INTRODUCTION

In the earliest days of 2020, a life-threatening disease caused by SARS-CoV-2 infection was introduced to the world from Wuhan, China. This disease—known now as COVID-19 (Guo et al., 2020)—later spread worldwide and turned into a global pandemic, as was officially declared by the World Health Organization (WHO) on March 11, 2020 (COVID-19, 2020). According to the latest statistics, 216 countries are currently involved in this pandemic, with more than 162 million confirmed cases and 3.3 million deaths worldwide (WHO, 2020). In Iran,
the number of infected people has now exceeded 2.5 million individuals, leading to more than 73,000 deaths (WHO, 2020).

The rapid global progression of the disease and the growing number of infected people have led to researches to identify the at-risk groups across the world. Consequently, several COVID-19-related clinical signs and symptoms were identified (Goyal et al., 2020; Jiang et al., 2020). Older age, male gender, and having co-morbidities such as chronic obstructive pulmonary disease (COPD), cardiovascular disease (CVD), and hypertension are the main known risk factors for both hospitalisation and mortality due to COVID-19 (Allameh et al., 2020; Grasselli et al., 2020; Nemati et al., 2020). Notably, the effects of COVID-19 go beyond its medical complications. These consequences constitute many problems, including mental health, economic status, and even political and military issues. Namely, this pandemic has reduced social interactions, increased social anxiety and other mental disorders, and imposed a considerable economic hardship on individuals, businesses, and governments worldwide (Xiang et al., 2020). These consequences are expected to be more severe in developing countries like Iran, where the health systems are less prepared to respond to health crises, and the economic system is under extra pressure due to global sanctions. Accordingly, as one nationwide survey showed, the prevalence of anxiety and stress reached 20% among the total population in Iran (Shahriarirad et al., 2021). Moreover, COVID-19 has led to an economic crisis by increasing medical costs in Iran (Murphy et al., 2020).

Despite the efforts investigating the aetiology of and the treatments for COVID-19, the concept of health disparity in COVID-19-related mortality has been neglected. There is a lack of evidence regarding how COVID-19 is affecting social groups with different socioeconomic statuses.

Health disparity refers to the unjust health inequality among social groups. Several social concepts such as poverty and poor access to knowledge, services, and goods are associated with health disparity. Health inequality is a measurable proxy to assess health inequality as a normative concept (Organisation, 2013). Several studies have already addressed health inequality in different aspects of health, including the incidence of both communicable and non-communicable diseases, exposure to risk factors, and access to health services (Emamian et al., 2011; Nemati et al., 2019; Pini et al., 2019). The association between socioeconomic status and health outcomes has already been proven. It has been shown that deprived people are at increased risk of getting both communicable and non-communicable diseases. They also have less access to health facilities, and health awareness is much lower among low SES. Although data are scarce regarding the social distribution of COVID-19, higher infection rates in more poor households have been reported in a few studies (Prats-Uribe, Paredes, & Prieto-Alhambra, 2020). Addressing such an association between the socioeconomic status and the morbidity and mortality of COVID-19 may increase the efficiency of preventive strategies by identifying the at-risk groups.

In this study, we used data from the hospital in Qazvin city in Iran to assess the role of socioeconomic inequality in the mortality of COVID-19. We also determined the contribution of each factor in the observed inequality.

2 | MATERIAL AND METHODS

2.1 | Study design and study participants

We performed a retrospective cohort study on 1922 patients with a primary diagnosis of COVID-19 who were admitted to hospitals in Qazvin, Iran, from February 20 to May 16, 2020.

We employed the data from an electronic database provided by Qazvin University of Medical Sciences since the earliest day of the COVID-19 epidemic emergence. This database includes epidemiological and clinical data of all hospitalised patients across Qazvin city. The data source is explained in more detail elsewhere (Nemati et al., 2020). First, study participants were categorised based on their SES into three groups: low, medium, and high SES, and then we investigated COVID-19 mortality among these groups. Next, the low and high SES groups were selected as the extreme SES groups to illustrate socioeconomic inequality in mortality due to COVID-19 and decompose the observed difference between these two compared groups.

2.2 | Inclusion criteria

The study was performed on patients admitted with a primary diagnosis of COVID-19 according to INIGCDT and hospitalised in the Qazvin city (Health, 2020). According to the guidelines of the INIGCDT, a primary diagnosis of COVID-19 is characterised by symptoms of fever, cough, or myalgia (referred herein as minor clinical criteria), coupled with either A) respiratory distress, low pulse oximetry reading (SpO2 = <93%), respiratory rate (RR) of >30 (herein...
considered as primary clinical criteria), or decreased level of consciousness; or B) patients being among high-risk groups who have an underlying medical condition along with suggestive chest X-ray or CT scan changes for COVID-19. In addition, other laboratory and chest imaging studies were performed during the patients’ admission course. The definitive diagnosis of COVID-19 was based on the results of rRT-PCR test (Health, 2020). The Length of Stay at the hospital (LOS) for all study participants was more than 24 hr, and cases without any contact number or those reluctant to participate in the study were excluded.

2.3 | Ethics approval

The Research Ethic Committee approved this study of Qazvin University of Medical Sciences (Code: IR.QUMS.REC.1399.007). Informed consent was obtained from the study participants before the phone interview.

2.4 | Socioeconomic Status variable and outcome assessment

Socioeconomic status was the main exposure that we collected through a phone interview with patients or their next of kin. Trained interviewers collected data on patients’ level of education, their location of residence, and self-reported SES. In low and middle-income countries, there is no access to data indicating people’s socioeconomic status (O’donnell, Van Doorslaer, Wagstaff, & Lindelow, 2007). Moreover, previous studies illustrated that due to severe underreporting, collecting data regarding salary and income is challenging and might lead to biased information. Therefore, the indirect approach is recommended (O’donnell et al., 2007). First, we collected a couple of living variables, including the level of education, location of residence, and self-reported SES as a proxy for socioeconomic status. Then the collected variables were coded from 1 to 5 from the lowest to the highest category. Afterward, we converted these values to a continuous variable using Principal Component Analysis (PCA). The suitability of the variables for PCA was checked using Kaiser-Meyer-Olkin (KMO) and Bartlett test of sphericity. The estimated KMO for the included variables in the current study was 0.62, and the Bartlett test was statistically significant ($\chi^2 = 167.8, p$-value < 0.001). Then we created the SES variable using weights of the first component that covered 65% of the whole variance. Then, patients were categorised into three quartiles based on their PCA scores. Gender, age, SARS-CoV-2 RT-PCR test result, co-existing disorders, admission in intensive care unit (ICU admission), type of hospital (educational versus non-educational private hospital), and length of stay were also collected from the hospital database as potential confounders. The patient’s outcome at discharge was the main interest that we collected from patients’ medical records and hospital data sets.

2.5 | Statistical analysis

Categorical variables were described as the number and proportion of frequency. We also provided mean and standard deviation (SD) for all continuous variables. First, we compared baseline characteristics of the study participants using the Chi-square test to check whether our groups were comparable. We then applied a multiple Poisson regression model to determine the most influential factors associated with death from COVID-19. Next, variables with the Wald test $p$ less than 0.2 were selected and entered into the Oaxaca-Blinder decomposition model. The Blinder-Oaxaca approach is a decomposition method that Blinder and Oaxaca first used to identify influential factors of inequality in the labour market (Blinder, 1973). In this method, we compared the gap in outcome between the two groups of hospitalised COVID-19 patients with high or low SES and determined how the overall gap between them could be attributed to explained (difference in outcome determinants) and unexplained parts (difference in the effects of the determinants) of the model. The explained part indicates how differences in the mean of variable $x$ could affect outcomes in both compared groups, whereas, in the unexplained part, we would like to know the effect of the difference in the role of independent variables between the compared groups on the desired outcome. In Equations, (1) and (2), $X$, $\beta$, and $\varepsilon$ are the mean of determinant, regression coefficients, and error terms, respectively,

$$Y_{lowSES} = \beta X_{lowSES} + \varepsilon_{lowSES}$$  \hfill (1)

$$Y_{highSES} = \beta X_{highSES} + \varepsilon_{highSES}$$  \hfill (2)

We also used equation (3) in order to decompose the observed inequality between high and low SES groups,

$$Y_{high} - Y_{low} = (X_{high} - X_{low}) \beta_{high} + X_{low} (\beta_{high} - \beta_{low})$$  \hfill (3)

Therefore, the gap in outcome between the compared groups would be due to two primary sources, i.e. (i) difference in means of the determinants and (ii) difference in $\beta$s between high and low SES patients (O’donnell et al., 2007).

3 | RESULT

Data of 1922 COVID-19 hospitalised patients in Qazvin city, Iran, were collected. Among them, 48.96% were categorised into the low SES category, while 26.17% and 24.87% were labelled as medium and high SES, respectively. The mean age (±SD) in low, medium and high SES group was 66.2 (±19.1), 52.7 (±18.1), and 47.7 (±18.1), correspondingly and it was significantly higher in the low SES in comparison to medium and high SES groups ($p$-value < 0.001). In addition, the low SES group was more likely to have co-morbidities (more than 50% of patients in the low SES group ($p$-value < 0.001) compared to 30.54% and 40.56% patients in the high and medium-SES groups, respectively) (Table 1). We also observed that being admitted to
private hospitals was much lower in the low SES group (3.29%) than in other categories (8.79%). Moreover, while the mortality rate was 18.49% in the low SES group, it was significantly lower in the medium SES (10.14%) and high SES (4.60%) groups (p-value < 0.001) (Table 1).

The association between SES and COVID-19 related mortality is depicted in Table 2. After adjustment for all investigated confounders, the death ratio was 2.39 times higher in the low SES group than the high SES group. We also observed that patients in the medium SES group were more likely to die from COVID-19 when they were compared to patients in the high SES group (adjusted IRR = 1.96, 95% CI = 1.18, 3.25, p-value = 0.009) (Table 2).

As shown in Table 3, the incidence rate of death in the low SES group (22.8%) was significantly higher than the high SES group (5.69%), and we observed a 17.13% gap in death proportion between high and low SES patients. Overall, 9.60% of the observed gap was due to the factors that the decomposition model examined. Age was the primary variable explaining 6.91% of the observed difference, followed by co-morbidities (1.53%) and length of stay (0.95%) (p-value < 0.05). We also observed that 7.53% of the gap was related to the unexplained part of the model. The coefficients of age (10.61) and RT-PCR test (3.43) were statistically significant in the unexplained part of the decomposition model (Table 3).

4 | DISCUSSION

This study aimed to investigate and decompose socioeconomic inequality regarding mortality of COVID-19 during the epidemic in Iran. Thus, our study is among the first attempts investigating the socioeconomic inequality in COVID-19 mortality to the best of our knowledge.

We found that while COVID-19 mortality was concentrated in the low SES people in Iran, there was a 17.13% difference between the low and high SES patients. Based on our decomposition model, the primary variable contributing to this gap was age. Several studies have shown that COVID-19 mortality is associated with age, i.e., older patients are more likely to die (Goyal et al., 2020; Nemati

| Variables | High SES N (%) | Medium SES N (%) | Low SES N (%) | p-value |
|-----------|----------------|------------------|--------------|---------|
| Gender    |                |                  |              |         |
| Female    | 218 (45.61%)   | 232 (46.12%)     | 454 (48.25%) |         |
| Male      | 260 (54.39%)   | 271 (53.88%)     | 487 (51.75%) | 0.573   |
| Age group |                |                  |              |         |
| <30       | 81 (16.95%)    | 61 (12.13%)      | 50 (5.31%)   |         |
| 31–40     | 112 (23.43%)   | 65 (12.92%)      | 46 (4.89%)   |         |
| 41–50     | 95 (19.87%)    | 97 (19.28%)      | 71 (7.55%)   |         |
| 51–60     | 74 (15.48%)    | 102 (20.28%)     | 103 (10.95%) |         |
| 61–70     | 57 (11.92%)    | 98 (19.48%)      | 209 (22.21%) |         |
| >70       | 59 (12.34%)    | 80 (15.90%)      | 462 (49.10%) | <0.001  |
| ICU admission |            |                  |              |         |
| No        | 441 (92.45%)   | 461 (91.83%)     | 845 (90.09%) |         |
| Yes       | 36 (7.55%)     | 41 (8.17%)       | 93 (9.91%)   | 0.272   |
| RT-PCR test result |         |                  |              |         |
| Negative  | 305 (63.94%)   | 319 (63.42%)     | 606 (64.40%) |         |
| Positive  | 172 (36.06%)   | 184 (36.58%)     | 335 (35.60%) | 0.933   |
| Co-morbidity |            |                  |              |         |
| No        | 332 (69.46%)   | 299 (59.44%)     | 466 (49.52%) |         |
| Yes       | 146 (30.54%)   | 204 (40.56%)     | 475 (50.48%) | <0.001  |
| Hospital  |                |                  |              |         |
| Educational | 436 (91.21%)   | 477 (94.83%)     | 910 (96.71%) | <0.001  |
| Private   | 42 (8.79%)     | 26 (5.17%)       | 31 (3.29%)   |         |
| Outcome   |                |                  |              |         |
| Recovery  | 456 (95.40%)   | 452 (89.86%)     | 767 (81.51%) |         |
| Death     | 22 (4.60%)     | 51 (10.14%)      | 174 (18.49%) | <0.001  |
| Total     | 478 (24.87%)   | 503 (26.17%)     | 941 (48.96%) |         |

Abbreviations: SES: Socioeconomic Status. Bold indicates p-values <0.05 are statistically significant.
On the other hand, in our study population, the low risk of COVID-19 incidence (Prats-Uribe et al., 2020). Previous et al. reported a dose-response association between SES and likely to follow the protective recommendations, and the probability of staying at home was higher among them. Parts-Urbe et al. reported a dose-response association between SES and risk of COVID-19 incidence (Prats-Urbe et al., 2020). Previous studies have shown that deprived people are at increased risk of getting infectious diseases (Balasegaram et al., 2012; Semenza & Giesecke, 2008). Pini et al. have argued that low SES is associated with lower living standards. They mostly live in more crowded and deprived areas with poor housing conditions. Poor nutrition and hygiene are two other factors affecting their health and making them more fragile against infectious diseases such as COVID-19 (Pini et al., 2019). Maintaining social distance as the main WHO protective recommendation is more complicated and practically impossible in such conditions.

On the other hand, as they earn less money and have less access to health information obeying self-protection procedures would be more difficult (Pini et al., 2019). Additionally, the cost of self-protection procedures along with the economic crises in Iran and the inefficiency and poor performance of the health system in providing personal protective equipment’s have led to the circumstances in which low SES people did not have access to affordable and adequate protective measures such as face masks and shields. Hence, it seems that unprotected attendance in crowded places has been more common among low SES people during the COVID-19 epidemic. Also, delays in referral and admission to hospital are more common among deprived patients. Thereby, diseases are tended to be diagnosed in more advanced stages, and more severe outcomes are expected (Qandian et al., 2020).

Accordingly, we showed that co-morbidities were much higher among more deprived patients, which was in line with previous findings (Emamian et al., 2011). The unhealthy lifestyle is more prevalent among low SES groups, and several studies have reported higher non-communicable diseases and their risk factors. Emamian et al. reported a higher prevalence of non-communicable diseases in low SES people in Iran. Hence, it is predictable that non-communicable disease is concentrated in more deprived groups (Emamian et al., 2011).

In this study, length of stay in the hospital was also identified as one determinant of higher mortality rates in low SES patients. Longer LOS was shown to be responsible for 0.9% of the gap in COVID-19 mortality across socioeconomic groups. Thus, longer LOS in the low SES could be attributed to the higher proportion of severe cases in deprived patients. Although we did not provide data on the severity of the disease, higher mean age and co-morbidity in low SES cases in deprived patients. Although we did not provide data on the severity of the disease, higher mean age and co-morbidity in low SES patients. Although we did not provide data on the severity of the disease, higher mean age and co-morbidity in low SES patients.

In the unexplained part of the Blinder-Oaxaca decomposition model, age and COVID-19 RT-PCR test were the most critical factors. The positive values for these variables showed that increased age and a higher proportion of positive RT-PCR test results in the low SES group would result in worse outcomes than patients in the high SES group. In other words, positive values of each factor imply a more substantial effect on the low SES COVID-19 patients.

The current study is one of the first attempts to address and decompose socioeconomic inequality in COVID-19 mortality during the coronavirus pandemic. Using a robust statistical model, we conducted this study on a uniquely large sample size of participants to investigate how COVID-19 affects different socioeconomic groups. Moreover, we applied a decomposition model to identify the essential factors responsible for the gap between the compared groups. However, our findings must be interpreted in the context of our limitations. The main limitation of our study

### Table 2: Association between socioeconomic status and death among COVID-19 cases hospitalised in Qazvin city adjusted for age, sex, hospital type, RT-PCR test results, ICU admission, LOS and co-morbidities

| Variables          | N of death (%) | Adjusted IRR (95% CI) | p-value |
|--------------------|----------------|-----------------------|---------|
| Gender             |                |                       |         |
| Female             | 96 (10.62%)    | Reference             |         |
| Male               | 151 (14.83%)   | 1.53 (1.18, 1.99)     | <0.001  |
| Age group          |                |                       |         |
| <30                | 8 (4.17 %)     | Reference             |         |
| 31-40              | 7 (3.14%)      | 0.75 (0.27, 2.09)     | 0.593   |
| 41-50              | 22 (8.37%)     | 1.57 (0.69, 3.55)     | 0.272   |
| 51-60              | 26 (9.32%)     | 1.62 (0.72, 3.60)     | 0.237   |
| 61-70              | 38 (10.14%)    | 1.61 (0.74, 3.50)     | 0.226   |
| >70                | 146 (24.29%)   | 3.69 (1.78, 7.67)     | <0.001  |
| RT-PCR test results|                |                       |         |
| Negative           | 102 (8.29%)    | Reference             |         |
| Positive           | 145 (20.98%)   | 1.94 (1.49, 2.54)     | <0.001  |
| ICU admission      |                |                       |         |
| No                 | 198 (11.33%)   | Reference             |         |
| Yes                | 49 (28.82%)    | 2.16 (1.54, 3.03)     | <0.001  |
| Co-morbidities     |                |                       |         |
| No                 | 88 (8.02%)     | Reference             |         |
| Yes                | 159 (19.27%)   | 1.53 (1.16, 2.03)     | 0.003   |
| Hospital           |                |                       |         |
| Educational        | 239 (13.11%)   | Reference             |         |
| Private            | 8 (8.08%)      | 0.57 (0.27, 1.20)     | 0.145   |
| LOS                | –              | 1.02 (1.00, 1.03)     | <0.001  |
| SES                |                |                       |         |
| High               | 22 (4.60%)     | Reference             |         |
| Medium             | 51 (10.14%)    | 1.96 (1.18, 3.25)     | 0.009   |
| Low                | 174 (18.49%)   | 2.39 (1.51, 3.80)     | <0.001  |

**Abbreviations:** CI: Confidence Interval; IRR: Incidence Rate Ratio; LOS: Length of Stay.

Bold indicates p-values <0.05 are statistically significant.
was the limited socioeconomic information. Collecting asset data has been suggested as the best approach to determine SES in developing countries. However, in the current study, due to the low response rate that we encountered while collecting such data, we used data on education, the location of residence, and self-reported SES as a proxy of SES.

Additionally, we did not have access to data on the cause of death and could not adjust for competing risks. However, the outcome of interest in our study was the status upon discharge from the hospital (recovery versus death). Therefore, we presume that the leading cause of death in the admitted patients was COVID-19. Moreover, we included having co-morbidities into our multiple regression model as a confounding factor to control its effect on the causal pathway.

**5 | CONCLUSION**

Patients with a low SES were at a higher risk of COVID-19 fatal outcomes, and the disease was more severe among them. Age, co-morbidities and LOS were found to be the main drivers of this inequality. However, none of the variables contributing to the observed gap were related to the health care, and a variable such as access to ICU care has been almost equal between the low and high SES groups. The socioeconomic status could not be changed in a short time. However, we suggested that the low SES people must be considered as a priority in all actions taken by governments. Providing emergency financial supports or free access to protective equipment like face masks/shields might be helpful to reduce the vulnerability of low SES groups to COVID-19 complications.

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**CONFLICT OF INTERESTS**

All authors declare that they had no conflict of interests.

| Prediction | 95% CI | p value |
|------------|-------|---------|
| The adjusted proportion of death in the Low SES group | 22.83% | 19.85, 25.81 | <0.001 |
| The adjusted proportion of death in the High SES group | 5.69% | 3.38, 8.01 | <0.001 |
| Differences | 17.13% | 13.33, 20.90 | <0.001 |

**TABLE 3** Decomposition of the gap between the high and low SES group regarding COVID-19 mortality during the epidemic in Qazvin city, Iran

Abbreviations: CI: Confidence Interval; LOS: Length of Stay. Bold indicates p-values <0.05 are statistically significant.
AUTHOR CONTRIBUTION
Saeed Nemati: Methodology, Software, Formal analysis, writing original drafts. Elnaz Saeedi: Methodology, Software, Formal analysis. Sepideh Abdi: Methodology, Software, Formal analysis. Ali Qandian: Project administration, Writing - Review & Editing. Kalhor Esmaeil: Project administration, Validation, Writing-Review & Editing. Samin Moradi: Investigation, Data collection. Narges Joshanng: Investigation, Data collection. Anita Eftekharzadeh: Writing-Review & Editing. Mojtaba Vand Rajabpour: Methodology, Writing-Review & Editing. Hamid Reza Najari: Conceptualization, Recourses, Methodology, Validation, Writing-Review & Editing, Funding acquisition.

DATA AVAILABILITY STATEMENT
Research data are not shared.

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