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COVID-19 Mortality among Iranian Physicians: Occupational Hazards and Systemic Vulnerabilities

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ABSTRACT

Background: The COVID-19 pandemic severely strained global healthcare systems, with frontline healthcare workers facing heightened risks. Iranian physicians encountered unique challenges, including resource limitations and systemic vulnerabilities, potentially contributing to elevated number of deaths within this professional group. This study aimed to investigate COVID-19-related mortality among Iranian physicians.

Methods: A nationwide, cross-sectional descriptive study was conducted using data from Iran's national COVID-19 registry spanning December 2019 to December 2021. Supplementary data, including demographic, clinical, and healthcare utilization information, were collected from families of deceased physicians via structured checklists. Descriptive statistics and comparative analyses were performed to characterize mortality patterns.

Results: Of the 1,086,258 registered COVID-19 cases, 3,483 occurred among healthcare workers, including 80 physicians who died from COVID-19.
Mortality was geographically concentrated in Tehran, Mazandaran, and Kermanshah provinces. The mean age of deceased physicians was 59.4 ± 16.2 years. Respiratory symptoms were common, while pre-existing comorbidities were less frequent than expected. A significant proportion (67.5%) of physician deaths occurred without ICU admission or mechanical ventilation.

Conclusion: COVID-19 related mortality among Iranian physicians was significantly impacted by regional disparities, older age, and likely occupational hazards and systemic healthcare limitations. The elevated number of deaths compared to global figures points to potential resource constraints and healthcare system strain in Iran. These findings emphasize the critical need for strengthened healthcare infrastructure, improved resource allocation, and enhanced protective measures for healthcare workers to mitigate future mortality risks and improve pandemic preparedness in Iran.

Keywords: COVID-19, Physician Mortality, Healthcare Workers, Iran, Epidemiology.

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Introduction

Coronavirus Disease 2019 (COVID-19) pandemic, originating in late 2019, rapidly escalated into an unprecedented global health crisis, impacting nearly every facet of human life [1]. Initially identified as a cluster of pneumonia cases in Wuhan, China, the novel coronavirus, SARS-CoV-2, spread with alarming speed across international borders, leading to millions of infections and fatalities worldwide by mid-2020 [2]. At the forefront of this global battle against the pandemic were healthcare workers, including physicians, nurses, and ancillary staff, who faced immense physical and psychological strain [3, 4]. These frontline professionals were disproportionately exposed to the virus, placing them at significantly elevated risk of infection and mortality, a situation often compounded by shortages of personal protective equipment (PPE) and overwhelming workloads[2]. The pandemic starkly illuminated pre-existing vulnerabilities within global healthcare systems, underscoring the critical need for robust infrastructure, resource allocation, and healthcare worker protection strategies [5].

Within this global context, Iranian healthcare workers, and particularly physicians, encountered a unique set of challenges during the COVID-19 pandemic. Beyond the universal stressors of increased patient loads and viral exposure, Iranian physicians faced significant occupational hazards stemming from inconsistent access to adequate PPE and the demanding nature of Infection Prevention and Control (IPC) measures [6]. Studies have documented high levels of stress, anxiety, and burnout among Iranian healthcare professionals, directly linked to communication issues, perceived lack of managerial support, and the sheer volume of workplace demands [6, 7]. Furthermore, the efficacy of IPC measures within Iranian healthcare settings was hampered by infrastructural limitations, including inadequate facilities for social distancing and insufficient rest areas, further contributing to the occupational risks faced by physicians[8]. These challenges were exacerbated by pre-existing systemic vulnerabilities within the Iranian healthcare system, including resource limitations intensified by long-standing international sanctions, which restricted access to essential medicines and medical devices[9]. This constrained resource environment, coupled with geographical disparities in healthcare infrastructure across Iran, created a complex and challenging landscape for physicians battling the pandemic [10].

Consequently, COVID-19-related deaths among Iranian physicians appear to be notably elevated in comparison to some international counterpart [11]. Indeed, Ing et al. reported that Iran accounted for the second-highest proportion (15%) of reported physician deaths among the countries included in their analysis during the early phase of the pandemic, following Italy [11]. This disproportionate impact is further underscored by regional comparisons, with Jatoi et al. noting that Iran accounted for half of all physician deaths reported in South Asia [12]. Basiri et al. further highlighted the elevated risk, demonstrating that Iranian physicians experienced significantly higher COVID-19 infection and number of deaths compared to the general Iranian population[13]. These findings underscore the urgent need for a detailed examination of the factors contributing to COVID-19 related mortality within this critical professional group in Iran.

While existing literature provides valuable insights into the occupational hazards, systemic challenges, and reported COVID-19-related deaths among Iranian physicians during the COVID-19 pandemic [7, 9, 11], a comprehensive investigation into the specific characteristics of COVID-19-related deaths within this population remains crucial. Specifically, detailed analyses of demographic factors, geographical distribution of cases, clinical presentations, and the prevalence of comorbidities among deceased physicians in Iran are essential to fully understand the scope and nature of this tragedy. Furthermore, examining the utilization of critical care resources, such as ICU admission and mechanical ventilation, in fatal cases can shed light on potential areas for healthcare system improvement and targeted interventions.

Therefore, this study aims to investigate COVID-19 related mortality among Iranian physicians. The objectives of this research are to: (1) describe the demographic profile of physicians who died from COVID-19, including age distribution and geographical location within Iran; (2) analyze the distribution of deceased physicians across different provinces to identify regional variations in mortality; (3) characterize

the clinical symptoms and pre-existing comorbidities observed in deceased physicians; and (4) examine the utilization of intensive care unit (ICU) admission and mechanical ventilation in this population. By retrospectively analyzing data on COVID-19 related deaths among Iranian physicians, this study seeks to provide a detailed epidemiological profile of mortality in this critical occupational group.

Methodology

This study was conducted as a nationwide retrospective descriptive-analytical study using data from Iran's national COVID-19 registry, supplemented by additional information collected through structured interviews with the families of deceased physicians. The study covered the period from December 2019 to December 2021 (corresponding to December 1398 to December 1400 in the Iranian calendar) and aimed to describe the demographic, clinical, and occupational characteristics, as well as the clinical course and outcomes, of physicians who died from COVID-19 in Iran.

Data Sources and Participants

The study population comprised all physicians within Iran who received a laboratory-confirmed diagnosis of SARS-CoV-2 infection via a positive Polymerase Chain Reaction (PCR) test. The primary source of data was Iran's national COVID-19 registry system. This centralized, nationwide database systematically records all confirmed COVID-19 cases, providing a robust foundation for identifying the study cohort. To enrich the dataset with detailed clinical and outcome information, a supplementary data collection process was implemented, focusing on physicians identified as deceased within the registry.

To enhance data accuracy and reliability, information obtained through structured interviews with the families of deceased physicians was cross-checked against available hospital records.

Data Collection Procedures

For deceased physicians, secondary data collection was conducted through direct contact with their families. Structured checklists were meticulously developed and utilized as the data collection instrument. These checklists were designed to gather comprehensive information across several key domains, including demographic characteristics, clinical presentations, pre-existing comorbidities, the progression of the disease, healthcare service utilization, and COVID-19 vaccination status. Data collection from families was conducted by trained researchers who followed a standardized protocol to ensure consistency and accuracy in the information gathered.

Although occupational specialty, workplace, and contact with COVID-19 patients were included among the variables considered during data collection, these variables were not included in the final descriptive analysis, as the primary analytical focus of the study was on the demographic and clinical characteristics and outcomes of deceased physicians.

Variable Definitions

The study variables were systematically categorized to facilitate a thorough and structured analysis of factors potentially associated with COVID-19 mortality in physicians. These categories and specific variables included. The categorization of variables was primarily intended to facilitate descriptive presentation and comparison of participant characteristics, taking into consideration the clinical and descriptive relevance of each variable and the structure of the collected data.

- Demographic Variables: Age (categorized into <30 years, 30–50 years, 50–70 years, and >70 years), Gender (male, female), Marital status (single, married, separated/divorced, widowed), and Number of children (no children, 1, 2, 3, or more than 3 children).
- Clinical Variables: Underlying diseases (presence or absence of hypertension, cancer, kidney disease, asthma, hypothyroidism, dyslipidemia, immunodeficiency, and other specified conditions), Clinical symptoms (onset, nature, and progression of symptoms, including body aches, sore throat, respiratory symptoms, fever, and chills), Time from symptom onset to death (categorized as less than 1 week, 1 to 2 weeks, and more than 2 weeks), Duration of hospitalization (categorized as not hospitalized, less than 5 days, 5–10 days, 10–15 days, or more than 15 days), ICU admission (yes/no), and Mechanical ventilation use (yes/no).

Table 1: Distribution of Physicians Who Died from COVID-19 Across Different Provinces of Iran, December 2019–December 2021 Iran

Province	Number of deceased physicians
Tehran	20 (25%)
Mazandaran	15 (18.75%)
Kermanshah	12 (15%)
Gilan	10 (12.5%)
West Azerbaijan	6 (7.5%)
Khorasan Razavi	6 (7.5%)
East Azerbaijan	3 (3.75%)
Chaharmahal and Bakhtiari	3 (3.75%)
Ghom	2 (2.5%)
Kordestan	2 (2.5%)
Kerman	1 (1.25%)

- Vaccination Status: COVID-19 vaccination status (categorized as unvaccinated, 1 dose, 2 doses, and 3 or more doses).
- Occupational Variables: Medical specialty (general practitioner, internal medicine specialist, infectious disease specialist, surgeon, anesthesiologist, emergency physician, and other specialties), and Place of employment (hospital, clinic, healthcare center, or private practice).
- Outcome Variable: Disease outcome (death due to COVID-19 or recovery), with the date of death recorded for deceased individuals.
- Contact with COVID-19: Assessment of physicians' exposure to COVID-19 patients based on reported history and workplace setting.

Statistical Analysis

The collected data were analyzed using SPSS software, version 22 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the characteristics of the study population. Normally distributed continuous variables are presented as mean and standard deviation (±SD), while non-normally distributed variables are presented as median and interquartile range (IQR). Categorical variables are presented as frequencies and percentages.

Results

During the study period, a total of 1,086,258 COVID-19 cases were registered nationwide, including 3,483 cases among healthcare workers. All 80 physicians who died from COVID-19 were included within this group of 3,483 infected healthcare workers.

The distribution of deceased doctors due to COVID-19 across different provinces shows significant regional variations. Table 1 presents the distribution of doctors who died due to COVID-19 in various provinces of the country.

Figure 1 demonstrates the age distribution of deceased physicians. According to the results, 6.25% of the deceased physicians were younger than 30 years, 25% were aged 30–50 years, 43.7% were aged 50–70 years, and 25% were older than 70 years. A considerable proportion of the reported deaths occurred among older physicians. The mean age of the deceased individuals was 59.4 ± 16.2 years, and the median age was 55 years.

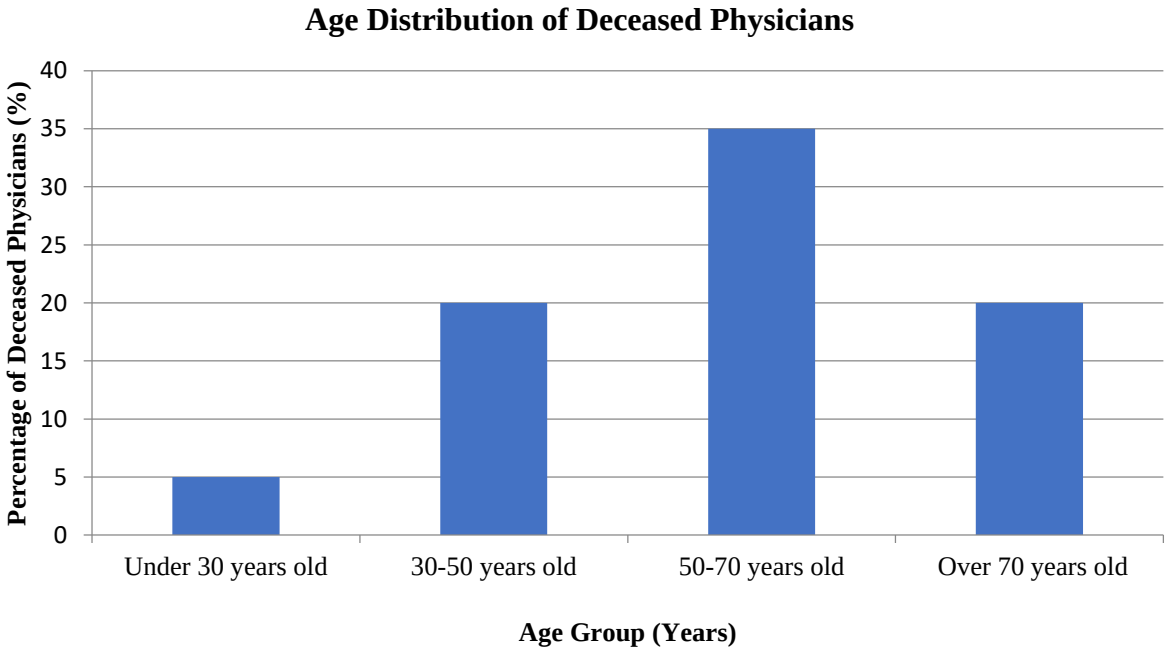

Figure 1. Frequency distribution of categorical age of the study population

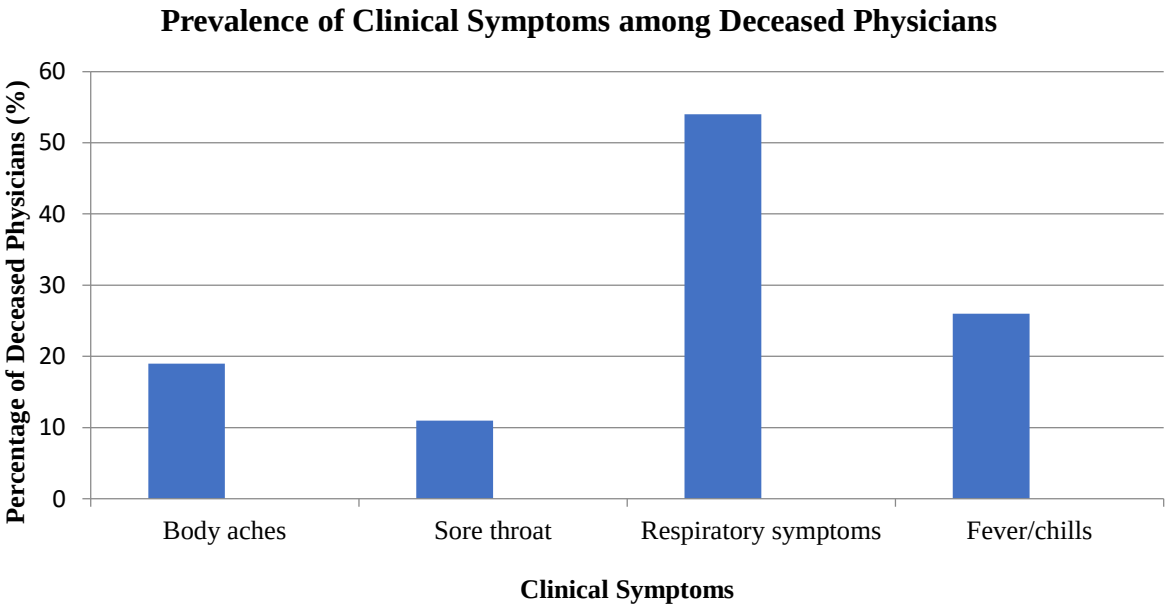

Figure 2. Frequency distribution of each symptom in the study population

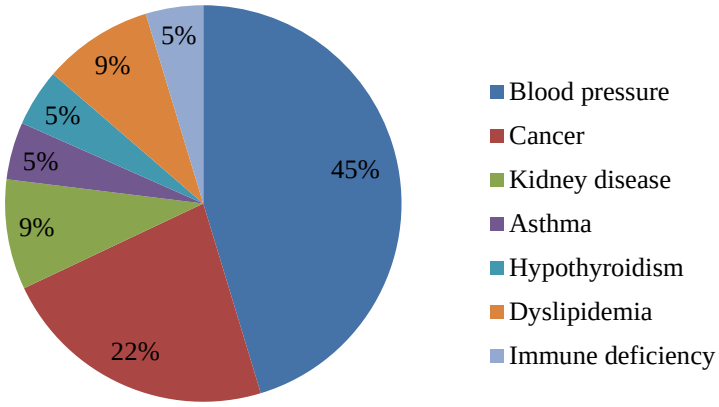

Figure 3. Distribution of each underlying disease in the population with these diseases

An analysis of clinical symptoms in deceased physicians revealed that 23.3% (18 individuals) experienced body aches, 14% (11 individuals) suffered from sore throat, and respiratory symptoms were observed in 67.5% (54 individuals). Fever and chills were reported as common symptoms in 32.5% (26 individuals) of the individuals. Figure 2 shows the prevalence of each symptom in the studied population.

Respiratory symptoms were the most frequently reported clinical manifestations, affecting 67.5% (54/80) of deceased physicians, whereas sore throat was reported in 14.0% (11/80) of cases.

Hypertension, as a significant comorbidity, is often associated with adverse outcomes in COVID-19 and presented in 11.6% of physicians. Other chronic conditions, such as asthma and hypothyroidism, were very rare among the study group, each affecting only 1.2% of them. The low prevalence of asthma, especially considering the respiratory nature of COVID-19, was significant. These findings may suggest that asthma did not play a critical role in adverse outcomes in this group, or they may reflect effective management of this condition among these healthcare professionals.

The prevalence of dyslipidemia was also low, with only 2.3% of the physicians affected. This finding indicated that abnormal lipid levels were not a common issue in this population and aligned with the overall low prevalence of chronic conditions observed in the study. Dyslipidemia is often associated with cardiovascular diseases, which have been a concern in COVID-19 patients, but it does not appear to have been a significant factor among these physicians. Figure 3 shows the distribution of each underlying condition among the population with various comorbidities.

One critical aspect of COVID-19 clinical management in this population was the use of mechanical ventilation. According to Figure 4, regarding ICU admission the results showed that 26 physicians (32.5%) were admitted to the ICU, while 54 doctors (67.5 %) died without being hospitalized in the ICU.

Among the 26 physicians admitted to the ICU, 7 (27%) required mechanical ventilation, whereas 19 (73.1%) did not receive mechanical ventilation (Figure 5). The percentages presented in Figure 5 were calculated using the 26 ICU-admitted physicians as the denominator.

According to Figure 4, 26 physicians (32.5%) were admitted to the ICU, while 54 physicians (67.5%) were not admitted to the ICU. The percentages were calculated using the total study population (n = 80) as the denominator. Among the 26 physicians admitted to the ICU, 7 (26.9%) received mechanical ventilation, whereas 19 (73.1%) did not receive mechanical ventilation (Figure 5).

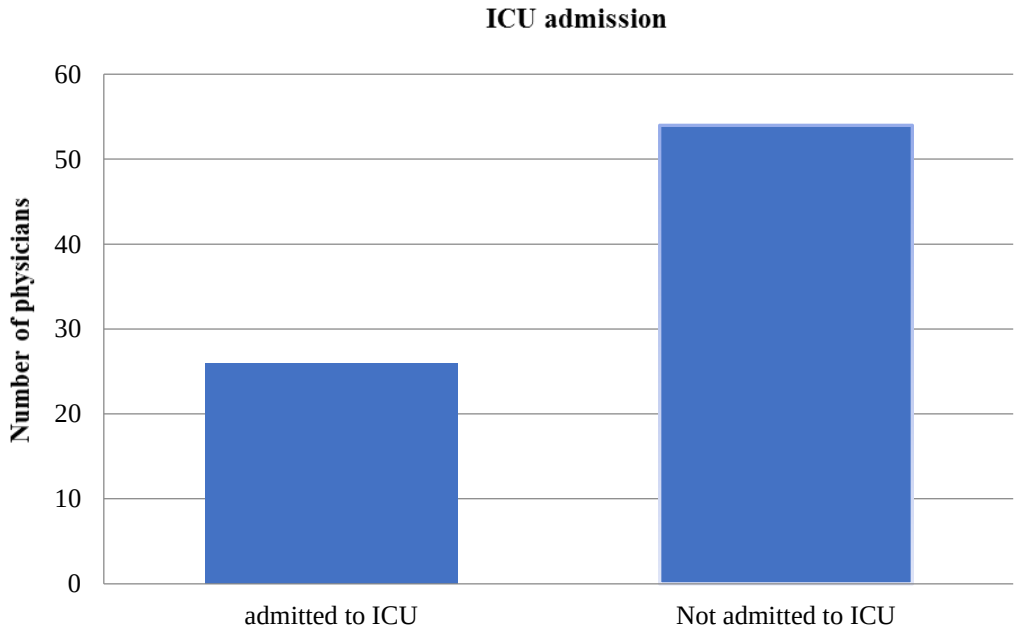

Figure 4. Status of the study population regarding ICU admission

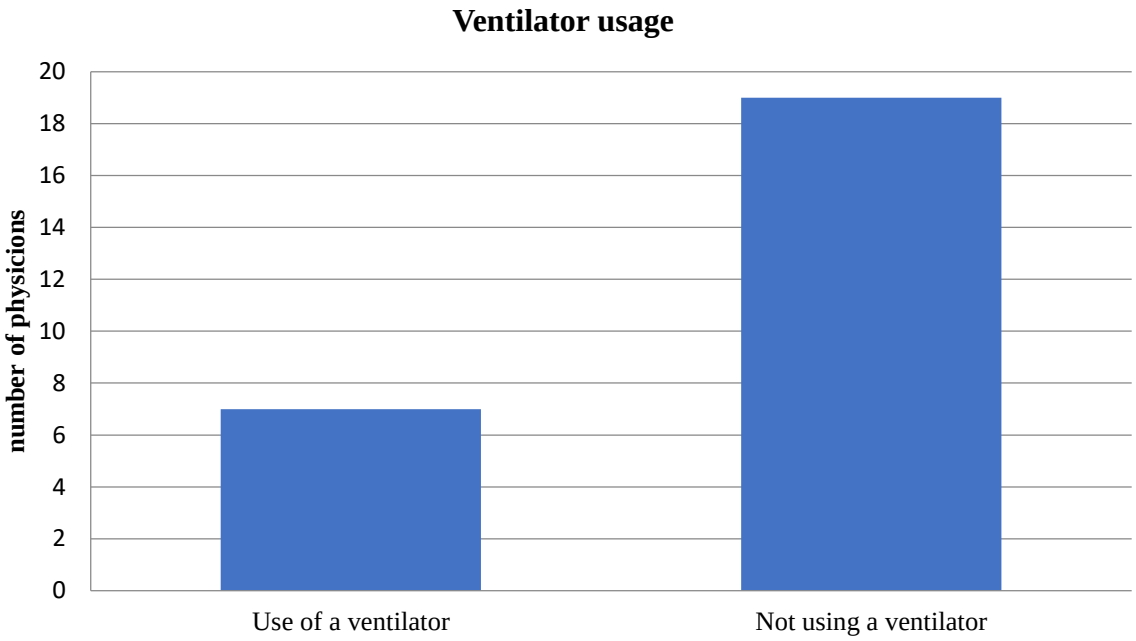

Figure 5. Status of the study population regarding ventilator usage

Discussion

This nationwide study provides an overview of COVID-19 mortality among Iranian physicians from the pandemic's onset in December 2019 to December 2021. Among 1,086,258 registered COVID-19 cases, 3,483 were reported among healthcare workers (HCWs), including 80 physicians who died from the infection. Our analysis of these 80 deaths highlights the substantial burden of COVID-19 on physicians and provides insights into the geographical distribution, demographic characteristics, clinical presentations, and potential healthcare system challenges associated with physician mortality in Iran.

Magnitude and Geographical Context of Physician Mortality in Iran

The concentration of physician fatalities in provinces like Tehran (25%), Mazandaran (18.75%), and Kermanshah (15%) indicates considerable geographical variation in the distribution of reported deaths. This pattern may partly reflect differences in population size and viral transmission, particularly in densely populated urban centers such as Tehran [14]. In addition, regional differences in healthcare system capacity, resource allocation, and patient loads may have contributed to variations in the reported number of deaths. This aligns with international observations where regional differences in HCW mortality were linked to healthcare access and system resilience [15, 16]. Iranian studies have previously highlighted geographical imbalances in healthcare resources [10, 17], suggesting that these pre-existing disparities may have represented relevant contextual factors during periods of high healthcare demand, although their specific contribution to physician mortality was not assessed in this study. suggesting these pre-existing disparities may have further increased physicians' vulnerability during periods of high healthcare demand.

Direct comparison of mortality rates across countries is challenging because the total number of physicians at risk in Iran during the study period was unavailable. Furthermore, the absolute number of physician deaths in our study does not allow the calculation of a physician-specific mortality rate. Therefore, international comparisons should be interpreted cautiously, particularly when differences in the studied populations and denominators are taken into account.

[11, 14]. The reported mortality rates among HCWs in Brazil (~132/100,000 HCWs) and South Africa (~289/100,000 HCWs) by late 2021 provide an international context for understanding the occupational burden of the pandemic. However, these figures cannot be directly compared with our findings because they represent mortality rates among HCWs as a broader professional group, whereas our study reports the absolute number of deaths among physicians without a corresponding denominator for the physician population at risk.

Demographic Vulnerability and Clinical Profile: Convergence and Divergence

Our finding that older physicians accounted for a substantial proportion of deaths (mean age 59.4 years, median age 55 years; 68.75% were older than 50 years) is consistent with global data identifying advanced age as a major risk factor for severe COVID-19 and mortality across all populations, including HCWs [14, 15, 18]. This highlights the substantial loss of experienced medical personnel during the pandemic.

Another notable finding was the relatively low prevalence of major comorbidities typically associated with severe COVID-19 outcomes in the general population. Hypertension was present in only 11.6%, and conditions like CKD, diabetes (often linked with dyslipidemia), asthma, and immunodeficiency were rare or absent in our deceased physician cohort. Another notable finding was the relatively low prevalence of major comorbidities typically associated with severe COVID-19 outcomes in the general population [19, 20], CKD [18], hypertension, and diabetes [21] as strong independent predictors of mortality, even among HCWs [16]. While HCWs might represent a generally healthier subgroup than the general population, the low prevalence observed here is particularly noteworthy among those who succumbed to the disease. Several possible explanations may account for this finding. First, comorbidities may have been underreported by family members, despite the use of structured checklists for data collection. Second, the Iranian physician cohort may have had a lower baseline prevalence of these specific non-communicable diseases (NCDs) than populations reported in international studies.

Third, intense and sustained occupational exposure may have contributed to severe outcomes, even among physicians without significant underlying health conditions. Several possible explanations may account for this finding. First, comorbidities may have been underreported by family members, despite the use of structured checklists for data collection. Second, the Iranian physician cohort may have had a lower baseline prevalence of these specific non-communicable diseases (NCDs) than populations reported in international studies. Third, intense and sustained occupational exposure may have contributed to severe outcomes, even among physicians without significant underlying health conditions [22, 23].

However, because our study included only deceased physicians and did not include a comparison group of surviving infected physicians, the relative contributions of comorbidities and occupational exposures to mortality cannot be established.

The predominance of respiratory symptoms (67.5%) aligns with the primary pathology of COVID-19. In contrast, sore throat was reported in only 14% of cases, indicating that this specific symptom was considerably less frequent than respiratory symptoms overall. The observed difference highlights the importance of distinguishing between the broader category of respiratory manifestations and individual symptoms when interpreting the clinical presentation of COVID-19.

Occupational Exposures and Potential Risks

In light of the relatively low prevalence of comorbidities observed in our cohort, occupational exposures warrant consideration as a possible context for understanding physician mortality during the study period. However, our findings do not establish occupational factors as the dominant or direct causes of death. International literature extensively documents the risks associated with direct patient care, presence during aerosol-generating procedures (AGPs), inadequate PPE quality or inconsistent use, extended work hours, and contact with contaminated environments [20, 22, 23]. Although these factors may have increased physicians' vulnerability during the pandemic, our study did not include a detailed assessment of specific procedures, intensity or duration of exposure, PPE availability or use, or working hours. Furthermore, although occupational specialty, workplace, and contact with COVID-19 patients were considered during data collection, these variables were not included in the final descriptive analysis. Therefore, the observed deaths cannot be directly attributed to specific occupational exposures. Shortages of appropriate PPE, a widely reported global issue particularly in resource-constrained settings [5, 11, 24, 25], have been discussed in the literature as potential contributors to occupational risk. However, their specific role in the outcomes observed in our cohort cannot be determined [26]. The high mortality among Internal Medicine specialists reported elsewhere [27] highlights the potential vulnerability of physicians in specialties involving frequent patient contact. However, because specialty-specific mortality and exposure data were not included in our final descriptive analysis, this finding cannot be directly extrapolated to our cohort.

Critical Care Utilization and Clinical Course

The observation that a majority of deceased physicians (67.5%) died without ICU admission is noteworthy and warrants cautious interpretation. Although this finding raises concerns regarding potential challenges in access to critical care, it does not necessarily indicate insufficient ICU capacity, resource shortages, or triage-related decisions. This finding should be interpreted in the context of reports from other resource-strained settings, where ICU bed shortages and staffing constraints were identified as potential challenges during pandemic surges [28, 29] and, in some settings, necessitated difficult triage decisions [30]. Sanctions-related constraints have also been discussed as potential contextual challenges affecting resource availability [9]; however, their specific impact on critical care access among physicians in our study was not assessed.

However, this finding must also be considered alongside patterns of clinical deterioration. The phenomenon of "silent hypoxemia" [31], in which patients develop severe oxygen desaturation without experiencing proportionate dyspnea, may delay recognition of disease severity or timely medical evaluation. This possibility may be particularly relevant to healthcare workers (HCWs), who may continue working despite experiencing symptoms. However, our study did not assess help-seeking behavior or the timing of

clinical recognition. Furthermore, literature suggests that extremely high viral exposures, potentially faced by frontline physicians, could lead to exceptionally rapid clinical deterioration, with death occurring before ICU admission could be effectively initiated or shortly thereafter [16, 22]. Although these mechanisms may offer possible explanations for some deaths occurring without ICU admission, neither exposure intensity nor the timing and rate of clinical deterioration were measured in our study; therefore, these explanations remain speculative.

Therefore, the high proportion of deaths occurring without ICU admission may reflect a combination of clinical and healthcare-related factors, but their individual contributions cannot be determined. Because our study did not collect information on ICU bed availability, hospital capacity, reasons for non-admission, or the clinical circumstances surrounding ICU referral, this finding should not be interpreted as direct evidence of insufficient critical care capacity or restricted access to ICU services. Among the 26 physicians admitted to the ICU, 7 (26.9%) received required mechanical ventilation, whereas 19 (73.1%) did not receive mechanical ventilation (Figure 5). These figures describe the use of mechanical ventilation among ICU-admitted physicians; however, the clinical indications for ventilation and the reasons for its non-use in the remaining patients were not available in our dataset.

The Crucial Missing Element: Vaccination Impact

An important limitation of our study is the absence of an analysis stratified by COVID-19 vaccination status, despite vaccination status being among the variables collected. The study period (December 2019 to December 2021) encompasses significant portions of Iran's national vaccination campaign, including the rollout of primary vaccination series. International evidence overwhelmingly demonstrates that vaccination substantially reduced COVID-19 severity, hospitalization, and mortality among HCWs, even with breakthrough infections caused by variants like Delta and Omicron [32-36]. While effectiveness against infection waned, protection against severe outcomes remained substantial, particularly after booster doses [1, 37, 38]. Therefore, presenting vaccination status and examining clinical characteristics according to vaccination history would have provided additional insight into the clinical profiles of deceased physicians. However, because our study included only deceased physicians and lacked a comparison group of surviving infected physicians, it could not establish the association between vaccination status and mortality risk or evaluate vaccine effectiveness. The absence of this analysis represents a limitation in contextualizing the impact of vaccination during the later phase of the study period.

Psychosocial Burden and Systemic Stress

The immense psychological toll on HCWs globally is well-documented, manifesting as stress, anxiety, depression, and burnout [6, 7, 39]. Psychological distress has also been discussed as a potential contributor to altered immune function [22]; however, its direct effect on COVID-19 severity or mortality cannot be inferred from these observations. While psychosocial stressors were not directly assessed in our study, the intense pressure, long hours, fear of infection, and grief experienced by HCWs during the pandemic may have contributed to the challenging environment and overall system strain, with possible implications for care quality and individual well-being. Nevertheless, these factors were not measured in our cohort, and their contribution to physician mortality remains unknown.

Strengths and Limitations

This study's strengths include its nationwide scope and use of a national registry, as well as its focused investigation on physician mortality with detailed data collection from families of the deceased. However, several limitations must be acknowledged. The retrospective descriptive-analytical design limits causal inference. Although supplementary clinical, comorbidity, and vaccination-related information obtained through family interviews was cross-checked against available hospital records, the retrospective nature of data collection and reliance on family-reported information for certain details may still have introduced some degree of recall and reporting bias. Furthermore, the absence of a direct comparison group of infected physicians who survived limits the ability to identify factors associated with mortality or assess their relative contributions to

fatal outcomes. The critical omission of vaccination status analysis, despite its collection during the study, hinders a full understanding of the potential role of vaccination in the clinical characteristics and outcomes observed over the study period. Potential underreporting in the national registry system cannot be excluded. Finally, the occupational data lacked granularity regarding specific high-risk activities (e.g., frequency of AGPs). Although occupational specialty, workplace, and contact with COVID-19 patients were considered during data collection, these variables were not included in the final descriptive analysis. Furthermore, the total number of SARS-CoV-2-infected physicians and the overall physician population at risk in Iran were unavailable. Consequently, a physician-specific population-based mortality rate could not be calculated, and the findings should be interpreted in terms of reported COVID-19-related deaths rather than the overall mortality burden among Iranian physicians.

Implications and Future Directions

These findings highlight the need for continued attention to health policy and healthcare system preparedness in Iran. Key priorities include strengthening health system resilience by investing in critical care and ensuring equitable resource allocation [10, 17]. Robust protocols should be implemented to protect HCWs through guaranteed access to PPE access, training, and systemic controls [40, 41]. Timely vaccination [42] and sustained mental health support [43] are also vital. Future longitudinal studies and the development of forecasting models [44] are needed to track HCW outcomes with detailed data on exposures, vaccinations, and comorbidities, particularly to clarify the relatively low prevalence of comorbidities observed in our cohort and compare deceased and surviving physicians to improve mortality risk assessment. Further research should also investigate the potential contributions of occupational exposures, healthcare resource availability, and vaccination status to clinical outcomes.

Conclusion

The COVID-19 pandemic inflicted a heavy toll on Iranian physicians, marked by high mortality that appears substantial even in international comparisons. While older age was a clear risk factor, the surprisingly low prevalence of conventional comorbidities underscores the likely overwhelming impact of occupational hazards – intense viral exposure, potential PPE inadequacies, and systemic pressures within a resource-strained healthcare system, evidenced further by the high number of deaths occurring outside of ICU settings. Regional disparities highlight inequities demanding attention. The vital protective role of vaccination, extensively documented globally, remains unanalyzed here but is paramount for future protection. Protecting Iran's physician workforce is not only an ethical imperative but essential for maintaining healthcare system functionality during public health crises. Addressing the systemic vulnerabilities revealed by this study is crucial for enhancing resilience against future threats.

Authors' contributions

M.A and K.K designed the study interpreted the patients' data, managed the patients, and supervised the research. N.H and Z.KH collected and interpreted the patient data. N.H and A.T interpreted the patients' data and wrote the manuscript. M.J A and A.S interpreted the patient data, drafted, and wrote the manuscript. A.Z. and H.A participated in the descriptive analysis, the initial drafting of the article, and the final drafting of the discussion section. All the authors helped revise the manuscript.

Data acquisition and ethical considerations

This study was conducted in full accordance with the ethical principles of the Declaration of Helsinki. Prior to commencement, the research protocol was rigorously reviewed and approved by the Ethics Committee of Mashhad University of Medical Sciences. Ethical approval was granted on 7th October 2022 with the ethics committee approval code IR.MUMS.REC.1401.223. Strict measures were implemented to ensure patient confidentiality and data security throughout the study. For data collection involving family members of deceased physicians, verbal informed consent was obtained from the next of kin prior to data collection. This consent process, along with the overall study protocol, was specifically reviewed and approved by the Ethics Committee to ensure ethical appropriateness for research involving deceased individuals and sensitive personal information.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data availability statement

The dataset supporting this article's conclusions is confidential and cannot be made publicly available. However, data may be available upon reasonable request and with permission of the original data providers, subject to compliance with applicable confidentiality agreements and data protection laws, via contact through the corresponding author.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

In the development and composition of this document, generative AI was not utilized beyond the scope of fundamental grammar, spelling, and reference verification tools.

Ethical Considerations

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