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Health-care determinants of mortality and recovered cases from COVID-19: Do heath systems respond COVID-19 similarly?

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Abstract:

BACKGROUND: The COVID-19 pandemic has spread rapidly across the world and has currently impacted most countries and territories globally. This study aimed to identify health-care determinants of mortality and recovery rates of COVID-19 and compare the efficiency of health systems in response to this pandemic.

MATERIALS AND METHODS: A cross-sectional study was conducted using data obtained from the World Bank database, that provides free and open access to a comprehensive set of health- and socioeconomic-related data, by September 12, 2020. An adjusted linear regression model was applied to determine predictors of mortality (per 1 million population [MP]) and recovery rates (per 1 MP) in the included countries. One-way analysis of variance was applied to assess health systems' efficiency in response to COVID-19 pandemic using mortality and recovery rate (output variables) and current health expenditure (CHE) per capita (input variable).

RESULTS: Globally, San Marino and Qatar had the highest mortality rate (1237/1 MP) and confirmed case rate (43,280/1 MP) until September 12, 2020, respectively. Iran had a higher mortality rate (273/1 MP vs. 214.5/1 MP) and lower recovery rate (4091.5/1 MP vs. 6477.2/1 MP) compared to countries with high CHE per capita. CHE per capita (standardized coefficient [SC] = 0.605, $P < 0.001$) and population aged 65 years and over as a percentage of total population (SC = −0.79, $P < 0.001$) significantly predicted recovered cases from COVID-19 in the included countries.

CONCLUSION: This study revealed that countries with higher CHE per capita and higher proportion of older adults were more likely to have a higher recovery rate than those with lower ones. Furthermore, our study indicated that health systems with higher CHE per capita statistically had a greater efficiency in response to COVID-19 compared to those with lower CHE per capita. More attention to preventive strategies, early detection, and early intervention is suggested to improve the health system efficiency in controlling COVID-19 and its related mortalities worldwide.

Keywords:

COVID-19, efficiency, health expenditure, health services research, mortality

Introduction

Coronavirus disease 2019, known as COVID-19, is an infectious disease caused by a novel discovered coronavirus in the city of Wuhan, Hubei Province, China, in December 2019.[1] The COVID-19 spread quickly across the world and affected around 213 countries and territories worldwide currently. According to the World Health Organization, a total of 28,789,086 confirmed cases and 921,882 deaths have reported around the world by September 12, 2020.[2]

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For more than two decades, regulators, policymakers, researchers, and clinicians have endeavored to improve the performance of health care by designing and applying indicators of performance. Different factors may affect the performance of health-care systems against coronavirus disease worldwide. For example, the study by Khan *et al.* indicated that COVID-19 is negatively associated with length of stay.[3] Countries have different capacities to prevent, detect, and respond to disease outbreaks.[4] Heath systems' capacities are one of the key determinants to improve the health of patients with COVID-19. Timely access to health professionals, medicines, medical equipment, and health facilities can promote the health of patients in countries.

According to the world health report 2000, improving health is obviously the main goal of a health system that the government takes ultimate responsibility for the performance of a country's health system.[5] Human resources consist of two-third or more of the total recurrent health expenditures in many countries, but without physical capital such as hospitals and equipment, and consumables, health systems would not be able to provide health care effectively for people.[5-7] High-income countries are more likely to allocate a higher percentage of their gross domestic product (GDP) to health-care system compared with low-income countries. Studies show an increasing trend in health expenditure as a share of GDP in Organization for Economic Co-operation and Development countries that will reach around 14% in 2060.[2] Population aging, chronic diseases, advances in medical sciences, and rising competitions in health markets, along with health-care legislations, have led to an increasing trend of health expenditure in high-income countries.

In this study, first, we aimed to identify health-care determinants of deaths and recovered cases due to COVID 19 at the national level. In addition, regarding the need for improvement in the efficiency of health systems in order to produce the desired outcomes, particularly in the time of the pandemic, we compared health systems' efficiency using mortality and recovery rates (output variables) and current health expenditure (CHE) as the input variable. The efficiency of a health system is defined as the degree to which the inputs to the health system are used to provide desired health system outputs.[8]

Materials and Methods

This cross-sectional research was conducted using existing data in the World Bank database, that provides free and open access to a comprehensive set of health- and socioeconomic-related data, in September 2020. In this study, first, we aimed to identify determinants of mortality and recovery rate and coronavirus test uptake worldwide by September 12, 2020. Then, we compared the health system efficiency using mortality and recovery rates of COVID-19 (as the output variables) and CHE as the input variable. Regarding existing data, 217 countries were included in the present study.

Health-care determinants of recovered ceases, mortality, and coronavirus test uptake

In this study, dependent variables were mortality due to COVID-19 (per 1 million population [MP]), recovery cases (per 1 MP), and coronavirus test uptake (per 1 MP). Also, explanatory variables were physicians rate (per 1 MP), nurses and midwives rate (per 1 MP), hospital beds rate (per 1 MP), CHE per capita (current international $) by purchasing power parity (PPP), population aged 65 years and over (percentage of the total population), and cause of death, by noncommunicable diseases (percentage of total). Regarding considerable missing data for health-care indicators in 2019 and 2018 in the World Bank database, we included the mean of indicators in the past 5 years from 2014 to 2018. The adjusted linear regression model was applied to identify determinants of mortality, recovered cases, and coronavirus tests in the study countries.

Heath system efficiency

Measuring health system efficiency shows the association between health-care inputs and the outputs they produce. Output variables were mortality and recovery rates, and the input variable consisted of CHE per capita. One-way analysis of variance (ANOVA) was applied to compare the means of outcome variables (mortality and recovery rates of COVID-19) across the quartiles of CHE per capita.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Kermanshah University of Medical Sciences (IR. KUMS. REC.1399.060).

Results

Globally, San Marino and Qatar had the highest mortality rate (1237/1 MP) and confirmed case rate (43,280/1 MP) by September 12, 2020, respectively. Iran had a higher mortality rate (273/1 MP vs. 214.5/1 MP) and lower recovery rate (4091.5/1 MP vs. 6477.2/1 MP) compared to countries with high CHE per capita. Overall, the results of one-way ANOVA indicated that countries with higher health-care expenditure significantly ($P < 0.001$) had a higher mortality and recovery rates compared with low-income ones [Table 1]. Figure 1 represents the distribution of deaths, recovered cases, and coronavirus test uptake according to CHE per capita in the included countries.

Table 1: The difference between mortality and recovery rates regarding current health expenditure per capita

CHE per capita category	*n*	Mean	SD	SE	95% CI for mean	
					Lower bound	Upper bound
Mortality (per 1 MP)						
Quartile 1 (lowest CHE per capita)	39	12.43	13.63	2.182550	8.01704	16.85373
Q2	41	118.22	192.605406	30.079911	57.43306	179.02060
Q3	45	131.91	167.940334	25.035067	81.45180	182.36153
Q4 (highest CHE per capita)	44	214.47727	269.261651	40.592721	132.61425	296.34030
Total	169	122.51527	199.685814	15.360447	92.19090	152.83963
Recovered cases (per 1 MP)						
Q1 (lowest CHE per capita)	39	482.87323	681.685396	109.157024	261.89639	703.85007
Q2	43	2832.14660	3735.584188	569.671248	1682.50348	3981.78972
Q3	47	4061.90982	4896.331357	714.203332	2624.29308	5499.52656
Q4 (highest CHE per capita)	41	6477.23492	8763.531260	1368.633644	3711.12314	9243.34670
Total	170	3512.29855	5720.807399	438.765898	2646.13059	4378.46650

SD=Standard deviation, SE=Standard error, CI=Confidence interval, CHE=Current health expenditure, MP=Million population

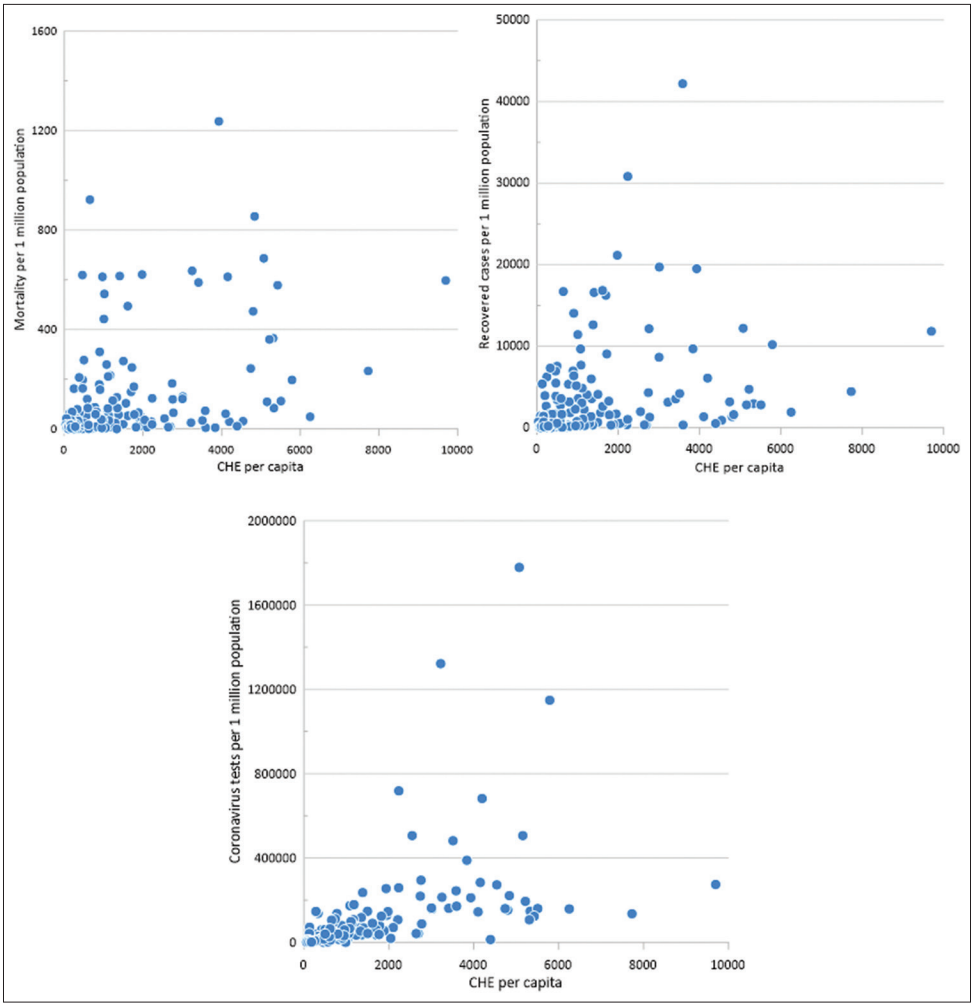

Figure 1: Distribution of mortality, recovery rates and coronavirus test uptake regarding current health expenditure per capita in the included countries

On the other side, regarding the income category, Iran had a higher mortality rate (273/1 MP vs. 178.7/1 MP) and lower recovery rate (4091.5/1 MP vs. 5327.3/1 MP) compared with high-income countries. Overall, the results of one way ANOVA indicated that high-income countries significantly ($P < 0.001$) had a higher mortality and recovery rates compared with low-income ones. Figure 2 shows the trend of mortality rate of COVID-19 in Iran compared to ten high-income countries since the beginning of this pandemic until September 12, 2020. Table 2 shows the predictors of recovered coronavirus cases in the included countries. The regression analysis

showed that CHE per capita (standardized coefficient [SC] = 0.605, $P < 001$) and population over 65 years old (SC = −0.79, $P = 0.003$) could predict recovery rate in the study countries.

Table 3 indicates the determinants of coronavirus tests in the study countries. The linear regression analysis indicated that CHE per capita (SC = 0.915, $P < 0.001$) and physician rate (SC = −.313, $P = 0.031$) significantly predict the rate of coronavirus test uptake in the included countries. In addition, one-way ANOVA indicated that the high-income countries significantly had a higher mean of coronavirus tests compared to those with lower income.

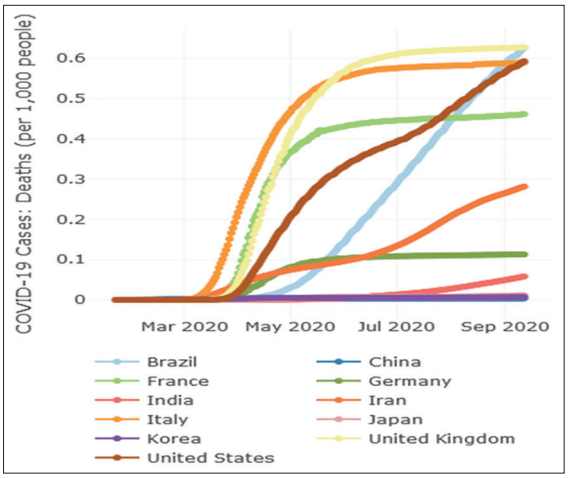

Figure 2: Trend of deaths due to COVID-19 in Iran compared to ten high-income countries[9]

Discussion

The main aim of the present study was to determine the predictors of mortality and recovery rates of COVID-19 in some selected countries. Second, we aimed to examine health systems' efficiency in response to COVID-19 pandemic. Our study showed that CHE per capita (positively) and population aged 65 years and over (negatively) had association with recovered cases from COVID-19 significantly. The findings showed that countries with higher health-care expenditure were more likely to have higher recovered coronavirus cases compared to those with lower ones.

The findings imply that patients with COVID-19 in countries with higher health expenditure probably have better financial and physical access to health-care resources (human resources, diagnostic and treatments equipment and tools, and medicines) which, in turn, would increase the probability of utilizing health care among patients with COVID-19.

Our findings also showed that countries with a lower proportion of elderly people tend to have higher recovered coronavirus cases compared to others. The results indicate that the elderly are more at risk of mortality due to COVID-19. In agreement with our

Table 2: Health-care determinants of recovered cases from COVID-19 in the included countries using adjusted linear regression model

Model	Unstandardized coefficients		Standardized coefficients	*t*	*P*
	B	SE	β		
Constant	2340.273	4936.828		0.474	0.637
Physicians	585.214	922.836	0.114	0.634	0.529
Nurses and midwives	−27.074	45.887	−0.065	−0.590	0.558
Hospital beds	−52.323	628.189	−0.014	−0.083	0.934
CHE per capita	3.223	0.794	0.605	4.060	<0.001
Population over 65 years	−1081.921	272.848	−0.790	−3.965	<0.001
CDNCD	78.395	81.551	0.154	0.961	0.341

[a]Dependent variable: Recovered cases (per 1 MP). SE=Standard error, MP=Million population, CDNCD=Cause of death, by noncommunicable diseases, CHE=Current health expenditure

Table 3: Health-care determinants of coronavirus tests in the included countries using adjusted linear regression models

Model	Unstandardized coefficients		Standardized coefficients	*t*	Significance
	B	SE	β		
Constant	−72,243.247	107,520.778		−0.672	0.505
Physicians	−44,097.817	19,884.145	−0.313	−2.218	0.031
Nurses and midwives	−89.361	989.110	−0.008	−0.090	0.928
Hospital beds	−10,454.996	13,535.978	−0.101	−0.772	0.443
CHE per capita	133.437	17.111	0.915	7.798	<0.001
Population over 65 years	1574.699	5879.028	0.042	0.268	0.790
CDNCD	1225.792	1764.111	0.087	0.695	0.490

[a]Dependent Variable: Coronavirus tests (per 1 MP). SE=Standard error, MP=Million population, CDNCD=Cause of death, by non-communicable diseases

results, studies reveal a higher rate of hospitalization and mortality in older adults.[10-12] For example, the study by Al-Tawfiq in the USA indicated that people in higher age groups, particularly with a median age of 47.4 years, were more at risk of death due to COVID-19.[10] Furthermore, Lu *et al*. found that age (odds ratio = 7.86, 95% confidence interval: 5.46–11.29) and associated comorbidities such as diabetes, chronic lung disease, and hypertension significantly increase the probability of mortality in patients with COVID-19.[13]

In this study, also, we identified health-care determinants of coronavirus test uptake in the included countries. Interestingly, our finding showed that physician rate negatively predicted the rate of coronavirus tests in the studied countries. The findings indicate that countries with a higher number of physicians per inhabitants were less likely to have coronavirus tests compared to those with lower ones. The findings presumably draw our attention toward the different prevalence of COVID-19, and the size, composition, and distribution of health resources in the included countries. For example, some high-income countries with higher physician rate such as Switzerland, Germany, and Sweden had < 170,000 tests/1 MP, while high-income countries such as Singapore (389,303 tests/1 MP) and Qatar (244,262 tests/1 MP) with lower physician rate had a higher rate of coronavirus tests. Overall, given the results of one-way ANOVA, our study showed that high-income countries significantly had a higher rate of physicians and coronavirus tests than low-income countries.

In this study, we compared the performance of countries in response to coronavirus pandemic worldwide. Regarding CHE per capita and recovery rates, our study showed that countries with higher CHE per capita statistically had a better performance compared to those with lower ones. Besides, Iran significantly had a lower recovery rate and higher mortality rate compared to countries with higher CHE per capita that statistically was indicative of poorer Iran's health system performance in comparison to high-income countries. On the other words, high-income countries that have spent more on health experience lower mortality and higher recovery rates than Iran. The finding draws our attention to the health system efficiency in which we compare delivery system inputs and health within a health system. Consuming excess resources can lead to health system inefficiency among the countries.[8] Studies indicate that inefficient use of resources can limit treatments to other patients, reduce consumption opportunities in other parts of the economy like nutrition or education, and decrease people's tendency to contribute for funding of health services.[14-16]

The imbalance between resources also may lead to barriers to satisfactory performance.[17,18] Regarding our results, low-income countries need to balance financial resources among different categories of inputs properly. Thus, regular monitoring seems necessary within health systems to improve the distribution of existing and future inputs. In order to improve efficiency, we think that more attention to preventive strategies, early detection, and early intervention of COVID 19 can improve the efficiency of health systems in controlling coronavirus disease worldwide.[19,20] Early intervention, particularly on the 1st day of symptom onset, may reduce the rate of hospitalization and inpatient costs subsequently.

Limitations

We should note that different variables may be used to assess the efficiency of the health sector such as hospital beds, health staff, and health technologies. In the present study, we just used CHE per capita as the input variable to examine the performance of health systems against the coronavirus disease. Although there is no clear set of metrics to assess the efficiency of the health system, utilizing such variables can help to paint a picture of the performance of a health system which, in turn, may be the entry point for identifying the causes of any inefficiencies in the fight against COVID-19. Besides, we extracted and analyzed available data on COVID-19 until September 12, 2020. Our study suggests continuous monitoring of health systems' performance by policymakers and researchers regarding the variability of incidence and mortality rates of COVID-19 worldwide. Moreover, low-income countries may underestimate mortality and recovery rates of COVID-19 because of their limited capacities in data collection, recognition, and treatment of patients with COVID-19.

Conclusion

This study revealed that countries with higher CHE per capita and higher proportion of older adults were more likely to have a higher recovery rate than those with lower ones. Furthermore, our study indicated that health systems with higher CHE per capita statistically had a greater efficiency in response to COVID-19 compared to those with lower CHE per capita. More attention to preventive strategies, early detection, and early intervention is suggested to improve the health system efficiency in controlling COVID-19 and its related mortalities worldwide. In the end, our study suggests fundamental points that health policymakers need to take into consideration to improve efficiency in health systems. The study's recommendations include:

Investigating the utilization and prescription pattern of COVID-19-related medicines and their costs; improving the accuracy of COVID-19-related data and reports, improving the quality of health-care delivery; utilizing various tools (newspapers, booklets

and brochures, radio, television, social media, etc.) to educate patients and vulnerable groups in society; applying clinical guidelines to treat patients with COVID-19; improving health literacy to prevent from COVID-19 more effectively; telemonitoring of patients with COVID-19; organizing and improving hospital admissions; formulating guidelines for hospitalization of patients with COVID-19; applying guidelines to allocate human, financial, and physical resources in health-care facilities; strengthening primary health-care actions to protect people against COVID-19; and evaluating cost-effectiveness of medicines and heath technologies to combat COVID-19.

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Conflicts of interest

There are no conflicts of interest.

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