24 hours or more without adverse effects to patients, should await the testing results prior to undertaking surgery in patients with suspected SARS-CoV-2 infection</p> <p>At present, serological testing has limited use within the routine preoperative diagnostic workup for acute SARS-CoV-2 infection. However, it may be used in the diagnosis of COVID-19, including where patients are RT-PCR negative, or as a supplementary test with an unexpected positive or inconclusive RT-PCR result. It can also be used for sero-epidemiologic studies to determine population exposure and infection, and for evaluating vaccine effectiveness</p> <p>The use of chest CT scanning alone to diagnose COVID-19 is not recommended due to non-specific findings that may overlap with other respiratory illnesses</p>

treated with appropriate perioperative precautions,^{7,10,12} and if it is unlikely to worsen postoperative outcomes, surgery should be delayed for preoperative RT-PCR testing (Table 2). Patients from 'essential' professions that are at high risk of exposure to COVID-19 (e.g. workers in healthcare, allied health facilities, supermarkets, schools, delivery, factory and farming, and transport)²⁷ should be treated with caution and undergo RT-PCR testing if symptomatic.

Symptoms associated with COVID-19

An assessment of patient symptoms is insufficient as a sole method of diagnosing COVID-19 (Table 1), however, it can facilitate adjunctive investigations. Although characterized as a respiratory disease in the initial stages of the pandemic,^{28–32} gastrointestinal,³³ cardiovascular,³⁴ haematological,^{35,36} immunological³⁷ and neurological³⁸ manifestations of COVID-19 have been reported. Of these, only gastrointestinal manifestations have been found in the absence of respiratory symptoms.³⁹ Although cases of suspected SARS-CoV-2 reactivation have been reported, no specific associated clinical characteristics have been identified.⁴⁰

Table 2 Proposed preoperative diagnostic workup for COVID-19 (1 July 2020)¹³

Features of patient history	Advised preoperative investigation
<p>Any risk of potential SARS-CoV-2 exposure, including:</p> <ul style="list-style-type: none"> • Close contact with a confirmed case of COVID-19 in the past 2 weeks • Close contact with someone who displays symptoms of hyposmia (loss of smell), hypogeusia (loss of taste), cough, sore throat or dyspnoea in the past 2 weeks (including the 3 days prior to onset of symptoms) • Overseas or interstate (if state of journey's origin contains active cases of COVID-19) travel in the past 2 weeks, either by plane or cruise ship, or close contact with someone who has • Presence within an aged care facility in the past 2 weeks, either as a resident, worker or visitor • Presence within a detention facility in the past 2 weeks, either as a resident, worker or visitor • Presence within a group residential setting in the past 2 weeks, either as a resident, worker or visitor • Presence within other facilities that have relatively high risk of COVID-19 transmission • Profession that includes regular interaction with COVID-19 cases (e.g. workers in healthcare, allied health facilities, supermarkets, schools, delivery, factories, farming and transport) 	RT-PCR assay
<p>Any of the following symptoms in the past 2 weeks:</p> <ul style="list-style-type: none"> • Hyposmia • Hypogeusia • Cough • Sore throat • Dyspnoea • Unexplained fever 	RT-PCR assay
<p>Over 70 years of age AND any new-onset respiratory symptoms, including:</p> <ul style="list-style-type: none"> • Cough • Sore throat • Dyspnoea 	RT-PCR assay AND CT scan of chest
<p>Surgery required within 24 h AND presence of ANY of the above history features</p>	No preoperative investigation for SARS-CoV-2 infection†

†Proceed to surgery with surgical staff wearing full PPE and taking appropriate intraoperative precautions, especially for potential aerosol-generating procedures.^{7,10,12} Isolate patient postoperatively and test for SARS-CoV-2 infection when possible.

From 31 selected studies investigating a total of 53 538 patients with laboratory-confirmed SARS-CoV-2 infection, the symptoms most frequently reported in association with COVID-19 included fever, cough, sore throat, dyspnoea (including shortness of breath or tachypnoea), diarrhoea, nausea or vomiting, and myalgia or arthralgia (Table 3).^{1,17,18,28,31,39,41–65} The literature also suggests that olfactory or gustatory dysfunction, particularly of sudden onset,

Table 3 Findings from 31 selected studies with the most frequently reported symptoms associated with COVID-19^{1,17,18,28,31,39,41–65}

Finding	No. studies	Cohort median	Interquartile range
Sample size, n	31	253	100.5–883.8
Median age, years	27	53.3	46.5–62.3
ICU admission rate	18	23%	6.8–32
Case-fatality rate	20	12.5%	0.9–23.3
Symptoms			
Fever	30	71.6%	53.6–82.6
Cough	30	62.6%	45.8–73.2
Dyspnoea	26	28.7%	13–44
Myalgia/arthralgia	20	26.5%	15.0–54.2
Sore throat	18	13.9%	6.4–35
Diarrhoea	27	10.4%	5.3–22.1
Nausea/vomiting	20	7.5%	4.3–17.5

ICU, intensive care unit.

can be key early manifestations of COVID-19,^{66,67} with the presence of hyposmia and hypogeusia potentially facilitating discrimination between COVID-19 and other influenza-like illnesses.⁶⁸

Laboratory findings associated with COVID-19

Immunological dysfunction due to COVID-19 can potentially result in the derangement of haematological, hepatic and renal laboratory markers.^{18,28,31,39,41–43,46,47,50,52,53,57,61,63,64,69–73} The immunopathogenesis of SARS-CoV-2 infection is typified by an aggressive inflammatory response,⁷⁴ and accordingly, elevated inflammatory markers are common.^{18,28,41–43,46,47,50,52,61,63,64,69–72} Lymphopaenia and an increased neutrophil to lymphocyte ratio can occur in many patients with SARS-CoV-2 infection.^{37,52,74} Close monitoring of inflammatory markers and serum cytokine and chemokine levels is crucial to the optimal management of COVID-19 patients,^{37,75} as severe SARS-CoV-2 infection can result in the manifestation of a cytokine storm syndrome.⁷⁶ However, although useful for gauging disease severity,⁴⁶ no individual laboratory marker within a multi-system workup provides specific utility for diagnosing active SARS-CoV-2 infection.⁷⁷ Thus, non-diagnostic laboratory investigations have little utility within the preoperative screening for COVID-19 (Table 1).

Reverse transcription-polymerase chain reaction (RT-PCR)

At the time of this publication, the RT-PCR test is considered the gold standard diagnostic test for SARS-CoV-2 infection.⁷⁸ Given the poor outcomes reported after surgery in COVID-19 patients,^{1–3} RT-PCR testing is imperative for all elective surgery patients suspected of SARS-CoV-2 infection. However, diagnostic accuracy remains challenging,⁷⁹ with the test's false-negative rate estimated to be 2–29%.⁸⁰ Accordingly, due to the test's high specificity but relatively moderate sensitivity, a positive result on RT-PCR should be treated with more weight in surgical decision-making than a negative result.⁸¹ Test outcome may be influenced by site of sample collection,⁸² variation in specimen collection protocol and handling,⁸³ and time since exposure to SARS-CoV-2.⁸⁴ Corresponding to temporal fluctuations in viral load,^{21,85,86} the probability of recording a false negative result has been reported as

being highest in the 4 days prior to the onset of symptoms, with the lowest probability occurring on the day of symptom onset.⁸⁴ Thus, if a patient displays any symptoms associated with COVID-19, RT-PCR testing should be conducted even if the patient has previously tested negative for SARS-CoV-2 (Table 1). Further, as RT-PCR is less sensitive for SARS-CoV-2 early in its incubation period, a 14-day quarantine prior to surgery should be considered in asymptomatic patients with a history of potential exposure to the virus (Appendix II), so as to allow time for resolution or presentation of the symptomatic phase.⁸⁷ Although repeat testing may overcome the limitations in RT-PCR sensitivity⁷⁹ and the probability of an incorrect result,⁸⁸ the decision to repeat a RT-PCR test should incorporate both the patient's risk of COVID-19 and the local supply of diagnostic resources.

RT-PCR tests detecting SARS-CoV-2 should demonstrate high sensitivity and specificity in addition to minimal cross-reactivity with other coronaviruses, and a cycle threshold value below 40 is generally accepted as the criterion for positivity.⁸⁹ Although the SARS-CoV-2 genes selected for amplification vary depending on the manufacturer,^{83,90,91} within Australia and New Zealand there is good concordance in the analytical performance between in-house developed and commercial RT-PCR tests.^{92,93} Surgical staff are encouraged to seek clarification from their local pathology service regarding the local availability of validated tests^{94,95} (including other methods for nucleic acid amplification⁹⁶) and their turnaround times.

Serological testing

Serological detection of antibodies produced in the host immune response to SARS-CoV-2 infection can be utilized as a method of diagnosing COVID-19.^{78,97} Seroconversion or a four-fold or greater rise in antibody levels between acute and convalescent samples is considered definitive laboratory evidence of SARS-CoV-2 infection.⁹⁸ Large-scale analyses of seropositivity for immunoglobulin (Ig) M and G produced in response to SARS-CoV-2 infection have revealed the propensity for variation between populations depending on demographic differences and the population's overall duration of exposure to the virus.^{99–101} IgG and IgA are the antibodies most reliably detected in blood samples following SARS-CoV-2 infection, however global seroprevalence rates following the

first wave of the pandemic ranged from 0.1% to 47%, with considerable geographic variation.¹⁰²

Serological testing alone has little utility within preoperative screening for COVID-19 as it can neither confirm nor exclude a diagnosis of acute SARS-CoV-2 infection, nor provide information on potential infectivity (Table 1). Positivity for IgG or IgM may not be an assurance of protective immunity,¹⁰³ and there is uncertainty as to the period of immunity conferred.¹⁰⁴ The type of assay to use has been debated, with enzyme-linked immunosorbent assay possibly more reliable than blotting assays,¹⁰⁵ and questions have been raised regarding which antigen (derived from SARS-CoV-2) should be targeted^{106,107} whilst ensuring that other coronaviruses do not cross-react.^{107,108} Point-of-care antibody test kits are now available,¹⁰⁹ however most are unreliable and not accurate enough to confirm past exposure to SARS-CoV-2.¹⁰⁸

Temporal considerations for SARS-CoV-2

To appropriately integrate testing for SARS-CoV-2 infection into preoperative surgical triage,¹² the temporal dynamics of the virus must be considered. The incubation period of SARS-CoV-2 has been estimated to be approximately four to five days^{30,110,111} and viral load decreases after symptom onset,^{21,85,86} although SARS-CoV-2 RNA may be detected up to 37 days later.⁶² The virus is infectious both before²² and after the onset of symptoms,²¹ however infectivity is likely to decline after the first week of symptoms, when live virus may not be isolated in cell culture despite high viral loads in respiratory tract samples.²⁰

In an evidence-based timeline of the various diagnostic markers of SARS-CoV-2 infection,⁷⁸ Sethuraman *et al.* estimated that RT-PCR detection (which merely confirms the presence of viral RNA, not viable virus^{20,112}) is likely to produce a positive result in the first 3 weeks after symptom onset.¹¹³ Antibodies are most likely to be detected in serological tests after approximately 2 weeks of symptoms,¹¹⁴ with IgG levels generally greater than IgM levels from about 4 weeks after symptom onset.¹¹⁵ It is important to note that RT-PCR positivity has not been shown to correlate with clinical severity,¹¹³ and has been found in cases when symptoms have completely resolved.¹¹⁶

Thoracic imaging for COVID-19

Thoracic imaging serves the purpose of characterizing the extent of pulmonary involvement from COVID-19, rather than providing a method of definitively diagnosing SARS-CoV-2 infection. Chest computed tomography (CT), radiography and ultrasonography have all been discussed within the literature as imaging modalities that can potentially provide evaluative utility alongside RT-PCR assays. However, due to the considerable overlap between findings associated with pulmonary involvement in COVID-19 and those of other respiratory illnesses, no single thoracic imaging modality should be used as a sole method of diagnosing SARS-CoV-2 infection.

Outside its known utility within the initial evaluation of suspected community-acquired pneumonia,¹¹⁷ there is little evidence that chest radiography provides added diagnostic specificity for cases of suspected COVID-19.^{118,119} Similarly, although

ultrasonography can potentially provide a low-cost, easily-disinfected, radiation-free alternative to CT in settings of high COVID-19 prevalence or low medical resources,^{120–122} in settings of low COVID-19 prevalence and adequate resources its lack of specificity limits diagnostic utility. Ground-glass opacities, consolidation, pleural thickening, interlobular septal thickening and air bronchograms have been reported in the literature as the chest CT findings most commonly associated with COVID-19, with lesions more likely to be found in the lower lobes.¹²³ However, there is variation in reported CT features based on time within the COVID-19 disease course.^{124,125} Chest CT could potentially have even greater sensitivity for detecting respiratory involvement of SARS-CoV-2 infection than RT-PCR,^{126,127} however multiple meta-analyses within the literature have estimated the specificity of the modality to be below 40% for COVID-19.^{128,129} Thus while the sole use of chest CT to screen for SARS-CoV-2 infection cannot be recommended,¹³⁰ it can be useful for characterizing the pulmonary involvement within COVID-19 patients that have been confirmed by RT-PCR (Table 1).

Conclusions

On the basis of a rapid review of the literature, evidence-based recommendations have been produced along with a proposed schema for the preoperative screening of surgical patients with suspected SARS-CoV-2 infection in a low prevalence setting. RT-PCR testing remains the gold standard diagnostic test for SARS-CoV-2 infection. However, relevant patient history suggesting potential exposure to the virus and clinical presentation, particularly the presence of hyposmia or hypogeusia, must also be considered within preoperative screening for COVID-19. Surgical decision-making should incorporate the urgency of the individual patient's condition, the temporal dynamics of SARS-CoV-2, and local supply of medical resources. A printable questionnaire has also been developed for verbally screening patients for COVID-19 during face-to-face or telemedicine consultations.

Acknowledgements

The authors acknowledge Dr Vanessa Beavis, representing the Australian and New Zealand College of Anaesthetists (ANZCA); Dr Vicky H. Lu, representing the Royal Australian and New Zealand College of Ophthalmologists (RANZCO); Dr James Churchill, representing the Royal Australasian College of Surgeons Trainees' Association (RACSTA); Dr Chloe Ayres, representing the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG); Dr Shane Kelly, representing St John of God Healthcare.

Conflicts of interest

None declared.

References

1. COVIDSurg Collaborative. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet* 2020; **396**: 27–38.
2. Doglietto F, Vezzoli M, Gheza F *et al.* Factors associated with surgical mortality and complications among patients with and without coronavirus disease 2019 (COVID-19) in Italy. *JAMA Surg.* 2020. <https://doi.org/10.1001/jamasurg.2020.2713>.
3. Lei S, Jiang F, Su W *et al.* Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. *EClinicalMedicine* 2020; **21**: 100331.
4. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br. J. Surg.* 2020. <https://doi.org/10.1002/bjs.11746>.
5. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect. Dis.* 2020; **20**: 533–4.
6. Maddern GJ. Evidence, not eminence, in coronavirus disease 2019. *ANZ J. Surg.* 2020; **90**: 1537.
7. Tivey DR, Davis SS, Kovoor JG *et al.* Safe surgery during the coronavirus disease 2019 crisis. *ANZ J. Surg.* 2020; **90**: 1553–7.
8. Royal Australasian College of Surgeons. *Guidelines for Safe Surgery: Open versus Laparoscopic*, 1st edn. [Cited 9 Jun 2020.] Available from URL: <https://umbraco.surgeons.org/media/5214/2020-04-15-recommendations-on-safe-surgery-laparoscopic-vs-open.pdf>
9. Royal Australasian College of Surgeons. *Guidelines for Personal Protective Equipment*, 1st edn. [Cited 9 Jun 2020.] Available from URL: <https://umbraco.surgeons.org/media/5302/2020-05-05-covid19-ppe-guidelines.pdf>
10. Tan L, Kovoor JG, Williamson P *et al.* Personal protective equipment and evidence-based advice for surgical departments during COVID-19. *ANZ J. Surg.* 2020; **90**: 1566–72.
11. Royal Australasian College of Surgeons. *Surgery Triage: Responding to the COVID-19 Pandemic*, 2nd edn. [Cited 9 Jun 2020.] Available from URL: https://umbraco.surgeons.org/media/5254/2020-04-22_racs-triage-of-surgery-web.pdf
12. Babidge WJ, Tivey DR, Kovoor JG *et al.* Surgery triage during the COVID-19 pandemic. *ANZ J. Surg.* 2020; **90**: 1558–65.
13. Royal Australasian College of Surgeons. *Guidelines on the Preoperative Diagnostic Workup for COVID-19*, 1st edn. [Cited 5 Jul 2020.] Available from URL: <https://www.surgeons.org/-/media/Project/RACS/surgeons-org/files/news/covid19-information-hub/Guidelines-on-the-Preoperative-Diagnostic-Workup-for-COVID-19.pdf?rev=6da3bef72d4f42bc8727a3ef43776dc5&hash=52DC2A4B1F7B2B88F1F789F949D77C12>
14. Watt A, Cameron A, Sturm L *et al.* Rapid versus full systematic reviews: validity in clinical practice? *ANZ J. Surg.* 2008; **78**: 1037–40.
15. World Health Organization. *Pneumonia of unknown cause – China. Disease outbreak news: 5 January 2020.* [cited 25 Jun 2020.] Available from URL: <https://www.who.int/csr/don/05-january-2020-pneumonia-of-unknown-cause-china/en/>
16. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst. Rev.* 2016; **5**: 210.
17. Bhatraju PK, Ghassemieh BJ, Nichols M *et al.* COVID-19 in critically ill patients in the Seattle region – case series. *N. Engl. J. Med.* 2020; **382**: 2012–22.
18. Zheng F, Liao C, Fan QH *et al.* Clinical characteristics of children with coronavirus disease 2019 in Hubei, China. *Curr. Med. Sci.* 2020; **40**: 275–80.
19. Australian Commission on Safety and Quality in Health Care. *COVID-19: Elective Surgery and Infection Prevention and Control Precautions*. 3rd edn. [Cited 23 July 2020.] Available from URL: <https://www.safetyandquality.gov.au/publications-and-resources/resource-library/covid-19-elective-surgery-and-infection-prevention-and-control-precautions>
20. Wolfel R, Corman VM, Guggemos W *et al.* Virological assessment of hospitalized patients with COVID-2019. *Nature* 2020; **581**: 465–9.
21. He X, Lau EHY, Wu P *et al.* Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat. Med.* 2020; **26**: 672–5.
22. Arons MM, Hatfield KM, Reddy SC *et al.* Presymptomatic SARS-CoV-2 infections and transmission in a skilled nursing facility. *N. Engl. J. Med.* 2020; **382**: 2081–90.
23. Bai Y, Yao L, Wei T *et al.* Presumed asymptomatic carrier transmission of COVID-19. *JAMA* 2020; **323**: 1406.
24. Gandhi M, Yokoe DS, Havlir DV. Asymptomatic transmission, the Achilles' heel of current strategies to control COVID-19. *N. Engl. J. Med.* 2020; **382**: 2158–60.
25. Mizumoto K, Kagaya K, Zarebski A, Chowell G. Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. *Euro. Surveill.* 2020; **25**: 2000180.
26. Healthdirect Australian Government. *Groups at Higher Risk of Developing COVID-19*. [Cited 3 May 2020.] Available from URL: <https://www.healthdirect.gov.au/coronavirus-covid-19-groups-at-higher-risk-faqs>
27. The plight of essential workers during the COVID-19 pandemic. *Lancet* 2020; **395**: 1587.
28. Chen N, Zhou M, Dong X *et al.* Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 2020; **395**: 507–13.
29. Zhu N, Zhang D, Wang W *et al.* A novel coronavirus from patients with pneumonia in China. *N. Engl. J. Med.* 2019; **382**: 727–33.
30. Li Q, Guan X, Wu P *et al.* Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N. Engl. J. Med.* 2020; **382**: 1199–207.
31. Wang D, Hu B, Hu C *et al.* Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA* 2020; **323**: 1061.
32. Zhou P, Yang XL, Wang XG *et al.* A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 2020; **579**: 270–3.
33. Parasa S, Desai M, Thoguluva Chandrasekar V *et al.* Prevalence of gastrointestinal symptoms and fecal viral shedding in patients with coronavirus disease 2019: a systematic review and meta-analysis. *JAMA Netw. Open* 2020; **3**: e2011335.
34. Zheng YY, Ma YT, Zhang JY, Xie X. COVID-19 and the cardiovascular system. *Nat. Rev. Cardiol.* 2020; **17**: 259–60.
35. Zhang Y, Xiao M, Zhang S *et al.* Coagulopathy and antiphospholipid antibodies in patients with Covid-19. *N. Engl. J. Med.* 2020; **382**: e38.
36. Klok FA, Kruip M, van der Meer NJM *et al.* Incidence of thrombotic complications in critically ill ICU patients with COVID-19. *Thromb. Res.* 2020; **191**: 145–7.
37. Qin C, Zhou L, Hu Z *et al.* Dysregulation of immune response in patients with COVID-19 in Wuhan, China. *Clin. Infect. Dis.* 2020; **71**: 762–8.
38. Helms J, Kremer S, Merdji H *et al.* Neurologic features in severe SARS-CoV-2 infection. *N. Engl. J. Med.* 2020; **382**: 2268–70.
39. Pan L, Mu M, Yang P *et al.* Clinical characteristics of COVID-19 patients with digestive symptoms in Hubei, China: a descriptive,

- cross-sectional, multicenter study. *Am. J. Gastroenterol.* 2020; **115**: 766–73.
40. Ye G, Pan Z, Pan Y *et al.* Clinical characteristics of severe acute respiratory syndrome coronavirus 2 reactivation. *J. Infect.* 2020; **80**: e14–e7.
 41. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N. Engl. J. Med.* 2020; **382**: 2534–43.
 42. Tian J, Yuan X, Xiao J *et al.* Clinical characteristics and risk factors associated with COVID-19 disease severity in patients with cancer in Wuhan, China: a multicentre, retrospective, cohort study. *Lancet Oncol.* 2020; **21**: 893–903.
 43. Yang K, Sheng Y, Huang C *et al.* Clinical characteristics, outcomes, and risk factors for mortality in patients with cancer and COVID-19 in Hubei, China: a multicentre, retrospective, cohort study. *Lancet Oncol.* 2020; **21**: 904–13.
 44. Docherty AB, Harrison EM, Green CA *et al.* Features of 20 133 UK patients in hospital with COVID-19 using the ISARIC WHO Clinical Characterisation Protocol: prospective observational cohort study. *BMJ* 2020; **369**: m1985.
 45. Diaz LA, Garcia-Salum T, Fuentes-Lopez E *et al.* Symptom profiles and risk factors for hospitalization in patients with SARS-CoV-2 and COVID-19: a large cohort from South America. *Gastroenterology* 2020. <https://doi.org/10.1053/j.gastro.2020.05.014>.
 46. Cummings MJ, Baldwin MR, Abrams D *et al.* Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet* 2020. [https://doi.org/10.1016/S0140-6736\(20\)31189-2](https://doi.org/10.1016/S0140-6736(20)31189-2).
 47. Argenziano MG, Bruce SL, Slater CL *et al.* Characterization and clinical course of 1000 patients with coronavirus disease 2019 in New York: retrospective case series. *BMJ* 2020; **369**: m1996.
 48. CDC COVID-19 Response Team. Characteristics of health care personnel with COVID-19 – United States, February 12–April 9, 2020. *MMWR Morb. Mortal. Wkly Rep.* 2020; **69**: 477–81.
 49. CDC COVID-19 Response Team. Coronavirus Disease 2019 in Children – United States, February 12–April 2, 2020. *MMWR Morb. Mortal. Wkly Rep.* 2020; **69**: 422–6.
 50. Chen J, Qi T, Liu L *et al.* Clinical progression of patients with COVID-19 in Shanghai, China. *J. Infect.* 2020; **80**: e1–6.
 51. Chen T, Wu D, Chen H *et al.* Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *BMJ* 2020; **368**: m1091.
 52. Guan WJ, Ni ZY, Hu Y *et al.* Clinical characteristics of coronavirus disease 2019 in China. *N. Engl. J. Med.* 2020; **382**: 1708–20.
 53. Huang C, Wang Y, Li X *et al.* Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; **395**: 497–506.
 54. Lu X, Zhang L, Du H *et al.* SARS-CoV-2 infection in children. *N. Engl. J. Med.* 2020; **382**: 1663–5.
 55. Tian S, Hu N, Lou J *et al.* Characteristics of COVID-19 infection in Beijing. *J. Infect.* 2020; **80**: 401–6.
 56. Tostmann A, Bradley J, Bousema T *et al.* Strong associations and moderate predictive value of early symptoms for SARS-CoV-2 test positivity among healthcare workers, the Netherlands, March 2020. *Euro Surveill.* 2020; **25**: 2000508.
 57. Wang D, Yin Y, Hu C *et al.* Clinical course and outcome of 107 patients infected with the novel coronavirus, SARS-CoV-2, discharged from two hospitals in Wuhan, China. *Crit. Care.* 2020; **24**: 188.
 58. Xu XW, Wu XX, Jiang XG *et al.* Clinical findings in a group of patients infected with the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: retrospective case series. *BMJ* 2020; **368**: m606.
 59. Yang W, Cao Q, Qin L *et al.* Clinical characteristics and imaging manifestations of the 2019 novel coronavirus disease (COVID-19): a multi-center study in Wenzhou city, Zhejiang, China. *J. Infect.* 2020; **80**: 388–93.
 60. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation between chest CT findings and clinical conditions of coronavirus disease (COVID-19) pneumonia: a multicenter study. *AJR Am. J. Roentgenol.* 2020; **214**: 1072–7.
 61. Zheng F, Tang W, Li H, Huang YX, Xie YL, Zhou ZG. Clinical characteristics of 161 cases of corona virus disease 2019 (COVID-19) in Changsha. *Eur. Rev. Med. Pharmacol. Sci.* 2020; **24**: 3404–10.
 62. Zhou F, Yu T, Du R *et al.* Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 2020; **395**: 1054–62.
 63. Colaneri M, Sacchi P, Zuccaro V *et al.* Clinical characteristics of coronavirus disease (COVID-19) early findings from a teaching hospital in Pavia, North Italy, 21 to 28 February 2020. *Euro. Surveill.* 2020; **25**: 2000460.
 64. Xu X, Yu C, Qu J *et al.* Imaging and clinical features of patients with 2019 novel coronavirus SARS-CoV-2. *Eur. J. Nucl. Med. Mol. Imaging* 2020; **47**: 1275–80.
 65. Yang S, Shi Y, Lu H *et al.* Clinical and CT features of early stage patients with COVID-19: a retrospective analysis of imported cases in Shanghai, China. *Eur. Respir. J.* 2020; **4**: 55, 2000407.
 66. Lechien JR, Chiesa-Estomba CM, De Siati DR *et al.* Olfactory and gustatory dysfunctions as a clinical presentation of mild-to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study. *Eur. Arch. Otorhinolaryngol.* 2020; **277**: 2251–61.
 67. Benezit F, Le Turnier P, Declerck C *et al.* Utility of hyposmia and hypogeusia for the diagnosis of COVID-19. *Lancet Infect. Dis.* 2020. [https://doi.org/10.1016/S1473-3099\(20\)30297-8](https://doi.org/10.1016/S1473-3099(20)30297-8).
 68. Yan CH, Faraji F, Prajapati DP, Boone CE, DeConde AS. Association of chemosensory dysfunction and COVID-19 in patients presenting with influenza-like symptoms. *Int. Forum Allergy Rhinol.* 2020; **10**: 806–13.
 69. Cheng Y, Luo R, Wang K *et al.* Kidney disease is associated with in-hospital death of patients with COVID-19. *Kidney Int.* 2020; **97**: 829–38.
 70. Kim ES, Chin BS, Kang CK *et al.* Clinical course and outcomes of patients with severe acute respiratory syndrome coronavirus 2 infection: a preliminary report of the first 28 patients from the Korean cohort study on COVID-19. *J. Korean Med. Sci.* 2020; **35**: e142.
 71. Petrilli CM, Jones SA, Yang J *et al.* Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: prospective cohort study. *BMJ* 2020; **369**: m1966.
 72. Aggarwal S, Garcia-Telles N, Aggarwal G, Lavie C, Lippi G, Henry BM. Clinical features, laboratory characteristics, and outcomes of patients hospitalized with coronavirus disease 2019 (COVID-19): early report from the United States. *Diagnosis* 2020; **7**: 91–6.
 73. Zhao XY, Xu XX, Yin HS *et al.* Clinical characteristics of patients with 2019 coronavirus disease in a non-Wuhan area of Hubei Province, China: a retrospective study. *BMC Infect. Dis.* 2020; **20**: 311.
 74. Tay MZ, Poh CM, Renia L, MacAry PA, Ng LFP. The trinity of COVID-19: immunity, inflammation and intervention. *Nat. Rev. Immunol.* 2020; **20**: 363–74.
 75. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *J. Autoimmun.* 2020; **109**: 102433.

76. Mehta P, McAuley DF, Brown M, Sanchez E, Tattersall RS, Manson JJ. COVID-19: consider cytokine storm syndromes and immunosuppression. *Lancet* 2020; **395**: 1033–4.
77. Rodriguez-Morales AJ, Cardona-Ospina JA, Gutierrez-Ocampo E *et al.* Clinical, laboratory and imaging features of COVID-19: a systematic review and meta-analysis. *Travel Med. Infect. Dis.* 2020; **34**: 101623.
78. Sethuraman N, Jeremiah SS, Ryo A. Interpreting diagnostic tests for SARS-CoV-2. *JAMA* 2020; **323**: 2249.
79. Woloshin S, Patel N, Kesselheim AS. False negative tests for SARS-CoV-2 infection – challenges and implications. *N. Engl. J. Med.* 2020; **383**: e38.
80. Arevalo-Rodriguez I, Diana Buitrago-Garcia D, Simancas-Racines D *et al.* False-negative results of initial RT-PCR assays for COVID-19: a systematic review. *medRxiv* 2020; **2020**: 20066787.
81. Watson J, Whiting PF, Brush JE. Interpreting a COVID-19 test result. *BMJ* 2020; **369**: m1808.
82. Wang W, Xu Y, Gao R *et al.* Detection of SARS-CoV-2 in different types of clinical specimens. *JAMA* 2020; **323**: 1843–44. <https://doi.org/10.1001/jama.2020.3786>.
83. Hong KH, Lee SW, Kim TS *et al.* Guidelines for laboratory diagnosis of coronavirus disease 2019 (COVID-19) in Korea. *Ann. Lab. Med.* 2020; **40**: 351–60.
84. Kucirka LM, Lauer SA, Laeyendecker O, Boon D, Lessler J. Variation in false-negative rate of reverse transcriptase polymerase chain reaction-based SARS-CoV-2 tests by time since exposure. *Ann. Intern. Med.* 2020. <https://doi.org/10.7326/M20-1495>.
85. Zou L, Ruan F, Huang M *et al.* SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N. Engl. J. Med.* 2020; **382**: 1177–9.
86. To KK, Tsang OT, Leung WS *et al.* Temporal profiles of viral load in posterior oropharyngeal saliva samples and serum antibody responses during infection by SARS-CoV-2: an observational cohort study. *Lancet Infect. Dis.* 2020; **20**: 565–74.
87. Lothar SA. Preoperative SARS-CoV-2 screening: can it really rule out COVID-19? *Can. J. Anaesth.* 2020. <https://doi.org/10.1007/s12630-020-01746-w>.
88. Li Y, Yao L, Li J *et al.* Stability issues of RT-PCR testing of SARS-CoV-2 for hospitalized patients clinically diagnosed with COVID-19. *J. Med. Virol.* 2020; **92**: 903–8.
89. Centers for Disease Control and Prevention. *CDC 2019–Novel Coronavirus (2019-nCoV) Real-Time RT-PCR Diagnostic Panel*. [Cited 10 Jun 2020.]. Available from URL: <https://www.fda.gov/media/134922/download>
90. Corman VM, Landt O, Kaiser M *et al.* Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. *Euro. Surveill.* 2020; **25**: 2000045.
91. Cheng MP, Papenburg J, Desjardins M *et al.* Diagnostic testing for severe acute respiratory syndrome-related coronavirus 2: a narrative review. *Ann. Intern. Med.* 2020; **172**: 726–34.
92. Public Health Laboratory Network. *PHLN Guidance on Laboratory Testing for SARS-CoV-2 (the Virus that Causes COVID-19)*. [Cited 19 Jun 2020.]. Available from URL: <https://www.health.gov.au/sites/default/files/documents/2020/03/phln-guidance-on-laboratory-testing-for-sars-cov-2-the-virus-that-causes-covid-19.pdf>
93. The Royal College of Pathologists of Australasia. *PHLN Module: SARS-CoV-2 and other coronaviruses Module (March 23, 2020)*. [Cited 19 Jun 2020.]. Available from URL: <https://rcpaqap.com.au/phln-module-sars-cov-2-coronaviruses-module/>
94. Sheridan C. Fast, portable tests come online to curb coronavirus pandemic. *Nat. Biotechnol.* 2020; **38**: 509–22.
95. Bond K, Nicholson S, Hoang T, Catton M, Howden B, Williamson D. *Post-Market Validation of Three Serological Assays for COVID-19*. Melbourne, Australia: Doherty Institute, 2020.
96. Lu R, Wu X, Wan Z, Li Y, Jin X, Zhang C. A novel reverse transcription loop-mediated isothermal amplification method for rapid detection of SARS-CoV-2. *Int. J. Mol. Sci.* 2020; **21**: 2826.
97. Tang YW, Schmitz JE, Persing DH, Stratton CW. Laboratory diagnosis of COVID-19: current issues and challenges. *J. Clin. Microbiol.* 2020; **58**: e00512–20.
98. Public Health Laboratory Network. *Public Health Laboratory Network Guidance for Serological Testing in COVID-19 (22 June 2020)*. [Cited 2 July 2020.]. Available from URL: <https://www.health.gov.au/sites/default/files/documents/2020/06/phln-guidance-for-serological-testing-in-covid-19-phln-guidance-on-serological-testing-in-covid-19.pdf>
99. Xu X, Sun J, Nie S *et al.* Seroprevalence of immunoglobulin M and G antibodies against SARS-CoV-2 in China. *Nat. Med.* 2020; **26**: 1193–95. <https://doi.org/10.1038/s41591-020-0949-6>.
100. Steensels D, Oris E, Coninx L *et al.* Hospital-wide SARS-CoV-2 antibody screening in 3056 staff in a tertiary center in Belgium. *JAMA* 2020; **324**: 195.
101. Stringhini S, Wisniak A, Piumatti G *et al.* Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. *Lancet* 2020; **396**: 313–9.
102. Ioannidis J. The infection fatality rate of COVID-19 inferred from seroprevalence data. *medRxiv* 2020.
103. Weinstein MC, Freedberg KA, Hyle EP, Paltiel AD. Waiting for certainty on COVID-19 antibody tests – at what cost? *N. Engl. J. Med.* 2020; **383**: e37.
104. Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science* 2020; **368**: 860–8.
105. Infantino M, Damiani A, Gobbi FL *et al.* Serological assays for SARS-CoV-2 infectious disease: benefits, limitations and perspectives. *Isr. Med. Assoc. J.* 2020; **22**: 203–10.
106. Stadlbauer D, Amanat F, Chromikova V *et al.* SARS-CoV-2 seroconversion in humans: a detailed protocol for a serological assay, antigen production, and test setup. *Curr. Protoc. Microbiol.* 2020; **57**: e100.
107. Petherick A. Developing antibody tests for SARS-CoV-2. *Lancet* 2020; **395**: 1101–2.
108. Ou X, Liu Y, Lei X *et al.* Characterization of spike glycoprotein of SARS-CoV-2 on virus entry and its immune cross-reactivity with SARS-CoV. *Nat. Commun.* 2020; **11**: 1620.
109. Li Z, Yi Y, Luo X *et al.* Development and clinical application of a rapid IgM-IgG combined antibody test for SARS-CoV-2 infection diagnosis. *J. Med. Virol.* 2020; **92**: 1518–24. <https://doi.org/10.1002/jmv.25727>.
110. Lauer SA, Grantz KH, Bi Q *et al.* The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann. Intern. Med.* 2020; **172**: 577–82.
111. Pung R, Chiew CJ, Young BE *et al.* Investigation of three clusters of COVID-19 in Singapore: implications for surveillance and response measures. *Lancet* 2020; **395**: 1039–46.
112. Weiss P, Murdoch DR. Clinical course and mortality risk of severe COVID-19. *Lancet* 2020; **395**: 1014–5.
113. Zheng S, Fan J, Yu F *et al.* Viral load dynamics and disease severity in patients infected with SARS-CoV-2 in Zhejiang province, China, January–March 2020: retrospective cohort study. *BMJ* 2020; **369**: m1443.
114. Lou B, Li TD, Zheng SF *et al.* Serology characteristics of SARS-CoV-2 infection since exposure and post symptom onset. *Eur. Respir. J.* 2020: 2000763.
115. Xiao AT, Gao C, Zhang S. Profile of specific antibodies to SARS-CoV-2: the first report. *J. Infect.* 2020; **81**: 147–78.
116. Lan L, Xu D, Ye G *et al.* Positive RT-PCR test results in patients recovered from COVID-19. *JAMA* 2020; **323**: 1502.

117. Bartlett JG, Mundy LM. Community-acquired pneumonia. *N. Engl. J. Med.* 1995; **333**: 1618–24.
118. The Royal Australian and New Zealand College of Radiologists. *Guidelines for CT Chest and Chest Radiograph Reporting in Patients with Suspected COVID-19 Infection* (24 April 2020). [Cited 29 Jun 2020.] Available from URL: <https://www.ranzcr.com/documents-download/other/5122-guidelines-for-ct-chest-and-chest-radiograph-reporting-in-patients-with-suspected-covid-19-infection>
119. Chate RC, Fonseca E, Passos RBD, Teles G, Shoji H, Szarf G. Presentation of pulmonary infection on CT in COVID-19: initial experience in Brazil. *J. Bras. Pneumol.* 2020; **46**: e20200121.
120. Buonsenso D, Pata D, Chiaretti A. COVID-19 outbreak: less stethoscope, more ultrasound. *Lancet Respir. Med.* 2020; **8**: e27.
121. Soldati G, Smargiassi A, Inchingolo R *et al.* Is there a role for lung ultrasound during the COVID-19 pandemic? *J. Ultrasound Med.* 2020; **39**: 1459–62.
122. Peng QY, Wang XT, Zhang LN. Chinese critical care ultrasound study G. findings of lung ultrasonography of novel corona virus pneumonia during the 2019-2020 epidemic. *Intensive Care Med.* 2020; **46**: 849–50.
123. Bao C, Liu X, Zhang H, Li Y, Liu J. Coronavirus disease 2019 (COVID-19) CT findings: a systematic review and meta-analysis. *J. Am. Coll. Radiol.* 2020; **17**: 701–9.
124. Pan F, Ye T, Sun P *et al.* Time course of lung changes at chest CT during recovery from coronavirus disease 2019 (COVID-19). *Radiology* 2020; **295**: 715–21.
125. Bernheim A, Mei X, Huang M *et al.* Chest CT findings in coronavirus Disease-19 (COVID-19): relationship to duration of infection. *Radiology* 2020; **295**: 200463.
126. Fang Y, Zhang H, Xie J *et al.* Sensitivity of chest CT for COVID-19: comparison to RT-PCR. *Radiology* 2020; **296**: E115–7.
127. Ai T, Yang Z, Hou H *et al.* Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology* 2020; **296**: E32–40.
128. Kim H, Hong H, Yoon SH. Diagnostic performance of CT and reverse transcriptase-polymerase chain reaction for coronavirus disease 2019: a meta-analysis. *Radiology* 2020; **296**: 201343.
129. Xu B, Xing Y, Peng J *et al.* Chest CT for detecting COVID-19: a systematic review and meta-analysis of diagnostic accuracy. *Eur. Radiol.* 2020. <https://doi.org/10.1007/s00330-020-06934-2>.
130. Simpson S, Kay FU, Abbara S *et al.* Radiological society of North America expert consensus statement on reporting chest CT findings related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA - secondary publication. *J. Thorac. Imaging* 2020; **35**: 219–27.

Appendix I

Search strategy

Table NaN

No.	Reason	Query	Results (6 May 2020)
1	COVID-19 pandemic	(((((("COVID-19" [tiab]) OR "SARS-CoV-2" [tiab]) OR "2019-nCoV" [tiab]) OR coronavirus [tiab]) OR "novel coronavirus" [tiab]) OR "corona virus" [tiab]) OR "severe acute respiratory syndrome coronavirus" [tiab])	19 687
2	Clinical presentation	((((((((((infecti* [tiab]) OR pathology [tiab]) OR pathological [tiab]) OR sign [tiab]) OR signs [tiab]) OR symptom [tiab]) OR symptoms [tiab]) OR symptomatic [tiab]) OR asymptomatic [tiab]) OR "clinical presentation" [tiab]) OR "clinical findings" [tiab]) OR pneumonia [tiab])	3 494 934
3	Point-of-care and serologic testing	((((((((((("Point-of-Care Testing"[Mesh]) OR ((point*of*care OR rapid OR bedside OR real*time OR near*patient OR fast OR prompt OR early) AND (test OR tests OR testing OR assay* OR PCR OR molecular OR diagnostic OR diagnosi* OR diagnostics OR diagnose* OR detection OR assessment* OR use*)))) OR ((Bedside AND (Computing OR Technology)))) OR ((in field detection" OR POC OR POCT)))) OR (((((((((((("Serologic Tests"[Mesh]) OR "Molecular Diagnostic Techniques"[Mesh]) OR ("IgM" OR "IgG" OR "Ag")) OR ((Immunoglobulin OR "antiviral immunoglobulin-G")) OR ((Serologic* AND (test OR testing OR tests OR conversion* OR assay* OR analysis OR diagnostic OR diagnostics OR diagnosi* OR diagnose* OR screen*))) OR ((Serology or seroconversion OR seroepidemiology OR serodiagnos* or seroprevalence*)) OR (((Antibod* AND (test OR tests OR testing OR serum OR detection* OR response*)))) OR ((Antigen OR antigeni* OR antigens*)) OR Immunoassa*) OR ((Molecular AND (diagnostic OR diagnostics OR diagnosi* OR diagnose*))) OR Dynamic* profile)))	4 672 773
4	Diagnosis	((((((((((("Diagnosis"[Mesh]) OR ("Diagnostic Techniques and Procedures"[Mesh])) OR "Diagnostic Tests, Routine"[Mesh]) OR "Diagnostic Test Approval"[Mesh]) OR "Reagent Kits, Diagnostic"[Mesh]) OR "Predictive Value of Tests"[Mesh]) OR ((Sensitivity and Specificity"[Mesh])) OR ((detect* OR laboratory OR evaluat* OR validat* OR clinical OR perform* OR sensitivity OR specificity OR area under the curve OR positive predictive value OR PPV OR negative predictive value OR NPV OR predictive value OR feasibility OR accuracy OR likelihood ratio OR false negative OR false positive OR Positive rate OR validation OR diagnostic odds ratio OR DOR OR valid*)) OR ((Diagnostic AND (value OR panel OR tool*))) OR ((diagnosa* OR diagnosi* OR diagnose* OR diagnos* OR diagnostic OR diagnostics)) OR (((Test OR tests OR testing) AND (infection OR virus OR disease OR diseases OR disease, OR antibod* OR blood OR nucleic acid or diagnostic OR diagnostics OR diagnosi* OR diagnose* OR diagnose*))))))	17 661 043
5	Computed tomography imaging	((((((((((("Radiography, Thoracic"[Mesh]) OR "Tomography, X-Ray Computed"[Mesh]) OR "Tomography, X-Ray" [Mesh]) OR ((CT X*Ray* OR CT))) OR (((CT OR CAT OR chest OR lung or lungs or thoracic* OR thorax*) AND (Scan or screen* or imaging or film or radiograph* or radiogram or radiolog*))) OR Compute* tomograph*) OR ((Cine-CT or "Cine CT")) OR ((Thoracic* OR thorax* OR lung OR lungs OR Chest) AND CT)) OR ((("Chest CT" AND (scan or imaging))) OR ((X*ray* computed or x-ray compute*)) OR ((Compute* assist* tomograph* OR compute* axial tomograph*)) OR ((chest radiological imaging OR Roentgenolog* or roentgen ray* or roentgen OR Grenz Ray* or X*Radiation*))	664 529
6	X-ray Imaging	((((((("Radiography, Thoracic"[Mesh]) OR "Mass Chest X-Ray"[Mesh]) OR "X-Rays"[Mesh]) OR ((CXR OR CR OR x*ray* OR radiograph*))) OR (((chest AND (film* OR radiograph*))) OR (((chest OR lung OR lungs OR thoracic* OR thorax*) AND (x*ray* OR radiograph* or radiogram* or radiolog*))) OR (((Chest X-ray radiography OR chest radiological imaging OR thoracic radiology OR Roentgenolog* or roentgen ray* or roentgen OR Grenz Ray* or X*Radiation*))	1 438 818
7	RT-PCR Testing	((((((((((((((("Polymerase Chain Reaction"[Mesh]) OR "Reverse Transcriptase Polymerase Chain Reaction"[Mesh]) OR "Real-Time Polymerase Chain Reaction"[Mesh]) OR ((polymerase chain reaction) OR "PCR" OR "PCRs" OR ((Inverse OR Nested OR Anchored OR Kinetic) AND (Polymerase Chain Reaction)))) OR ((reverse AND (transcriptase OR transcription) AND (PCR OR PCRs OR polymerase chain reaction))) OR ((RT-PCR OR RT-PCR diagnostic panel OR RT-PCR assay* OR rRT-PCR OR qPCR OR qRT-PCR OR RT-qPCR OR mPCR OR WHO-PCR)) OR ((RT-PCR OR (RT-PCR diagnostic panel) OR (RT-PCR assay*) OR rRT-PCR OR qPCR OR qRT-PCR OR RT-qPCR OR mPCR OR WHO-PCR)) OR (((Real*Time AND (Polymerase Chain Reaction OR PCR OR PCRs OR RT-PCR)))) OR ((Real*time AND ((reverse AND (transcriptase OR transcription) AND (PCR OR PCRs OR polymerase chain reaction)))) OR ((Real*time AND RT-PCR) OR ((reverse real*time) AND (PCR OR PCRs OR polymerase chain reaction)) OR ((real reverse AND (transcriptase OR transcription) AND (PCR OR PCRs OR polymerase chain reaction))) OR ((Quantitative Real*Time AND (Polymerase Chain Reaction OR PCR OR PCRs))) OR (((qualitative AND (real*time) AND ((reverse AND (transcriptase OR transcription) AND (PCR OR PCRs OR polymerase chain reaction)))) OR ((Multiplex AND (PCR OR PCRs OR polymerase chain reaction))) OR ((nucleic acid OR nucleic acid detection OR RNA)) OR ((("Hologic Panther Fusion" OR "Hologic" OR "Hologic Panther" OR "DiaSorin Simplexa" OR "DiaSorin" OR "Roche Cobas 6800" OR "DiaSorin Simplexa COVID*19 Direct" OR "Cepheid Xpert Xpress SARS*CoV*2" OR "Cepheid Xpert Xpress" OR "QIAstat-Dx Respiratory SARS*CoV*2 Panel" OR "QIAstat-SARS" OR "QIAstat")) OR (((lateral flow immunoassay) OR "LFIA")) OR "LAMP assay" [Supplementary Concept]) OR (((reverse AND (transcriptase OR transcription) AND (loop*mediated isothermal	2 724 819

Table NaN Continued

No.	Reason	Query	Results (6 May 2020)
8	Ultrasound imaging	amplification)) OR "RT-LAMP" OR (loop*mediated isothermal amplification) OR LAMP))) OR (((open reading frame 1ab) OR ORF1ab))) OR (((magnetic chemiluminescence enzyme immunoassay) OR MCLIA))) OR (((magnetic chemiluminescence enzyme immunoassay) OR MCLIA OR MCLA))) OR "Enzyme-Linked Immunosorbent Assay"[Mesh]) OR ((enzyme*linked immunosorbent assay*) OR ELISA)) OR "Luminescent Measurements"[Mesh]) OR (((chemiluminescence immunoassay) OR CLIA OR chemiluminescence)) OR spike protein) OR nucleocapsid protein ((((("Ultrasonography"[Mesh]) OR (POCUS OR LU OR LUS OR US))) OR (((Point*of*care OR bedside OR rapid OR real*time OR near*patient OR fast OR prompt OR early))) AND ((Ultrasound OR ultrasonography OR ultrasonic OR sonography OR sonographic))) OR (((Chest OR thoraci* OR thorax* OR lung or lungs))) AND ((Ultrasound OR ultrasonography OR ultrasonic OR sonography OR sonographic))) OR (((Chest OR thoraci* OR thorax* OR lung or lungs))) AND US)) OR (((Point*of*care OR bedside OR rapid OR real*time OR near*patient OR fast OR prompt OR early))) AND ((Image OR imaging OR images))) OR (((Chest OR thoraci* OR thorax* OR lung or lungs))) AND ((Image OR imaging OR images))) OR (((Ultrasound OR ultrasonography OR ultrasonic OR sonography OR sonographic))) AND ((diagnosa* OR diagnosi* OR diagnose* OR diagnos* OR diagnostic OR diagnostics))	2 361 046
9	Treatments for COVID-19 in title	Ivermectin [TI] OR Stromectol [TI] OR Mectizan [TI] OR Eqvalan [TI] OR Ivomec [TI] OR "MK-933" [TI] OR "MK 933" [TI] OR MK933 [TI] OR Macrolide* [TI] OR "extracorporeal membrane oxygenation" [TI] OR ECMO [TI] OR "life support" [TI] OR Paracetamol [TI] OR Acetaminophen [TI] OR Antipyretic [TI] OR Amide* [TI] OR Ibuprofen [TI] OR NSAID [TI] OR Ibumetin [TI] OR Motrin [TI] OR Nuprin [TI] OR Rufen [TI] OR Salprofen [TI] OR Dolgit [TI] OR Brufen [TI] OR Phenylpropionate* [TI] OR "anti-inflammatory" [TI] OR "anti inflammatory" [TI] OR angiotensin [TI] OR "ACE-inhibitor*" [TI] OR "ACE inhibitor*" [TI] OR renin [TI] OR steroid* [TI] OR methylprednisolone [TI] OR tocilizumab [TI] OR atlizumab [TI] OR actemra [TI] OR roactemra [TI] OR heparin [TI] OR liquaemin heparin OR hydroxychloroquine [TI] OR oxychlorochin [TI] OR oxychloroquine [TI] OR hydroxychlorochin [TI] OR plaquenil [TI] OR sulfate [TI] OR quinolone* [TI] OR chloroquine [TI] OR chlorochin [TI] OR chingamin [TI] OR nivaquine [TI] OR khingamin [TI] OR aralen [TI] OR arequin [TI] OR arechine [TI] OR remdesivir [TI] OR alanine [TI] OR antiviral [TI] OR "anti-viral" [TI] OR "anti viral" [TI] OR vasodilator* [TI] OR corticosteroid* [TI] OR lipoic [TI] OR bevacizumab [TI] OR lopinavir [TI] OR protease [TI] OR pyrimidin* [TI] OR ritonavir [TI] OR cytochrome [TI] OR azole* [TI] OR interferon [TI] OR beta [TI] OR gamma [TI] OR "lopinavir-ritonavir" [TI] OR "lopinavir/ritonavir" [TI] OR azithromycin [TI] OR antibiotic* [TI] OR sumamed [TI] OR toraseptol [TI] OR vinzam [TI] OR Zithromax OR Azitrocin [TI] OR Ultrone [TI] OR oseltamivir [TI] OR interleukin [TI] OR lenzilumab [TI] OR monoclonal [TI]	1 115 209
10	Sensitivity string	2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8	19 561 598
11	Specifying for COVID-19	1 AND 10	15 340
12	Eliminating treatments for COVID-19 in title	11 NOT 9	14 178
13	Specifying to timeframe since World Health Organization was alerted of SARS-CoV-2	Apply filter: Publication date from 31 Dec 2019	5762
14	Specifying for humans	Apply filter: Humans, and results imported into EndNote	1395

Appendix II

Printable questionnaire for screening patients for symptoms of COVID-19 or history of potential SARS-CoV-2 exposure¹²

Table NaN

Question	Yes	No
<p>Have you been <u>diagnosed with COVID-19</u> in the past?</p> <p>Over the past 2 weeks, have you been in <u>close contact</u> with someone who has been suspected of, or diagnosed with COVID-19?</p> <p>Over the past 2 weeks, have you been <u>unwell</u> or experienced any of the following symptoms:</p> <p>Loss of smell</p> <p>Loss of taste</p> <p>Fever</p> <p>Cough</p> <p>Sore throat</p> <p>Shortness of breath or difficulty breathing</p> <p>Diarrhoea</p> <p>Nausea or vomiting</p> <p>Muscle aches</p> <p>Over the past 2 weeks, have you been in <u>close contact</u> with someone who has been <u>unwell</u> or displayed any of the above <u>symptoms</u> (including in the 3 days prior to the onset of their symptoms)?</p> <p>Have you <u>travelled overseas</u> in the past 2 weeks, either by plane or cruise ship, or been in contact with someone who has?</p> <p>Have you <u>travelled interstate</u> in the past 2 weeks?†</p> <p>Have you been within an <u>aged care facility</u>, either as a resident, worker, or visitor, in the past 2 weeks?</p> <p>Have you been within a <u>detention facility</u>, either as a resident, worker, or visitor, in the past 2 weeks?</p> <p>Do you live in a <u>group residential setting</u>, or have you visited one in the past 2 weeks?</p> <p>Do you regularly interact with people with COVID-19 as part of your <u>job</u>?</p>		

†Applicable only if active cases within state of journey's origin.