

RESEARCH ARTICLE

Case fatality and mortality rates, socio-demographic profile, and clinical features of COVID-19 in the elderly population: A population-based registry study in Iran

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Abstract

We aimed to investigate COVID-19 case fatality rate (CFR), mortality, and screening in the older population of East Azerbaijan Province. We conducted a population-based registry study from Death Registration System in the elderly population (N = 433 445) from the outbreak that emerged up to May 30, 2021 (before vaccination). We analyzed CFR and mortality rates due to COVID-19 as well as the case findings and characteristics in the elderly population. Logistic regression analysis was carried out for the association between COVID-19 mortality and effective factors. During the study, the province had 18 079 confirmed cases and 4390 deaths. The male to female CFR risk ratio was 3.2. The overall CFR and mortality rates were 24% and 1%, respectively. CFR and mortality ranged from 9.56% to 0.37% in the 60–64 age group to 70% and 2.6% in the age group ≥85 years, respectively. We found a significant trend in CFR and mortality of COVID-19 with advanced age. Male sex, advanced age, marital status, and living alone were associated with an increased risk of COVID-19 fatality. COVID-19 mortality measures were higher in the older population of this province. Advanced treatment supports and interventions are needed to reduce mortality rates of COVID-19 in the elderly population.

KEYWORDS

case fatality, COVID-19, East Azerbaijan, elderly, mortality, screening, aging population

1 | INTRODUCTION

On December 31, 2019, China reported to the World Health Organization (WHO) an outbreak of acute pneumonic disease, Coronavirus 2019 (COVID-19), from Wuhan.¹ On February 20, 2020, COVID-19 was detected in Qom city in Iran. Almost 2 weeks later, the Iranian Health Ministry announced that the coronavirus has been spread in all of Iran's provinces.² The frequency of infected cases, case fatality rate (CFR), and percent of improvement for COVID-19 until May 1, 2021 in Iran have been reported as 2 311 813, 3.59%, and 91.46%, respectively.³

The WHO predicts that the world's elderly population will increase from 800 million to 2 billion by 2050. Of them, 29% are in developed countries and 9% in developing countries. According to the latest national census, the prevalence of the aging population was 9.69% and 11.74% in Iran and East Azerbaijan province, respectively. Findings indicated that in the United States, Italy, Spain, France, the United Kingdom, and Iran the majority of deaths due to COVID-19 occur in the elderly.^{4,5} The aging population and the incidence of chronic infection require long-term care in these countries.⁶ Centers for Disease Control and Prevention (CDC) reported that the rate of hospitalization, admission to the Intensive care unit (ICU), and death

due to COVID-19 in the elderly is higher compared to other age groups.⁷ The elderly are considered among the most vulnerable group of society in the COVID-19 pandemic for a variety of reasons: weakened immune system, chronic underlying diseases that can mask the symptoms of infection, multidrug therapy, inattention, and inability to fully observe the principles of personal hygiene and self-care, poor hygiene of the living environment, loneliness, and lack of adequate support from other family members, so forth.⁸

It is estimated that out of every 10 deaths due to COVID-19, 8 cases occurred in people with age group 65 years and above. This proportion is 90 and 630 times higher in the age groups of 65–74 and above 85 years than people with 18–29 years, respectively.⁷ Likewise, the rate of COVID-19 hospitalization increases with advanced age. The risk of hospitalization in 74–65 years is five times more than in the age group of 18–29 years.^{9,10}

Since to make the best decisions on COVID-19 prevention and control measures and regulations, an accurate estimation of mortality and epidemiological measures are required, especially fatality and mortality rates and associated comorbidities in high-risk groups.

Previous investigations on COVID-19 mortality often focused on hospitalized patients with limited participants,⁵ adult age groups,¹¹ and children.¹² Given that the risk of case fatality and mortality due to COVID-19 is higher in elderly patients, advanced prevention and treatment supports are required. Quantifying mortality measures, risk factors, and early detection of COVID-19 infection among older people is an essential step in COVID-19 prevention and planning for health managers and policymakers. In the elderly population, mortality measures and characteristics of COVID-19 are poorly understood at the population level, at least in Iran. We aimed to estimate and analyze the CFR and mortality rates due to COVID-19 in the older population of East Azerbaijan Province, Iran.

2 | MATERIAL AND METHODS

2.1 | Study design and setting

This population-based registry study was performed based on the Death Registration System (DRS) or known vital registration system, and Health Information System in East Azerbaijan Province (Tabriz University of Medical Sciences) from February 20, 2020 (emerged COVID-19 outbreak in Iran) up to May 30, 2021 (*before or concurrent with COVID-19 vaccination*). The study population was the elderly population (above 60 years) living in East Azerbaijan Province of Iran. DRS system is a valid and reliable data source for mortality in Iran.^{13,14} In the DRS system, all deaths, as well as COVID-19 deaths, were collected from all over community-based health houses and health centers, hospitals, legal medicine, civil registration bureau, cemeteries, and other probable sources based on the same “death certificates” in each county and then all confirmed deaths were included in the DRS.

We reviewed and analyzed estimates for mortality and morbidity due to COVID-19 for the total older population of East Azerbaijan

Province from the outbreak that emerged up to May 30, 2021. We calculated COVID-19 CFR and mortality rate via the DRS system. CFR was calculated by dividing the number of people who died from COVID-19 by all cases diagnosed with COVID-19 infection during the study time interval as defined in the previous study.¹⁵ Mortality rate was calculated by dividing the total number of deaths due to COVID-19 infection by the total elderly population during the study time interval.¹⁵

We also collected characteristics and common symptoms of the older population who had been screened for COVID-19. Since the outbreak of coronavirus, according to the plan of the Iran Health Ministry, in the first stage, all suspected people are screened by healthcare providers and if necessary, they are referred to clinicians to continue the process of diagnosis and treatment.^{16,17} In the health care system of Iran, COVID-19 morbidity statistics, screening, prevention, and intervention programs have been collected from all hospitals and sampling centers, and then registered by the Primary Health Care system of the University. COVID-19 case findings, suspected, and confirmed cases have been recorded by the various Community Health Workers (CHWs).¹⁶ CHWs have face-to-face contact with large numbers of community members as part of their usual routine performance in the health care system of Iran.¹⁸ Detailed methods of COVID-19 case finding and screening programs among Iranian health workers have been published previously.^{16,17}

2.2 | Inclusion and exclusion criteria

All over 60 years of age were eligible if they had inclusion criteria as listed below: older people who resided in one city of the East Azerbaijan Province for at least 6 months except Sarab and Maragheh (since these two cities have separate health register systems). We also excluded subjects who did not match the inclusion criteria.

2.3 | Statistical analysis

STATA software version 13.0 was carried out for data analysis. Variables were summarized by frequencies, percentages, and standard deviation. χ^2 test was used to assess the relationship between COVID-19 death and dichotomous variables. *T*-test was used for the comparison of continuous variables. Logistic regression analysis was used to estimate odds ratios and 95% confidence intervals (CIs) for COVID-19 mortality and morbidity risk and effective factors.

3 | RESULTS

Table 1 shows the demographic characteristics of the older population (total) in East Azerbaijan Province. Overall, the older population size was 433 445 people in this province. The sex distribution for the older population of the Province was 223 688 (51.62%) females, and the sex ratio (female to male) was 1.07. The age distribution was

TABLE 1 Demographic characteristics of the older population of East Azerbaijan Province based on the national census in 2020

Variable	N = 433 445 (%)	Sex	
		Male (%) N = 209 757	Female (%) N = 223 688
Age groups			
60–64	141 490 (32.65)	73 543 (51.98)	67 947 (48.02)
65–69	105 619 (24.38)	53 949 (51.08)	51 670 (48.92)
70–74	68 564 (15.82)	33 110 (48.29)	35 454 (51.71)
75–79	50 375 (11.62)	23 224 (46.10)	27 151 (53.90)
80–84	37 965 (8.76)	12 898 (33.97)	25 067 (66.03)
≥85	29 332 (6.77)	12 933 (44.09)	16 399 (55.91)
Location			
Urban	305 023 (70.39)	136 081 (44.61)	168 942 (55.39)
Rural	128 322 (29.61)	73 576 (57.34)	54 746 (42.66)
Married status			
Single	3897 (0.9)	1663 (42.67)	2234 (57.33)
Married	331 652 (76.53)	195 819 (59.04)	135 833 (40.96)
Divers	3431 (0.79)	1183 (34.48)	2248 (65.52)
Widow	94 365 (21.78)	10 992 (11.65)	83 373 (88.35)
Living condition			
Alone	82 447 (19.02)	33 099 (40.15)	49 348 (59.85)
With family	350 898 (80.98)	176 558 (50.32)	174 340 (49.68)

141 490 (32.65%) in the 60–64 age group. The majority (70.39%) of older people lived in urban areas. More than three-quarters of older people were married while 19% of them lived alone. Of those, almost 60% were females.

Table 2 indicated COVID-19 infection, CFR, and mortality by demographic characteristics in the older population in East Azerbaijan Province from February 20, 2020 up to May 30, 2021. During the study, the province had 18 079 (4.17%) confirmed cases and 4390 (24.28%) deaths. Regarding sex distribution, 3293 (75%) and 5398 (48%) of death and confirmed cases were males. The overall CFR and mortality rates were 24.28% and 1.01% in the older population, respectively. CFR and mortality ranged from 9.56% and 0.37% in the 60–64 age group to 70.94% and 2.64% in the age group ≥85, respectively. We found a significant trend in CFR and mortality due to COVID-19 by advanced age ($p = 0.001$).

Regarding sex, CFR was 37.89% and 11.68% in males and females, respectively. The male to female risk ratio was 3.2. Similarly, the mortality rate in males was higher than in females (1.57% vs. 0.50%). Analysis indicated that the male sex increased odds of COVID-19 death more than four times that of females. We found a significant positive association between marital status (widow and diverse) and life alone with death by COVID-19 infection ($p = 0.001$).

We also found no association between COVID-19 death and habitat in urban and rural areas ($p = 0.316$).

Table 3 presents common features of COVID-19 suspected cases and results of the screening program based on sex distribution in the elderly population of East Azerbaijan Province from February 20, 2020 up to May 30, 2021. The overall elderly population of 433 345 (100%) were screened for suspected signs and symptoms for COVID-19 infection during the study (up to May 30, 2021). Of those, 223 688 (51.62%) were females. Among screened suspected cases of the elderly population, 24 346 (5.62%) and 48 412 (1.12%) were conducted for paraclinical tests and rapid diagnostic test (RDT), respectively. Moreover, 1.51% of participants had a history of cough during the past 2 weeks. Concerning cough, fever, gastrointestinal symptoms, needs for hospitalization, required for two drug regimes, required for the paraclinical test, and required for RDT test; there were significant differences between male and female.

4 | DISCUSSION

Our population-based registry study was provided estimates for morbidity, and mortality measures of COVID-19, and the most comprehensive features, demographic characteristics, and results of the screening program in the older people of East Azerbaijan province up to date at the population level. To our knowledge, this is the first study to report detailed results of COVID-19 morbidity and mortality rates in the older population of East Azerbaijan Province based on the DRS system as the most comprehensive and valid death data source in Iran.

In this study, CFR and mortality ranged from 9.56% to 70.94% and 0.37% to 2.64% in the older population, respectively. Overall, COVID-19 was responsible for 32.07% and 1.01% of CFR and mortality rate in the elderly population of the Province, respectively. The study found a high rate of COVID-19 mortality in advanced age groups and male sex, which is consistent in hospitalized patients in Iran⁵ and Brazil.¹⁹

In the current study, the proportion of COVID-19-confirmed cases was 4.17% among the elderly population of this province during the study. This study is one of the rare studies which investigated COVID-19 mortality and epidemiological aspects in Iran at the community level in the older population, while previous studies had focused on hospitalized patients.^{3,5,20–22}

CFR is varied from 0.4% to 15% in the general population.^{15,23} Systematic review studies were reported pooled estimated of 2.67%²⁴ and 7.4%²⁵ due to COVID-19 in the general population. However, limited studies estimated CFR in elderly patients and populations. A study in Korea found 20.4% CFR for COVID-19 in the elderly patients,²² which was lower than our study (32%). In the present study, the CFR was 9.56% among patients aged 60–64 years, 16.49% aged 65–69 years, 23.94% aged 70–74 years, 35.72% aged 75–79, 50% aged 80–84 years, and 70.94% among those aged ≥85 years.

TABLE 2 COVID-19 case fatality and mortality by demographic characteristics in the older population of East Azerbaijan Province from February 2020 to May 2021

Variable	COVID-19 infection			CFR (%)	Mortality (%)	OR (95% CI)	p value
	Alive	Death	Total				
Total cases	N = 13 689	N = 4390	18 079	24.28	1.01	-	-
Age group							
60–64	4926 (35.99)	521 (11.87)	5447 (30.13)	9.56	0.37	1	1
65–69	3831 (27.99)	757 (17.24)	4588 (25.38)	16.49	0.72	1.86 (1.65–2.11)	0.001
70–74	2404 (17.56)	757 (17.24)	3161 (17.48)	23.94	1.10	2.98 (2.63–3.36)	0.001
75–79	1425 (10.41)	792 (18.04)	2217 (12.26)	35.72	1.57	5.25 (4.62–5.96)	0.001
80–84	786 (5.74)	789 (17.97)	1575 (8.71)	50.09	2.08	9.49 (8.28–10.87)	0.001
≥85	317 (2.32)	774 (17.63)	1091 (6.03)	70.94	2.64	23.08 (19.63–27.1)	0.001
Sex							
Male	5398 (39.43)	3293 (75.01)	8691 (48.07)	37.89	1.57	4.61 (4.26–4.98)	0.001
Female	8291 (60.57)	1097 (24.99)	9388 (51.93)	11.68	0.50	1	1
Location							
Urban	9901 (72.33)	3141 (71.55)	13042 (72.14)	24.08	1.03	1	1
Rural	3788 (27.67)	1249 (28.45)	5037 (27.86)	24.80	0.97	1.03 (0.96–1.12)	0.316
Marital status							
Single	93 (0.68)	18 (0.41)	111 (0.61)	16.21	0.46	1	1
Married	10773 (78.70)	3039 (69.23)	13812 (76.4)	22.00	0.92	1.46 (0.87–2.57)	0.140
Divers	63 (0.46)	35 (0.80)	98 (0.54)	35.71	1.02	2.87 (1.42–5.86)	0.001
Widow	2760 (20.16)	1298 (29.57)	4058 (22.45)	31.98	1.38	2.42 (1.45–4.30)	0.004
Living condition							
Alone	2177 (15.90)	806 (18.36)	2983 (16.5)	27.02	0.98	1.18 (1.08–1.30)	0.001
With family	11 512 (84.10)	3584 (81.64)	15 096 (83.5)	23.74	1.02	1	1

Similar to our study, the CFR for all countries is beginning to increase after age 50 and 60 years.⁵ The other countries have the more consistent distribution of the CFR, which is not exceeding 25% in the age group of 80–85, in contrast to 50% in the present study and 25% in Italy and 22% for the Netherlands.²⁶ Currently, a study in 20 European countries, Canada, and America found CFR ranged from 4.9% to 40.4%.⁴ Consistent with our findings, this study also found a positive relationship between older age groups and the COVID-19 fatality rate.⁴ In China, a study reported 8.3% fatality of COVID-19 infection in elderly patients.¹⁰

These findings showed a high CFR among the elderly population in this study. Despite that numerous reasons make hard to obtain accurate estimates for the CFR and mortality rate due to COVID-19,¹⁵ however our study conducted based on population and registry-based study, and total elderly population was assessed for COVID-19 suspected signs and symptoms, the results may be close to actual COVID-19 mortality and fatality rates in elderly people. Failure to initiate immunization against COVID-19 during the study period may be one of the leading causes of higher death rates. The findings of this study emphasized improving

hospitalized health services for older people with COVID-19 infection and decreasing mortality measures in this group of communities.

Regarding sex distribution, CFR was 37.89% and 11.68% in males and females in this study, respectively. However, the proportion of positive PCR was higher in females than in males. Consistent with our study, a study from China observed the high attack rate of COVID-19 infection among females.²⁷ However, similar to our study, a population-based registry study was found male sex was associated with higher disease severity and CFR,²⁸ and also a large between countries study showed that male COVID-19 patients had higher mortality with a risk ratio varying between 1.08 in Canada and 2.01 in the Netherlands. However, in this study male to female fatality risk ratio was 3.2.²⁹

The overall elderly population of the province was assessed regarding COVID-19 probable infection by first-line healthcare providers. This is a good practice for the first-line healthcare providers and the health system of the province. The overall detection rate of COVID-19 in the province was 4.17% up to May 30, 2021. It seems that this detection rate is low for 32% CFR. Likewise, the proportion

TABLE 3 Results of the COVID-19 screening and clinical features in the elderly population in East Azerbaijan Province from February 2020 to May 2021

Variable	Sex		Total N = 433 345	p value
	Male N = 209 657 (%)	Female N = 223 688 (%)		
Cough				
Yes	3010 (0.96)	3557 (0.82)	6567 (1.52)	0.001
No	206 647 (47.69)	220 131 (51.80)		
Fever				
Yes	822 (0.19)	966 (0.22)	1788 (0.41)	0.041
No	208 835 (48.19)	222 722 (51.40)		
Difficult breathing				
Yes	1100 (0.25)	1184 (0.27)	2284 (0.53)	0.833
No	208 557 (48.13)	222 504 (51.35)		
Impaired sense of smell				
Yes	562 (0.13)	645 (0.15)	1207 (0.28)	0.199
No	209 295 (48.30)	223 043 (51.47)		
Impaired sense of taste				
Yes	426 (0.1)	516 (0.12)	942 (0.22)	0.052
No	209 231 (48.28)	223 172 (51.50)		
Gastrointestinal symptoms				
Yes	446 (0.1)	574 (0.13)	1020 (0.24)	0.002
No	209211 (48.28)	223 114 (51.49)		
Prescribed hospitalization				
Yes	637 (0.15)	816 (0.19)	1453 (0.34)	0.005
No	209 020 (48.23)	222 872 (51.43)		
Prescribed two-drug regime				
Yes	3297 (0.76)	3804 (0.88)	7101 (1.64)	0.001
No	206 360 (47.62)	219 884 (50.74)		
Prescribed Paraclinic test				
Yes	11 490 (2.65)	12 856 (2.97)	24 346 (5.62)	0.001
No	198 167 (45.73)	2 108 329 (48.65)		
Prescribed RDT test				
Yes	43 519 (1.00)	4893 (1.13)	48 412 (11.17)	0.001
No	205 306 (47.38)	218 795 (50.49)		

of PCR tests was only 11.17%. This proportion is low and it is one of the probable reasons for the low detection rate of COVID-19.

4.1 | Limitations

This study is the most comprehensive effort in East Azerbaijan Province at the population level, which addresses mortality measures, screening, and some epidemiological aspects of COVID-19 patients among the elderly population. However, our study had some limitations. This study was performed based on

electronically recorded data of the DRS system, despite that the DRS system is comprehensive mortality information in Iran. The incompleteness and misclassification of the vital registration data in this region was a limitation of this study. The misclassification in vital records may have had an impact on the accuracy of the cause of COVID-19 death estimations. We provided detailed methods for accurate estimation of COVID-19 case fatality and mortality rates in an article previously.¹⁵ However, the present study and analyzed data on COVID-19 is the most comprehensive information on COVID-19 in the primary healthcare system of Iran.

5 | CONCLUSION

This population-based registry study identified the proportion of 4.17% confirmed COVID-19 cases in the elderly population of East Azerbaijan Province up to May 30, 2021. The overall CFR and mortality were 24% and 1%, respectively. Advanced age, male gender, marital status, and living alone were associated factors of COVID-19 mortality.

Our findings in comparison to other countries indicated that mortality and fatality rates were higher in this Province. Advanced treatment supports and interventions are needed to reduce mortality measures of COVID-19 in the elderly population in this region.

ACKNOWLEDGEMENTS

The authors thank the Infectious and Tropical Research Center, Tabriz, and Clinical Research Development Unit, Razi Educational for their cooperation during this study. This study was performed with the financial support of Tabriz University of Medical Sciences. The authors also indicate that they did not have a financial relationship with the organization that sponsored the research.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

ETHICS STATEMENT

The present study was derived from recorded data and no human interviews or samples were used. The study protocol was approved by the Ethics Committee, Tabriz University of Medical Sciences, under the code IR.TBZMED. REC.1399/015.

AUTHOR'S CONTRIBUTIONS

Hosein Azizi and Elham Davtaleb Esmaeili developed the original idea, developed the manuscript, interpreted and analyzed data, collected data, and drafted all the manuscript sections. Behrouz Naghili, Ali Fakhari, and Farzad Khodamoradi contributed to the protocol development, revising, editing, technical comments, and interpretation. All authors contributed to the manuscript development and/or made substantive suggestions for revision. All authors read and approved the final version of the manuscript.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

REFERENCES

- Nakhlband A, Fakhari A, Azizi H. Interferon-alpha position in combating with COVID-19: A systematic review. *J Med Virol.* 2021;93:5277-5284.
- Ahmadi A, Fadaei Y, Shirani M, Rahmani F. Modeling and forecasting trend of COVID-19 epidemic in Iran until May 13, 2020. *Med J Islam Repub Iran.* 2020;34:27.
- Jalili M, Payandemehr P, Saghaei A, Sari HN, Safikhani H, Kolivand P. Characteristics and mortality of hospitalized patients with COVID-19 in Iran: a National Retrospective Cohort Study. *Ann Intern Med.* 2021;174:125-127.
- Hoffmann C, Wolf E. Older age groups and country-specific case fatality rates of COVID-19 in Europe, USA and Canada. *Infection.* 2021;49:111-116.
- Navayi M, Fanoodi A, Salmani F, Abedi F, Shetty S, Riahi SM. Over 60 years of age as an independent prognostic factor of in-hospital mortality among COVID-19 patients: a cohort study in an Iranian high-incidence area. *Public Health.* 2021;200:33-38.
- Benksim A, Addi RA, Cherkaoui M. Vulnerability and fragility expose older adults to the potential dangers of COVID-19 pandemic. *Iran J Publ Health.* 2020;49:122.
- CDC Centers for Disease Control and Prevention Coronavirus disease 2019 (COVID-19). 2020.
- Liu K, Chen Y, Lin R, Han K. Clinical features of COVID-19 in elderly patients: a comparison with young and middle-aged patients. *J Infect.* 2020;80:e14-e18.
- Zhu X, Yuan W, Shao J, et al. Risk factors for mortality in patients over 70 years old with COVID-19 in Wuhan at the early break: retrospective case series. *BMC Infect Dis.* 2021;21:1-9.
- Niu S, Tian S, Lou J, et al. Clinical characteristics of older patients infected with COVID-19: a descriptive study. *Arch Gerontol Geriatr.* 2020;89:104058.
- Murillo-Zamora E, Hernandez-Suarez CM. Survival in adult inpatients with COVID-19. *Public Health.* 2021;190:1-3.
- Martins-Filho P, Quintans-Júnior L, de Souza Araújo A, et al. Socio-economic inequalities and COVID-19 incidence and mortality in Brazilian children: a nationwide register-based study. *Public Health.* 2021;190:4-6.
- Jafari N, Kabir M, Motlagh M. Death registration system in IR Iran. 2009.
- Sheidaei A, Gohari K, Kasaeian A, et al. National and subnational patterns of cause of death in Iran 1990–2015: applied methods. *Arch Iran Med.* 2017;20:2-11.
- Azizi H, Esmaeili ED, Fakhari A. Challenges and accurate estimates of mortality and case-fatality rates due to COVID-19. *New Microbes New Infect.* 2020;38:100775.
- Azizi H, Davtaleb-Esmaeili E. Iranian first-line health care providers practice in COVID-19 outbreak. *Iran J Publ Health.* 2020;49:119-121.
- Raeisi A, Tabrizi JS, Gouya MM. IR of Iran national mobilization against COVID-19 epidemic. *Arch Iran Med.* 2020;23:216-219.
- Azizi H, Fakhari A, Farahbakhsh M, Esmaeili ED, Mirzapour M. Outcomes of community-based suicide prevention program in primary health care of Iran. *Int J Ment Health Syst.* 2021;15:1-11.
- Peres, IT, Bastos, et al. Sociodemographic factors associated with COVID-19 in-hospital mortality in Brazil. *Public Health.* 2021;192:15-20.
- Akbariqomi M, Hosseini MS, Rashidiani J, et al. Clinical characteristics and outcome of hospitalized COVID-19 patients with diabetes: a single-center, retrospective study in Iran. *Diabetes Res Clin Pract.* 2020;169:108467.
- Alamdari NM, Afaghi S, Rahimi FS, et al. Mortality risk factors among hospitalized COVID-19 patients in a major referral center in Iran. *Tohoku J Exp Med.* 2020;252:73-84.
- Lee JY, Kim HA, Huh K, et al. Risk factors for mortality and respiratory support in elderly patients hospitalized with COVID-19 in Korea. *J Korean Med Sci.* 2020;35:e223.
- Rajgor DD, Lee MH, Archuleta S, Bagdasarian N, Quek SC. The many estimates of the COVID-19 case fatality rate. *Lancet Infect Dis.* 2020;20:776-777.
- Ahamed T, Anjum A, Rahman MM, Haider N, Kock R, Uddin MJ. Estimation of novel coronavirus (COVID-19) reproduction number and case fatality rate: a systematic review and meta-analysis. *Health Sci. Rep.* 2021;4:e274.

25. Kahathuduwa CN, Dhanasekara CS, Chin S-H. Case fatality rate in COVID-19: a systematic review and meta-analysis. *MedRxiv* 2020.
26. Natale F, Ghio D, Tarchi D, Goujon A, Conte A. COVID-19 cases and case fatality rate by age. *Eur Commission*. 2020;52:154-164.
27. Qian J, Zhao L, Ye R-Z, Li X-J, Liu Y-L. Age-dependent gender differences in COVID-19 in Mainland China: comparative study. *Clin Infect Dis*. 2020;71:2488-2494.
28. Forsblom E, Silén S, Kortela E, et al. Male predominance in disease severity and mortality in a low Covid-19 epidemic and low case-fatality area—a population-based registry study. *Infect Dis*. 2021;53:1-11.
29. Green MS, Nitzan D, Schwartz N, Niv Y, Peer V. Sex differences in the case-fatality rates for COVID-19—a comparison of the

age-related differences and consistency over seven countries. *PLoS One*. 2021;16:e0250523.

How to cite this article: Esmaeili ED, Fakhari A, Naghili B, Khodamoradi F, Azizi H. Case fatality and mortality rates, socio-demographic profile, and clinical features of COVID-19 in the elderly population: a population-based registry study in Iran. *J Med Virol*. 2022;94:2126-2132.
[doi:10.1002/jmv.27594](https://doi.org/10.1002/jmv.27594)