Original Article

Trends in COVID-19

Incidence, mortality, and case fatality in Iraq

Nagham A. Mawlood, *MD, PhD,* ***Riyadh K. Lafta,*** *MD, PhD.*

ABSTRACT

الأهداف: الكشف عن الاتجاه الوبائي لمرض فيروس كورونا 19 (COVID-19) في العراق، وتوزيع الحالات حسب العمر والجنس والمحافظات، وتقييم العبء على النظام الصحي من خلال تقدير معدلات المرض والوفيات.

المنهجية: أجريت هذه الدراسة البيومترية في عام 2021م. رسمنا معدلات التوزيع، والحدوث، والوفيات، ومعدل الوفيات خلال فترة 17 شهرًا في تصميم القياسات الحيوية. قمنا بتوزيع استبيان شبه منظم على عدد من متخذي القرار في وزارة الصحة بخصوص تحديات النظام الصحي التي تمت مواجهتها خلال هذه الجائحة.

النتائج: أكثر من نصف الحالات (55.1%) كانت بين الذكور و 67.5% في الفئة العمرية 30-60 سنة. كان معدل الوفيات أيضًا سائدًا بين الذكور (62.7%)، وكانت نسبة 50.0% من الوفيات في الفئة العمرية >50 عامًا. كانت الفئة العمرية السائدة لكلا الجنسين 30-60 سنة. بلغ معدل الإماتة 1.2% مرة أخرى أعلى بين الذكور (1.3% مقابل 1.1%).

الخلاصة: أظهر اتجاه COVID-19 في العراق ذروتين، أغسطس - أكتوبر 2020م ومارس - يوليو 2021م، مع تأثر الذكور أكثر بالمرض والوفيات. كان التحدي الرئيسي الذي واجهه النظام الصحي العراقي هو الزيادة السريعة لحالات COVID-19 ومحدودية السعة السريرية والمعدات الطبية.

Objectives: To detect the epidemiological trend of coronavirus disease-19 (COVID-19) in Iraq, the distribution of cases by age, gender, and governorates, and to assess its burden on the health system by estimating morbidity and mortality rates.

Methods: This biometric study was carried out in 2021. The distribution, incidence, mortality, and case fatality rates in a 17-month period was sketched in a biometric design. A semi-structured questionnaire was distributed to a number of decision makers in the Ministry of Health regarding health system challenges that have been faced during this pandemic.

Results: More than half (55.1%) of the cases were among males, and 67.5% were in the age group 30-60 years. Mortality was also predominant among males (62.7%), and 50.0% of the deaths were in the age group >50 years. The predominant age group for both genders was 30-60 years. Case fatality rate was 1.2%; again higher among males (1.3% versus 1.1%).

Conclusion: The trend of COVID-19 in Iraq showed 2 peaks, August-October 2020 and March-July 2021, with males being more affected by morbidity, mortality, and fatality. The main challenge faced by the Iraqi health system was the rapid increase of COVID-19 cases with limited bed capacity and medical equipment.

Keywords: COVID-19, trend, mortality, Iraq

Saudi Med J 2022; Vol. 43 (5): 500-507
doi: 10.15537/smj.2022.43.5.20220088

From the Ministry of Health (Mawlood), from the Family and Community Medicine Department (Lafta), College of Medicine, Mustansiriya University, Baghdad, Iraq, and from the Global Health Department (Lafta), University of Washington, Seattle, United States of America.

Received 28th January 2022. Accepted 10th April 2022.

Address correspondence and reprint request to: Dr. Nagham A. Mawlood, Ministry of Health, Baghdad, Iraq. E-mail: drnagham74@gmail.com ORCID ID: https://orcid.org/0000-0001-9851-8905

Many disasters (natural and man-made) have been occurred worldwide in the last decades, causing major disruption to life and health. The unpredictable nature of these disasters urged the health professionals to be adapted to the resulted rapid and unprecedented changes of the environment.[1] Pandemics have a memorable occurrence in the history of populations via causing them to live in a state of anxiety and fear, and disrupt the natural flow of their life.[2] Contrastive to natural disasters, which usually have a known onset and size of population affected, pandemics usually start insidiously and propagate rapidly depending on the route of transmission, virulence of the agent, and other human and environmental circumstances.[3]

The first rising of coronavirus disease-19 (COVID-19) cases was around the end of December 2019 or early January 2020.[4,5] The rapid increase in infections and deaths resulted in anxiety, panic, stigma, mistrust, and rumor-mongering among people. This

incident was labeled on January 30, 2020, as a Public Health Emergency of International Concern. On March 11, 2020, World Health Organization (WHO) formally announced the outbreak of the new coronavirus COVID-19 a pandemic, after it has spread to more than 100 countries and lead to several thousands of cases in the first few months of its appearance.[6] As of October 2021, more than 240 million people globally have contracted the disease and approximately 5,000,000 people died. Three countries (United States of America [USA], India, and Brazil) comprised more than 42.0% of the world cases and 37.0% of the world deaths.[7]

Primarily, the case-fatality-rate (CFR) for coronavirus was 2-3.0% globally; though, the age group of 70-79 years, which is the high risk group, has an 8.0% CFR.[8] Center for Disease Control and Prevention found that the CFR increased with age, as it increased from 0.2% in patients aged below 39 years to 14.8% in those over 80 years, with death risk been greater among males (2.8%) than females (1.7%).[9] The prevalence of the infection in the population has a considerable influence on the overall mortality rate, once the number of infected individuals among population has reached large sizes, this will overwhelm the health care systems which may lose its aptitude to treat all patients reported.[10]

The numbers of cases and deaths in many African countries were low compared to European and American countries, some possible reasons may be related to low test capacity, relatively young population, and probably, under reporting, which may result in delayed action against the pandemic.[11,12] However, CFR differed between countries; 2.0% in Pakistan, 1.45% in India, 4.7% in Iran, 3.4% in the United Kingdom (UK), and 3.5% in Italy. This difference could be due to a multifactorial combination of viral immunogenicity, genetic factors of the host, and demographic differences.[13] The reduction in workforces and the increasing unemployment, attributed to COVID-19, caused a significant economic burden worldwide that superimposed the health impact.[14]

Coronavirus disease-19 pandemic made a global public awareness and panic, as in addition to the morbidity and mortality, it has major adverse psychological, social, and economic sequels.[15] The features of this highly infectious and fatal disease have forced governments to adopt unfamiliar measures in most countries, such as declaring a state of emergency, general incarceration of the population, imposition of social distancing, and the application of restrictive social (and health care) visiting policies.[16]

The purpose of this study was to recognize the epidemiological trend of COVID-19 in Iraq, the distribution of cases by age, gender, and governorates, and to assess the burden on the health system by estimating the morbidity, mortality, and case fatality rate, in addition to the health authorities' opinion on the obstacles emerged in dealing with this pandemic.

Methods. This study was designed as 2 main parts; first, as a biometric descriptive study that involves treatment and processing of already available data from the Ministry of Health and related facilities to sketch the epidemiological trend of COVID-19 including: distribution, morbidity, mortality, and CFR in a 17-month-period (March 2020 through July 2021). The second part was designed as a qualitative study to throw light on the burden of the pandemic on the health system via interviewing the decision makers in the Ministry of Health and Baghdad health directorates. A semi-structured questionnaire (with some open-ended questions) was distributed to a number of decision makers regarding the health system challenges that have been faced during this pandemic, such as health resources, people's commitment to health authorities' instructions, availability of vaccine, the main reasons for recurrent peaks in the disease trend, and the possible solutions for any future scenarios, including the plans to overcome any emerging situation.

The challenges include comprehensiveness of the health services, access (geographic accessibility, acceptability, and affordability), referral systems, vertical integration and coordination of health services, and continuity of care.

Data were categorized by age and gender, then plotted against time to see the trend of the disease for each age group and gender. Data were examined and triple checked for missed information and conformed to WHO reports.

This study did not include human or any sort of intervention. Hence, the ethical considerations were not needed apart from the approvals of the Ethical Committee in the College of Medicine, Mustansiriyah University, Baghdad, Iraq, and the permissions from the Ministry of Health. However, the participants were assured that the information they declare would not be used for any purpose other than research work.

Statistical analysis. The data analysis was carried out using Statistical Packages for Social Sciences,

Disclosure. Authors have no conflict of interests, and the work was not supported or funded by any drug company.

version 26.0 (IBMCorp, Armonk, NY, USA). Data were presented in simple measures of frequency and percentages. Linear regression was used to sketch the trend of the disease.

Results. Figures 1 & 2 show the trend of COVID-19 in Iraq during the period from March 2020 through July 2021. There are 2 peaks; a moderate one (August-October 2020) and a high one (March-July 2021). Figures 2 & 3 show the trend of mortality during the same period. Figure 4 demonstrates that males are affected more than females, 55.1% of the cases were among males, with the predominant age group for both genders (67.5%) being 30-60 years. The trend of deaths is illustrated in Figure 5 with a predominance of male gender, Mortality was also predominant among males (62.7%) and 50.0% of the deaths were among the age group >50 years. Case fatality rate was 1.2%; again higher among males than females (1.3% versus 1.1%). A comparison between the number of cases and deaths in each governorate showed that Diyala, Anbar, Wasit (Middle region) have low numbers of deaths compared to cases; while Sulaimaniyah (North) has a high number of deaths (not tabulated).

Table 1 describes the challenges and obstacles that faced the Iraqi health system during this pandemic and the possible reasons stated by decision makers in the Ministry of Health and health directorates, the main challenges were: shortage of health personnel, limited bed capacity due to old buildings of hospitals, and insufficient oxygen supply.

Discussion. More than half of the cases were males, and two-third aged 30-60 years. This goes with a study in Victoria, Australia[17] regarding the age group of cases, although the vulnerable age group for death was ≥60 years, but it disagreed with a study in India where male constituted 65.4%, with age group 18-35 years formed 37.5% of the cases.[18] The results of meta-analysis in 8 countries showed that the highest frequency of cases (in Germany, Chile, Portugal, South Korea, New Zealand, Turkey, Canada, and USA) was in the age group 20-39 years; while in Italy, Netherlands, and UK the highest frequency was among the age group >80 years.[19] The differences in the access of COVID-19 testing could be the main reason, rather than in the actual number of cases, as testing the elderly was a priority. They were labeled as a high risk group, due to the severe complications they might face, taking in consideration the limited capacities in testing at the beginning of the pandemic. However, younger age groups began to receive a parallel consideration as testing capacities improved especially with increasing numbers of asymptomatic patients in most populations that may facilitate the transmission of the infection.[19,20]

Two-third of the total deaths were males, half of whom age more than 60 years. Certain groups especially those age groups above 65 years or those with previous medical illnesses are more affected by COVID-19 complications and can result in more fatalities. Physiological effect due to aging process, such as waning of the immune system, dysfunction, and degeneration of body tissues can be the leading cause for deterioration and death.[21] Coronavirus infection is now labeled as "the third leading cause of death for children and adults (697.5 deaths/million)", that comes only after heart problems (1287.7 deaths/million) and cancer (1219.8 deaths/million).[22]

Gender could play a part in vulnerability to coronavirus disease, however, this is still unclear. Several reports have indicated that men have a higher

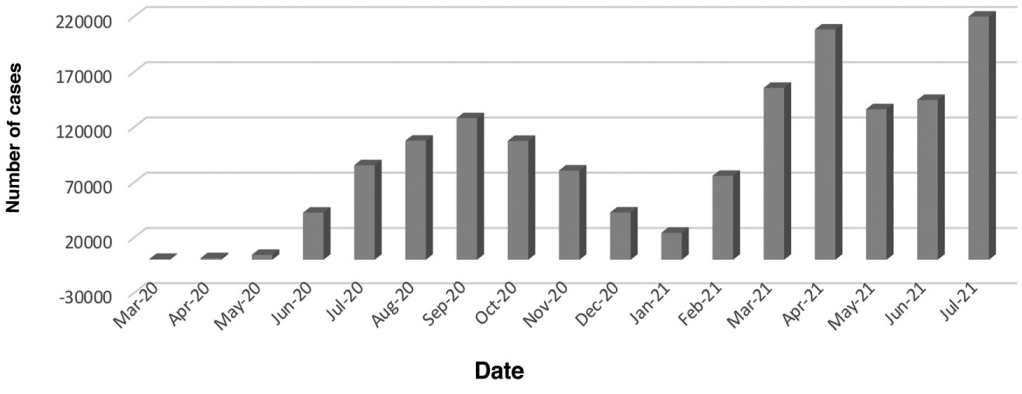

Figure 1 - Coronavirus disease-19 cases in Iraq (March 2020- July 2021).

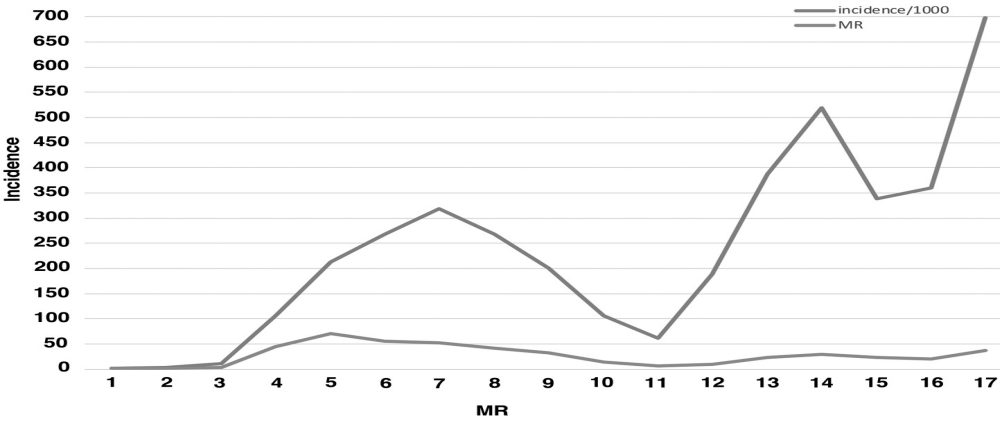

Figure 2 - Coronavirus disease-19 incidence and mortality (MR) rates in Iraq (March 2020-July 2021).

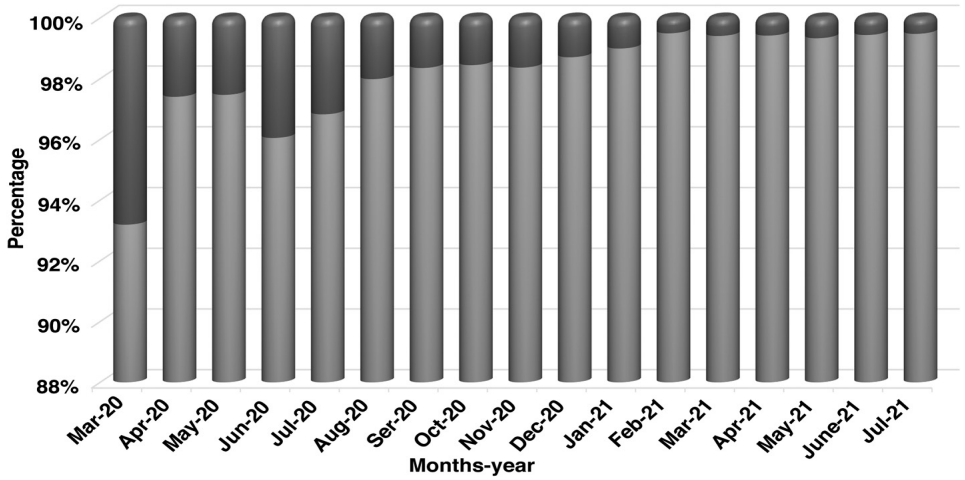

Figure 3 - Coronavirus disease-19 cases and deaths by month in Iraq (March 2020- July2021).

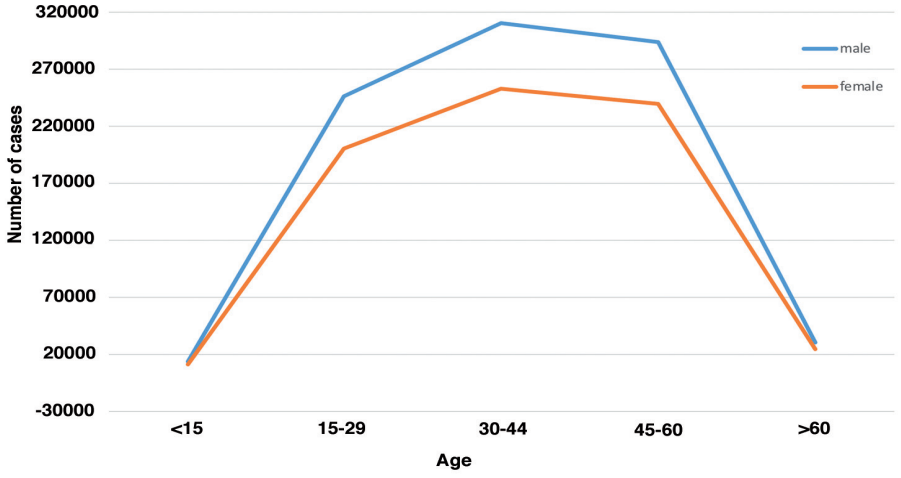

Figure 4 - Distribution of coronavirus disease-19 cases in Iraq by age and gender.

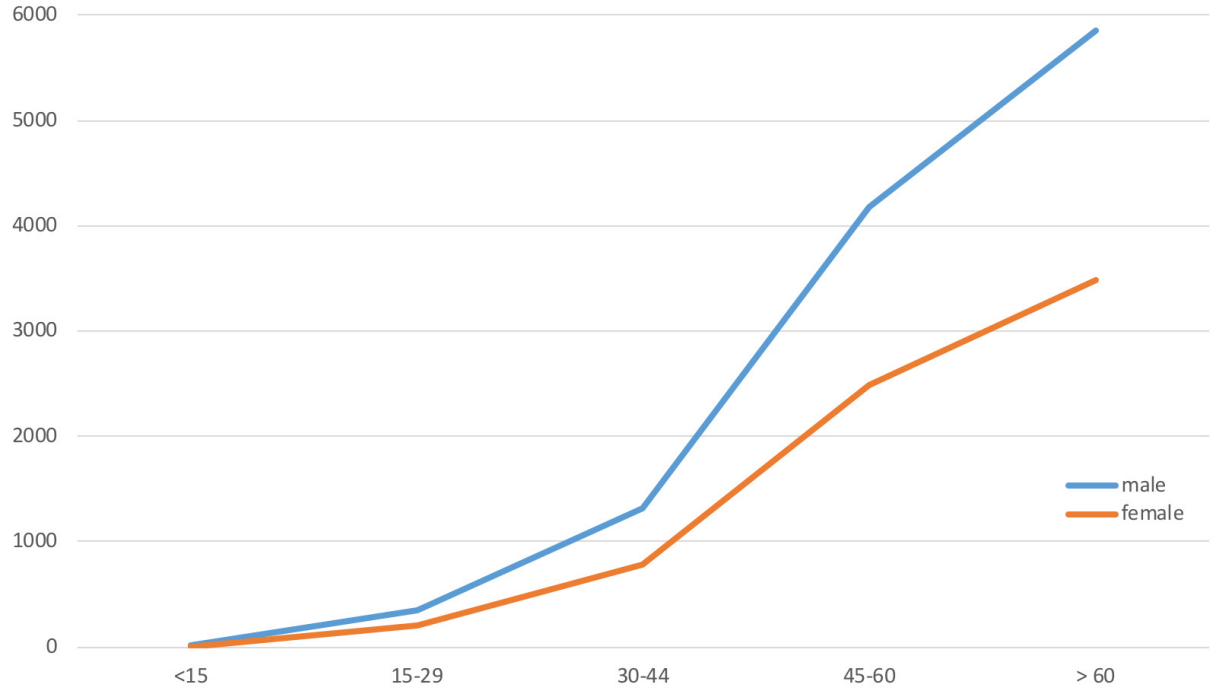

Figure 5 - Distribution of coronavirus disease -19 deaths in Iraq by age and gender.

Table 1 - Main challenges and obstacles faced by the Iraqi health system during the pandemic.

Obstacles	*Reasons*
Sudden flare up in number of patients beyond hospitals capacity	Poor adherence to health instructions and delayed closure of borders with neighboring countries
Rapid turnover of decision makers in	
Discredit the role of epidemiologists in controlling the pandemic	Inexperience, panic, overwork, pressure from other governmental unprofessional parties
Uncertainty in decision making	
Miss management due to lack of knowledge about the virus	Lack scientific approach in the treatment (no randomized trials)
Depending on passive rather than active surveillance	Overload on HCWs and burden on health system
Lack of periodic medical examination for frontline HCWs	Poor planning and deficient experience
Weak implementation of vaccination campaigns especially house to house	Poor planning and limited amounts of vaccine
Poor public cooperation	Panic, listening to rumors and negative effect of some religious and community leaders
Challenges	
Shortage of HCWs	Migration of doctors due to the unfavorable security condition
Deficient supply of medicines	Domination of certain companies over the governmental supply
Problems in maintaining PPE	Lack of national budget
Limited bed capacity	old buildings of hospitals with no extension/renovation
Insufficient oxygen supply	Depending on oxygen cylinders
Inadequate training of HCWs	Lack of continuing medical education
Insufficient amount of PCR	Restricted to the Central Laboratory of Ministry of Health
Delayed supply of vaccination	Logistic problems

HCWs: healhtcare workers, PPE: personal protective equipment, PCR: polymerase chain reaction

number of infection and case fatality rates than women. Reasons behind that might include variability in gender norms and habits, or differences in social roles in each society.[23] Islam et al[24] attributed that to several factors, such as occupational and lifestyle that may increase the likelihood of exposure among men or differences in underlying comorbidities between both genders.

The disease trend in the current study showed 2 peak; a moderate one (August-October 2020) following "Eid al Fitr" celebration, and a higher one (March-July 2021), while Saudi Arabia reported a single peak (June-July 2020). In Egypt, there the highest peak was in June 2020 with 2 moderate peaks in January 2021 and in June 2021. Iran experienced 2 moderate peaks in November 2020 and in April 2021, and a highest peak in August 2021.[25] Although large gatherings of people like religious ceremonies with massive overcrowding can participate in the disease trend fluctuation, small and informal social gatherings are thought to be an important source of transmission; birthdays, wedding, and funeral occasions can empirically quantify the impending role of small social gatherings in COVID-19 spread.[26]

Case fatality rate seems to be relatively low in the current study compared to other countries, a study that included 20 European countries (severely affected with COVID-19), in addition to USA and Canada, concluded that the country-specific CFR showed a broad spectrum, ranging from 0.6 (Iceland) to 18.1% (France).[27] However, CFR in the current study was higher among males, which was consistent with most of the countries in Hoffmann and Wolf's study.[27] Many heterogeneous reasons related to country-specific differences in cases and deaths have been evaluated, including genetic, socioeconomic, and environmental factors.[28]

Coronavirus disease-19 cases distribution, deaths, and CFR by months during the period of the study showed that the highest number of deaths was in July 2020, and the maximum number of cases was in July 2021, whilst the CFR reached its peak at the beginning of the pandemic. These results were in line with WHO COVID-19 weekly global report, in which the elevated trend in the last 2 months (Jun-July 2021) was largely attributed to increase number of cases in the Western Pacific region (14.0% increase) and the Americas (8.0% increase), while at the country level, the peak numbers of new cases in the same period were reported by USA, Iran, and India.[29]

The highest global death rate reported by WHO was in January 2021, while the highest global CFR was in April 2020.[30] Hasan et al[31] in a meta-analytic study concluded that the weekly worldwide coronavirus CFR got a top at 7.2% during the 17th epidemiological week (April 22-28, 2020). The topmost 5 countries with coronavirus CFR were Yemen (28.9%), Italy (13.2%), UK (12.4%), Belgium (11.6%), and France (11%). Case fatality rate is a key measure of disease burden that is crucial for effective pandemic monitoring and control.[17,32] However, many reasons restrict obtaining an accurate estimate of CFR and Mortality rate by COVID-19.[33]

The decline in CFR in this study was consistent with other studies in USA (New York), where the death rate among inpatients declined 18-20.0% in a 3-4 months period, from 25.6% in March to 7.6% in June 2020.[34] In another study in England, the death rate decreased among patients that were admitted in May related to those admitted in March 2020 (from 11.2% to 9.0%).[35] The relative drop in CFR could be due to some reasons, such as: increased public awareness, widespread testing that detects even asymptomatic or mild cases, precision of severely ill patients' management, favorable outcomes for infection of younger people, and experience gained by health professionals.[31]

The morbidity and mortality statistics by governorates demonstrated that the highest incidence rates were in Wasit, Duhok, and Baghdad, whilst Sulaimaniyah recorded the highest mortality and case fatality rates. Despite the geographical variability between Iraqi governorates, it is generally expected that increased population density rises the susceptibility of some regions to get infection due to the high occurrence of social and economic interactions. Population density is certainly a crucial hint in studying virus spread, however, limited access to medical services due to a shortage of health personnel, hospitals beds (especially intensive care units) and intensive care beds, testing intensity and access to testing, in addition to low income level in more closely inhabited areas could be possible factors.[21]

The main challenges faced by the Iraqi health system during this pandemic as stated by decision makers in the Ministry of Health were shortage of medical personnel as a result of migration of doctors due to unfavorable security condition, also the limping health system and services represented by shortage of medicines and insufficient oxygen supply. In a study in Nepal, the most challenging aspects were the availability of testing kits, medical supplies, and personal protective equipment.[36] In a study in France, the main challenges were increase health workers' awareness regarding management of suspected and confirmed cases, preparedness by education, and training that have been regularly organized for frontline health workers.[37]

Moreover, the burden on the healthcare system was also attributed to the rapidly increasing number of cases. Governments have to take several measures to improve the capacity of the health system in order to tackle the prevailing healthcare crises, some healthcare professionals advise that the government should actively work on the security of the health workers. Lockdowns must be focused on places where clusters of cases are detected.[38]

Many obstacles emerged during the process of the pandemic control, especially the sudden flare up in the number of cases beyond hospitals' capacity (due to poor adherence of people to health instructions), in addition to the delay in closing the borders with the neighboring countries, and the slow and weak implementation of vaccination campaigns. The main reasons for loss of people's role and cooperation during the pandemic were economic problems in making a living especially among those with daily work, which contributed to a negative outcome, in addition to panic that is fed by rumors from the social media especially with respect to vaccination. People generally rely on social media to gain information on the virus.[39,40]

The interviewed decision makers made some suggestions to overcome the obstacles such as: establish modern hospitals in accordance with international health standards, intensify community sensitization, and engagement to encourage COVID-19 vaccine demand and uptake. Organizational, and institutional efforts and coordination approaches are compulsory for management of any global health crisis.[40]

Important suggestions to overcome psychological problems that affect people or health personnel were also raised, such as psychological education of health workers, in addition to periodic home visits of psychiatrists to the patients to provide psychological/social support.

The findings of this study form a baseline information that would be helpful for quality improvement and governmental work for improving medical services.

Study limitation. We depended in the data collection on the numbers from the surveillance system of the Ministry of Health, there might be a sort of underestimation as many people with COVID-19 may not go to the health facilities, especially if the disease is not severe, because they were afraid of being (or their family contacts) quarantined.

In conclusion, the trend of COVID-19 in Iraq showed 2 peaks (August-October 2020 and March-July 2021), with males being more affected by morbidity, mortality, and CFR. The main challenge faced by Iraqi health system was the rapid increase of coronavirus cases with limited bed capacity, and medical equipment, while the main obstacle was poor compliance of the people. Enhancing the number and quality of critical care units and hospital beds capacity to cope for the increasing numbers of patients is an urgent need.

Acknowledgment. *The authors gratefully acknowledge the Iraqi Journal of Community Medicine for English language editing.*

References

1. Karnjus I, Prosen M, Ličen S. Nurses' core disaster-response competencies for combating COVID-19: a cross-sectional study. ***PLOS ONE*** 2021; 16: e0252934.
2. Bostan S, Erdem R, Öztürk Y, Kılıç T, Yılmaz A. The effect of COVID-19 pandemic on the Turkish society. ***Electron J Gen Med*** 2020; 17: 2516-3507.
3. MacDonald AU, Harahus JM, Hall E, Reed M, Baldisseri MR. COVID-19 disaster preparedness. ***Elsevier*** 2022: 23-34.
4. Huang C, Wang Y, Li X. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. ***The Lancet*** 2020; 395: 497-506.
5. Wu F, Zhao S, Bin Y, Chen Y, Wang W, Song Z, et al. A new coronavirus associated with human respiratory disease in China. ***Nature*** 2020; 579: 265-269.
6. Naronglerdrit P, Mporas I, Sheik-Akbari A. COVID-19 detection from chest x-rays using transfer learning with deep convolutional neural networks. ***Elsevier*** 2021: 255-273.
7. COVID-19 Map - Johns Hopkins Coronavirus Resource Center. [Updated 2022; Accessed 2021 Oct 20]. Available from: https://coronavirus.jhu.edu
8. World Heal Organization. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19). [Updated 2020; 2021 Oct 2]. Available at: https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report
9. Adly H, AlJahdali I, Garout M, Khafagy A, Saati A, Saleh A. Correlation of COVID-19 pandemic with healthcare system response and prevention measures in Saudi Arabia. ***Int J Environ Res Public Health*** 2020; 17: 6666.
10. Emanuel E, Persad G, Upshur R, Thome B, Parker M, Glickman A, et al. Fair allocation of scarce medical resources in the time of Covid-19. ***N Engl J Med*** 2020; 382: 2049-2055.
11. Tolossa T, Bizuneh W, Dejene S, Atomssa E, Getachew M, Fetensa G, et al. Time to recovery from COVID-19 and its predictors among patients admitted to treatment center of Wollega University Referral Hospital (WURH), Western Ethiopia: survival analysis of retrospective cohort study. ***PLOS ONE*** 2021; 16: e0252389.
12. Mbung E. Effects of COVID-19 in South African health system and society: an explanatory study. ***Elsevier*** 2020; 14: 1809-1814.
13. Sarfaraz S, Quratulain S, Syed G. Determinants of in-hospital mortality in COVID-19; a prospective cohort study from Pakistan. ***PLOS ONE*** 2021; 16: e0251754.
14. Al-Qerem A and Anan S. COVID-19 vaccination acceptance and its associated factors among a Middle Eastern population. ***Front Public Health*** 2021; 9: 632914.

15. AboKresha S, Abdelkreem E, and Ali R. Impact of COVID-19 pandemic and related isolation measures on violence against children in Egypt. ***J Egypt Public Health Assoc*** 2021; 96: 11.
16. Nussbaumer-Streit B, Mayr V, Dobrescu A, Chapman A, Persad E, Klerings I, et al. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. ***Cochrane Database Syst Rev*** 2020; 4: CD013574.
17. Marschner I. Estimating age-specific COVID-19 fatality risk and time to death by comparing population diagnosis and death patterns: Australian data. ***BMC Med Res Methodol*** 2021; 21:126.
18. Kushwaha S, Khanna P, Rajagopal V and Kiran T. Biological attributes of age and gender variations in Indian COVID-19 cases: A retrospective data analysis. ***Clinical Epidemiol Glob Health*** 2021; 11: 100788.
19. Leong R, Lee T, Chen Z, Zhang C and Xu J. Global temporal patterns of age group and sex distributions of COVID-19. ***Infect Dis Rep*** 2021; 13: 582-596.
20. Monod M, Blenkinsop A, Xi X. Age groups that sustain resurging COVID-19 epidemics in the United States. ***Science*** 2021; 371: 1336.
21. Goujon A, Natale F, Ghio D, Conte A, Dijkstra L. Age, gender, and territory of COVID-19 infections and fatalities. ***Publications Office of the European Union, Luxembourg (EN)*** 2020.
22. Koh H, Geller A, VanderWeele T. Deaths from COVID-19. ***JAMA*** 2021; 325: 133-134.
23. Sobotka T, Brzozowska Z, Muttarak R. Age, gender and COVID-19 infections. ***MedRvix*** 2020; 05: 20111765.
24. Islam N, Shkolnikov V, Acosta R. Excess deaths associated with covid-19 pandemic in 2020: age and sex disaggregated time series analysis in 29 high income countries. ***BMJ*** 2021; 373: n1137.
25. Worldometer. Info › Coronavirus. [Updated 2022; Accessed October 31, 2021]. Available from: https://www.worldometers
26. Whaley C, Cantor J, Pera M. Assessing the Association Between Social Gatherings and COVID-19 Risk Using Birthdays. ***JAMA Intern Med*** 2021; 181: 1090-1099.
27. Hofmann C, Wolf E. Older age groups and country specific case fatality rates of COVID 19 in Europe, USA and Canada. ***Infection*** 2021; 49: 111–116.
28. Esteve A, Permanyer I, Boertien D, Vaupel J. National age and co-residence patterns shape covid-19 vulnerability. ***MedRxiv*** 2020; 13: 20100289.
29. World Health Organization. COVID-19 Weekly Epidemiological Update Edition 53. [Updated 2021; 2021 Aug 20]. Available from: https://www.who.int
30. World Health Organization. COVID-19 Weekly Epidemiological - Report. [Update 2021; 2021 May 2]. Available from: https://reliefweb.int
31. Hasan M, Haider N, Florian L, Khan R, McCoy D, Zumla A, et al. The global case-fatality rate of COVID-19 has been declining since May 2020. ***Am J Trop Med Hyg*** 2021; 104: 2176-2184.
32. Shah M, Ahammed T, Anjum A, Ahmed A, Chowdhurya A, Suchanaa J. Finding the real COVID-19 case-fatality rates for SAARC countries. ***Biosaf Health*** 2021; 3: 164-171.
33. Azizi H, Esmaeili E and Fakhar A. Challenges and accurate estimates of mortality and case-fatality rates due to COVID-19. ***New Microbes New Infect*** 2020; 38: 100775.
34. Horwitz L, Jones S, Cerfolio R, Francois F, Greco J, Rudy B, et al. Trends in COVID-19 risk-adjusted mortality rates. ***J Hosp Med*** 2021; 16: 90-92.
35. Dennis J, McGovern A, Thomas N, Wilde H, Vollmer SJ, Mateedn BA. Trends in 28-day mortality of critical care patients with coronavirus disease 2019 in United Kingdom: a national cohort study, March 2020 to January 2021. ***Crit Care Med*** 2021; 49: 1895-1900.
36. Sharma S. Public health challenges during the COVID-19 outbreak in Nepal: a commentary. ***J Health Res*** 2020; 34: 373-376.
37. Peiffer-Smadja N, Lucet J, Bendjelloul G, Bouadma L, Gerard S, Choquet C, et al. Challenges and issues about organizing a hospital to respond to the COVID-19 outbreak: experience from a French reference center. ***Clin Microbiol Infect*** 2020; 26: 669-672.
38. Khalid A, Ali S. COVID-19 and its challenges for the healthcare system in Pakistan. ***Asian Bioeth Rev*** 2020; 12: 551-564.
39. Atkinson-Clement C, Pigalle E. What can we learn from Covid-19 pandemic's impact on human behaviour? The case of France's lockdown. ***Humanit Soc Sci*** 2021; 8: 81.
40. Ahmad A, Murad H, Gardner M. The impact of social media on panic during the COVID-19 pandemic in Iraqi Kurdistan. ***J Med Internet Res*** 2020; 22: e19556.