ORIGINAL ARTICLE

Assessing the Performance Indicators of Hospitals Before and After the Pandemic of COVID-19: A Time Series Study from January 2019 to December 2021

Sima Rafiei[1], PhD;
Ahad Alizadeh[2], PhD;
Rohollah Kalhor[1], PhD;
Aidin Aryankhesal[3], PhD;
Ahmad Ghashghaee[4], MSc

[1]Social Determinants of Health Research Center, Research Institute for Prevention of Non-Communicable Diseases, Qazvin University of Medical Sciences, Qazvin, Iran
[2]Health Products Safety Research Center, Qazvin University of Medical Sciences, Qazvin, Iran
[3]School of Health Management and Information Sciences, Iran University of Medical Sciences, Tehran, Iran
[4]Student Research Committee, Qazvin University of Medical Sciences, Qazvin, Iran

Correspondence:
Ahmad Ghashghaee,
Student Research Committee,
Qazvin University of Medical Sciences,
Qazvin, Iran
Tel: +98 447310917653
Email: ahmad.ghashghaee1996@gmail.com
Received: 23 April 2023
Revised: 21 May 2023
Accepted: 01 June 2023

Abstract

Background: The pandemic of COVID-19 affect all healthcare systems globally, and its effect on different hospital performance indicators has been debated. The study aimed to compare the impacts of COVID-19 on hospital performance indicators using pre-and post-pandemic data from training hospitals.

Methods: We conducted an observational cohort study of hospital performance indicators from two healthcare facilities affiliated with Qazvin University of Medical Sciences in the north-west of Iran. The R statistical software was used to analyze monthly data on three basic performance indicators, including bed turnover, average length of stay (LOS), and bed occupancy rate before and during the outbreak of Coronavirus disease-19 (COVID-19).

Results: The pandemic had a remarkable effect on the level of bed turnover, the average length of stay (LOS), and the bed occupancy rate after one month from the COVID-19 outbreak ($P<0.05$). Moreover, regression results showed that after the pandemic, the first two mentioned indicators increased monthly at 108.18 and 0.15, respectively, while LOS decreased by 0.09 monthly ($P<0.05$).

Conclusion: Based on the study findings, a significant decline in hospital occupancy rate and bed turnover was observed after one month since the beginning of the outbreak. This reduction was associated with a longer LOS. Using ITS in pandemics such as COVID-19 can evaluate the effect of various policies on outcome measures and help policymakers make effective decisions.

Please cite this article as: Rafiei S, Alizadeh A, Kalhor R, Aryankhesal A, Ghashghaee A. Assessing the Performance Indicators of Hospitals Before and After the Pandemic of COVID-19: A Time Series Study from January 2019 to December 2021. J Health Sci Surveillance Sys. 2023;11(Supplement 3):649-656.

Keywords: Bed occupancy rate, Bed turnover, COVID-19 pandemic, Interrupted time series, Length of stay

Introduction

The challenges arising from the COVID-19 pandemic have affected all healthcare systems worldwide. According to the World Health Organization report, this pandemic has had 651 918 402 confirmed cases and 6 656 601 confirmed death until December 2022.[1] Besides an increased risk of excess mortality and morbidity for communities, the effect of the COVID-19 pandemic on different hospital performance indicators has been debated in the literature. As experienced in most countries, an out-of-control increase in COVID-19 cases demands a high volume of patient admissions which overwhelms healthcare services.[1] To resolve bed capacity issues, most healthcare systems canceled elective surgeries and unnecessary admissions to provide adequate medical services for COVID-19 patients. Several studies reported reduced hospital clients regarding acute coronary syndrome, strokes, and even appendicitis.[2] Furthermore, the COVID-19 pandemic

influenced the admission rate and affected objective hospital performance indicators such as efficiency and effectiveness. These augmented tensions and resource limitations in low- and middle-income communities, necessitate gathering evidence-based information about the condition of hospital performance indicators during the COVID-19 pandemic.[1, 3] Information on admission trends, length of stay, and bed turnover is necessary to determine hospital plans for effectively allocating medical resources during the pandemic.[4] In countries where the number of beds and staffing norms are considerably low, evidence-based data about performance indicators can be beneficial for allocating insufficient resources to patients in extreme need.

To manage the pandemic in Iran, the government introduced several phases of lockdown from 19 February 2020 to the least strict restrictions on April 11 when the limitations in the country were eased.[5] However, COVID-19 cases began to rise again on June 4, 2020; the number of daily confirmed deaths increased to more than 200 by July 6 and 235 on July 28. Consequently, different infectious control protocols were introduced, and local authorities imposed a new phase of restrictions to fight more effectively against the disease.[6-8] Therefore, in this study, we aimed to explore the change in hospital bed turnover, occupancy rate, and LOS at two major referral centers in the province of Qazvin, Iran, in the pre-COVID-19 era and during the pandemic.

Methods

Study Setting

This study was done in two training hospitals affiliatedwith Qazvin University of Medical Sciences in Qazvin province, the southwest region of Iran.

Study Design

We conducted an interrupted time series analysis (ITSA) to evaluate monthly changes in the public hospitals' three main hospital performance indicators due to the COVID-19 pandemic. ITSA includes multiple measurements of specific outcomes repeatedly over time. R software version 4.1.1 was used for data analysis. Utilizing the interrupted time series analysis method, the trend of the investigated indicators and the immediate changes after the pandemic, were analyzed. The objective of the binary segmentation algorithm was to identify points of change in the data's mean and dispersion (based on the differences of two consecutive times).[9]

Data Collection

Monthly values of hospital performance measures were gathered from two public hospitals from January 2019 through December 2021. The hospitals' information systems were mined for relevant data, and if that proved insufficient, the hospital's curative deputy at Qazvin University of Medical Sciences was consulted. A main indicator (hospital bed turnover, occupancy rate, and Length of Stay) was investigated in these hospitals.

Hospital Bed Turnover

The bed turnover rate (BTR) is a metric that represents the number of patients treated in a specific amount of time, typically one year. This rate is used to measure the hospital beds productivity.

The hospital bed turnover rate can be calculated as follows: Hospital Bed turnover rate=Number of discharges (including deaths) in a given time / Number of beds during that period.

Bed Occupancy Rate

The formula for determining the occupancy rate is as follows: the number of beds that are effectively occupied (bed-days) for curative care (HC. 1 in SHA classification) is divided by the number of beds that are available for curative care, which is then multiplied by 365 days. The resulting ratio is then multiplied by 100 to determine the occupancy rate.

(Inpatient Days of Care / Bed Days Available) ×100

Length of Stay

The length of stay, also known as LOS, is a clinical metric measuring time between a patient's admission to a hospital and their discharge.

Statistical Analysis

An interrupted time series with segmented regression analysis was used to examine the impact of the COVID-19 pandemic on monthly hospitalizations rate. To assess the changing trend of data, we included 36 data points (one year before and two years after the pandemic) to examine the impact of the pandemic on performance indicators considered in the study.[9, 10] Segmented linear regression modeling contained a linear slope for time, a binary term for the change-point (0 represented before the pandemic and 1 stood for after the COVID-19 outbreak), and an interaction between the two terms. This interaction shows changes to the intercept and the weekly rate before and after the pandemic. β1 is the monthly change in outcome variable before the intervention, β2 is the average level of change in the hospital performance indicators in the first month after the intervention, and the post-intervention linear trend measures the monthly average change in the trend of indicators after the pandemic. Data was analyzed using R statistical software (Version 4,1,1; STATA Corporation, College Station, TX, USA).

Results

Here the researchers present the study findings and the

impact of the COVID-19 pandemic on hospital LOS according to ITS analysis. As results show, in both hospitals,, the hospital length of stay was downward before the COVID-19 pandemic, and a significant decreasing trend continued in the first month of the corona outbreak. However, both graphs showed an increasing trend after this point in time. The cumulative chart of the two hospitals also revealed a similar tendency.

As reported in Figure 1, the study level of hospital length of stay was estimated at 5.5 days in hospital A and 4.8 days in hospital B. The overall estimate of both hospitals indicated that the rate increased by 0.07 monthly before the COVID-19 pandemic. The mentioned indicator's increase was not statistically significant (P=0.15). At the beginning of the pandemic, a significant increase in the rate of 1.13 (P<0.05; 95% CI=0.38, 1.88) continued (Table 1).

Regression results showed that the mentioned indicator decreased monthly after the pandemic at the rate of 0.09 (P<0.05; 95% CI=-0.19-0). Figure 1 visually displays these results before and during the COVID-19 pandemic.

Table 2 depicts the interrupted time series analysis results for bed turnover in both hospitals. According to provided data, the coefficient of the level indicates a significant decrease of the indicator after one month from the COVID-19 pandemic (P<0.05; 95% CI=-2.76, -0.48).

However, after the pandemic, the bed turnover rate increased monthly at the rate of 0.15 (P<0.05; 95% CI=0, 0.3) over time. Figure 2 shows the trend of changes in the indicator over time.

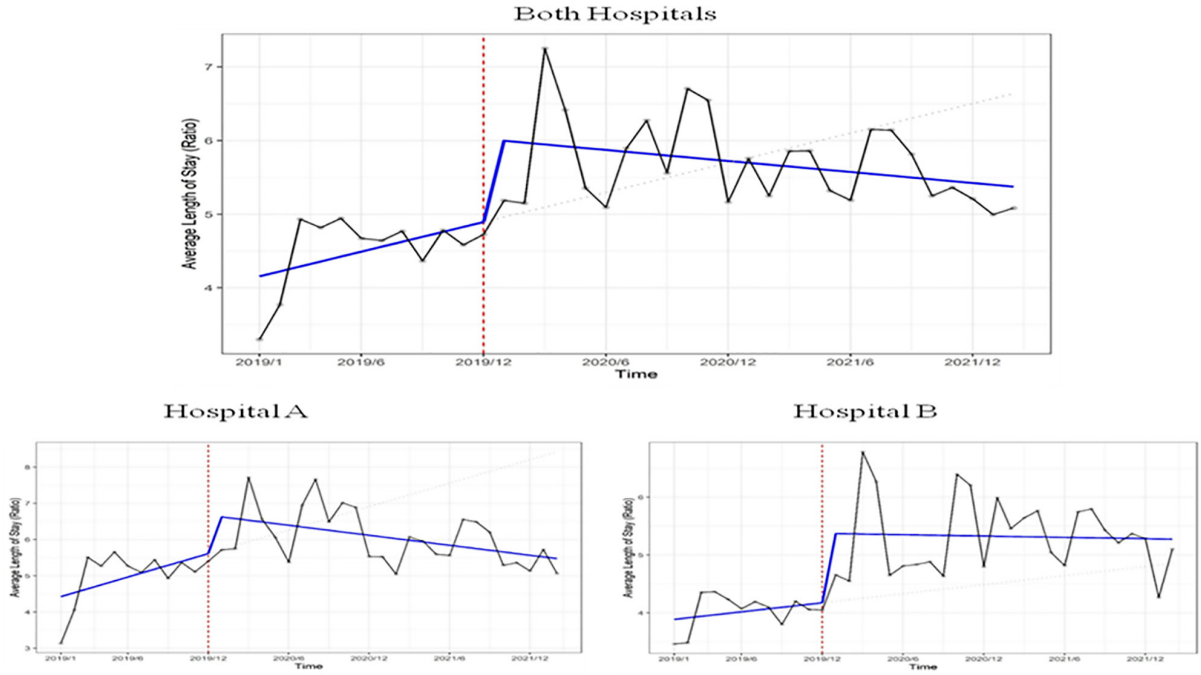

Figure 1: Interrupted time series analysis for hospital length of stay

Table 1: Estimated coefficients of regression model for overall hospital LOS rate before and during the COVID-19 pandemic

Variables	Coefficient	P value	Confidence interval	
			Lower	Upper
Pre-intervention slope, β1	0.07	0.15	-0.03	0.16
Change in slope, β2	1.13	0.004	0.38	1.88
Post-intervention linear trend	-0.09	0.022	-0.19	0

P value: The probability under the assumption of no effect or no difference (null hypothesis), of obtaining a result equal to or more extreme than what was actually observed

Table 2: Estimated coefficients of regression model for overall bed turnover before and after the COVID-19 pandemic

Variables	Coefficient	P value	Confidence interval	
			Lower	Upper
Pre-intervention slope, β1	-0.08	0.249	-0.22	0.06
Change in slope, β2	-1.62	0.007	-2.76	-0.48
Post-intervention linear trend	0.15	0.046	0	0.3

Figure 2: ITS analysis for bed turnover

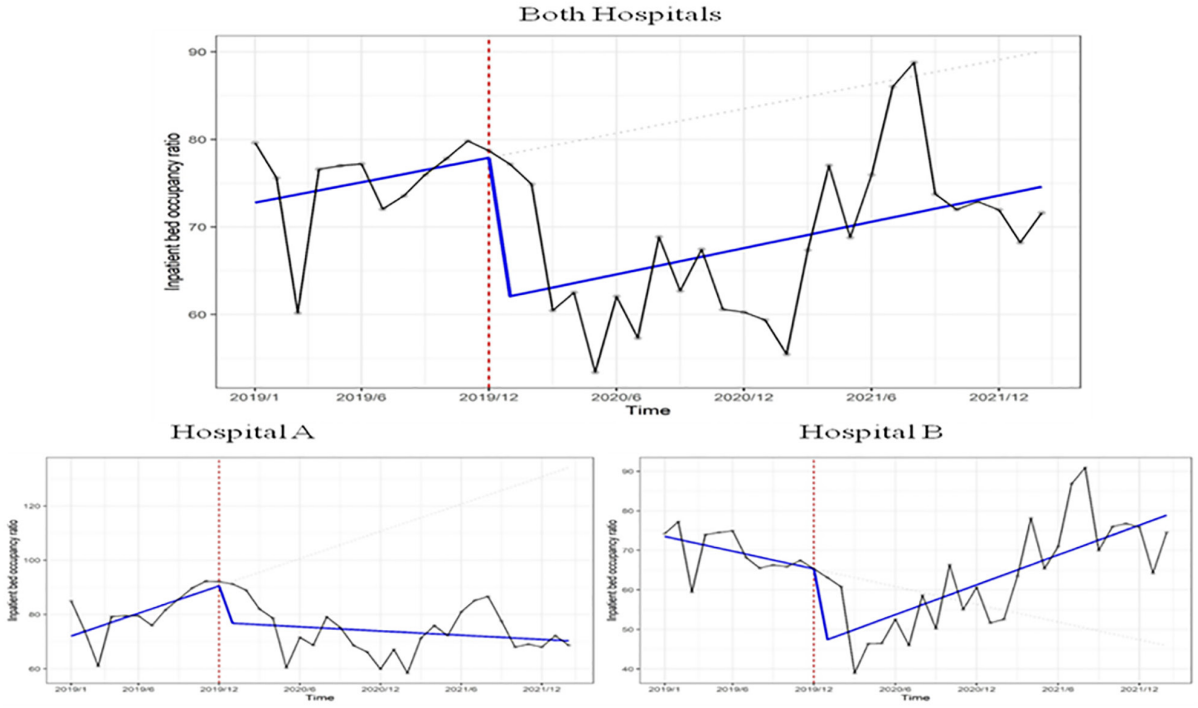

Figure 3: Interrupted time series analysis for bed turnover.

Based on Figure 3, the starting level of bed occupancy rate was at 78.98% in hospital A and 65.14% in hospital B. Study findings revealed that the occupied bed days decreased by 11.75 days monthly before the pandemic. The reduction in occupied days was insignificant statistically (P>0.05). A remarkable decrease in the rate of 1579.82 per 10 000 population (P<0.05; 95% CI=-2591.41,–568.23) was estimated at the beginning month of the Civid19 pandemic of Covid-19. In addition, a significant increase in the monthly trend of hospitalization rate (compared with the period before Covid-19) was recognized, and it was estimated at 108.18 hospitalizations per 10 000 population (P>0.05, 95% CI=-22.79, -23.91) (Table 3).

Table 3: Estimated coefficients of regression model for bed occupancy rate before and after the COVID-19 pandemic

Variables	Coefficient	P value	Confidence interval	
			Lower	Upper
Pre-intervention slope, β1	-11.75	0.85	-136.76	-113.25
Change in slope, β2	-1579.82	0.003	-2591.41	-568.23
Post-intervention linear trend	108.18	0.102	-22.79	-239.16

Figure 3 indicates a visual display of bed occupancy rates before and after the pandemic.

Overall, the results showed statistically significant improvements regarding the occupied bed days and bed turnover, the exception being the hospital length of stay rate with a decreasing trend over time ($P<0.05$).

Discussion

The current study is one of the few studies that surveyed changes in some of the main hospital performance indicators before and after the COVID-19 outbreak. Before the COVID-19 era, a reduction in all studied variables was found. Literature also reported similar results and recognized a remarkable decrease in hospital occupation rate and bed turnover in the early era of the epidemic.[7] In Italy, the number of daily clients for 15 hospitals decreased from 18 in the pre-COVID-19 period to 13.3 throughout the pandemic.[8] In the United States, hospital admissions decreased by 42% during COVID-19, with a considerable decrease in heart diseases, chronic obstructive pulmonary disease, and acute appendicitis.[11] Besides the US, hospital admission rate decreased in Japan, Belgium, Hong Kong, Norway, Sierra Leone, and South Korea.[12-17] These significant declines might be due to the policies implemented in many healthcare systems, in which elective surgeries were postponed, and patients with urgent needs were prioritized for hospitalization and treatment. In most of the studies, the COVID-19 pandemic was mentioned to account for the decline in both acute and elective care admissions.[7] The most frequently cited reasons included patients' adherence to physical distancing guidelines, worrying about contracting COVID-19 infection at healthcare facilities, inability to have a treatment-seeking behavior due to cognitive malfunctioning or physical impairment, and avoiding visiting hospitals for non-urgent medical conditions.[4, 7] Improving primary healthcare services in Iran was another crucial factor that significantly decreased the hospital admission rate. In case of canceling emergency cases and patients in need of acute medical services, it is expected that the average diagnosis-related group relative weight for the hospital would be lower and be a sign of a shorter length of stay. Accordingly, we observed a shorter stay in the studied hospitals during the pandemic. In a study by Khullar, the reduction in hospital visits, due to the panic about COVID-19, has played an important role in reducing hospital occupation rate and service capacity.[18] As affirmed by Behzadifar et al., elective surgeries were entirely canceled bacause of an urgent need to manage COVID-19 patients.

Furthermore, physicians were unwilling to perform elective surgeries due to the possibility of infection agents spreading to non-covid-19 patients. On the other hand, patients who were scheduled for elective surgery did not refer to hospitals due to the lack of medical services, resulting in decreased occupied bed days.[4] Because of health workforce shortage and consequent fatigue among the existing workforce, some hospitals postponed the admission of non-urgent patients.[19] Particularly, in the early onset of the disease, non-dedicated COVID-19 hospitals decreased hospital admissions to minimize the spread of infection by reducing workers' contact with infected people.[20] Likewise, the UK experienced a major interruption in delivering hospital services, mainly during COVID-19 pandemic-imposed lockdown. A report released in April 2020 showed a 61% decline in planned hospital admissions in Scotland, a nearly 50% decline in hospitals' emergency unit activities in England, a 41% decline in accident and emergency services, and 26% for hospital admissions.[21, 22] Such a decline in hospital visits may be due to the population's behavioral changes, includingthe fear of contracting COVID-19 or reluctance to access healthcare services to avoid other seasonal illnesses.[23]

In our study, the increasing trend in hospital occupation rate after the first month of the COVID-19 outbreak may have contributed to a significant increase in the percentage of respiratory tract infections, enhanced awareness of populations toward COVID-19 infection, and an increased vigilance with infection control at hospitals practiced by healthcare practitioners. Consequently, study findings revealed an increase in the number of admitted patients in the second half of the year 2019, which supports this idea. In fact, gaining adequate experience in response to the COVID-19 pandemic over the months after the disease outbreak, hospitals adopted new policies to admit COVID-19-infected patients by allocating particular wards for these patients. In addition, hospitals continued their routine activities and offered various healthcare services to different patients.[4] These reasons can contribute to an increasing slope of hospital occupation rate in our study after some time passed from the COVID-19 outbreak. In England, hospital service delivery increased in March 2020, with overall

referrals to emergency departments and hospital visits for particular medical conditions, including acute heart failure syndromes and certain cancers. However, the recovery of hospital services was stopped after imposing rigid restrictions in September 2020.[24-26] To resolve the issue, NHS has applied new policies in response to the COVID-19 pandemic. Consequently, more resources were allocated to the healthcare system to continue routine healthcare delivery per adherence to infection control guidelines.[27]

Our study findings showed that the average length of hospital stay was five days which was relatively similar to the values reported by Saudi Arabia (6 days), the United States (6 days), Peru (7 days), and London 96 days).[28-31] The overall estimate of both hospitals in our research indicated that the rate increased by 0.07 every month before the COVID-19 pandemic. In the first month of the pandemic, a statistically significant increase in the rate of 1.13 continued. In this study, as individuals affected by COVID-19 infection constituted the majority of hospital-admitted patients, the length of hospital stay was significantly longer. Research s results in France confirmed this findings and stated that those suffering from dyspnea might have longer discharging time due to respiratory problems.[32]

Furthermore, as COVID-19 patients might have at least one organ failure, such as diabetes, hypertension, cardiovascular and pulmonary disease, a prolonged hospital stay is more expected.[33, 34] Thus, the additional medical therapy needed for patients with organ failure could demand more time than those without any particular comorbidity. However, establishing a multi-level healthcare delivery system and empowering primary healthcare (PHC) centers would shorten the hospital length of stay dramatically. PHC professionals can provide appropriate and timely healthcare services for vulnerable patients in rural areas.[35] Furthermore, the existence of multi-level hospitals can be beneficial in reducing the burden of diagnosis and treatment procedures in high-level hospitals by referring mild patients tolower-level care facilities.[35]

The main strengths of our research were covering the whole population of Qazvin, referring to two main COVID-19 dedicated hospitals, selecting a proper length of study (three years), and using hospital information system-recorded data. In addition, the ITS design as a dominant methodological technique to examine the effect of a phenomenon on healthcare systems' performance indicators was another key strength of this study. However, the analyzed data regarding the correlation between the COVID-19 pandemic and hospital performance criteria should be interpreted cautiously due to several factors affecting study results.

Conclusion

Based on the study findings, a significant decline in hospital occupancy rate and bed turnover was observed after one month since the beginning of the outbreak. This decline was associated with a longer length of stay. Using ITS in health-related pandemics such as COVID-19 can evaluate the effect of different policies on outcome and help policymakers make effective decisions.

Suggestions for Further Study

1- Conducting a qualitative study to assess hospitals' performance following a coronavirus outbreak.

2- Research on the hospital's performance indicators, focusing on each indicator to explain the changes in the meaningful trend following the onset of the Corona pandemic.

3- Research on emergency performance indicators, focusing on each indicator to explain the significant changes in trends following the onset of the Corona pandemic.

4- Research on the interrelationships of indicators and their influence on each other after the start of Corona.

5- Time series investigation of hospital performance indicators before and after corona vaccination

6- Time series investigation of emergency performance indicators before and after corona vaccination

Conflict of interest: None declared.

References

1 World Health Organization. Coronavirus disease (COVID-19) pandemic. https://wwww.hoint/emergencies/diseases/novel-coronavirus-2019?adgroupsurvey={adgroupsurvey}&gclid=CjwKCAiA 8SdBhBGEiwA WdgtcMqxz 3xgM4osC p8UMZDT JhuLxX7ES CGRXIxhH62Me9ozk2S0L3y72BoCbdYQAvD_BwE. 2022.

2 Kaufman HW, Chen Z, Niles J, Fesko Y. Changes in the number of US patients with newly identified cancer before and during the coronavirus disease 2019 (COVID-19) pandemic. JAMA network open. 2020 Aug 3;3(8):e2017267. PMID: 32749465. PMCID: PMC7403918.

3 Rodriguez-Morales AJ, Cardona-Ospina JA, Gutiérrez-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. doi: 10.1016/j.tmaid.2020.101623. PMID: 32179124. PMCID: PMC7102608.

4 Behzadifar M, Aalipour A, Kehsvari M, Darvishi Teli B, Ghanbari MK, Gorji HA, et al. (2022) The effect of COVID-19 on public hospital revenues in Iran: An interrupted time-series analysis. PLoS ONE 17(3): e0266343; doi: 10.1371/journal.pone.0266343. PMID: 35358279. PMCID: PMC8970352.

5 Salimi R, Gomar R, Heshmati B. The COVID-19 outbreak in Iran. Journal of global health. 2020

Jun;10(1). PMID: 32566156. PMCID: PMC7296218.

6 Nojomi M, Moradi-Lakeh M, Pourmalek F. COVID-19 in Iran: What was done and what should be done. Med J Islam Repub Iran 2021; 35: 97.

7 Butt A.A. Kartha A.B. Masoodi N.A., Azad A.M., Asaad N.A. Alhomsi M.U. et al. Hospital admission rates, length of stay, and in-hospital mortality for common acute care conditions in COVID-19 vs. pre-COVID-19 era. Public Health 2020; 189: 6-11. doi: 10.1016/j.puhe.2020.09.010. PMID: 33126120. PMCID: PMC7505566.

8 Filippo O. De, Ascenzo F. D', Angelini F. , Bocchino P.P. , Conrotto F. , Saglietto A. , et al. Reduced rate of hospital admissions for ACS during covid-19 outbreak in northern Italy. N Engl J Med 2020; 383 (2020): 88-89; doi: 10.1056/NEJMc2009166. PMID: 32343497. PMCID: PMC7224608.

9 Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. Int J Epidemiol 2017; 46(1):348–55. doi: 10.1093/ije/dyw098. PMID: 27283160. PMCID: PMC5407170.

10 Nasiri T, Shams L, Hosseini-Shokouh SM. The Economic Effects of COVID-19 on the Hospital Industry in Iran and the World. Ann Ig 2021; 33(1):103–4; doi: 10.7416/ai.2021.2412. PMID: 33354700.

11 Baum A., Schwartz M.D. Admissions to Veterans Affairs hospitals for emergency conditions during the COVID-19 pandemic. J Am Med Assoc (2020), 10.1001/jama.2020.9972; doi: 10.1001/jama.2020.9972. PMID: 32501493. PMCID: PMC7275263.

12 Okuno T, Takada D, Jung-ho S, et al. Impact of the coronavirus disease 2019 pandemic on surgical volume in Japan: A Cohort Study Using Administrative Data. medRxiv. doi: 10.1101/2020.11.18.20233882. PMID: 34783905. PMCID: PMC8592826.

13 Tan YN, Vandekerckhove PJ, Verdonk P. The long road to recovery: at six months since the first COVID-19 wave, elective orthopedic care has still not fully recovered in Belgium. J Exp Orthop 2020; 7: 1–8; doi: 10.1186/s40634-020-00316-9. PMID: 33349907. PMCID: PMC7752098.

14 Wong JSH, Cheung KMC. Impact of COVID-19 on orthopaedic and trauma service: an epidemiological study. J Bone Joint Surg Am 2020; 102: e80. doi: 10.2106/JBJS.20.00775. PMID: 32675668. PMCID: PMC7431143.

15 Magnusson K, Helgeland J, Grøsland M, Telle K. Impact of the COVID-19 pandemic on emergency and elective hip surgeries in Norway. Acta orthopaedica 2021; 92(4): 376–380. DOI: 10.1080/17453674.2021.1898782. PMID: 33757405. PMCID: PMC8381886.

16 Sevalie S, Youkee D, van Duinen AJ, Bailey E, Bangura T, Mangipudi S, Mansaray E, Odland ML, Parmar D, Samura S, Van Delft D. The impact of the COVID-19 pandemic on hospital utilisation in Sierra Leone. BMJ Global Health 2021; 1; 6(10): e005988. doi: 10.1136/bmjgh-2021-005988. PMID: 34635552. PMCID: PMC8506048.

17 Huh K, Kim Y-E, Ji W, et al. Decrease in hospital admissions for respiratory diseases during the COVID-19 pandemic: a nationwide claims study. Thorax 2021; 1; 76(9): 939–41. doi: 10.1136/thoraxjnl-2020-216526. PMID: 33782081. PMCID: PMC8011422.

18 Khullar D, Bond A.M., Schpero W.L. COVID-19 and the Financial Health of US Hospitals. JAMA. 2020; 323(21):2127–8; doi: 10.1001/jama.2020.6269.

19 Kazempour-Dizaji M, Sheikhan F, Varahram M, Rouzbahani R, Yousef Vand M, Khosravi B, et al. Changes in a Hospital's Costs and Revenues Before and After COVID-19: A Case Study of an Iranian Hospital. Health Scope 2021; doi: 10.5812/jhealthscope.111620.

20 Khan JR, Awan N, Islam MM, Muurlink O. Healthcare Capacity, Health Expenditure, and Civil Society as Predictors of COVID-19 Case Fatalities: A Global Analysis. Front Public Health 2020; 8:347; doi: 10.3389/fpubh.2020.00347. PMID: 32719765. PMCID: PMC7349997.

21 Mulholland RH, , Wood R, Stagg HR, et al. Impact of COVID-19 on accident and emergency attendances and emergency and planned hospital admissions in Scotland: an interrupted time-series analysis. J R Soc Med 2020; 113: 444–453. doi: 10.1177/0141076820962447. PMID: 33012218. PMCID: PMC7686524.

22 Thornton J. Covid-19: A&E visits in England fall by 25% in week after lockdown. BMJ 2020; 369: m1401. doi: 10.1136/bmj.m1401. PMID: 32253175.

23 Shah SA, Quint JK, Nwaru BI, Sheikh A. Impact of COVID-19 national lockdown on asthma exacerbations: interrupted time-series analysis of English primary care data. Thorax 2021; 76: 860–866. doi: 10.1136/thoraxjnl-2020-216512. PMID: 33782080. PMCID: PMC8011425.

24 Wyatt S, Mohammed MA, Fisher E, McConkey R, Spilsbury P. Impact of the SARS-CoV-2 pandemic and associated lockdown measures on attendances at emergency departments in English hospitals: a retrospective database study. Lancet Reg Heal 2021; 2: 100034. doi: 10.1016/j.lanepe.2021.100034. PMID: 34173630. PMCID: PMC7837109.

25 Ferry AV, Keanie C, Denvir MA, Mills NL, Strachan FE. Chest pain presentations to hospital during the COVID-19 lockdown: lessons for public health media campaigns. PLoS One 2021; 16: e0249389. doi: 10.1371/journal.pone.0249389. PMID: 33793662. PMCID: PMC8016249.

26 Morris EJA, Goldacre R, Spata E, et al. Impact of the COVID-19 pandemic on the detection and management of colorectal cancer in England: a population-based study. Lancet Gastroenterol Hepatol 2021; 6: 199–208. doi: 10.1016/S2468-1253(21)00005-4.

27 Fowler A, Abbott TEF, Pearse RM. Can we safely continue to offer surgical treatments during the COVID-19 pandemic? BMJ Quality & Safety 2021;

30(4): 268–270. doi: 10.1136/bmjqs-2020-012544. PMID: 33219135.

28 Alwafi H, Naser AY, Qanash S, et al. Predictors of length of hospital stay, mortality, and outcomes among hospitalised COVID-19 patients in Saudi Arabia: a cross-sectional study. J Multidiscip Healthc 2021; 14: 839–852. doi: 10.2147/JMDH.S304788. PMID: 33883900. PMCID: PMC8055273.

29 Nguyen NT, Chinn J, Nahmias J, et al. Outcomes and mortality among adults hospitalized with COVID-19 at US medical centers. JAMA Network Open 2021; 4(3): e210417. doi: 10.1001/jamanetworkopen.2021.0417. PMID: 33666657. PMCID: PMC8547263.

30 Mejia F, Medina C, Cornejo E, et al. Oxygen saturation as a predictor of mortality in hospitalized adult patients with COVID-19 in a public hospital in Lima, Peru. PLoS ONE 2020; 15(12): e0244171. doi: 10.1371/journal.pone.0244171. PMID: 33370364. PMCID: PMC7769479.

31 Fraser S, Baranowski R, Patrini D, et al. Maintaining safe lung cancer surgery during the COVID-19 pandemic in a global city. E-clinical medicine 2021; 39: 101085. doi: 10.1016/j.eclinm.2021.101085. PMID: 34430839. PMCID: PMC8376626.

32 Wargny M, Potier L, Gourdy P, et al. Predictors of hospital discharge and mortality in patients with diabetes and COVID-19: updated results from the nationwide CORONADO study. Diabetologia 2021; 64(4): 778–794. doi: 10.1007/s00125-020-05351-w. PMID: 33599800. PMCID: PMC7890396.

33 Fiorentino G, Coppola A, Izzo R, et al. Effects of adding L-arginine orally to standard therapy in patients with COVID-19: a randomized, double-blind, placebo-controlled, parallel-group trial. Eclinicalmedicine 2021; 40: 101125. doi: 10.1016/j.eclinm.2021.101125. PMID: 34522871. PMCID: PMC8428476.

34 Choi YJ, Park JY, Lee HS, et al. Variable effects of underlying diseases on the prognosis of patients with COVID-19. PLoS ONE 2021; 16(7): e0254258. doi: 10.1371/journal.pone.0254258. PMID: 34280188. PMCID: PMC8289057.

35 Sarti TD, Lazarini WS, Fontenelle LF, Almeida A. What is the role of Primary Health Care in the COVID-19 pandemic? Epidemiol Serv Saude 2020; 29(2):e2020166. doi: 10.5123/s1679-49742020000200024. PMID: 32348404.