Mustafa *et al.*
*European Journal of Medical Research* (2022) 27:84
https://doi.org/10.1186/s40001-022-00704-0

European Journal of Medical Research

RESEARCH Open Access

# Misdiagnosis of COVID-19 infection before molecular confirmation in Sulaimaniyah City, Iraq

Hemn Muhammed Mustafa[1], Darya Saeed Abdulateef[2] and Heshu Sulaiman Rahman[2,3*]

## Abstract

**Background:** During the last 2 years, in the Kurdistan Region, Northern Iraq, there were thousands of COVID-19 cases that have not been reported officially, but diagnosed and confirmed by private laboratories and private hospitals, or clinicians based on typical clinical signs, as well as few people using home self-test after appearing of some flu-like clinical symptoms. Thus, this study aims to assess the misdiagnosis and mismanagement of cases before COVID-19 confirmation.

**Methods:** This study enrolled 100 consecutive patients who visited an outpatient clinic of Shar Hospital that had symptoms highly suspicious of COVID-19 infection while misdiagnosed previously to have other types of disease. Detailed questionnaires were filled for all studied patients, including age, gender, main presenting symptoms, and duration of these symptoms with the following questions: who made the false diagnosis, depending on which diagnostic test the false diagnosis was made, which medication was used for the false diagnosis, who prescribed those medications, and how long those medications were used. They were investigated by RT-PCR on their nasopharyngeal swab for confirmation.

**Results:** Most of the false diagnoses were typhoid (63%), influenza (14%), pneumonia (9%), gastroenteritis (5%), common cold (4%), brucellosis (4%), and meningitis (1%). Regarding the false diagnosis of cases, 92% were made by non-physician healthcare workers, and only 8% were made by physicians. All false diagnoses with typhoid, gastroenteritis, and common cold were made by non-physician healthcare workers, together with about half of the diagnosis of pneumonia and brucellosis, with statistically significant results ($P < 0.001$).

**Conclusions:** We realized that some patients had been misdiagnosed before the COVID-19 infection confirmation. Their health conditions improved drastically after correct diagnosis and treatment, and this research is considered the first research to be conducted in Iraq in this regard.

**Keywords:** COVID-19, Misdiagnosis, Molecular diagnosis, Non-physician healthcare workers, Iraq

## Introduction

COVID-19 is an infectious pandemic disease caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) [1]. Up to date, scientists are trying to identify a new antiviral specific drug to overcome this disease. Different methods are under study and evaluation worldwide to control the virus, including blood plasma, blood purification, antimicrobial, and antiviral agents; though, there are no approved drugs yet [2, 3].

The COVID-19 virus emerged in December 2019 in Wuhan city, Hubei Province, China, and then spread rapidly worldwide. An ongoing outbreak of pneumonia

*Correspondence: heshu.rhaman@univsul.edu.iq

[2] Department of Physiology, College of Medicine, University of Sulaimani, Sulaimani New, Street 29, Zone 207, Sulaymaniyah 46001, Republic of Iraq
Full list of author information is available at the end of the article

associated with emerging viral infections to global public health is called SARS-CoV-2 [4, 5].

Up to now, six species of coronavirus are well known to cause human diseases, whereas four species lead to diseases in humans and causing common cold in immunocompetent individuals, including alpha-Coronaviruses (HCoV-229E and HCoV-NL63) and beta-Coronaviruses (HCoV-HKU1 and HCoV-OC43) [6]. While the other two species are zoonotic infectious agents named the Middle East Respiratory Syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV) [7]. Back in 2003 and 2012, the causative agent of the SARS-CoV was isolated from an outbreak in China, while MERS-CoV was from an outbreak in Saudi Arabia in 2012 [8].

Despite some diversity in initial symptoms, generally, the reported clinical features of confirmed COVID-19 patients are fever and respiratory symptoms such as cough, dyspnea, shortness of breath, sore throat, and sputum formation, as well as myalgia, headache, hemoptyses, and gastrointestinal symptoms, like nausea, abdominal pain, vomiting, and diarrhea have been seen [9, 10]. Up to date, it is not understood why some patients infected with SARS-CoV-2 have mild or even asymptomatic diseases, but others develop severe by the same infectious virus [11].

Some hospitalized patients showed bilateral lung ground-glass opacity on computed tomography (CT) imaging. In contrast, particular patients in the intensive care unit (ICU) progressed to acute respiratory distress syndrome (ARDS) or acute kidney injury. Few of them developed a secondary bacterial infection (pneumonia), shock, and might result in death [12, 13]. Most of the patients in ICU required ventilator and oxygen therapy, anti-inflammatory, antibacterial, and antiviral therapies, or even plasma transferring from recovered peoples [14].

In the Kurdistan region in Northern Iraq, the first case appeared on March 1, 2020, and up to date (September 25, 2021), 325,432 confirmed COVID-19 cases (291,882 recovered, 5795 deaths, and 27,755 active cases) had been reported by the Ministry of Health/Kurdistan Regional Government (KRG). Most cases are asymptomatic carriers; some show mild-to-moderate clinical signs, while a minority have severe symptoms [15].

The number of confirmed cases in Kurdistan/Iraq is increasing rapidly; people with severe cases visited the public hospitals for diagnosis, hospitalization, and treatment, while those with moderate symptoms either visited the hospitals or non-physician healthcare workers to be diagnosed, treated, and recommended. However, asymptomatic carriers and individuals with minor symptoms either quarantined themselves at home or avoided visiting public areas to reduce others' exposure to the disease. Moreover, those who visited non-physician healthcare workers were mainly misdiagnosed and mistreated for other diseases such as typhoid fever, brucellosis, pneumonia, influenza, common cold, gastroenteritis, and meningitis. Thus, in this research, we addressed to assess the false positivity of typhoid serology in COVID-19 confirmed cases to avoid misdiagnosis and mistreatment and consequently improve the health conditions of COVID-19 patients.

## Methods and materials

### Inclusion criteria

Adult patients who were highly suspicious of COVID-19, whose RT-PCR test was positive using a nasopharyngeal swab, previously diagnosed falsely with other infectious diseases rather than COVID-19, and received mistreatment for the misdiagnosed disease, were included.

### Exclusion criteria

The patients with negative RT-PCR tests or suspected to have a disease other than COVID-19 infection were excluded.

### Patients and methodology

This study enrolled 100 consecutive patients (60 males and 40 females) who visited an outpatient clinic of Shar Hospital. They had symptoms highly suspicious of COVID-19 infection while misdiagnosed previously to have other types of disease.

Detailed questionnaires were filled for all studied patients, including a clear history (age, gender, main presenting symptoms, and duration of these symptoms). Additionally, the following questions were asked from all the patients: who made the false diagnosis, depending on which diagnostic test the false diagnosis was made, which medication was used for the false diagnosis, who prescribed those medications, and how long those medications were used. All the answers to the above questions were reported, and their questionnaires were coded. All patients gave a history of false diagnosis before the presentation to the hospital and before confirming COVID-19 infection.

The laboratory records of those patients were checked, and they revealed that their diagnosis with typhoid fever was dependent on typhoid IgM/IgG rapid test, diagnosis of brucellosis was based on Rose Bengal test, chest X-ray finding was used for the pneumonia diagnosis, while the diagnosis of gastroenteritis, influenza and common cold were only based on clinical presentations.

All who had a history and symptoms highly suspicious for COVID-19 infection were investigated by RT-PCR on their nasopharyngeal swab for confirmation, and

the patients with positive results for COVID-19 were included in this study. Finally, all patients were evaluated thoroughly, and the decision of hospitalization or home management was made by an expert physician.

### Statistical analysis

All data were entered into SPSS software version 22, and coding of the variables was done. The descriptive parameters, age, and duration of treatment used till confirmation of COVID-19 were shown as mean ± SD. All remaining data were categorical variables and evaluated as frequency and percentages. The patients were grouped into seven groups according to the false diagnosis, and the comparisons in descriptive parameters between these groups were performed using one-way ANOVA and post hoc test. The Chi-square test was used to find association and comparison between categorical variables. The significant statistical value was set at 0.05. A stacked bar chart was used to demonstrate the frequency (percentage) of each symptom in the studied participants. The box plot was used to compare the mean age between hospitalized and non-hospitalized patients and also between dead and alive patients. Mann–Whitney *T*-test was used to find significant statistical value, and $P < 0.05$ was regarded as significant.

## Results

In this study, 100 subjects who were confirmed to have COVID-19 based on RT-PCR of nasopharyngeal swabs were falsely diagnosed previously. Most of the false diagnoses were typhoid fever (63%), followed by influenza (14%) and pneumonia (9%). Few of them were also falsely diagnosed as having gastroenteritis (5%), common cold (4%), brucellosis (4%), and meningitis (1%) (Table 1). The mean age of the participants of COVID-19 confirmed patients with the previous false diagnosis was 42.34 ± 15.56 years, and most of the patients were male (60%) (Table 1).

All the patients who were falsely diagnosed with typhoid, their diagnoses were made based on positive

**Table 1** General and clinical characteristics of the studied participants according to types of misdiagnosis before COVID-19 confirmations

| | Types of misdiagnosis[a] | | | | | | | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | Total | Typhoid | Influenza | Pneumonia | Gastro-enteritis | Common cold | Brucellosis | |
| Total no. | 100 | 63 | 14 | 9 | 5 | 4 | 4 | |
| Parameters | N (%) mean (SD) | N (%) mean (SD) | N (%) mean (SD) | N (%) mean (SD) | N (%) mean (SD) | N (%) mean (SD) | N (%) mean (SD) | |
| Age[b] | 42.34 (15.56) | 41.21 (15.5) | 44.36 (14.04) | 52.56 (11.61) | 38.4 (14.69) | 43.25 (18.75) | 29.25 (20.65) | 0.159 |
| Sex | | | | | | | | |
| Male | 60 (60) | 37 (58.7) | 7 (50) | 7 (77.8) | 2 (40) | 2 (50) | 4 (100) | 0.407 |
| Female | 40 (40) | 26 (41.3) | 7 (50) | 2 (22.2) | 3 (60) | 2 (50) | 0 (0.0) | |
| Investigation based on | | | | | | | | |
| Typhoid IgM and IgG rapid test | 63 (63) | 63 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | < 0.001 |
| Rose Bengal | 4(4) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (100) | |
| Chest X-ray | 5 (5) | 0 (0) | 0 (0) | 5 (55.6) | 0 (0) | 0 (0) | 0 (0) | |
| None (clinical presentation) | 28 (28) | 0 (0) | 14 (100) | 4 (44.4) | 5 (100) | 4 (100) | 0 (0) | |
| MisDX made by | | | | | | | | |
| Non-physician healthcare worker | 92 (92) | 63 (100) | 14 (100) | 4 (44.4) | 5 (100) | 4 (100) | 2 (50) | < 0.001 |
| Physician | 8 (8) | 0 (0) | 0 (0) | 5 (55.6) | 0 (0) | 0 (0) | 2 (50) | |
| Duration of the mistreatment (days) | 5.44 (1.733) | 5.63 (1.47) | 4.21 (1.12) | 6 (2.55) | 4.4 (1.67) | 5.75 (1.5) | 7.25 (2.5) | 0.002 |
| Hospitalized | 28 (28) | 15 (23.8) | 4 (28.6) | 2 (22.2) | 2 (40) | 3 (75) | 1 (25) | 0.236 |
| Died[a] | 4 (4) | 1 (1.6) | 2 (14.3) | 1 (11.1) | 0 (0) | 0 (0) | 0 (0) | 0.361 |

[a] One patient was diagnosed with meningitis by a physician, its data is not shown in this table

[b] Descriptive parameters were shown as mean (SD). All other parameters were categorical variable shown as numbers (percentages)

typhoid IgM and IgG rapid tests, and who were falsely diagnosed with brucellosis based on positive Rose Bengal tests. All falsely diagnosed pneumonia was based on a chest X-ray. In contrast, all other patients who were falsely diagnosed to have influenza, common cold, and gastroenteritis, the diagnosis was made based on clinical presentations. All these results were statistically significant (Table 1).

Most (92%) of the false diagnoses were made by non-physician healthcare workers, and only 8% of the false diagnosis were made by physicians. All false diagnoses with typhoid fever, gastroenteritis, and common cold were made by non-physician healthcare workers, together with about half of the diagnosis of pneumonia and brucellosis, with statistically significant results ($P<0.001$). One patient, 62-year-old male, was falsely diagnosed by a physician as having meningitis because fever, headache, and confusion were the main presenting symptoms; later, after 2 days, he was confirmed with RT-PCR for having COVID-19. The mean duration of receiving treatment for the false diagnosis till the COVID-19 diagnosis was 5.44 days (Table 1).

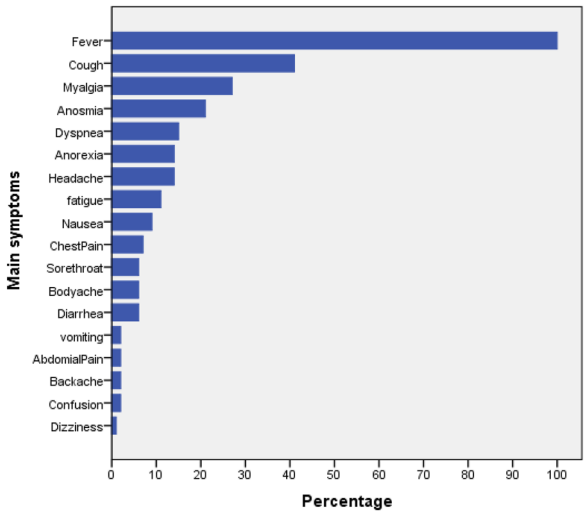


**Fig. 1** Percentages of the main presenting symptoms in confirmed COVID-19 infected patients

Among the studied patients with false diagnoses, the hospitalization rate was 28%, and the rate of death was 4%. There are no significant differences in the rate of death and hospitalization in patients who were diagnosed falsely with different diseases before confirmation with COVID-19 (Table 1).

The most frequent symptoms present in all patients were fever (100%), followed by cough (41%), myalgia (27%), and anosmia (21%) (Fig. 1). The most frequent medication used to treat patients with a false diagnosis before COVID-19 confirmation is revealed in Table 2. The ceftriaxone vial was the most frequently prescribed medication to the false diagnosed typhoid patients (65%).

Figure 2 shows a comparison between mean age in patients who were hospitalized and non-hospitalized patients. The mean age of patients who were hospitalized was significantly higher compared to non-hospitalized patients. The same was true in COVID-19 patients with false diagnosed typhoid ($P<0.001$).

As shown in Fig. 3, the mean age of patients who died was higher than the mean age of patients alive from the disease, but the data failed to reach a significant level statistically. The delay in the diagnosis of COVID-19 does not show a significant correlation with the rate of hospitalization and death ($P<0.05$).

## Discussion

In the Kurdistan region, Northern Iraq, after appearing of the first COVID-19 case, every effort by health teams and government-run security agencies promptly and seriously was intensified to quarantine citizens in their homes, blocked traffic in all directions, banned travels between the Kurdistan cities and between the Kurdistan region and federal Iraqi provinces for about 60 days to prevent the virus's spread [11]. This was followed by a silent period with very few or even no reported cases for about 2 weeks which made the people force the KRG to lift the lockdown and curfew. After that, the COVID-19 infection has started again, and hundreds (some days reached more than a thousand) of cases were reported daily that was associated with higher severity of clinical signs, increased hospitalization rate, and also higher mortality rate, with various treatment choices, and outcomes of the disease in comparison to the previous cases.

**Table 2** The most frequent medication (mistreatment) used to treat the patients based on the misdiagnosis

| False diagnosis | Typhoid | Influenza | Pneumonia | Gastro-enteritis | Common cold | Brucellosis |
|---|---|---|---|---|---|---|
| Number | 63 | 14 | 9 | 5 | 4 | 4 |
| Most frequent medication | Ceftriaxone vial | Dexamethasone combined with diclofenac sodium | Levofloxacin Tab | Metronidazole | Amoxiclav | Rifampicin with doxycycline |
| No. (%) | 41 (65%) | 9 (64.3) | 3 (33.3%) | 5 (100%) | 3 (75%) | 4 (100%) |

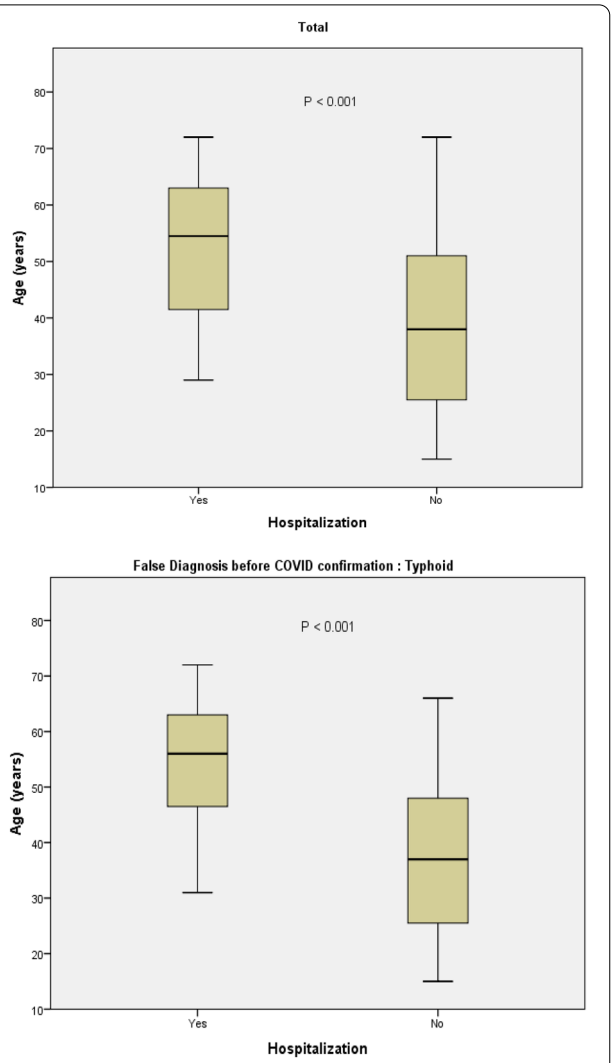


**Fig. 2** Mean age compared between hospitalized and non-hospitalized patients, in the **a** total confirmed COVID-19 infected patients with previous misdiagnosis and, **b** COVID-19 infected patients with false typhoid fever diagnosis

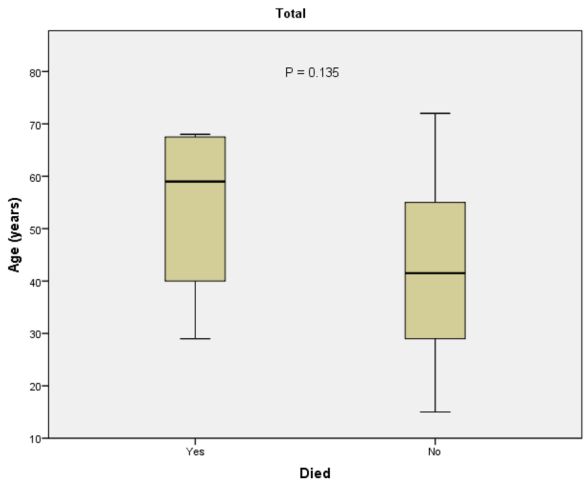


**Fig. 3** Mean age compared between dead and live patients, in the misdiagnosed COVID-19 confirmed patients

The majority of cases are asymptomatic carriers, and some show mild-to-moderate clinical signs, while the minority has severe debilitating symptoms [16].

Despite all these facilities and services offered to COVID-19 patients in Public Hospitals in various areas of the Kurdistan region, there are still some misdiagnosed and mistreated COVID-19 cases, especially by non-physician healthcare workers, that lead to sad consequences.

In the Kurdistan region or even Iraq, there is no published data about the misdiagnosis and mistreatment information of the COVID-19 patients with other infectious diseases, especially typhoid fever, influenza, pneumonia, gastroenteritis, common cold, brucellosis, and meningitis.

In this current study, we realized that men are misdiagnosed more often than women which might be due to men being more commonly infected with COVID-19 than women [17], since the majority of outdoor works are done by men (business, running shops, employee, and office works). Additionally, we emphasized that the majority of misdiagnosed people are aged above 40 years, which might be due to the fact the disease is more common in adult mature individuals or the condition is mostly affected peoples with comorbidities such as hypertension, diabetes, cancer, hypocholesteremia which are more common in older people than younger ones [18].

On the other hand, among the infections misdiagnosed with COVID-19 cases, typhoid fever is the commonest, while meningitis is the less common one. This result might be due to that the typhoid fever is endemic in our region, and annually too many peoples being diagnosed with this disease in all age groups for both sexes [19]. Another factor is that the typhoid serology is not as sensitive as detecting the specific typhoid IgM and IgG antibodies and globally; this diagnostic test is no more recommended for typhoid fever diagnosis [20].

In our region, because of a severe economic crisis there are too many non-physician healthcare workers who have established a local clinic in neighborhoods for diagnostic evaluations, therapeutic remediation, surgical assistance, and pharmaceutical prescription without having sufficient skills in those fields, and this mostly results in misleading sick people that results in misdiagnosis and mistreatment of patients. Regarding the patients with

COVID-19 infections, in a total of 100 positive cases, 92 cases were misdiagnosed and treated by non-physician healthcare workers in which some patients' life ended with death.

About the clinical signs of COVID-19 misdiagnosed patients, the majority of diseases people presented fever which might be due to that the fever is a common clinical sign of all infectious diseases including viral infections [21]. At the same time, dizziness was reported to be a less common symptom.

Furthermore, ceftriaxone is commonly used as a treatment of choice by misdiagnosed COVID-19 patients. At the same time, amoxiclav is a less commonly used antibiotic, which might be due to that ceftriaxone is a broad-spectrum antibiotic that is most commonly used for the treatment of typhoid fever [22]. In this study, most COVID-19 cases were misdiagnosed with typhoid fever.

## Conclusion

In conclusion, we realized that non-physician healthcare workers are the primary cause of misdiagnosis and mistreatment of COVID-19 patients in Sulaimaniyah city, Kurdistan Region, Iraq. Additionally, a single typhoid IgM and IgG rapid test are neither a specific nor a sensitive diagnostic option for the diagnosis of typhoid fever. It gives a high pseudo-positive result in people infected with other diseases and not typhoid fever, leading to misdiagnosis followed by mistreatment, especially in COVID-19 patients.

#### Abbreviations

ARDS: Acute respiratory distress syndrome; CT: Computed tomography; COVID-19: Corona virus disease-2019; ICU: Intensive care unit; IgM: Immunoglobulin M; KRG: Kurdistan Regional Government; RT-PCR: Real-time polymerase chain reaction; SARS: Severe acute respiratory syndrome coronavirus-2; WHO: World Health Organization.

#### Author contributions

NAO and MSM conducted the research work; SJA analyzed the data and performed the statistical analysis; HSR edited, revised, corrected, and submitted the manuscript. All authors participated in the writing the original draft of the manuscript. All authors read and approved the final manuscript.

#### Funding

This research did not receive any specific grant from any funding agency in the public, commercial, or not-for-profit sector.

#### Availability of data and materials

All data generated or analyzed during this study are included in this published article.

## Declarations

#### Ethics approval and consent to participate

All procedures performed in this study involving human participants followed the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The ethical approval for this study was obtained from the Ethical and Scientific Committee of Physiology Department and the Ethical Committee of the College of Medicine, University of Sulaimani, with Reference Number 12/2021 on December 25, 2020, with meeting number 5.

#### Consent for publication

Written inform consent was obtained from the patients for publication.

#### Competing interests

The authors declare that they have no competing interests.

#### Author details

[1]Department of Medicine, College of Medicine, University of Sulaimani, Sulaimani New, Street 29, Zone 207, Sulaymaniyah 46001, Republic of Iraq. [2]Department of Physiology, College of Medicine, University of Sulaimani, Sulaimani New, Street 29, Zone 207, Sulaymaniyah 46001, Republic of Iraq. [3] Department of Medical Laboratory Sciences, Komar University of Science and Technology, Sulaimaniyah, Iraq.

Received: 1 November 2021 Accepted: 14 May 2022
Published online: 03 June 2022

#### References

1. Centers for Disease Control and Prevention (CDC). 2019 Novel Coronavirus (2019-nCoV). Wuhan: Centers for Disease Control and Prevention; 2020.
2. Al-Muharraqi M. Testing recommendation for COVID-19 (SARS-CoV-2) in patients planned for surgery-continuing the service and 'suppressing' the pandemic. Br J Oral Maxillofac Surg. 2020. https://doi.org/10.1016/j.bjoms.2020.04.014.
3. Basile C, Combe C, Pizzarelli F, Covic A, Davenport A, Kanbay M, Kirmizis D, Schneditz D, van der Sande F, Mitra S. Recommendations for the prevention, mitigation and containment of the emerging SARS-CoV-2 (COVID-19) pandemic in haemodialysis centres. Nephrol Dial Transplant. 2020. https://doi.org/10.1093/ndt/gfaa069.
4. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA. 2020;323:1061–9.
5. WHO. Critical preparedness, readiness and response actions for COVID-19. Geneva: WHO; 2020.
6. Wrapp D, Wang N, Corbett KS, Goldsmith JA, Hsieh C-L, Abiona O, Graham BS, McLellan JS. Cryo-EM structure of the 2019-nCoV spike in the prefusion conformation. Science. 2020;367:1260–3.
7. Woo PC, Lau SK, Li KS, Poon RW, Wong BH, Tsoi H-W, Yip BC, Huang Y, Chan K-H, Yuen K-Y. Molecular diversity of coronaviruses in bats. Virology. 2006;351:180–7.
8. Yin Y, Wunderink RG. MERS, SARS and other coronaviruses as causes of pneumonia. Respirology. 2018;23:130–7.
9. World Health Organization. Home care for patients with COVID-19 presenting with mild symptoms and management of their contacts. Geneva: World Health Organization; 2020.
10. Jin X, Lian J-S, Hu J-H, Gao J, Zheng L, Zhang Y-M, Hao S-R, Jia H-Y, Cai H, Zhang X-L. Epidemiological, clinical and virological characteristics of 74 cases of coronavirus-infected disease 2019 (COVID-19) with gastrointestinal symptoms. Gut. 2020. https://doi.org/10.1136/gutjnl-2020-320926.
11. Aziz PY, Hadi JM, Aram MS, Aziz SB, Rahman HS, Ahmed HA, Abdulla MA, Ali SMA. The strategy for controlling COVID-19 in Kurdistan Regional Government (KRG)/Iraq: identification, epidemiology, transmission, treatment, and recovery. Int J Surg Open. 2020. https://doi.org/10.1016/j.ijso.2020.06.006.
12. Awulachew E, Diriba K, Anja A, Getu E, Belayneh F. Computed tomography (CT) imaging features of patients with COVID-19: systematic review and meta-analysis. Radiol Res Pract. 2020. https://doi.org/10.1155/2020/1023506.
13. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology. 2020. https://doi.org/10.1148/radiol.2020200642.

14. Grasselli G, Greco M, Zanella A, Albano G, Antonelli M, Bellani G, Bonanomi E, Cabrini L, Carlesso E, Castelli G. Risk factors associated with mortality among patients with COVID-19 in intensive care units in Lombardy, Italy. JAMA Intern Med. 2020. https://doi.org/10.1001/jamainternmed.2020.3539.
15. Rahman HS, Aziz MS, Hussein RH, Othman HH, Omer SH, Khalid ES et al. The transmission modes and sources of COVID-19: A systematic review. Int J Surg Open. 2020;26:125–36. https://doi.org/10.1016/j.ijso.2020.08.017.
16. Faraj AM, Qadir SA, Mohammed OA, Aziz PY, Alkhafaji M, Rahman HS, et al. Current Potential Options for COVID-19 Treatment in Iraq-Kurdistan Region and the Rest of the World: A Mini-review. Iraqi J Sci. 2022:948–58. https://doi.org/10.24996/ijs.2022.63.3.4.
17. Sharma G, Volgman AS, Michos ED. Sex differences in mortality from COVID-19 pandemic: are men vulnerable and women protected? JACC Case Rep. 2020;2:1407–10.
18. Guan W-J, Liang W-H, Zhao Y, Liang H-R, Chen Z-S, Li Y-M, Liu X-Q, Chen R-C, Tang C-L, Wang T. Comorbidity and its impact on 1590 patients with Covid-19 in China: a nationwide analysis. Eur Respir J. 2020. https://doi.org/10.1183/13993003.01227-2020.
19. Watkins LKF, Winstead A, Appiah GD, Friedman CR, Medalla F, Hughes MJ, Birhane MG, Schneider ZD, Marcenac P, Hanna SS. Update on extensively drug-resistant *Salmonella* serotype *typhi* infections among travelers to or from Pakistan and report of ceftriaxone-resistant *Salmonella* serotype *typhi* infections among travelers to Iraq—United States, 2018–2019. Morb Mortal Wkly Rep. 2020;69:618.
20. Enabulele O, Awunor SN. Typhoid fever in a Tertiary Hospital in Nigeria: another look at the Widal agglutination test as a preferred option for diagnosis. Niger Med J. 2016;57:145.
21. Keeling MJ, Rohani P. Modeling infectious diseases in humans and animals. Princeton: Princeton University Press; 2011.
22. Zaki NM, Hafez MM. Enhanced antibacterial effect of ceftriaxone sodium-loaded chitosan nanoparticles against intracellular *Salmonella typhimurium*. AAPS PharmSciTech. 2012;13:411–21.

## Publisher's Note