IJID Regions 3 (2022) 138–142

Contents lists available at ScienceDirect

IJID Regions

journal homepage: www.elsevier.com/locate/ijregi

# Predictive Ability of Factors in diagnosing COVID-19: Experiences from Qatar's Primary Care Settings

Dr. Mohamed Ahmed Syed, MFPH, PhD, Directorate of Clinical Affairs*, Dr. Ahmed Sameer Al Nuaimi, PhD, Directorate of Clinical Affairs

*Primary Health Care Corporation, P.O. Box 26555 Doha, Qatar*

ARTICLE INFO

*Keywords:*
Primary care
COVID-19
Qatar
Screening tools
SARS-CoV2

ABSTRACT

*Objective:* The aim of this paper is to establish the predictive ability of demographic and clinical factors in diagnosing Coronavirus Disease 2019 (COVID-19) in Qatar's publicly funded primary care settings.

*Methods:* Reverse transcription polymerase chain reaction (rt-PCR) test and COVID-19 screening data (COVID-19 related factors) were extracted from electronic medical records for all individuals who visited a primary health care centre in Qatar between 15th March to 15th June 2020. Data analysis was undertaken to assess the validity of individual factors in predicting a positive rt-PCR test.

*Results:* Fever/history of fever [N= 1471 (54.7%); OR 4.6 (95% CI 4.16 - 5.08)], followed by cough [N=1020 (37.9%); OR 1.82 (95% CI 1.65 - 2)] and headache [N=372 (13.8%); OR 1.45 (95% CI 1.27 - 1.67)] were the most frequently reported clinical symptoms amongst individuals who tested positive for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV2) infection by rt-PCR. Only five factors, fever/history of fever, cough, working/living in an area reporting local transmission, gender and headache (ranked according to predictive power), were found to be statistically significant. Fever/history of fever alone had a specificity of 79.2% and it gradually increased to 99.9% in combination with runny nose, cough, male gender and age ≥ 50.

*Conclusions:* The study identified predictive ability of factors in diagnosing COVID-19, individually and in combination. It proposes a scoring system for use in publicly funded primary care settings in Qatar without an rt-PCR test, thus enabling early isolation and treatment where necessary. Further similar studies are needed as newer variations of SARS-CoV2 are continuously emerging to ensure its accuracy.

## Introduction

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV2) is a novel infectious virus which causes Coronavirus Disease 2019 (COVID-19). It has spread to nearly every corner of the world and impacted societies significantly (Kevadiya et al 2021). Since it was declared a Public Health Emergency of International Concern (PHEIC) on the 30th January 2020, it continues to be a global public health emergency (BBC 2022). As of 8th March 2022, 443 895 905 cases and 5 993 901 deaths were reported globally (World Health Organisation 2022). As new variants of the virus emerge, further waves are anticipated.

Primary care provides infrastructure and plays a variety of key roles such as disease surveillance, diagnosis and treatment, prevention, patient education etc. (Clarke 2015). As the patient's first point of contact is with the health system, challenges are faced by primary care arising from the COVID-19 pandemic (Majeed et al 2020). Additional visits to primary care are expected (Pandemic Influenza Preparedness Team 2008). Early diagnosis is essential to reduce spread of infection.

Reverse transcription polymerase chain reaction (rt-PCR) is a method that detects the virus using a laboratory technique combining reverse transcription of RNA into DNA (in this context called complementary DNA or cDNA) and amplification of specific DNA targets using polymerase chain reaction (Freeman et al 1999). It is considered the gold standard in diagnosing SARS-CoV2 infection Centers for Disease Control and Prevention (Centers for Disease Control and Prevention 2022). However, it had also been reported that rt-PCR has imperfect sensitivity (Yang et al. 2020a, Arevalo-Rodriguez et al. 2020, Zhao et al 2020). Furthermore, availability of testing supplies and laboratory workforce may prevent its application in some clinical settings (Duffy et al 2020).

SARS-Cov2 is most infectious in the early stages (Woelfel et al 2020, Yang et al 2020b). Therefore, screening people with compatible symptoms is fundamental to determining who should be quarantined and tested (Gostic et al 2020). Targeted screening guided by a structured

* Corresponding Author: Dr. Mohamed Ahmed Syed, Directorate of Clinical Affairs, Primary Health Care Corporation, P.O. Box 26555 Doha, Qatar. Tel: 0097440271046

*E-mail address:* ahmed.sy3d@gmail.com (Dr.M.A. Syed).

https://doi.org/10.1016/j.ijregi.2022.03.018
Received 2 November 2021; Received in revised form 10 March 2022; Accepted 22 March 2022

questionnaire based on clinical symptoms is a potentially feasible and valid alternative. The aim of this paper is to establish the predictive ability of demographic and clinical factors in diagnosing COVID-19 in Qatar's publicly funded primary care settings.

## Methods

### *Study settings*

Primary Health Care Corporation (PHCC) is a publicly funded primary care provider in Qatar. It has 27 health centres across the country which use an integrated electronic medical record (EMR) system. Citizens and resident of Qatar are eligible to register with a PHCC health centre and utilise its services for a nominal annual fee. A majority of the country's population is registered with PHCC.

### *Study population and design*

The study population comprised all PHCC registered individuals who presented to a PHCC health centre with a suspected SARS-CoV2 infection, completed a COVID-19 screening questionnaire and undertook an rt-PCR test between 15$^{th}$ March to 15$^{th}$ June 2020. A case-control study design was employed – individuals with a positive rt-PCR test (cases) were compared to individuals with a negative test result (controls).

### *Data collection*

rt-PCR test and COVID-19 screening data (COVID-19 related factors) required for the study was extracted from PHCC's EMR system. COVID-19 screening data included:

- Demographic information
  - Age
  - Gender
  - Working/living in an area reporting local transmission
  - Contact with a suspected or confirmed case
- Clinical symptoms of SARS-CoV2 infection
  - Fever/history of fever, arthralgia, cough, headache, runny nose, shortness of breath, sore throat, and diarrhoea
- Health Status
  - Diagnosis of diabetes mellitus, hypertension, cardiac disease, asthma/chronic obstructive pulmonary disease (COPD), chronic kidney disease and dyslipidaemia

### *Data analysis*

Data extracted from PHCC's EMR was reviewed and cleaned. Statistical Package for Social Sciences (IBM SPSS, USA ver. 23) was used for statistical analysis of data. Frequency distributions for selected variables were done to measure the strength of association between 2 categorical variables and report as odds ratio (OR). The statistical significance of these associations was assessed using Chi-square test of independence at $P < 0.05$ level of statistical significance.

Receiver operating characteristic (ROC) analysis was undertaken to assess the validity of individual factors in predicting a positive rt-PCR test. The positive predictive value was calculated for four pre-test probabilities. The 25% pre-test probability was the positivity rate of an rt-PCR test in the current study sample. The 50% pre-test probability was undertaken for study participants with clinical symptoms, while the 90% pre-test probability was undertaken for study participants with clinical symptoms and contact history. A pre-test probability of 90% was not applicable for a negative predictive value and therefore was not undertaken. Parallel combinations of factors were identified to increase the specificity and positive predictive value compared to individual factors. Combinations were considered positive only if each individual factor was positive.

Demographic information, clinical symptoms and health status of having at least one health condition were factors tested for their ability to predict a positive COVID-19 test result in a multivariate model using discriminant analysis. The unstandardized canonical discriminant function coefficients were used to calculate a prediction score for each statistically significant factor identified by the discriminant model. The score was calculated by summing scores of individual factors when present in a specific tested individual.

### *Ethical considerations*

The study presented a minimal risk of harm to its subjects, and the data collected for it were anonymised. None of the subjects' personal information was available to the research team. Overall, the study was conducted with integrity according to generally accepted ethical principles and was approved by the PHCC's Research Sub-Committee (PHCC/DCR/2020/06/059).

## Results

### *Overview*

A total of 8,335 individuals presented at a PHCC health centre with a suspected SARS-CoV2 infection, completed a COVID-19 screening questionnaire and undertook an rt-PCR test during the study period. Of those, 2688 (32.24 %) individuals had a positive rt-PCR test result.

### *rt-PCR results by demographics*

There were no differences in adults 30-39 (OR 1.43; 95% CI 1.26 - 1.62), 40-49 (OR 1.75; 95% CI 1.51 - 2.01) and ≥ 50 age (OR 1.59; 95% CI 1.36 - 1.86) groups by positive rt-PCR test results compared to adults 18-29. Males had a higher positivity rate (OR 1.61; 95% CI 1.47 - 1.78). Individuals working or living in an area of local transmission were also found to have a higher positivity rate (OR 1.83; 95% CI 1.66 - 2.02). Similarly, individuals reporting contact with a suspected or confirmed COVID-19 case had a lower positivity rate (OR 0.72; 95% CI 0.65 - 0.79) (Table S1 - See supplementary file).

### *rt-PCR results by clinical symptoms*

Fever/history of fever (N=1471; 54.7%), followed by cough (N=1020; 37.9%) and headache (N=372; 13.8%) were the most frequently reported clinical symptom amongst individuals who tested positive for SARS-CoV2 infection by rt-PCR (Table S2 - see supplementary file). Symptoms most strongly associated with a positive rt-PCR test were fever (OR 4.6; 95% CI 4.16 - 5.08) followed by arthralgia (OR 1.92; 95% CI 1.33 - 2.76), cough (OR 1.82; 95% CI 1.65 - 2), headache (OR 1.45; 95% CI 1.27 - 1.67) and runny nose (OR 1.4; 95% CI 1.19 - 1.65). Sore throat was negatively associated with a positive rt-PCR test result (OR 0.79; 95% CI 0.71 - 0.87). All symptoms except shortness of breath and diarrhoea had a statistically significant association with a positive rt-PCR test result (Table S2 - See supplementary file).

### *rt-PCR results by health status*

Of all health conditions considered in the study, only diabetes mellitus was positively associated with a SARS-CoV2 infection (OR 1.19; 95% 1.04 - 1.36). All other conditions were inversely associated with a SARS-CoV2 infection. Asthma/COPD was the strongest predictor for the absence of an infection. The absence of asthma/COPD as a diagnosis significantly increased the likelihood of a positive rt-PCR test result by 90 % (Table S3 - See supplementary file).

**Table 1**
Predictive ability of individual factors

| | Area Under Curve | P |
|---|---|---|
| Fever/history fever | 0.67 | <0.001 |
| Cough | 0.56 | <0.001 |
| Working/living in an area reporting local transmission | 0.56 | <0.001 |
| Male gender | 0.56 | <0.001 |
| Headache | 0.52 | 0.004 |
| Runny nose | 0.51 | 0.06[NS] |
| ≥ 50 age | 0.51 | 0.09[NS] |
| Arthralgia | 0.50 | 0.47[NS] |
| Shortness of breath | 0.50 | 0.83[NS] |
| Diarrhea | 0.50 | 0.64[NS] |
| Absence of a contact with an individual suspected/confirmed with SARS-CoV2 infection* | 0.537 | <0.001 |
| Absence of sore throat* | 0.527 | 0.031 |
| Absence of any of the health conditions listed* | 0.515 | <0.001 |

* Validity parameters not presented for absence of a factor

**Table 2**
Overall predictive accuracy of a positive rt-PCR test result

| | Unstandardized Canonical Discriminant Function Coefficients | Score |
|---|---|---|
| Fever or History Fever | 1.931 | 9 |
| Sore Throat | -0.623 | -3 |
| Diarrhoea | -0.593 | -3 |
| Runny Nose | 0.559 | 3 |
| Male gender | 0.506 | 2 |
| Cough | 0.475 | 2 |
| ≥ 50 age | 0.329 | 2 |
| Working/living in an area reporting local transmission | 0.277 | 1 |
| Headache | 0.267 | 1 |
| Diagnosis of at least one health condition | -0.209 | -1 |
| Constant | -0.945 | 0.209 |

Wilks' Lambda=0.855
P=<0.001
Predictive accuracy for positive cases = 45.3%
Predictive accuracy for negative controls = 87.1%
Overall predictive accuracy = 73.6%

*Predictive ability of individual factors*

All factors were tested for their ability to predict a positive rt-PCR test result. Only five factors, fever/history of fever, cough, working/living in an area reporting local transmission, gender and headache (ranked according to predictive power), were found to have statistically significant predictive ability in univariate modelling (Table 1).

*Overall predictive accuracy of a positive rt-PCR test result*

Ten factors were retained in the multivariate modelling analysis (See Table 2). The model was statistically significant with an overall predictive accuracy of 73.6%. The unstandardized canonical discriminant function coefficients were used to calculate prediction scores for each of the nine factors (Fever/history fever = 9; runny nose = 3; male gender, cough and age >50 = 2; working/living in area of transmission and headache = 1; sore throat and diarrhoea = -3; having at least one health condition = -1).

*Predictive ability of combined factors*

The COVID-19 score ranged between a minimum of (-4) to a maximum of 17 points. A higher resulting score would increase the probability of testing positive for COVID-19. This score and a combination of single predictors were tested for their ability to predict a positive COVID-19 test result. The COVID-19 score alone was associated with a reasonably good criterion to predict the COVID-19 status, as the area under ROC curve was higher than 0.7 (Table 3). The optimum cut-off value for a score of ≥3 is 62.0 % sensitive and 71.9% specific in predictive positive COVID-19 status.

Testing negative at the most sensitive cut-off value for the score of -6 (100%) would exclude a possible diagnosis of COVID-19 with 100.0% confidence at any pre-test probability for a symptomatic case (Table 4). Obtaining a COVID-19 score of 15 or higher would predict a positive COVID-19 diagnosis with 100% confidence under any pre-test probability, since the specificity of this cut-off value of the score is 100%.

A report of fever/history of fever alone had a specificity of 79.2% and it gradually increased to 99.9% in combination with runny nose, cough, male gender and age ≥ 50. A combination of five factors (fever/history fever + runny nose + cough + male gender + ≥ 50 age) would predict a positive COVID-19 test result with a confidence level ranging between 53.9%, 77.8% and 96.9% at the 25%, 50% and 90% pre-test probabilities. On the contrary, a sensitivity of 54.7% for fever/history of fever only decreases to 0.2 % for a combination of five factors (fever/history fever + runny nose + cough + male gender + ≥ 50 age) (Table 4).

## Discussion

*Summary*

Increases in COVID-19 cases seriously disrupt the health system (Tangcharoensathie et al 2021). The study identified predictive ability of factors in diagnosing COVID-19, individually and in combination. It proposes a scoring system for use in publicly funded primary care settings in Qatar. In developing the scoring system, the study took into consideration demographic data, clinical symptoms and health status. Other published studies evaluating performance of screening questionnaires did not use disease predictors included in this study and their combinations along with a scoring system (Aldobyany et al 2020, Ornaghi et al 2020). Furthermore, they were conducted in tertiary care settings.

*Strengths and limitation*

The key strengths of the study are that it included all individuals who presented to any PHCC primary health care centre in Qatar with a suspected SARS-CoV2 infection. The study included data extracted from the EMR which included data on multiple disease predictors collected by trained data collectors who followed a standard data collection protocol. The key limitations of the study are that it included data for a three-month period only and did not include data on the loss of smell and taste. It was also limited to individuals who presented to health centres and not from general screening. Furthermore, the study was conducted before

**Table 3**
Predictive ability of combined factors

| | Area Under Curve | P |
|---|---|---|
| COVID-19 score | 0.72 | <0.001 |
| Fever/history fever | 0.67 | <0.001 |
| Fever/history fever + runny nose | 0.52 | 0.024 |
| Fever/history fever + runny nose + cough | 0.51 | 0.25[NS] |
| Fever/history fever + runny nose + cough + male gender + ≥ 50 age | 0.50 | 0.92[NS] |

**Table 4**
Validity parameters for COVID-19 score and clinical symptoms

| Positive if ≥ cut-off value | Sensitivity | Specificity | Accuracy | PPV at pre-test probability | | | NPV at pre-test probability | |
|---|---|---|---|---|---|---|---|---|
| | | | | 25% | 50% | 90% | 25% | 50% |
| **COVID-19 score** | | | | | | | | |
| -6 | 100.0 | 0.1 | 32.3 | 25.0 | 50.0 | 90.0 | 100.0 | 100.0 |
| -5 | 99.9 | 0.2 | 32.4 | 25.0 | 50.0 | 90.0 | 85.1 | 65.6 |
| -4 | 99.4 | 1.2 | 32.9 | 25.1 | 50.2 | 90.1 | 86.8 | 68.6 |
| -3 | 98.1 | 4.6 | 34.8 | 25.5 | 50.7 | 90.3 | 88.0 | 70.9 |
| -2 | 96.8 | 8.9 | 37.2 | 26.1 | 51.5 | 90.5 | 89.2 | 73.3 |
| -1 | 92.5 | 17.8 | 41.9 | 27.3 | 53.0 | 91.0 | 87.7 | 70.4 |
| 0 | 85.4 | 33.5 | 50.2 | 30.0 | 56.2 | 92.0 | 87.3 | 69.6 |
| 1 | 79.3 | 45.5 | 56.4 | 32.7 | 59.3 | 92.9 | 86.8 | 68.7 |
| 2 | 67.6 | 64.7 | 65.6 | 38.9 | 65.7 | 94.5 | 85.7 | 66.6 |
| **3 (Optimum cut-off value)** | **62.0** | **71.9** | **68.7** | **42.4** | **68.8** | **95.2** | **85.0** | **65.4** |
| 4 | 58.5 | 76.0 | 70.3 | 44.8 | 70.9 | 95.6 | 84.6 | 64.7 |
| 5 | 56.2 | 79.0 | 71.6 | 47.1 | 72.8 | 96.0 | 84.4 | 64.3 |
| 6 | 54.5 | 80.8 | 72.3 | 48.6 | 73.9 | 96.2 | 84.2 | 64.0 |
| 7 | 52.0 | 82.6 | 72.8 | 49.9 | 75.0 | 96.4 | 83.8 | 63.3 |
| 8 | 47.5 | 85.6 | 73.4 | 52.5 | 76.8 | 96.8 | 83.0 | 62.0 |
| 9 | 41.0 | 88.9 | 73.4 | 55.1 | 78.7 | 97.1 | 81.9 | 60.1 |
| 10 | 34.4 | 91.6 | 73.1 | 57.7 | 80.4 | 97.4 | 80.7 | 58.3 |
| 11 | 24.5 | 94.5 | 71.9 | 59.9 | 81.8 | 97.6 | 79.0 | 55.6 |
| 12 | 16.0 | 97.1 | 71.0 | 65.2 | 84.9 | 98.1 | 77.6 | 53.6 |
| 13 | 9.2 | 98.6 | 69.8 | 68.8 | 86.9 | 98.4 | 76.5 | 52.1 |
| 14 | 3.4 | 99.7 | 68.6 | 78.2 | 91.5 | 99.0 | 75.6 | 50.8 |
| 15 | 0.6 | 100.0 | 67.9 | 100.0 | 100.0 | 100.0 | 75.2 | 50.3 |
| 16 | 0.2 | 100.0 | 67.8 | 100.0 | 100.0 | 100.0 | 75.1 | 50.1 |
| **Clinical factors** | | | | | | | | |
| Fever/history fever | 54.7 | 79.2 | 71.3 | 46.7 | 72.5 | 95.9 | 84.0 | 63.6 |
| Fever/history fever + runny nose | 4.8 | 98.3 | 68.1 | 48.3 | 73.7 | 96.2 | 75.6 | 50.8 |
| Fever/history fever + runny nose + cough | 2.2 | 99.3 | 68.0 | 51.9 | 76.4 | 96.7 | 75.3 | 50.4 |
| Fever/history fever + runny nose + cough + male gender + ≥ 50 age | 0.2 | 99.9 | 67.8 | 53.9 | 77.8 | 96.9 | 75.0 | 50.0 |

the emergence of newer variants of concern and prior to the introduction of a vaccination programme.

*Comparison with existing literature*

Grant et al (2020) in a systematic review and meta-analysis reported fever (78 %) and cough (57 %) as the most prevalent symptoms of COVID-19 while headache, arthralgia, runny nose and diahorrea were found to be less prevalent. These reports are in line with findings of this study. In terms of combinations of symptoms, a study reported the probability of having a positive test increased with the increased number of symptoms (Cadegiani et al 2021). However, in our study, the probability was associated with specific combinations of symptoms. Such information is likely to be more useful in real world clinical settings.

*Implications for research and/or practice*

During an outbreak, health systems can be overwhelmed with suspected COVID-19 cases. The findings of the study can help allocate resources efficiently and effectively. Furthermore, they can be incorporated with e-triaging systems.

## Conclusion

The study identified predictive ability of factors in diagnosing COVID-19, individually and in combination. It proposes a scoring system for use in publicly funded primary care settings in Qatar without an rt-PCR test, thus enabling early isolation and treatment where necessary. Further similar research will be needed as newer variations of SARS-CoV2 are identified.

## Conflict of interest

All authors declare no conflict of interest.

## Funding source

Funding for the study was approved by Primary Health Care Corporation's Research Budget Working Group (Ref. No PHCC/DCR/2020/06/059).

## Ethical approval

The study was conducted with integrity according to generally accepted ethical principles and was approved by the Pri-

mary Health Care Corporation's research-sub committee (Ref. No. PHCC/DCR/2020/06/059). Informed consent was waived due to the retrospective nature of the study.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2022.03.018.

## References


Aldobyany A, Touman A, Ghaleb N, Alsaggaf R, Murtaza N, Hamada A, Alknawy M, AS Albanna, Alqurashi E.. Correlation Between the COVID-19 Respiratory Triage Score and SARS-COV-2 PCR Test. Front. Med. 2020;7.

Arevalo-Rodriguez I, Buitrago-Garcia D, Simancas-Racines D, et al. False-negative results of initial RT-PCR assays for COVID-19: a systematic review. medRxiv 2020 (published online Aug 13.) (preprint).

Cadegiani FA, Zimerman RA, Campello de Souza B, et al. The AndroCoV Clinical Scoring for COVID-19 Diagnosis: A Prompt, Feasible, Costless, and Highly Sensitive Diagnostic Tool for COVID-19 Based on a 1757-Patient Cohort. Cureus 2021;13(1):e12565 Published 2021 Jan 7. doi:10.7759/cureus.12565.

Centers for Disease Control and Prevention. CDC diagnostic tests for COVID-19. Available at https://www.cdc.gov/coronavirus/2019-ncov/lab/testing.html [Accessed 20th May 2021]

British Broadcasting Corporation (BBC). Coronavirus declared global health emergency by WHO. Available at https://www.bbc.com/news/world-51318246 [Accessed 20th May 2021]

Clark SJ.. Role of primary care providers in a pandemic–conflicting views and future opportunities. Isr J Health Policy Res 2015;4:58.

Kevadiya BD, Machhi J, Herskovitz J, Oleynikov MD, Blomberg WR, Bajwa N, Soni D, Das S, Hasan M, Patel M, Senan AM, Gorantla S, McMillan J, Edagwa B, Eisenberg R, Gurumurthy CB, Reid SPM, Punyadeera C, Chang L, Gendelman HE.. Diagnostics for SARS-CoV-2 infections. Nat Mater 2021;20(5):593–605.

Duffy CR, Hart JM, Modest AM, Hacker MR, Golen T, Li Y, et al. Lymphopenia and Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection Among Hospitalized Obstetric Patients. Obstetrics and gynecology 2020;136(2):229–31.

Gostic K, Gomez AC, Mummah RO, Kucharski AJ, JO Lloyd-Smith. Estimated effectiveness of symptom and risk screening to prevent the spread of COVID-19. Elife 2020;9 1–1.

Grant MC, Geoghegan L, Arbyn M, Mohammed Z, McGuinness L, Clarke EL, et al. The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS–CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries. PLoS ONE 2020;15(6).

Majeed A, Maile EJ, Bindman AB.. The primary care response to COVID-19 in England's National Health Service. J R Soc Med 2020;113(6):208–10.

Ornaghi S, Callegari C, Milazzo R, L La Milia, Brunetti F, Lubrano C, et al. Performance of an extended triage questionnaire to detect suspected cases of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection in obstetric patients: Experience from two large teaching hospitals in Lombardy, Northern Italy. PLoS ONE 2020;15(9).

Pandemic Influenza Preparedness Team-Department of Health. Pandemic Influenza: Surge Capacity and Prioritisation in Health Services-provisional UK guidance. Table 2: Expected Healthcare Demand During the Peak Week of a Pandemic-November 2007. London: Department of Health; 2008.

Tangcharoensathien V, Bassett MT, Meng Q, Mills A.. Are overwhelmed health systems an inevitable consequence of covid-19? Experiences from China, Thailand, and New York State. BMJ 2021;372:n83.

Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Müller MA, et al. Virological assessment of hospitalized patients with COVID-2019. Nature 2020:1–10.

World Health Organisation. Available at https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19—8-march-2022

Yang Y, Yang M, Shen C, et al. Evaluating the accuracy of different respiratory specimens in the laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections. medRxiv 2020a (published online Feb 17.) (preprint).

Yang J, Zheng Y, Gou X, Pu K, Chen Z, Guo Q, et al. Prevalence of comorbidities in the novel Wuhan coronavirus (COVID-19) infection: a systematic review and meta-analysis. Int J Infect Dis 2020b;94:91–5.

Zhao J, Yuan Q, Wang H, Liu W, Liao X, Su Y, Wang X, Yuan J, Li T, Li J, Qian S, Hong C, Wang F, Liu Y, Wang Z, He Q, Li Z, He B, Zhang T, Fu Y, Ge S, Liu L, Zhang J, Xia N, Zhang Z.. Antibody Responses to SARS-CoV-2 in Patients With Novel Coronavirus Disease 2019. Clin Infect Dis 2020;71(16):2027–34.