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Original Article

Using Relative and Absolute Measures for Socioeconomic Inequalities in Health: Experiences from a Retrospective Cohort Study on COVID-19

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Abstract

Background: One approach to reducing the burden of diseases can be to identify socioeconomically vulnerable groups. We aimed to estimate the socioeconomic inequality of in-hospital deaths using relative and absolute indices of socioeconomic inequality.

Methods: In this retrospective cohort study on Covid-19 patients; age, gender, marital status, education level, date of admission, diagnostic method, and final condition were measured. Socioeconomic inequality in in-hospital death was assessed using three approaches. We used the relative index of inequality (RII) to measure relative inequality. We used two approaches to evaluate absolute inequality: the slope index of inequality (SII) and the concentration index (ci).

Results: Overall, 587 patients' data were collected and 42 (7.2%) of these patients died in the hospital. There were statistically significant differences between the case-fatality rates of different levels of education ($P<0.001$). In addition, all the inequality indices showed that the distribution of COVID-19-related deaths was higher among the lower education levels. Accordingly, after controlling the effect of age, gender, and comorbidities the RII indicated that the case fatality rate in the lowest education level was 9.42 (95% CI: 2.23 to 39.01, $P<0.001$) times compared to the case fatality rate in the highest level of education.

Conclusion: The results of all three approaches indicate considerable education inequality in CFR in favor of groups of high education levels. These results can improve the prioritization and impact of public health interventions, including prevention and diagnosis of Covid-19 in favor of vulnerable groups.

Keywords: Socioeconomic inequality; Relative index of inequality; Concentration index

Introduction

The COVID-19 disease, reported in China in late December 2019 has rapidly spread across the globe (1, 2). By Jan 2023, it had affected more than 600 million people all over the world. The number of mortality cases has also reached 6 million by the same date (3). To reduce the number of mortality and morbidity cases various widespread measures have been taken at national and international levels (4, 5). Moreover, different studies at the international level have investigated

the predicting factors of the severe form of the disease and its related mortality. Their results indicate that factors such as older age, the male gender, and comorbidities are the most important predicting factors of COVID–19–related death (6-9).

A review of earlier evidence indicates that socioeconomic factors such as education, income, and ethnicity can affect the affliction of various communicable and non-communicable diseases and their related deaths through different routes (10, 11). Even though COVID-19 has affected different socioeconomic groups, low-, middle- and high-income countries, and different ethnicities, still, studies indicate that factors such as ethnicity (12, 13), poverty (13, 14), income (15), and educational status (16-18) can also impact the distribution of morbidity and mortality related to this disease; such that the odds of infection and the incidence of serious outcomes (death and severe form of disease) are higher in more socioeconomically vulnerable groups compared to other groups. Socioeconomically vulnerable groups usually have poorer access to healthcare services (19, 20), comorbidities are higher in these individuals (21), they usually live in more crowded houses (22, 23), and usually, their jobs are such that they cannot work remotely (22). In other words, all these factors raise the odds of contracting and dying of COVID-19.

Iran too has experienced many waves of the COVID-19 epidemic. The socioeconomic and health burden resulting from this epidemic on the one hand, and the socioeconomic pressure of the political–economic sanctions on the other hand, can widen the gap between various socioeconomic groups (24). The unjust economic sanctions imposed on Iran have reduced households' financial abilities to access health services, and have severely affected the health system in providing health services to households. Some of the problems arising from the sanctions are related to the purchase of diagnostic, health (prevention and vaccination), and treatment facilities.

Far, various studies have examined the clinical and epidemiological characteristics of COVID-19 patients in Iran. Nevertheless, to our knowledge, no study has investigated the association between socioeconomic indicators and the outcomes of the disease. The current study was conducted to examine the association between educational status —as an important indicator of socioeconomic status— and death due to COVID-19 and socioeconomic inequality in COVID-19 mortality.

Methods

The current study as a retrospective cohort study was conducted on the first wave of the COVID-19 epidemic, using the data of COVID-19 patients admitted to Baqiyatallah Al'Azam Hospital at Tehran, Iran. All COVID-19 cases diagnosed with lab tests reverse transcription polymerase chain reaction (RT-PCR) and/or were clinically or lung CT scans admitted to this center were included in the study.

This study was ethically approved by the Ethics Committee of Baqiyatallah University of Medical Sciences under code IR.BMSU.REC.1399.105.

Data collection

At the onset of the COVID-19 epidemic, this medical center launched a data registration system to record data related to COVID-19 patients. Three trained nurses (bachelor graduates) extracted data by looking up patient records, interviewing the patients' escorts to collect parts of the data, and feeding the data into the system. The patient's escort was interviewed in person at the time of admission to the hospital. In addition to registering general characteristics such as national ID, the following basic data were recorded: age, gender, marital status, socioeconomic status (education), date of admission, and diagnostic method (PCR and/or clinical diagnosis or CT scan). Furthermore, the patient's clinical characteristics including their symptoms at the time of admission and history of associated comorbidities were also registered. The patient's final condition (discharge upon improvement, deceased) was also recorded.

Socioeconomic status

The education status indicator was used to evaluate socioeconomic status (SES). This indicator was measured using two approaches, the number of years of education the individual had successfully completed, and the latest degree that s/he had earned. Eventually, the patients were categorized into the following subgroups: no formal education, primary/intermediate/high school, high school graduate (diploma), associate degree, bachelor degree, master, and higher.

Comorbidities

All patients were examined for having a history of diabetes, hypertension, cardiovascular diseases, asthma, respiratory diseases, and renal disorders on a self-reported basis.

Statistical analysis

Mean, standard deviation, median, and IQR were used to describe the participants' age. Frequency and percentage were used to show the distribution of cases discharged and deceased by age groups, gender, education, and comorbidities.

In the next stage, the logistic regression model was used to examine the association between age, gender, educational status, and in-hospital death. First, the association between each of these variables was investigated using the univariable model. Then, the simultaneous association between age, gender, and education with in-hospital death was examined in a multiple model. The level of significance was considered at 0.05 in these models.

Socioeconomic inequality in In-hospital death was evaluated using three approaches. We used the Relative Index of Inequality (RII) to measure relative inequality. RII is a regression–based index for measuring socioeconomic inequality (25, 26). To calculate RII we ranked the patients based on their education level (highest to lowest), such that the highest levels scored 0 and the lowest levels scored 1. RII shows the death ratio between individuals at the highest rank [score 1] (i.e., the lowest education level) and the individuals at the lowest rank [score 0] (i.e., the highest education level) (27). An RII > 1 indicates that the occurrence of death among individuals with lower educational status was higher. In model 1 age-adjusted RII was estimated. In model 2, to estimate the pure effect of education level, age, gender, and comorbidities were also adjusted.

We used two approaches to evaluate absolute inequality: the Slope Index of Inequality (SII) and the concentration index (ci). The rationale behind SII is like RII, the only difference being that SII shows the absolute difference in death rate between individuals in the highest rank (lowest education level) and the lowest rank (highest education level) (25).

Ci was also used to evaluate absolute inequality. This indicator quantitatively represents the degree of inequality of a health indicator at levels of education level —as a socioeconomic indicator. It is defined on a concentration curve (28). On the concentration curve, the 'x' axis represents the cumulative percentage of individuals that have been ranked based on their education level, from the lowest to the highest (28). The 'y' axis represents the cumulative percentage of individuals based on the in-hospital death outcome. If all individuals fall into the same category in terms of their health status index, regardless of their economic status, the concentration curve will be a 45-degree line, which indicates the line of equality. On the contrary, if the health variable is higher (or lower) among the poor the concentration curve will lie higher (or lower) than the line of equality. The farther the curve from the line of equality, the greater the distribution of the health index between poor and wealthy people. The ci is equivalent to double the area under the line of equality curve. Therefore, when the concentration curve lies on the line of equality, ci will be equal to zero, and when it is above or below it the value will be negative or positive, respectively (29). The numeral range of this index lies between -1 and +1.

The statistical analysis was done with STATA V.15.

Results

Overall, 587 patients' data were collected. Forty-two of these patients died in the hospital (case fatality rate: 7.2%). The mean age of the deceased patients was 64.2 (SD: 14.3) years and the mean age of the surviving patients was 54.1 (SD: 13.5) years. In terms of age, there was a statistically significant difference between the two recovered vs. deceased groups (P<0.001) (Table 1). As shown in Table 1, there were statistically significant differences between the educational levels of survivors and non-survivors. Accordingly, the frequency of the patient with no formal education in death cases was higher than survivors (28.6% vs 5.9%, P<0.001).

Table 1: Baseline and clinical characteristics of hospitalized Patients with COVID-19

Variable	***Survivors (N=545)***	***Non-Survivors (N=42)***	***P-value***
Demographic characteristics			
Age; mean (SD)	54.1 (13.5)	64.2 (14.3)	<0.001
Age; median (IQR)	55.0 (19.0)	62.0 (19.0)	<0.001
Gender; (Male); N (%)	364 (66.3)	32 (80.0)	0.07
Socioeconomic status			
Education level			
No formal education	32 (5.9)	12 (28.6)	<0.001
Primary, intermediate, and high school	117 (21.5)	16 (38.1)	
Diploma	104 (19.1)	3 (7.1)	
Associate`s Degree	40 (7.3)	0 (0.0)	
Bachelor`s Degree	126 (23.1)	6 (14.3)	
Master`s degree and Doctorate/PhD	105 (19.3)	5 (11.9)	
Missing	21 (3.8)	0 (0.0)	
Medical history variables			
Hypertension	156 (28.7)	16 (38.1)	0.21
Cardiovascular disease	93 (17.1)	10 (23.8)	0.29
Diabetes	123 (24.5)	14 (33.3)	0.20
Chronic kidney disease	49 (8.9)	7 (16.7)	0.10
Asthma and Chronic lung diseases	11 (2.0)	1 (2.4)	0.87
At least one comorbidity[a]	271 (50.3)	28 (66.7)	0.03

a: Anyone suffering from at least one of the mentioned diseases

Figure 1 shows the case fatality rate (CFR) of the disease based on educational status at different age strata. The results of this analysis indicate that in both age groups <60 and ≥60, the CFR was higher among those with no formal education, as opposed to those with higher education levels. The CFR in the age groups <60 and ≥60 with no formal education were 41.7% and 22.9%, respectively. Also, totally the CFR was 27.3% among the patients with no formal education, and 4.5% among those who had masters and Ph.D. degrees (P<0.001).

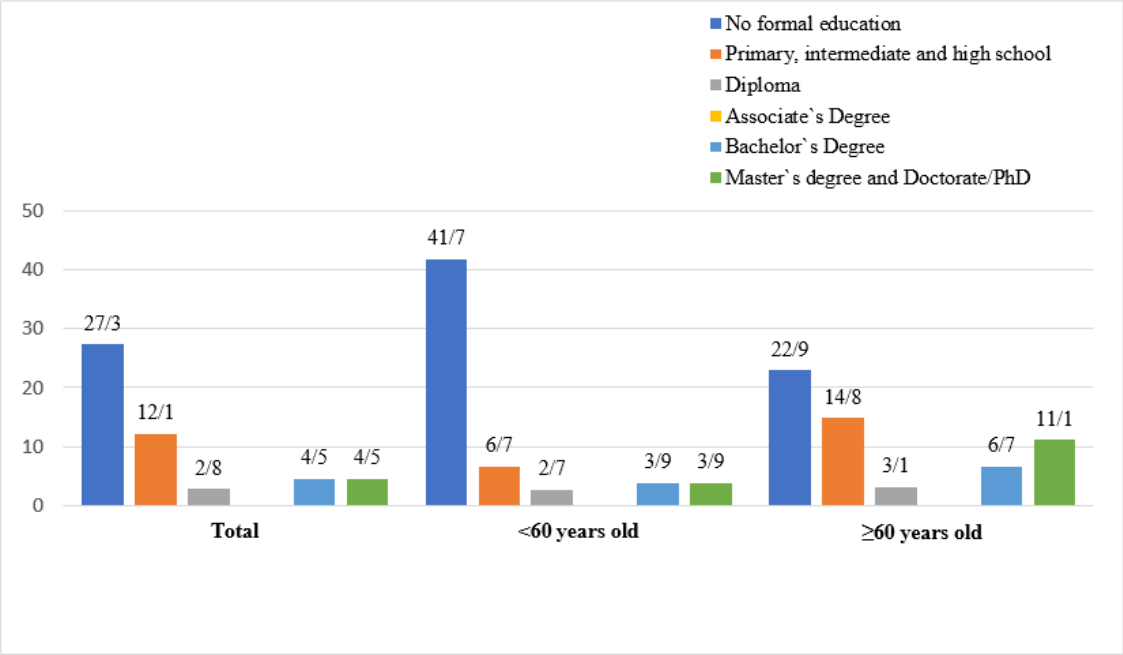

Fig. 1: Case fatality rate of covid-19 (%) according to the level of education and stratified by age

Results of multiple logistic regression indicated that age, gender, and educational status had a statistically significant association with COVID-19 mortality (Table 2). Based on our results, adjusted for education and age, the odds of COVID-19 mortality among men were 4.75 times (95% CI: 2.01 – 7.20, p<0.001) higher than among women.

Table 2: Multiple logistic regression model of in-hospital death, OR (95% CI for OR). N=581

Variable	***Adjusted OR***	***95%CI for OR***
Age	1.03[a]	1.01 to 1.06
Gender		
Female	Ref	
Male	4.75	2.01 to 7.20
Education level		
Master`s degree and Doctorate/PhD	Ref	
Bachelor`s Degree	1.00	0.29 to 3.41
Associate`s Degree	0.49	0.05 to 4.37
Diploma	0.66	0.15 to 2.87
Primary, intermediate, and high school	3.24	1.04 to 10.10
No formal education	7.56	2.14 to 26.68
At least one comorbidity[b]	1.64	1.23 to 2.09

a: Bold indicates p<0.05

b: Anyone suffering from at least one of the comorbidities

All the inequality indices also showed that the distribution of COVID-19-related deaths was higher among the lower education levels. Accordingly, after controlling the effect of age, gender, and comorbidities, the RII indicated that the mortality rate in the lowest education level was

9.42 (95% CI: 2.23 to 39.01, *P*<0.001) times compared to the mortality rate in the highest level of education. Age-adjusted SII showed that the difference in the mortality rate between individuals with no formal education and those with the highest level of education was 7.1%. Moreover, the concentration index also showed that the distribution of death was not in favor of individuals with low educational status -0.22 (95% CI: -0.38 to -0.03) (Table 3). In other words, death occurred more in patients with no formal education.

Table 3: Education-related inequality in COVID-19 death

Health indicator	*SII[a] (95% CI)*	*RII[a] (95% CI)*	*RII[b] (95% CI)*	*Concentration Index*
In-hospital COVID-19 death	7.1 (3.2 to 14.0)	5.21 (1.30 to 21.15)	9.42 (2.23 to 39.01)	-0.22 (-0.38 to -0.03)

a Adjusted for age
b Adjusted for age, gender, comorbidities
Bold indicates *P*< 0.05

Discussion

The current study was conducted to investigate the association between education level and COVID-19 in-hospital mortality and socioeconomic inequality of covid-19 in-hospital mortality. To our knowledge, this is the first study in Iran to examine socioeconomic inequality of covid-19 related deaths. The results showed that the distribution of death (a proxy of the severe form of the disease) due to COVID-19 was higher among individuals with lower education levels. In other words, the odds of death due to COVID-19 were higher among people with lower levels of education as opposed to people with higher levels.

Consistent with our findings, earlier studies too, have reported socioeconomic inequality in COVID-19 infection and death. Marcio José Concepción-Zavaleta et al using 2020 mortality data in Peru, showed considerably higher numbers of mortality cases compared to previous years, and a major proportion of this excess death rate was due to COVID-19 (16). Furthermore, this study indicated that although death due to all causes had increased during the pandemic in both individuals from higher and lower education levels, independent of the age effect, it was higher among those from lower education levels (16).

Although the incidence of COVID-19 was higher in regions of higher SES, COVID-19-related death was significantly higher in regions of lower SES (30). Various studies have considered different mechanisms for justifying the high rate of COVID-19-related deaths in socioeconomically vulnerable groups. Normally, socioeconomically vulnerable groups have lower access to healthcare (19, 20). Earlier literature also shows that health literacy is lower among socioeconomically vulnerable groups (31) and this can impact their observance of public health principles and physical distancing practices. The prevalence of health disorders and comorbidities is also higher among individuals with poorer SES (21). In addition to these reasons, in Iran, we may address the issue of political–economic sanctions as aggravating the socioeconomic inequality, including that in health services (24, 32, 33). The political–economic sanctions have made access to food and housing difficult for some people (34). The interaction between the effects of these sanctions and the COVID-19 pandemic makes the control of this disease more difficult among vulnerable individuals.

Our study also showed that the odds of dying of COVID-19 increase with age. Moreover, it is higher among men than in women. These findings are consistent with earlier results in the literature (6, 35, 36). However, despite our observa-

tion that the prevalence of comorbidities was higher among the COVID-19 deceased cases than those who survived and improved this difference was not statistically significant. One of the most important reasons behind this difference between our findings and those of earlier studies is perhaps the difference in sample size. Nevertheless, among those who died due to COVID-19 a higher percentage had at least one comorbidity, and under these terms, there was a statistically significant difference between the two groups.

Among the strengths of this study is its design and data collection process. The latter was done based on a specific system and by trained individuals. Moreover, to our knowledge, this is the first study in Iran to examine socioeconomic inequality in COVID-19-related deaths. Here, we used three different approaches to evaluate absolute and relative socioeconomic inequality in COVID-19 mortality, RII, SII, and Ci. The use of the relative inequality index allows for the adjustment of the effects of probable confounders.

This study has certain limitations as well. Even though there are different indicators for evaluating individuals' SES, here we used the level of education as an SES indicator. Earlier evidence shows that there is no single indicator that is better than the rest in measuring SES, and depending on the research question, each of these indices has its own weaknesses and strengths (10). In the current study, we assessed education as it has a direct impact on health literacy and the adoption of healthy behaviors and is easy to measure during the pandemic. Moreover, comorbidities were self-reported by the patients. Although the gold standard for assessing comorbidities is an examination by a physician, nevertheless, evidence indicates that self-reported measuring also has acceptable validity and reliability (37-40). Additionally, given we conducted our study on patients admitted to the hospital, the sample may not be representative of the entire population of COVID-19 patients, thus, generalizing the results to this population must be done with caution.

Conclusion

As the first study on socioeconomic inequality in COVID-19 mortality in Iran, the results indicated that independent of age and gender, the odds of COVID-19 mortality in admitted patients were significantly higher among those with lower education levels as compared to those with higher education levels. The results of this study can be helpful in policy-making against Covid-19 and improve the process of prioritization and impact of public health interventions, including prevention and diagnosis of Covid-19 in favor of vulnerable groups.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that they have no conflict of interest.

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