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Provincial Disparities in the COVID-19 Burden: Hospital Data Analysis from Iran

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Abstract

Background: Despite extensive evidence regarding the significant impact of the COVID-19 pandemic on population health in Iran, its effects at the sub-national level and comparisons across different geographic regions have garnered less attention. This study aimed to estimate key disease burden indicators, including incidence rate, mortality rate, case fatality rate, and disability-adjusted life years, across Iranian provinces during 2020 and 2021.

Methods: We obtained and analyzed hospital billing records of beneficiaries from the Iran Health Insurance Organization (IHIO) who were admitted for COVID-19 across Iran from the onset of the pandemic until December 2021. We identified cases using the WHO-recommended ICD-10 codes U07.1 and U07.2. In addition to reporting provincial-level rates of incidence, mortality, and case fatality rates, we also assessed disease burden by aggregating Years of Life Lost and Years Lived with Disability. Data management and analysis were conducted using Microsoft Excel Office 19 (Microsoft Corporation).

Results: Substantial interprovincial disparities were observed. Semnan (3,331) and Yazd (3,171) recorded the highest incidence rates per 100,000 people, whereas Qom (224) and Alborz (212) reported the highest death rates. In 2020, the highest case fatality rate (18.59%) was recorded in Razavi Khorasan province, while in 2021, the peak rate (12.52%) was observed in Qom province, both rates exceeding the national average. The burden of disease peaked in Qom (4,287) and the central provinces, while the lowest burden was observed in Kohgiluyeh and Boyer-Ahmad (1,042).

Conclusion: This study indicates geographic, age, and sex-based disparities in the burden of COVID-19 in Iran. Therefore, future pandemic preparedness policies must account for regional differences and allocate resources equitably based on the needs of various population subgroups. Further research on health inequalities and comprehensive data on social determinants of health is essential. This provides stronger evidence for policymakers to address disparities in COVID-19 case fatality and mortality rates.

Keywords: COVID-19, Disability-Adjusted Life Years, Subnational Health Disparities, Iran, Epidemiology

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↑What is "already known" in this topic:
Iran has been significantly affected by the COVID-19 pandemic. Numerous studies have assessed this impact by utilizing mortality and DALY measures across various geographical regions and time periods.

→What this article adds:
No comprehensive study has been identified in the literature that estimates the COVID-19 disease burden using Disability-Adjusted Life Years (DALY) and its components across various age and gender groups in sub-national regions.
• The burden of COVID-19 was estimated across various age and gender groups within sub-national regions.
• The most substantial differences in case fatality rates were observed in Qom and Razavi Khorasan.
• The elderly population aged over 80 years represented the highest proportion of DALYs.

Introduction

COVID-19 is a global infectious disease caused by the novel coronavirus SARS-CoV-2, first identified in 2019, which has resulted in severe illness affecting various aspects of life worldwide (1, 2). This pathogen is the seventh coronavirus known to infect humans and is responsible for the ongoing widespread outbreak (3, 4). On March 11, 2020, the World Health Organization declared coronavirus disease 2019 (COVID-19) a pandemic (4). On December 31, 2020, the first COVID-19 vaccine received emergency use listing from the WHO. Subsequently, additional vaccines were introduced and approved (5). As of now, official statistics report 1,813,188 deaths attributed to this disease. However, initial estimates suggest that the total global death toll due to COVID-19 in 2020 was at least 3 million, indicating 1.2 million more deaths than officially reported (5). The pandemic triggered the most severe global economic recession since the Great Depression (6), causing the annual growth rate of global Gross Domestic Product (GDP) to plummet from 2.7% in 2019 to -2.9% in 2020 (7). Public health was one of the areas most significantly impacted by COVID-19. To better understand this impact, it is essential to assess the overall health burden associated with the condition (8). The burden of disease can be described through several approaches. Although incidence and prevalence figures help illustrate how widespread a condition is and how severely it affects the population, they do not fully capture its broader implications. Therefore, additional composite indicators have been developed to enable meaningful comparisons across diseases from both health and economic perspectives. One widely used measure for this purpose is the disability-adjusted life year (DALY), which summarizes the total health loss in a population. A DALY reflects the reduction of one year of healthy life and combines years of life lost (YLLs) due to premature mortality with years lived with disability (YLDs) (9). The DALY serves as a measure for assessing the proportional impact of disability and premature mortality due to various causes or diseases. It provides a basis for examining COVID-19's burden relative to a wide range of health conditions and injuries (8). The presented global burden of disease estimates distinguish between the direct burden of COVID-19 and COVID-19-related outcomes. Reports indicate that the number of deaths due to COVID-19 and its related outcomes was 4,801,802 and 1,348,067, respectively, in 2020, and 7,887,554 and 2,685,536, respectively, in 2021. The estimated number of DALYs in 2020 was 123,352,762 and 39,413,336 years, respectively, and in 2021, 212,009,596 and 77,380,460 years, respectively (10). Studies show that the contribution of years of life lost due to premature mortality (YLL) from COVID-19 remains consistently high, accounting for 95% to 99% of the overall burden in various countries (11). The burden of COVID-19 is higher in developing countries (12).

Like many countries worldwide, Iran has been significantly affected by the COVID-19 pandemic. Numerous studies have quantified this impact using mortality and DALY measures across various geographical regions and time periods. Research on this topic has primarily been confined to specific geographical areas or sub-national levels (13-16). Nevertheless, the significance of geographical comparisons in policymaking is evident, and policy applications are particularly sensitive to location and scale (17). Several studies have also investigated geographical comparisons of the burden of COVID-19 in Iran (18, 19).

However, no comprehensive study has been identified in the literature that estimates the COVID-19 disease burden using DALY and its components (YLL and YLD) across different age and gender groups in sub-national regions. This study aims to fill that gap by presenting evidence based on hospital data for moderate and severe COVID-19 cases.

Methods

This cross-sectional applied study utilized data from COVID-19 patients who visited hospitals across Iran from the onset of the pandemic through December 2021. The study population comprised patients covered by the Iran Health Insurance Organization (IHIO), a major provider of basic health insurance. In 2020, the IHIO insured approximately 41.5 million individuals, nearly half of Iran's total population (about 84 million).

COVID-19 cases were identified based on the presence of ICD-10 codes U07.1 and U07.2 in hospital records. Since sampling was not conducted in this study, all patients with a final diagnosis code recorded at the time of discharge and whose medical records were complete were included in the analyses. Consequently, patients without hospital records, including those who visited outpatient clinics, were excluded from the study. These ICD-10 codes were designated by the World Health Organization (WHO) as emergency classifications for identifying COVID-19 cases in healthcare settings (20). Aggregated patient data were obtained anonymously, without any personally identifiable information, from IHIO. This study is part of a series of research projects utilizing these data, with previous studies published (14, 21). One such study, "COVID-19 Burden in Iran: Disability-Adjusted Life Years Analysis from Hospital Data, 2020–2021," estimated the national burden of COVID-19; however, provincial comparisons were omitted. The present study addresses this gap by focusing on a sub-national analysis of the disease burden. Patient discharge status (recovery or death) was used in this study to identify deceased patients. Because death certificates, based on the World Health Organization's methodology, did not provide this information, it was not possible to determine with certainty whether COVID-19 was the direct cause of death or an underlying condition in each case.

The burden of disease was quantified using disability-adjusted life years (DALYs) in accordance with the framework proposed by the World Health Organization (22). This framework...

DALYs (c, s, a, t) = YLLs (c, s, a, t) + YLDs (c, s, a, t)

where c denotes the cause, s the sex, a the age group, and t the reference year.

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Table 1. COVID-19 health states and disability weights

Health States	Health States Description	Disability weight (95% UI)	Description of patients included in each health status in this study
Moderate	The patient presents with fever, myalgia, and general weakness, which results in some difficulty performing daily activities.	0.051 (0.032-0.074)	Patients who were admitted to the hospital but received outpatient care were not considered hospitalized.
Severe	The patient presents with a high fever, pain, and significant weakness, which results in considerable difficulty performing daily activities.	0.133 (0.088-0.190)	Patients hospitalized in non-intensive care units
Critical	Intensive care unit admission	0.655 (0.579-0.727)	Patients hospitalized in intensive care units

YLLs (c, s, a, t) = N (c, s, a, t) x L (s, a)

where N represents the number of deaths and L indicates the standard life expectancy for the specified age and sex. Consistent with the methodology adopted in the Global Burden of Disease (GBD) 2010 study and subsequent analyses, a normative standard life table was utilized to represent life expectancy. In the present analysis, the relevant life table values were sourced from the WHO database (23).

In this framework, the years lived with disability (YLDs) were estimated to capture the non-fatal component of the disease burden. The equation used is as follows:

YLD (c, s, a, t) =I (c, s, a, t) ×DW (c, s, a) ×L (c, s, a, t)

where I (c, s, a, t) indicates the number of new (incident) cases for cause c in sex s, age group a, and time period t; DW (c, s, a) represents the disability weight corresponding to that cause, sex, and age group; and L (c, s, a, t) denotes the average duration of the condition (in years) until recovery or death. Since disability weights represent the health loss associated with various conditions, they directly affect YLD estimates. These weights are periodically reported within the Global Burden of Disease studies and are publicly accessible. However, an official disability weight specifically assigned to COVID-19 has not yet been established. Gianino et al. (24) have utilized the disability weight for lower respiratory tract infections (0.133), due to its similarity to COVID-19, to approximate YLDs. In this study, the agreed-upon weights for DALY calculations were applied, following the methodology recommended by the European Burden of Disease Network, to assess the burden of COVID-19 (25, 26). Table 1 presents the disability weights for various COVID-19 health statuses.

To present the disease burden based on the rate (per 100,000 population), the following equation was used:

$$DALY(per\ 100{,}000)_{a,s} = \frac{\sum DALY_{a,s}}{population_{a,s}}$$

$$YLL(per\ 100{,}000)_{a,s} = \frac{\sum YLL_{a,s}}{population_{a,s}}$$

$$YLD(per\ 100{,}000)_{a,s} = \frac{\sum YLD_{a,s}}{population_{a,s}}$$

In the above equation, $population_{a,s}$ is the insured population of the Iran Health Insurance Organization in age group a and gender groups. Data management and analysis were performed using Microsoft Excel Office 19 (Microsoft Corporation).

In addition to reporting the disease burden based on DALYs in this study, several related parameters have been documented at the provincial level, including incidence rate, mortality rate, and case fatality rate. The incidence rate referenced in this study pertains to cases of the disease that resulted in hospital admission and aligns with the classification provided in Table 1, which includes moderate, severe, and critical conditions. This indicator has been expressed as a percentage or per 100,000 people. The incidence rate was calculated as follows:

$$Incidence\ rate\ (\%\ or\ per\ 100{,}000)_{a,s} = \frac{\sum patients\ with\ COVID-19\ ICD\ codes_{a,s}}{population_{a,s}}$$

The case fatality rate and the mortality rate have been calculated as follows, in accordance with the definitions provided in epidemiology dictionaries and other scientific literature (27):

$$Mortality\ Rate\ \frac{Total\ number\ of\ deaths\ due\ to\ the\ COVID-19}{Total\ population\ at\ risk}$$

$$Case\ Fatality\ Rate\ (CFR) = \frac{Number\ of\ deaths\ due\ to\ COVID-19}{Total\ confirmed\ cases\ of\ the\ disease}$$

Results

Significant variations were observed among Iranian provinces across various epidemiological indicators used to assess the burden of COVID-19. Semnan and Yazd reported the highest incidence rates, with 3,330.7 and 3,170.8 cases per 100,000 population, respectively, while Sistan and Baluchestan experienced the lowest rate at 621.4 per 100,000 population. The highest mortality rates were recorded in Qom and Alborz, with 224.1 and 212.4 deaths per 100,000 population, respectively. In contrast, Kohgiluyeh and Boyer-Ahmad reported a significantly lower mortality rate of 53.7 per 100,000, ranking it the lowest among all provinces in the country. The overall case fatality rate (CFR) decreased by approximately 50% in 2021 compared to 2020, dropping from 13.29% to 6.75%. The highest CFRs in 2020 were estimated for Khorasan Razavi and Alborz provinces, at 18.59% and 18.09%, respectively, while in 2021, Qom recorded the highest rate at 12.52%.

According to estimates, COVID-19 resulted in a total of 3,224,841 years of life lost in Iran over a two-year period. The provinces with the highest absolute DALYs were Tehran, with 236,954 years in 2020 and 375,102 in 2021, and Isfahan, which recorded 126,089 in 2020 and 179,655 in 2021.

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Table 2. Key Indicators of COVID-19 Burden in Iran (2020–2021) at the provincial level

Province	Incidence Rate (Per 100,000 Population)		Incidence (Total)		Mortality Rate (Per 100,000 Population)		Mortality (Total)		Case Fatality Rate (%)		YLLs (Per 100,000 Population)		YLDs (Per 100,000 Population)		DALYs (Per 100,000 Population)		DALYs (Total)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Azerbaijan-East	1,008.3	2,284.9	40,846	92,310	111.9	132.6	4,533	5,357	11.10	5.80	1,766.2	2,316.9	5.3	8.4	1,771.5	2,325.3	71,763	93,942
Azerbaijan-West	712.7	1,551.5	24,510	53,449	90.8	113.5	3,123	3,910	12.75	7.32	1,587.0	2,174.5	3.3	6.8	1,590.3	2,181.3	54,690	75,146
Ardabil	815.5	1,528.7	10,650	19,797	103.1	108.8	1,346	1,409	12.64	7.12	1,654.8	1,833.3	4.2	6.7	1,659.0	1,840.0	21,667	23,828
Isfahan	1,195.4	2,359.1	63,870	126,070	164.4	210.8	8,784	11,265	13.76	8.94	2,352.9	3,351.0	6.9	10.8	2,359.9	3,361.8	126,089	179,655
Alborz	767.2	2,058.9	22,349	60,161	138.8	212.4	4,043	6,206	18.09	10.32	2,325.3	4,086.7	4.9	9.0	2,330.2	4,095.7	67,879	119,676
Ilam	1,095.1	2,800.7	6,593	16,636	93.4	92.6	562	550	8.53	3.31	1,580.6	1,584.6	5.0	8.6	1,585.5	1,593.2	9,545	9,464
Bushehr	612.8	1,405.7	7,666	17,445	57.3	95.0	717	1,179	9.35	6.76	1,114.9	1,944.4	2.9	5.0	1,117.9	1,949.4	13,985	24,192
Tehran	533.5	1,737.3	74,546	243,795	94.9	140.9	13,260	19,772	17.78	8.11	1,691.8	2,664.4	4.0	8.6	1,695.8	2,673.0	236,954	375,102
ChaharM & Bakhtiari	511.7	1,886.6	5,056	18,564	75.5	101.3	746	997	14.76	5.37	1,103.0	1,526.2	3.1	6.8	1,106.1	1,533.0	10,928	15,085
Khorasan-south	1,018.8	1,845.6	8,375	15,097	101.5	108.0	834	883	9.97	5.85	1,395.2	1,503.3	4.4	7.1	1,399.5	1,510.4	11,504	12,355
Khorasan-razavi	611.3	1,406.6	42,002	96,901	113.7	148.6	7,812	10,237	18.59	10.57	1,936.3	2,788.6	3.3	5.7	1,939.6	2,794.3	133,270	192,499
Khorasan-north	901.0	2,069.5	8,100	18,150	102.5	128.5	921	1,127	11.38	6.21	1,907.7	2,376.2	4.3	7.5	1,912.0	2,383.6	17,189	20,904
Khuzestan	510.8	1,843.4	25,213	92,059	67.0	117.3	3,307	5,858	13.11	6.36	1,362.5	2,453.9	3.0	6.6	1,365.5	2,460.6	67,401	122,882
Zanjan	1,064.4	1,424.6	11,783	15,699	123.8	106.9	1,370	1,178	11.63	7.50	1,864.7	1,604.8	5.5	6.2	1,870.1	1,611.1	20,702	17,754
Semnan	1,321.7	3,330.7	10,098	25,213	190.7	194.2	1,457	1,470	14.43	5.83	2,521.1	2,852.4	8.1	14.3	2,529.3	2,866.8	19,324	21,702
Sistan & Baluchestan	198.2	621.4	6,035	19,170	29.8	46.0	907	1,419	15.05	7.40	673.8	1,115.3	0.8	1.8	674.6	1,117.1	20,542	34,463
Fars	518.9	1,743.4	26,210	88,129	71.7	91.9	3,622	4,646	13.82	5.27	1,198.4	1,645.0	2.4	5.8	1,200.8	1,650.8	60,652	83,448
Qazvin	742.1	1,512.4	9,914	20,054	119.9	134.2	1,602	1,779	16.16	8.88	1,975.6	2,264.7	4.7	7.4	1,980.2	2,272.1	26,455	30,128
Qom	1,414.0	1,789.4	19,768	25,034	212.4	224.1	2,969	3,135	15.02	12.52	3,527.5	4,279.3	7.4	7.8	3,534.9	4,287.1	49,418	59,977
Kurdistan	574.5	2,074.0	9,623	34,553	72.6	80.1	1,216	1,334	12.63	3.86	1,116.1	1,211.9	2.6	6.3	1,118.7	1,218.2	18,738	20,295
Kerman	729.8	1,955.4	24,383	65,134	87.7	122.8	2,930	4,090	12.02	6.28	1,633.6	2,586.6	3.6	7.7	1,637.2	2,594.2	54,699	86,413
Kermanshah	668.0	1,847.2	13,353	36,796	75.7	101.8	1,513	2,028	11.34	5.51	1,344.6	1,895.9	3.4	7.3	1,348.0	1,903.2	26,947	37,912
Kohgiluyeh & BoyerA	715.4	1,895.7	5,387	14,123	38.0	53.7	286	400	5.31	2.83	652.0	1,034.8	3.3	7.0	655.3	1,041.8	4,934	7,761
Golestan	714.5	1,535.8	14,111	30,301	114.8	134.3	2,267	2,650	16.07	8.74	2,225.5	2,851.3	4.4	6.6	2,229.9	2,857.9	44,041	56,386
Gilan	505.1	2,039.7	12,986	52,278	70.3	112.3	1,807	2,878	13.93	5.51	1,210.5	2,108.7	2.4	6.0	1,212.9	2,114.7	31,184	54,200
Lorestan	878.3	2,325.5	15,818	41,650	92.0	100.5	1,657	1,800	10.47	4.32	1,577.4	1,667.3	4.4	8.4	1,581.9	1,675.7	28,490	30,012
Mazandaran	1,133.9	2,076.4	38,451	70,099	122.8	131.7	4,164	4,446	10.83	6.34	1,994.0	2,326.8	6.8	9.7	2,000.8	2,336.6	67,847	78,884
Markazi	933.1	1,521.9	13,791	22,265	119.9	114.4	1,772	1,674	12.85	7.52	1,608.2	1,615.3	4.6	6.8	1,612.8	1,622.1	23,837	23,731
Hormoz Gan	513.8	1,914.6	9,978	37,028	50.8	80.2	987	1,551	9.88	4.19	1,086.9	1,694.3	2.2	6.0	1,089.1	1,700.4	21,150	32,886
Hamadan	873.7	2,271.7	15,543	40,118	85.2	111.1	1,516	1,962	9.75	4.89	1,283.5	1,794.7	4.9	9.3	1,288.3	1,804.0	22,919	31,859
Yazd	1,503.3	3,170.8	18,581	39,730	174.0	153.5	2,151	1,923	11.57	4.84	2,511.9	2,327.6	7.1	11.7	2,519.0	2,339.3	31,135	29,311
National	710.6	1,793.4	597,160	1,507,407	94.4	121.1	79,330	101,788	13.29	6.75	1,598.7	2,227.4	3.8	7.1	1,602.5	2,234.5	1,346,677	1,878,164

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However, in terms of DALYs per 100,000 population, Qom experienced the highest burden, with rates of 3,534.9 in 2020 and 4,287.1 in 2021 (Table 2).

Table 3 presents province-specific monthly COVID-19 DALYs per 100,000 population from February 2020 to December 2021. This figure indicates significant spatial and temporal variations, with Qom, Alborz, and Golestan experiencing the highest peak DALY rates (e.g., Qom: 1,455.9 in August 2021), while Sistan & Baluchestan consistently reported the lowest values (e.g., 18.7 in December 2021). Nationally, DALYs peaked in August 2021 (546.6) and November 2020 (313.0), coinciding with COVID-19 waves.

Figure 1 illustrates age-specific and sex-specific variations in incidence, mortality, and CFR. Part A of this figure indicates that Gilan (2.95% females vs. 2.16% males) and Lorestan (3.52% vs. 2.91%) exhibit the widest gender gaps, while South Khorasan demonstrates nearly identical rates between sexes (2.86% vs. 2.87%). Mortality patterns are particularly severe in central provinces; for instance, Qom has the highest rates for both genders (0.42% females vs. 0.45% males), with South Khorasan showing the most pronounced gender disparity (0.18% vs. 0.24%). Case fatality rates consistently favor female patients nationwide, with the most substantial differences observed in Qom (12.4% vs. 14.9%) and Razavi Khorasan (11.2% vs. 14.8%), while Kohgiluyeh & Boyer-Ahmad recorded the lowest overall rates (3.1% vs. 4.0%) (Figure 1-A).

Part B of Figure 1 illustrates significant age-specific variations in all epidemiological indicators. Adults aged over 80 years consistently exhibited the highest values across all metrics, with particularly severe outcomes observed in Qom (CFR: 29.5%, mortality: 7.35%) and Alborz (CFR: 33.3%, mortality: 6.41%). Conversely, the age group under 20 demonstrated the lowest values for all metrics nationwide (average CFR: 3.3%, mortality: 0.012%), although exceptions such as Sistan & Baluchestan revealed unexpectedly high CFR (5.7%) within this youngest cohort. The steepest age gradient was noted in case fatality rates, where individuals over 80 years experienced a mortality risk 7-10 times higher than those aged 20–49 years (national averages: 22.8% vs 2.9%). Semnan exhibited the widest age disparity, with CFR ranging from 1.8% in the under 20 age group to 24.5% in the over 80 age group. Notably, Kohgiluyeh & Boyer-Ahmad maintained the lowest CFR across all ages (0.98%-11.8%), while Qom and Alborz reported the highest CFRs among the elderly (greater than 29%).

Figure 2 illustrates the provincial distribution of COVID-19 disease burden based on DALYs in Iran during 2020–2021, categorized by age and sex. The findings indicate significant disparities among demographic groups and regions. The elderly population aged over 80 years accounted for the highest proportion of DALYs in most provinces, with particularly high burdens observed in Semnan (59.6%), Alborz (58.2%), and Markazi (59.0%). Exceptions included Sistan & Baluchestan and Bushehr, where the 50–80 age group predominated. Younger individuals under 20 contributed minimally, with proportions ranging from just 0.4% in Kurdistan to 6.7% in Tehran. At the national level, males experienced a higher disease burden (53.7%) compared to females (46.3%), with the largest gender disparity noted in Tehran (57.6% male vs. 42.4%

Table 3. Key Indicators of COVID-19 Burden in Iran (2020–2021) at the Provincial Level.(DALY per 100,000 population)

Province	2020-2	2020-3	2020-4	2020-5	2020-6	2020-7	2020-8	2020-9	2020-10	2020-11	2020-12	2021-1	2021-2	2021-3	2021-4	2021-5	2021-6	2021-7	2021-8	2021-9	2021-10	2021-11	2021-12	Average	Std, dev
Azerbaijan-East	9.8	81.3	74.2	82.4	142.6	155.5	122.3	184.7	336.1	398.8	183.3	118.4	76.6	89.3	300.6	238.4	131.4	122.9	351.6	415.1	285.3	105.7	89.9	178.1	115.3
Azerbaijan-West	1.6	52.4	60.7	43.4	129.7	123.3	71.0	122.1	397.7	440.9	147.0	78.8	95.0	86.5	222.8	124.3	101.4	119.4	365.0	474.7	276.9	148.4	88.3	164.0	133.7
Ardabil	19.8	148.4	162.0	78.4	42.5	241.1	163.8	100.5	153.7	348.7	200.2	104.2	69.7	91.9	295.5	130.3	41.1	147.2	522.4	191.0	90.3	103.4	53.0	152.1	114.3
Isfahan	43.4	210.6	151.8	101.5	98.1	170.5	236.3	294.2	415.6	451.5	186.3	105.1	83.3	147.1	403.4	290.8	149.0	371.6	746.7	512.7	298.9	159.2	93.9	248.8	170.5
Alborz	43.5	236.0	140.6	82.3	88.8	264.2	198.2	247.7	410.2	400.2	218.6	129.5	130.7	195.3	620.4	398.0	282.9	542.5	787.6	524.2	230.2	154.6	99.8	279.4	192.5
Ilam	0.0	107.5	46.0	77.2	117.5	183.7	61.6	84.7	325.4	416.6	165.4	69.9	35.4	64.9	171.6	72.3	58.2	127.1	453.2	276.0	143.3	103.4	17.9	138.2	121.2
Bushehr	0.0	42.6	39.9	26.7	163.1	233.6	182.1	120.8	139.3	154.1	15.5	36.2	56.8	62.0	226.2	165.6	189.7	379.0	594.6	146.4	62.2	30.6	0.0	133.4	137.1
Tehran	21.4	134.7	102.1	53.5	93.6	186.2	145.7	236.7	311.4	276.6	131.3	85.9	83.1	109.9	332.9	237.8	149.1	431.6	561.2	322.1	182.9	121.9	54.6	189.8	132.6
ChaharM & Bakhtiari	12.1	41.3	23.1	44.4	73.4	70.4	108.5	132.3	227.5	278.3	94.9	77.4	46.9	75.6	234.0	123.2	75.2	101.9	306.3	196.0	122.3	94.8	79.4	114.7	80.3
Khorasan-south	5.8	88.6	91.6	28.6	62.2	97.2	61.7	77.7	322.2	424.8	139.3	70.5	53.3	114.3	136.4	109.9	86.3	172.9	297.3	137.3	98.2	105.7	128.3	126.5	97.5
Khorasan-Razavi	14.9	119.1	104.8	64.7	123.9	296.4	153.9	124.0	324.8	437.9	173.0	100.2	83.9	118.4	226.6	169.8	135.5	343.9	1008.8	296.1	123.9	112.4	74.9	205.7	203.7
Korasan-north	18.9	95.5	121.0	147.6	59.6	260.1	261.7	179.4	213.3	378.4	176.5	147.6	60.6	64.5	194.1	170.8	98.0	210.1	751.0	403.6	140.4	109.4	33.6	186.8	157.4
Khuzestan	5.1	57.2	90.1	188.3	242.3	207.9	92.9	113.8	151.9	156.6	59.3	75.6	170.1	261.4	286.0	202.2	114.0	130.4	645.4	344.1	114.1	85.2	32.0	166.4	134.3
Zanjan	3.8	148.0	121.7	88.0	183.1	249.9	104.3	136.1	296.2	385.3	153.9	84.0	66.0	79.4	314.2	172.9	51.2	100.3	236.0	226.5	173.2	84.0	23.5	151.4	96.9
Semnan	44.0	282.8	133.6	90.2	119.6	205.2	219.3	185.5	403.4	589.6	256.2	187.6	133.5	146.7	336.4	208.2	122.0	242.1	564.4	348.1	186.1	220.7	171.1	234.6	137.1
Sistan & Baluchestan	6.2	53.5	33.0	50.5	112.5	80.2	51.5	40.9	56.1	124.3	66.1	22.4	13.1	15.8	46.6	70.4	232.9	384.9	164.4	50.6	48.7	48.7	18.7	77.9	84.9
Fars	4.7	45.8	64.5	32.8	78.8	138.0	88.1	75.5	179.2	373.9	119.6	55.5	52.9	66.7	232.1	117.2	87.9	239.2	347.3	163.8	130.7	92.2	65.2	124.0	95.1
Qazvin	42.0	262.0	126.4	128.3	88.9	128.1	173.0	242.1	290.1	364.4	135.0	104.5	84.9	77.9	276.8	190.0	147.1	199.3	453.1	367.4	122.1	151.1	97.7	184.9	106.7
Qom	286.1	680.0	221.1	122.0	126.3	205.0	330.9	447.6	599.0	373.9	141.9	66.2	67.6	119.4	438.6	250.1	131.3	528.5	1455.9	767.8	276.1	112.2	73.4	340.0	317.2
Kurdistan	1.5	34.8	23.7	20.4	168.2	75.2	35.2	42.5	299.5	317.3	100.2	46.7	25.7	44.0	133.7	68.0	61.4	51.8	157.3	267.6	226.1	89.2	46.7	101.6	93.8
Kerman	2.4	48.2	63.4	109.3	116.7	244.3	156.7	140.2	201.7	345.1	209.2	137.6	107.3	92.2	143.5	184.3	243.1	448.4	509.8	263.0	178.8	141.7	144.5	184.0	120.0
Kermanshah	5.6	33.5	72.4	82.0	104.8	125.9	86.3	127.2	258.0	359.5	93.0	44.0	46.7	66.7	196.6	144.4	65.7	94.3	395.1	461.4	256.2	90.6	41.5	141.4	123.3
Kohgiluyeh & BoyerA	0.0	72.6	31.9	11.5	9.6	66.0	67.8	74.3	71.1	170.6	79.9	17.2	70.5	24.4	276.4	64.8	28.0	68.1	215.1	130.2	75.5	50.9	20.7	73.8	67.5
Golestan	69.3	415.7	145.1	99.7	198.4	346.1	156.1	118.6	123.4	323.8	228.9	151.9	96.3	83.8	164.0	158.5	91.4	469.6	1230.7	219.1	72.1	63.9	56.5	221.0	247.8
Gilan	66.3	279.0	115.1	62.2	39.9	65.8	109.1	68.9	80.1	129.0	197.5	152.0	101.2	91.5	261.7	82.1	44.7	216.7	741.7	204.4	94.7	79.9	44.0	144.7	147.4
Lorestan	24.9	120.9	136.5	98.6	121.5	169.4	126.1	129.9	241.9	301.8	110.3	71.4	48.9	75.5	277.7	173.5	70.0	136.7	307.2	232.9	97.7	107.7	76.4	141.6	79.7
Mazandaran	53.0	484.0	157.8	83.4	70.5	294.9	240.1	109.3	148.9	136.8	221.3	311.5	143.9	115.2	216.6	86.5	55.6	427.3	658.4	148.5	86.8	45.5	40.7	188.5	156.8
Markazi	13.2	164.2	98.6	33.4	73.9	143.1	146.0	160.9	388.8	293.4	97.2	36.0	46.9	71.0	383.0	178.9	47.2	164.0	256.4	227.9	124.5	47.3	39.2	140.6	107.9
Hormoz Gan	6.9	46.1	64.3	54.0	208.3	255.8	119.8	83.7	79.2	88.5	82.8	77.3	40.4	83.0	128.0	171.4	171.9	298.6	503.3	120.3	52.3	31.4	22.3	121.3	111.4
Hamadan	10.0	67.9	75.2	50.1	100.7	182.5	93.2	138.5	258.8	218.7	92.7	79.3	62.4	99.1	408.5	138.3	69.6	115.6	290.3	221.7	156.8	93.8	68.5	134.4	92.3
Yazd	23.3	191.4	127.6	48.2	116.6	207.5	213.2	184.2	553.5	733.7	119.7	96.9	65.4	88.6	215.3	161.6	165.9	550.4	327.7	118.0	172.0	242.5	135.0	211.2	175.4
National	21.4	133.9	92.9	74.3	117.7	186.6	130.9	139.1	250.6	313.0	141.4	95.0	79.1	100.0	250.9	165.3	121.0	270.1	546.6	286.2	155.8	101.1	63.4	166.8	113.0

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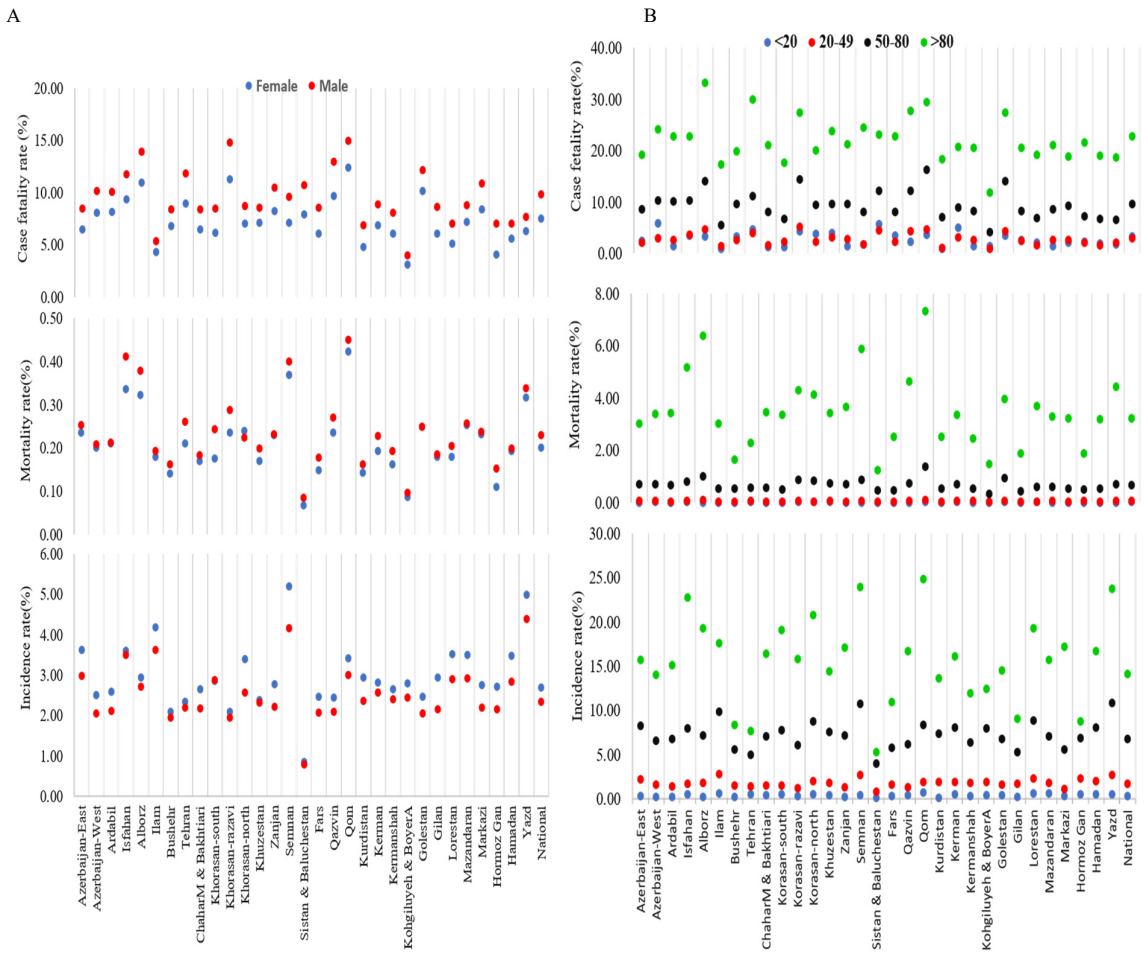

Figure 1. Age Group and Sex-Specific Variations in COVID-19 Incidence, Mortality, and Case Fatality Rates Across Iran (2020-2021). A: Sex-Specific Variations, B: Age Group-Specific Variations.

female). However, three provinces—Golestan, Mazandaran, and Khorasan-north—deviated from this trend, as females exhibited slightly higher DALYs.

Discussion

The study utilized hospital data from one of the largest basic health insurance providers in Iran to estimate the burden of COVID-19 and to highlight significant disparities across provinces. According to this study, the Disability-Adjusted Life Years (DALYs) for hospitalized COVID-19 cases, ranging from moderate to critical severity, were 1,346,677 in 2020 and 1,878,164 in 2021 (1,602.5 and 2,234.5 DALYs per 100,000 population, respectively). The Global Burden of Disease (GBD) Study in 2021 reported a total of 4,268,524 DALYs attributed to COVID-19 in Iran (95% confidence interval [CI]: 4,024,478 to 4,597,033), equating to 5,001 per 100,000 population (95% CI: 4,714 to 5,385) (10), which exceeds our estimate. This discrepancy may reflect the study's reliance on hospital-based data, which excludes mild or asymptomatic cases that do not require hospitalization, potentially leading to an underestimation of the burden. However, since years of life lost (YLL) constitute the overwhelming majority of the COVID-19 burden in both Iranian studies (e.g., 99.34% (28), 99.8% in 2020 and 99.7% in 2021 (14), 99% (29), 99.6% (15)) and international reports (e.g., 98% (24) and 91-98% (30)), and given that most patients with severe illness are likely to be hospitalized, the estimates still capture a substantial share of the true burden. Saied-Bokaie et al. (28) also reported a total burden of 2,376,552 DALYs between 19 February 2020 and 20 March 2022, using RT-PCR-confirmed data on hospitalized and outpatient cases.

The estimated DALYs per 100,000 population in 2020 ranged from 655.3 in Kohgiluyeh and Boyer-Ahmad to 3,534.90 in Qom. In 2021, these figures ranged from 1,041.80 to 4,287.10 in the same provinces. Following Kohgiluyeh and Boyer-Ahmad in both years, Sistan and Baluchestan exhibited the lowest estimated disease burden, with 674.6 DALYs in 2020 and 1,117.10 DALYs in 2021. The Global Burden of Disease (GBD) 2021 study (31) also reveals substantial regional disparities in the burden of COVID-19 across Iran. Although provinces such as Sistan and Baluchestan (3,027 DALYs per 100,000), Kohgiluyeh and Boyer-Ahmad (3,482), and Chaharmahal & Bakhtiari

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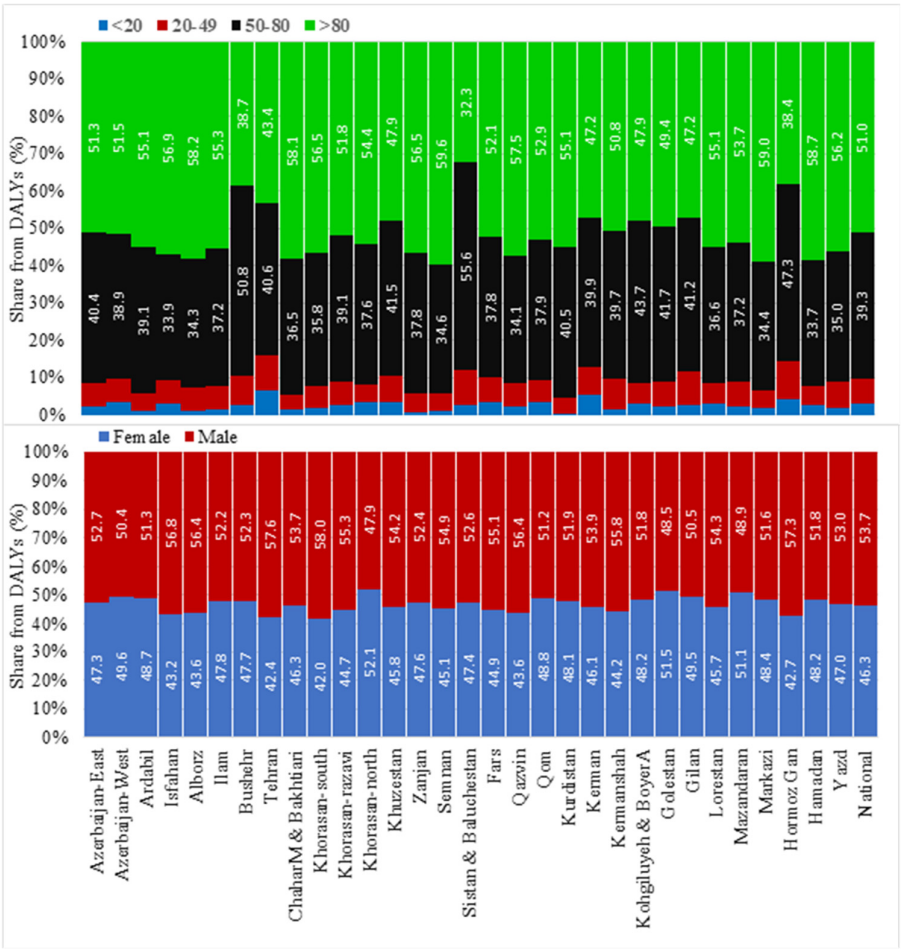

Figure 2. Share of Total COVID-19 DALYs by Major Age Groups and Gender (2020-2021)

(3,418) consistently ranked among the areas with the lowest burden in both datasets, notable discrepancies were observed in the provinces ranked highest. For instance, while our estimates identified Qom as bearing the heaviest burden, the GBD study reported Yazd (8,589) and Semnan (8,419) as the most affected. This divergence is particularly striking, as the burden in Yazd was nearly 2.8 times higher than that in Sistan and Baluchestan.

Based on the DALY calculation formula, recognized differences are expected to arise from several factors, including the incidence rate, disease duration, disability severity, number of deaths, case fatality rate, and age at death. The incidence rate of moderate to critical COVID-19 cases leading to hospital admission, which serves as the incidence proxy in this study, varied significantly across provinces. In 2020, it ranged from 198.2 per 100,000 population in Sistan and Baluchestan to 1,414.0 in Qom and 1,503.3 in Yazd, reflecting a more than 7.5-fold difference. In 2021, the range expanded further, from 621.4 in Sistan and Baluchestan to 3,330.7 in Semnan and a similarly high rate in Yazd. Significant variations in the incidence rate of COVID-19 have also been reported in other domestic studies (19, 32, 33) and in the Global Burden of Disease (GBD) report (31).

In the present study, the case fatality rate (CFR) exhibited a similar pattern of provincial variation. In 2020, the CFR ranged from 5.31% in Kohgiluyeh and Boyer-Ahmad and 8.53% in Ilam to 18.09% in Alborz and 18.59% in Khorasan Razavi. In 2021, it ranged from 2.83% in Kohgiluyeh and Boyer-Ahmad and 3.31% in Ilam to 12.52% in Qom. A meta-analysis by Alimohamadi et al. estimated the overall CFR of COVID-19 at 10%. The rate was 1% in the general population, 13% among hospitalized patients, 37% in ICU admissions, and 19% in individuals over 50 years of age (34).

Disparities in the COVID-19 burden are not unique to Iran; similar patterns have been observed globally—across major regions, between neighboring countries, and within nations. One study demonstrated differing COVID-19 trends even among countries with similar HDI levels. Europe and the Americas experienced significantly higher infection and mortality rates than Asia, partly due to variations in intervention timing and policies, such as strict border controls (30). In the EU, the average COVID-19 DALY during the first two waves was 4,354 years per 100,000 people, with considerable variation attributed to public health strategies, demographics, and cultural factors—for instance, herd immunity in Sweden, an older population in

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Italy, and rapid response in Estonia and Slovakia (24). A meta-analysis indicated that developing countries had higher COVID-19 prevalence and case fatality rates, which were linked to healthcare limitations, multi-generational households, and inadequate protection for older adults (12).

Several studies have highlighted a range of inter- and intra-country factors contributing to regional disparities in COVID-19 outcomes. In their detailed investigations, Chang et al. (35) categorized these factors into five groups: (1) demographic–geographic (e.g., sex ratio, population density, urbanization, education, climate, religious diversity), (2) political–legal (e.g., governance quality, corruption, leadership, legal strength, public trust), (3) socio-economic (e.g., GDP, inequality, life satisfaction), (4) technological development, and (5) healthcare-related (e.g., prior SARS experience, system infrastructure). In Iran, several studies published in recent years have underscored provincial disparities in various healthcare-related factors, including the overall number of hospital beds (36) and physicians (37). However, drawing definitive conclusions regarding the impact of these disparities on the estimated burden of disease—and the extent of that impact—requires more comprehensive and methodologically rigorous investigations, which could be addressed in future research. Here, we briefly highlight some existing evidence on these inequalities. For instance, Jalilian et al. (37) reported that, after adjusting for the confounding effect of the rural population (as a percentage of the total population), there was no statistically significant correlation between COVID-19 mortality and the distribution of human resources, hospital beds, or healthcare financial resources.

This study revealed significant gender- and region-based disparities in the burden of COVID-19 across Iran. Incidence and mortality rates demonstrated notable gaps between men and women in provinces such as Gilan and Qom, while overall mortality was lower among women, and case fatality rates consistently favored female patients nationwide. Several studies have confirmed that men generally bear a higher burden of COVID-19 than women (38-40). Although infection rates were occasionally higher among women (41), men consistently faced worse clinical outcomes, including greater rates of hospitalization, ICU admission, and mortality (38, 39). Conversely, women were significantly more likely to experience prolonged post-infection symptoms, such as anxiety, fatigue, and cognitive disturbances (42). Nevertheless, not all aspects of COVID-19 adhered to the common gender pattern. For instance, a large study conducted in China showed no statistically significant difference in the psychological burden of COVID-19 between women and men (43). Some evidence suggests that the gender gap in COVID-19 outcomes varies with age. In France, among individuals under 70 years old, men accounted for a much larger proportion of YLL than women. However, in certain age groups (e.g., the 80–89 years age group in France), women had a higher share of YLL than men, likely reflecting demographic patterns and women's higher life expectancy (43).

Our findings highlight a pronounced age-related gradient in the burden of COVID-19. Adults aged over 80 years consistently exhibited the highest case fatality and mortality rates, reaching up to 33.3% CFR in Alborz and 29.5% in Qom, while those under 20 experienced the lowest burden (national CFR: 3.3%, mortality: 0.012%). Despite this general trend, provinces such as Sistan & Baluchestan reported unexpectedly high CFRs in the youngest age group (5.7%). The mortality risk among individuals over 80 was 7–10 times higher than that in the 20–49 age group, with Semnan demonstrating the widest gap (CFR: 1.8% vs 24.5%). Middle-aged adults (50–80 years) served as the epidemiological bridge, while incidence rates also increased with age, albeit to a lesser extent (e.g., Isfahan: 22.8% in >80 vs 1.7% in 20–49). These findings align with international data. In France, 74% of YLLs were associated with individuals over 70, with 34% stemming from the 80–89 age group alone (43). South Korea reported a tenfold increase in DALYs from the 50–59 age group to those aged 80 and older (41). Similar patterns are evident in Iran (15, 28) and Europe, where YLLs comprised nearly all COVID-19 DALYs, concentrated among older adults (24). Nonetheless, the burden is influenced by social and demographic factors. In the U.S., excess mortality was higher among working-age Hispanic and Black populations (44), and in Scotland, deprived regions experienced 2.6 times more DALYs (8). Underlying conditions such as frailty and chronic diseases heighten risks in older individuals (45).

In recent years, various strategies have been developed to enhance health system preparedness for crises such as pandemics. Notable examples include the WHO Strategic Preparedness and Response Plan (SPRP) (46), the OECD report "Ready for the Next Crisis? Investing in Health System Resilience" (47), and the CDC COVID-19 Response Health Equity Strategy (48). Designing and implementing localized strategies that align with these global frameworks, while considering potential disparities across regions, age groups, genders, and socio-economic groups, can play a crucial role in reducing inequities in vulnerability and impact during future health emergencies. Therefore, the collection of essential individual-level data and socioeconomic status information is necessary to enable precise targeting. Preventive strategies in future pandemics and crises must directly address the most vulnerable groups and ensure equitable access to care. Accordingly, policies should be formulated to meet the specific needs of different population groups. Given the substantial disparities in provincial experiences and the varying success of regional strategies, public health interventions must be designed in accordance with the unique characteristics and dynamics of each province.

Limitations

The present study has several limitations that warrant consideration. Firstly, the data reported in this study were hospital-level data. Consequently, cases of COVID-19 treated on an outpatient basis and those whose disease status was mild enough not to require hospital visits were excluded from the disease burden estimation, resulting in an underestimation of the reported burden. Secondly, a limitation of utilizing hospital data is that not all regions in Iran have equal access to hospital care. Thus, a seemingly low disease burden in some underserved provinces, such as

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Ilam and Sistan and Baluchestan, may be attributed to an inability to seek hospital care or a lack of hospital admission capacity. In this study, we used hospital data (individuals covered by the Health Insurance Organization) representing approximately half of the country's population for our estimates and extrapolated it to the entire population. Consequently, the completion of electronic health records and subsequent digitization of data systems for other insurance organizations, such as the Social Security Organization, is essential for more accurate estimates. Finally, the identification and inclusion of COVID-19 patients in this study were based on the registration of ICD codes according to standards announced by WHO; however, the registration of these codes, particularly in the initial months of the pandemic, may not have been performed accurately. Despite the aforementioned limitations, the estimates of this study are considered among the most accurate burden estimates in Iran, especially at the sub-national level, due to reliance on reliable data obtained from a large insurance organization that covers a wide segment of the Iranian population. It is noteworthy that although confidence intervals were not formally calculated, several sources of uncertainty should be acknowledged. First, mortality data may be influenced by underreporting or misclassification, which could lead to overestimation or underestimation of years of life lost (YLL). Second, the use of standard life tables entails the assumption of uniform survival patterns that may not fully reflect local demographic variations. Third, population estimates, particularly for intercensal years, are subject to statistical uncertainties. Finally, disability weights are derived from global studies and may not accurately capture health priorities specific to each population. Taken together, these factors suggest that the reported DALY values should be regarded as approximate estimates rather than precise measurements.

Conclusion

This study provides a province-level assessment of the COVID-19 burden in Iran using hospital-based data, revealing substantial geographical, gender-based, and age-related disparities. Although the total DALYs estimated were lower than those reported by the Global Burden of Disease study, the results still capture a significant share of the true burden, particularly given the high proportion of fatal cases among hospitalized patients. The wide variation in DALYs across provinces, ranging from less than 700 to over 4,000 per 100,000 people, underscores the uneven impact of the pandemic, influenced by differences in incidence, case fatality, and healthcare access. Gender differences align with global trends, as men experience higher mortality rates while women face more prolonged post-infection symptoms. Age emerges as the most prominent risk factor, with the oldest age groups bearing a disproportionately high burden of death and disability. These findings highlight the necessity for localized and demographic-specific strategies to mitigate the pandemic's impact and inform future preparedness efforts. The use of composite health indicators, such as DALYs, is essential for a comprehensive assessment of the disease burden imposed by the pandemic and for measuring its overall impact. Furthermore, the collection of micro-level data on social determinants of health is vital, as it facilitates evidence-based and targeted policymaking. Policymakers should prioritize reducing mortality among older adults and high-risk groups, as a considerable proportion of the disease burden (DALYs or YLLs) arises from premature deaths in these populations. This approach ensures more effective management of the epidemic burden. Equity in the provision and distribution of vaccines and novel therapeutics must be strictly upheld. At the local level, equitable and nondiscriminatory access to testing and healthcare services for vulnerable and marginalized communities must be urgently ensured to prevent the exacerbation of health inequalities. To avoid overwhelming healthcare capacities with severe cases and to manage the substantial costs associated with hospitalizations, strategic and long-term investment in strengthening the resilience of health systems is imperative. Such investment should include reinforcing primary healthcare (PHC) organizations and enhancing the capacity and quality of nursing homes to prevent potential system collapse during future crises.

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The fluency and readability of the manuscript were enhanced through the use of an AI-assisted language tool. Furthermore, we affirm that all scientific content and interpretations accurately represent the authors' original work and opinions.

Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

All authors participated in the conceptualization and design of the study. Material preparation and data collection were conducted by Rajabali Daroudi, Soheila Damiri, Hossein Ranjbaran, Abolfazl Zendehdel, Zahra Shahali, Mahboubeh Ghavidast Kuhpayeh, and Roghayeh Esmaeili. Rajabali Daroudi, Soheila Damiri, and Behzad Raei made significant contributions to data analysis. The initial version of the manuscript was drafted by Soheila Damiri, Rajabali Daroudi, Behzad Raei, and Reza Bakhtiari Dastgerdi. All authors reviewed and approved the final manuscript.

Ethical Considerations

The protocol of this research was reviewed and approved by the Ethics Committee of the Tehran University of Medical Sciences, Deputy of Research and Technology (IR.TUMS.MEDICINE.RES.1399.966). All datasets used in this analysis had been anonymized prior to access; therefore, no informed consent was required. All study procedures complied with institutional and national regulations and followed the ethical principles outlined in the Declaration of Helsinki.

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Data Availability

The datasets generated or analyzed during the present

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study can be obtained from the corresponding author upon reasonable request.

AI Use Statement

During the preparation of this work, the authors used AI-based tools solely to improve the English language quality, including grammar, clarity, and readability. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the final version of the manuscript.

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