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Income inequality and its association with COVID-19 cases and deaths: a cross-country analysis in the Eastern Mediterranean region

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ABSTRACT

Introduction There is limited evidence on the associations between economic and social disparities in the Eastern Mediterranean region (EMR) with COVID-19 infections and deaths. This study aims to investigate the relationship between income inequalities using Gini coefficients and COVID-19 cases and deaths per million population in the EMR countries.
Methods Country-level data on monthly COVID-19 cases and deaths between March 2020 and October 2021, along with data on selected confounders, were collected from publicly available databases. Mixed-effect negative binomial and inverse hyperbolic sine transformation regressions were estimated to examine the association.
Results The study showed that, in the EMR, a unit increase in Gini coefficient is associated with approximately 7.2% and 3.9% increase in COVID-19 cases and deaths per million population, respectively. The magnitude and direction of the association between income inequality and COVID-19 cases and deaths per-million population still remain the same after excluding four warzone countries from the analysis.
Conclusion This increase in COVID-19 cases and deaths is underpinned by the fact that a large number of the population in the region is living in conditions of poverty, with inadequate housing, comorbidities and limited or virtually no access to essential healthcare services. Healthcare policy-makers across countries in the region need to implement effective interventions in areas of income inequality, where it may be linked to increasing the risk of COVID-19 cases and deaths.

WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ There is limited evidence on the association between economic and social disparities in the Eastern Mediterranean (EM) region and COVID-19 cases and deaths.

WHAT THIS STUDY ADDS?

⇒ Income inequality via Gini coefficients is significantly associated with COVID-19 infections and deaths in the EM region countries.
⇒ The results are valid even after excluding four war or conflict zone countries in the region.
⇒ The findings are based on non-aggregated country-level data, and the estimated regression accounted for the time effect while estimating COVID-19 cases and deaths.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY?

⇒ The increase in COVID-19 cases and deaths is underpinned by the fact that a large number of the population in the region is living in conditions of poverty, with inadequate housing, comorbidities and limited or virtually no access to essential healthcare services.
⇒ Targeted and effective interventions are needed to implement in areas with high-income inequalities.

INTRODUCTION

Since it appeared in December 2019, COVID-19 has become the largest pandemic in a century, causing a significant health and economic burden globally. As of 21 December 2022, there have been approximately 650.3 million COVID-19 infection cases and 6.65 million deaths recorded worldwide, of which the Eastern Mediterranean Region (EMR) accounts for 3.6% and 5.2%, respectively.[1] Many countries have been facing second or third waves of COVID-19 infections, mainly due to the evolution and spread of new variants of the virus. A number of these new variants are highly transmissible and responsible for significant increase in COVID-19 related hospitalisations and deaths.[2]

The prevalence of cases from COVID-19 infections and deaths is disproportionately higher among socioeconomically disadvantaged groups, and further enhanced by health disparities.[3–7] People living under poverty in crowded and unhealthy environments with poor access to water and sanitation are at greater risk of COVID-19 infections.[8] These populations also have increased risk of severe

COVID-19 disease and deaths, mainly because of their high rates of general ill health, which is a risk factor for COVID-19.[9–12] Existing underlying health conditions such as cardiovascular disease, dementia, diabetes and respiratory diseases also increase the risk of severe illness and mortality from COVID-19.[13] In fact, poor health outcomes are results of poverty and socioeconomic deprivation, which eventually can contribute to increase health inequalities.

Many factors (demographic or social–economic) are likely to be associated with COVID-19 infections; however, these factors might be different for severe COVID-19 diseases or fatality. For example, at the beginning of the pandemic COVID-19, infections were higher among relatively young expatriate workers in some EMR countries, but the incidence of severe COVID-19 disease or death was lower among this population.[8] Factors that appeared to be associated with increased COVID-19 infections and case fatality rates are ethnicity and income[14]; age and comorbidity[15 16]; deprivation[17]; older age, CO_2 emission rates, life expectancy and diabetes prevalence[18]; the percentage of the elderly population[19]; obesity[20]; population size of a country[21]; GDP per capita[22 23] and a democracy index.[23] It can be argued that income inequality is likely to have an association with ill health. For example, any measures that reduce the spread of health conditions (eg, COVID-19 infections and severe disease) across a population would likely to improve the distribution of income.[24] This is particularly true in developing countries where health issues are important determinants of income,[25] and in some countries, healthcare expenditures could be large relative to income.[26] Addressing health-related issues like providing clean water, malaria eradication campaigns or vaccination programmes not only can improve population health but also may reduce the gap between income distributions.[24] The same mechanisms apply to COVID-19 pandemic in the EMR countries—the World Bank (WB) estimated that there would be an increase of 2.8–3.4 million people living in extreme poverty in the Middle East North Africa region by the end of 2020, as opposed to an expected decrease in extreme poverty, prior to the pandemic.[27] During the pandemic, income loss was 30% more in the most deprived households than in the least deprived in Morocco[28]; in Lebanon, those most at risk of loss of income were women, young people aged 24–34 years old, and informal workers.[29] From a survey in Pakistan, those with no education reported more income loss than those with secondary education and above[30] and in Syria, COVID-19 had serious negative impacts on the low-earner refugees and internally displaced persons (IDPs), who generally work in the informal sectors.[27]

Many features of health among population in the EMR countries are directly or indirectly associated with COVID-19 infections and the severity of the disease. Health inequality in sheer magnitude, both within and between country, is one of the major challenges in the region. For example, an overall life expectancy varies from 59 years in Somalia to 84 years in Kuwait, and in terms of within-country inequality, Sudan has the worst under-5 mortality rate of 112 deaths per 1000 live births in some areas, compared with the best-off area with a rate of 30 deaths per 1000 live births.[8] The region suffers from one of the highest burdens of non-communicable diseases (NCDs) in the world. More than half of the EMR countries experience 70% or more of deaths from NCDs.[8]

Another major challenge is that the region belongs to a large number of war and/or conflict-zone countries and, the life expectancy in these countries is 9 years lower than the global average.[8] People living in a war or conflict zone are always at a greater risk of socioeconomic determinants that affect their health. Linked with the conflict or war, the region is also host to a large number of international refugees or IDPs. According to 2019 WB's Harmonized list of Fragile Situations, 10 out of 36 countries and territories are in the EM region.[8] In addition, like in other societies, people in the EMR suffer from unemployment, poverty, economic inequity and income inequality in terms of distribution of wealth, all of which are more prevalent in the region and negatively affect health.[8] The Middle East remains as the most unequal region in the world with a top decile income share corresponds to 64%, compared with 37%, 47% and 55% in Western Europe, USA and Brazil, respectively.[31] It may be due to enormous both between-country (oil-rich vs population-rich) and within-country inequality (which is generally underestimated due to a lack of accurate data) in the region. Moreover, some countries in the EMR have long been experiencing warzone conflicts, which further aggravate the challenges for policy-makers to tackle the pandemic and increase socioeconomic and health disparities, and inequalities among the people of these countries.

The COVID-19 pandemic has affected almost all countries in the world by economic declines and increasing poverty. In the EMR, even the wealthier nations in the GCC are negatively affected, mainly due to a collapse of the oil prices. GDP is expected to decrease by about 4% across the region in 2020 and by 13% in conflict-affected countries.[32] Based on WB estimates, it was suggested there would be an increase of between 2.8 and 3.4 million people living extreme poverty in the EMR countries by 2020, which, by contrast was a forecast of decrease from the prepandemic level.[33] It is evident that there was a significant projected increase in extreme poverty in the region, and that there was a wide variation in extreme poverty between countries.[34] A number of EMR countries with higher income inequality experience higher extreme poverty headcount ratios. For example, in Djibouti, Egypt and Iraq, the pre-COVID-19 extreme poverty rates were 31.8%, 24.1% and 11.8%, respectively,[34] and the Gini coefficients for these countries were 41.6, 31.5 and 29.5, respectively. The poorest people lost household income more often in Morocco, where 74% of the workers in the most deprived households lost income, which is 30% more than in least deprived households.[28]

In Afghanistan, the percentage of displaced households who could not pay their debts increased by 13% between 2019 and 2019.[35] The pandemic has severely affected the income of refuges and IDPs who are low earners, and most likely to work in the informal sector. Poverty rates increased among Syrian refugees in Jordan, the Kurdish region of Iraq and Lebanon, as observed from a recent WHO EMR report.[8]

People from the most disadvantaged groups need to remain in the labour force even during natural calamities like a pandemic to afford survival in a region that also includes much wealthier citizens.[36] This is quite a common scenario in many EMR countries where a large number of expatriate labourers, IDP, migrants and refugees of lower income group live in labour camps or large households, often in poor and overcrowded living conditions.[37] A number of EMR countries have limited access to sanitation, adequate water supply or hygiene services in order to wash frequently to reduce the risk of COVID-19 infections.[38] During the early stage of the pandemic, expatriate migrant workers in some EMR countries were quarantined in crowded accommodation without enough support for access to food, sanitation and healthcare services.[8] These might be associated with higher infection rates among migrant workers at the early stages of the pandemic in some Gulf Cooperation Council (GCC) countries.[39 40] Given higher possibilities of exposure for these disadvantaged groups, it is very difficult for them to maintain and comply with COVID-19 guidelines to prevent infections. Individuals with lower income generally reside in crowded accommodation with a lack of facilities, and have public-facing jobs such as services, cleaning, child and elder care, which can increase the risk of exposure to COVID-19 virus.[41] Essentially, income inequality may be associated with increasing opportunities for spreading the infection. Income inequality creates social stratifications in health and its negative impact on population health is well documented.[42]

In many EMR countries, inequalities in income, living conditions, access to healthcare services and occupations are appeared to be related to increased COVID-19 infections and deaths. For example, poor living conditions and big households make social isolation difficult and may be associated with high rates of household transmission among IDPs, refugees and low-earner migrant workers.[8] A study among IDP camp residents in Somalia revealed that 71% of people lacked access to washing facilities, 67% lacked access to soap and 47% said living conditions in camps needed to change to prevent the spread of COVID-19.[43] Households without access to safe water, good nutrition and cooking fuel are responsible for weakening immune systems, hence, are at greater risk of infections.[44] Although overall infections were relatively low in GCC countries, official figures during the early stages of the pandemic showed the infections were significantly higher among low-earner economic migrant workers.[45 46] In March 2020, Qatar reported 238 COVID-19 cases in an industrial zone residential compound of 360 000 migrant workers, which led to a strict lockdown of the area. In Saudi Arabia, more than half (53%) of COVID-19 cases in April 2020 were foreigners (who are predominantly low-earner migrant workers), and by May 2020, this figure rose to 71%.[40]

While investigating the association between income inequality and COVID-19, a question arises whether the relation can go in both directions, especially whether any pre-existing inequalities might be linked with higher rates of infection.[47] The relationship between inequality and the pandemic has been investigated in the literature.[48 49] Although the interest has turned to focus on the effect of a pandemic on inequality, it is still the case today.[50] However, a number of studies also looked at the effect of inequality on pandemics and indicated that socioeconomic inequalities are linked with health impacts of the Cholera, Ebola, Tuberculosis and HIV epidemics.[51–53] There has been a large volume of literature which have investigated the impact of inequality on health in general. For example, a study from the UK revealed that, given similar working conditions, civil servants of higher ranks had experienced less heart disease and other chronic conditions than their counter parts, after adjusting for some baseline risk factors.[54 55] These findings are in line with a relative income hypothesis—an individual's health depends on income relative to others in the society they belong to, rather than on absolute income.[55 56] There has been considerable debate about whether income inequality is more important than absolute income in determining health outcomes.[57 58]

The link between income and health is well established. In the context of macroeconomics, we understand from the relationship between income and life expectancy where poorer nations gain substantial increases in life expectancy with small increases in income.[24] While this reflects a correlation between income and health, it is also important to understand the impact of inequality. The relationship between individual health and income is such that an additional dollar of income raises an individual's health in a diminishing manner, suggesting that redistribution of income from the poor to the rich will reduce health (eg, life expectancy) of the poor more than it increases health of the rich, reducing average population health in a society.[24 59] Countries with more even distribution of income will have better average health if income and health is non-linearly related at individual level.[60] A similar principle is also applicable across societies. Within societies, differences in relative income can reflect social patterns in infectious disease.[61] A study on H1Ni mortality revealed that differential exposure to the virus, susceptibility to disease and access to healthcare once disease has developed can be attributed to socioeconomic disparities.[62] A similar pattern has been observed in COVID-19, with an increased rate of transmissions and worse health outcomes among poorer population living in overcrowded housing and work conditions.[63 64] Evidence from a few recent studies in the US showed moderate association between state-level income inequality and

COVID-19 cases and deaths.[65 66] After adjusted for confounders in state-level regressions, a study found a higher fatality rate among disadvantaged groups in the US,[66] and at the same time contradictory evidence from a US study showing that regions with higher income and education experienced greater risk of COVID-19 infections.[67] Although there is an established socioeconomic and health link, relative income inequality and infectious diseases hypothesis presents complex dynamics, which need to establish important relationships so that vulnerable population groups can be identified.[68] Moreover, cross-national evidence of a contextual association with COVID-19 is limited.[69] Nevertheless, a recent cross-country study by Chakraborty *et al*[70] investigated the association of time-invariant relative income inequality (via GDP per capita and Yitzhaki's index) with the severity of COVID-19 spread using an econometric (panel data analysis) approach.

A number of recent studies have investigated the relationship between income inequality and COVID-19 incidence and deaths.[71–75] Where the first three studies are based on data from the USA, the fourth one is from the Organisation for Economic Cooperation and Development (OECD) and the fifth is a global study based on 141 countries. All three studies except Tan *et al*[71] used country/county-level aggregated COVID-19 incidence and mortality data over a specific study duration, which missed to account for a time effect. These studies have found a positive relationship between the Gini coefficient (a measure of income inequality) and COVID-19 incidence and mortality.

The study aims to investigate the association between variation in socioeconomic factors such as income inequality and COVID-19 cases and mortality in the EMR countries. This is the first ever study in the region which investigates the existing level of income inequality and its relationship with COVID-19 cases and mortality between 1 March 2020 and 31 May 2021.

METHODS

Data

The study has used the latest monthly data on COVID-19 infections and deaths from the European Centre for Disease Control. The database contains recorded daily cases and deaths for each country, which are then converted into country specific monthly data. For each country in the EMR, data on 2020 estimate of population size are used from the Worldometer[76] to convert to cases and deaths per-million population.

The main explanatory variable is income inequality, measured using the Gini coefficient, which has an intuitive relationship with a fundamental inequality tool, the Lorenz curve.[77] A Gini coefficient of zero (0) represents a perfect geographical area where all income is shared equally to its population and 100 represents a completely unequal society where all income is concentrated to one individual. For income inequality, the study uses the value from the nearest year published on the WB website,[78] going back as far as 2009, except for Syria, which reports the value for 2003. Gini coefficients for most of the countries are from the WB website. However, for a number of GCC (GCC countries include six oil-rich nations in the Gulf peninsula—Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE) and other countries, there were no WB data; hence, the study used data available from the published literature or report, mainly sourced from the respective country.

The study also considers a number of potential confounders which include: 'GDP per capita', 'percentage of total population age over 65', 'average life expectancy at birth', 'number of physicians per 100 000 population', 'time since first case detected' and 'stringency index'. Elderly people aged over 65 are more susceptible to COVID-19 infections[79]; however, the risk of COVID-19 infections for the younger population with underlying conditions and unhealthy lifestyles such as obesity and smoking is also high. While the number of physicians per 100 000 population can be considered as a proxy for accessibility of healthcare facilities, stringency index represents strictness of government measures to prevent COVID-19 infections and deaths in a country. Number of physicians per 100 000 population, GDP per capita, percentage of total population age over 65, average life expectancy at birth and number of physicians per 100 000 population are collected from the WB online database,[78] and all these data are from 2019, except 'number of physicians per 100 000 population' for which an available nearest year was considered. Time since first case detected in a country was the duration between the date of first case detected and 31 October 2021 (last date of the study evaluation period). The end date was chosen to exclude the period of Omicron variant, and when most of the Eastern Mediterranean countries had lifted the lockdown measures.

Stringency index data are collected from the Oxford COVID-19 Government Response Tracker[80] and averaged at monthly. The original stringency index represents the strictness of 'lockdown style' policies that primarily restrict people's behaviour in the respective countries. Nine metrics were used to calculate the Stringency Index: school closures; workplace closures; cancellation of public events; restrictions on public gatherings; closures of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls. The index is calculated by taking the average of scores from nine (9) matrices, each taking values between 0 to 100. A higher score represents a stricter response. These indices simply indicate strictness of government policies, and should not be interpreted as 'scoring' the appropriateness or effectiveness of a country's response to the pandemic.

Since all data used in the study are in public domain, ethical approval from Qatar University Institutional Review Board was not required, and we have followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline. The variables and their sources can be seen from a table, given in online supplemental appendix 1.

Statistical analysis

We explored the association between country-level Gini coefficients and COVID-19 cases and deaths per-million population by estimating Spearman correlation coefficient in an unadjusted analysis. Two outcome variables, COVID-19 cases and deaths per-million population, are highly skewed to the right; hence, a negative binomial regression was considered given the overdispersion of the COVID-19 data. The regression model was estimated within a multilevel structure to account for clustering of monthly COVID-19 data (level-1) within countries (level-2). We considered a country-level random intercept (mixed-effect) model in adjusted analyses and a log-link was applied. Statistical significance of the estimated level-2 variance will suggest whether there is any country-level variation in COVID-19 data (cases and deaths per-million population). The reported likelihood ratio (LR) test will indicate whether a mixed-effect negative binomial provides a better fit over a standard negative binomial regression. For checking robustness of results, we also estimated the regression model using inverse hyperbolic sine (IHS) transformation for variables of interests.[81] The IHS transformation has several advantages such that it can handle skewness, retain zeros and negative values and can overcome drawbacks that generally lie within a natural log transformation.[82]

The potential confounders mentioned above were used in the adjusted model, along with a 'time trend' and binary quarterly seasonal dummies to evaluate temporal trends and seasonality in COVID-19 cases and deaths per-million population. We have considered January to March as Q1, April to June as Q2, July to September as Q3 and October to December as Q4, where Q1 as a reference category. We also considered monthly seasonal dummies in the regression, results of which are presented in online supplemental appendix 3.

Sensitivity analysis

The study includes four countries: Afghanistan, Libya, Syria and Yemen, which fall under conflict or warzone, and their healthcare systems are at the brink of collapse. These four countries were the last to report COVID-19 cases in the EMR region. Records of data collected from these war-torn countries are most likely to be underestimated given the authorities' chaotic response to the pandemic.[83] Moreover, a lack of COVID-19 testing, population displacement during the pandemic, malnutrition and poverty are the main factors contributing to unreliable and inaccurate COVID-19 cases and deaths reported for these countries.[83] We conducted a sensitivity analysis by estimating mixed-effect negative binomial regression excluding data for Afghanistan, Libya, Syria and Yemen and compared results with those based on all 22 countries of the EMR.

The analyses were carried out using STATA V.15.1.[84]

Patient and public involvement

This research did not have patient or public involvement.

RESULTS

Between 1 March 2020 and 31 October 2021, there were 16 638 061 COVID-19 cases and 306 907 deaths from COVID-19 across 22 countries in the WHO EMRO region. Table 1 provides the summary statistics of COVID-19 cases and deaths per-million population, Gini coefficients and potential confounders across 22 countries. On average, each of these countries experienced 2354.10 COVID-19 cases and 28.06 COVID-19 deaths per-million population during the study period. The lowest COVID-19 cases was 16.06 per-million population in Yemen and the highest was 7915.94 cases per-million population in Bahrain. However, the lowest and the highest COVID-19 deaths were 3.09 and 74.24 per-million population in Yemen and Iran, respectively. The unweighted mean (SD) of country-level Gini coefficient was 34.94 (5.42). It varies from 26.0 in UAE and Qatar to 45.9 in Saudi Arabia, suggesting that the lowest and highest income inequalities are in the GCC countries of the EM region (table 1). Overall, there was an increasing trend in monthly COVID-19 cases and deaths per-million population in the EMR countries (figures 1 and 2).

From an unadjusted crude analysis, Spearman rank correlation shows a small negative association between COVID-19 cases and Gini coefficient (rho=–0.056, p value=0.235). However, this association appeared to be positive between COVID-19 deaths and Gini coefficients (rho=0.044, p value=0.360).

Table 2 presents estimated risk ratios (RRs) from the negative binomial regression results for COVID-19 cases and deaths per-million population, respectively. An estimated over dispersion parameter (alpha) value of 1.079 (95% CI 0.945 to 1.231) for COVID-19 cases and 1.055 (95% CI 0.903 to 1.234) for COVID-19 deaths per million indicate validity of a negative binomial over Poisson regression. The statistical significance of estimated LR tests (p value <0.001) in table 2 suggests that a mixed-effect model was appropriate for both COVID-19 cases and deaths per-million population. There is a substantial country-level variation in COVID-19 cases and deaths per-million population (country-level variance (95% CI) was 0.423 (95% CI 0.214 to 0.834) and 0.110 (0.044 to 0.277), respectively), suggesting a multilevel structure is more appropriate than a pooled model.

The estimated model in table 2 reveals a significant association between income inequality and COVID-19 cases per-million population in the EMR countries. After controlling for potential confounders and other variables that remain fixed, a unit increase in Gini coefficient is associated with an 7.2% increase in the COVID-19 cases per million during the study period (incidence rate ratio (IRR)=1.072; 95% CI 1.006 to 1.142). To put these

Table 1 COVID-19 cases and deaths per million, Gini coefficients and selected confounders in EMR countries between March 2020 and October 2021

Country	COVID-19 data	Mean	SD	Min	Max
Kuwait	Cases per million	4766.41	3350.44	56.37	10965.56
	Deaths per million	28.43	21.47	0	81.09
	Gini coefficient	39.4			
Oman	Cases per million	2912.72	2753.35	35.61	9825.26
	Deaths per million	39.35	41.00	0.19	144.54
	Gini coefficient	26.19			
Bahrain	Cases per million	7915.94	8380.50	300.87	36376.58
	Deaths per million	39.84	58.71	0.57	212.78
	Gini coefficient	41.0			
Qatar	Cases per million	4081.97	3945.13	266.16	14844.10
	Deaths per million	10.41	14.18	0.34	56.99
	Gini coefficient	26.0			
Saudi Arabia	Cases per million	776.18	800.46	41.96	2986.98
	Deaths per million	12.44	10.19	0.28	34.44
	Gini coefficient	45.9			
UAE	Cases per million	3702.72	2742.70	64.36	9587.25
	Deaths per million	10.69	8.80	0.60	37.13
	Gini coefficient	26.0			
Egypt	Cases per million	158.75	115.09	6.8	415.56
	Deaths per million	8.94	5.85	0.44	19.13
	Gini coefficient	31.5			
Iran	Cases per million	3483.55	3238.63	517.61	13184.42
	Deaths per million	74.24	49.32	20.8	201.86
	Gini coefficient	42.0			
Iraq	Cases per million	2495.46	1963.04	16.54	6816.40
	Deaths per million	28.13	19.76	1.04	67.95
	Gini coefficient	29.5			
Jordan	Cases per million	4199.72	5547.73	5.94	21471.08
	Deaths per million	53.75	67.79	0	210.05
	Gini coefficient	33.7			
Lebanon	Cases per million	4742.25	4988.13	37.67	17660.86
	Deaths per million	62.80	82.12	0.44	238.44
	Gini coefficient	31.8			
Libya	Cases per million	2567.62	2391.49	1.44	8602.1
	Deaths per million	36.64	28.68	0	106.06
	Gini coefficient	39.7			
Morocco	Cases per million	1266.77	1595.34	16.52	6357.51
	Deaths per million	19.64	21.73	0.62	76.70
	Gini coefficient	39.5			
Pakistan	Cases per million	282.76	193.65	9.39	677.57
	Deaths permillion	6.32	4.29	0.12	15.22
	Gini coefficient	31.6			

Continued

Table 1 Continued

Country	COVID-19 data	Mean	SD	Min	Max
Palestine	Cases per million	4336.76	4089.33	19.91	11 762.76
	Deaths per million	44.64	44.23	0.19	127.90
	Gini coefficient	33.7			
Sudan	Cases per million	45.02	43.36	0.16	166.00
	Deaths per million	3.45	2.79	0.02	9.17
	Gini coefficient	34.2			
Syria	Cases per million	118.04	122.59	0.55	489.23
	Deaths per million	6.99	5.91	0.06	17.89
	Gini coefficient	37.5			
Tunisia	Cases per million	2985.76	3420.39	6.95	14 197.83
	Deaths per million	105.74	110.43	0	396.04
	Gini coefficient	32.8			
Yemen	Cases per million	16.06	20.46	0	67.96
	Deaths per million	3.09	3.45	0	11.09
	Gini coefficient	36.7			
Djibouti	Cases per million	672.42	868.50	28.94	3091.21
	Deaths per million	9.03	17.09	0	72.84
	Gini coefficient	41.6			
Somalia	Cases per million	67.23	69.66	0.31	253.13
	Deaths per million	3.69	4.86	0	17.73
	Gini coefficient	36.8			
Afghanistan	Cases per million	196.11	289.79	4.04	1175.36
	Deaths per million	9.14	13.64	0.10	48.37
	Gini coefficient	31.6			
Overall	**Cases per million**	**2354.10**	**3741.61**	**0**	36 376.58
	Deaths per million	**28.06**	**47.62**	**0**	**396.04**
	Gini coefficient	**34.94**	**5.42**	**26.00**	**45.90**
GDP per capita		9320.61	12 899.01	313.9	50 124.4
Percentage of population over 65		4.17	1.93	1.26	8.87
Life expectancy at birth		72.63	5.63	57.4	80.23
No. of physicians per 100 000 population		130.69	87.92	2.3	264.63
No. of days since first case detected		608.36	14.27	569.0	641.0
Stringency Index		59.57	19.77	11.3	99.52

EMR, Eastern Mediterranean Region.

numbers into context, one SD increase in Gini coefficient is equivalent to approximately an 18% increase in the mean value of Gini coefficient (table 1). Therefore, this 18% increase in income inequality corresponds to 18×7.2% or 129.6% increase in COVID-19 cases per million, an additional 3051 cases per million at the mean. The other variable that showed a significant positive association with COVID-19 cases is Stringency Index (IRR=1.032; 95% CI 1.024 to 1.041), suggesting that, if all other variables are kept fixed, a unit increase in Stringency Index corresponds to a 3.2% increase in COVID-19 cases in the region. 'Life expectancy at birth' and 'the number of days since first case detected' are appeared to be positively associated with COVID-19 cases at 1% level of significance (IRRs (p value) are 1.205 (<0.001) and 1.050 (0.001), respectively). There is also a significant increasing trend in the COVID-19 cases per-million population over the study period (table 2). This can be seen from the estimated IRRs and 95% CI (p values) for 'Time trend' variable in table 2 and figure 1. GDP per capita, percentage of population over 65 years old and number of physicians per 100 000 population appeared to be statistically non-significant at 5% level of significance in the multivariate analysis of COVID-19 cases (table 2).

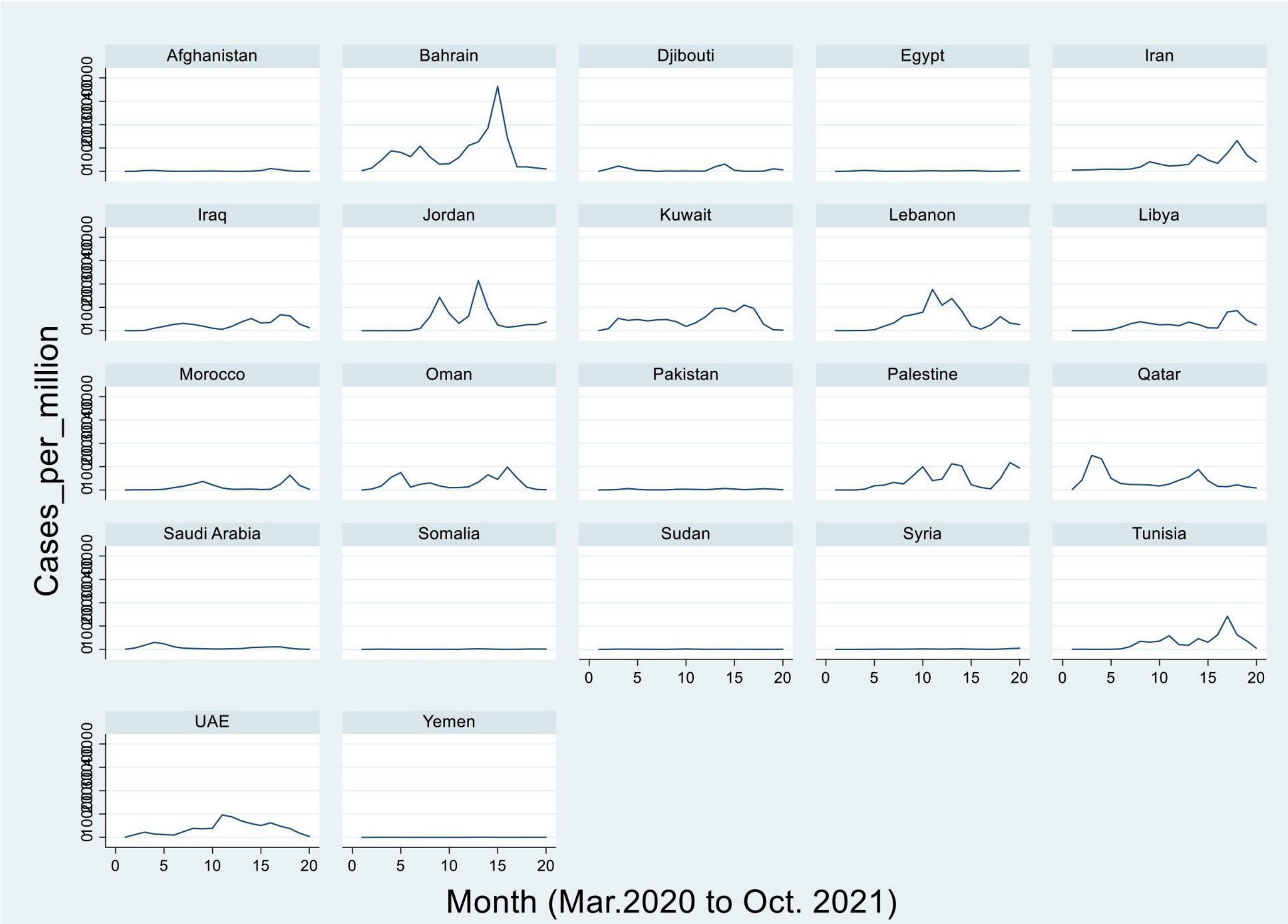

Figure 1 Monthly COVID-19 cases per million population during March 2020 to October 2021 in the Eastern Mediterranean region, by country.

For COVID-19 deaths, the negative binomial regression also estimates a significant association between income inequality and COVID-19 deaths per-million population (table 2). The adjusted model shows that a unit increase in Gini coefficient is related to a 3.9% increase in the COVID-19 deaths per-million during the study period (IRR=1.039; 95% CI 1.001 to 1.079). That means, it is equivalent to 18×3.9% or 70% increase in COVID-19 deaths per million or an additional 20 deaths per million at the mean. Similar to COVID-19 cases in table 2, stringency index shows a significant positive association with COVID-19 deaths per-million population. Like in COVID-19 cases, there is an increasing trend observed in the estimated IRRs from table 2, which are also in line with figure 2. GDP per capita, which can be seen as a proxy of the economic development of a country, is associated with decreasing COVID-19 deaths in the EMR countries (IRR=0.999; 95% CI 0.998 to 0.999).

The robustness check through results from the IHS regression models for COVID-19 cases and deaths are presented in online supplemental appendix 2. The IHS model produced similar results as in mixed-effect negative binomial regressions. After adjusting for the confounders, it was showing a positive and statistically significant association between Gini coefficients and COVID-19 cases and deaths per-million population. The estimated IHS regression for COVID-19 cases shows that 62% of the total variation in the dependent variable can be explained by the regressors. A 1% increase in the Gini coefficient is associated with a 1.65% increase in COVID-19 cases per million population (p value=0.003) in the EMR region (online supplemental appendix 2). A similar positive association from the IHS regression is linked with an increase in COVID-19 deaths per million population by 1.13% (p value=0.037). Like in the mixed-effect negative binomial regression, IHS models also produced statistically significant positive associations between stringency index and Gini coefficients (online supplemental appendix 2).

Sensitivity analysis

The magnitude and direction of the association between income inequality and COVID-19 cases and deaths per-million population still remain the same after excluding four warzone countries from the analysis (table 3). However, results from the sensitivity analysis indicate that a unit increase in Gini coefficient is associated with a 5.9% increase in COVID-19 cases per-million

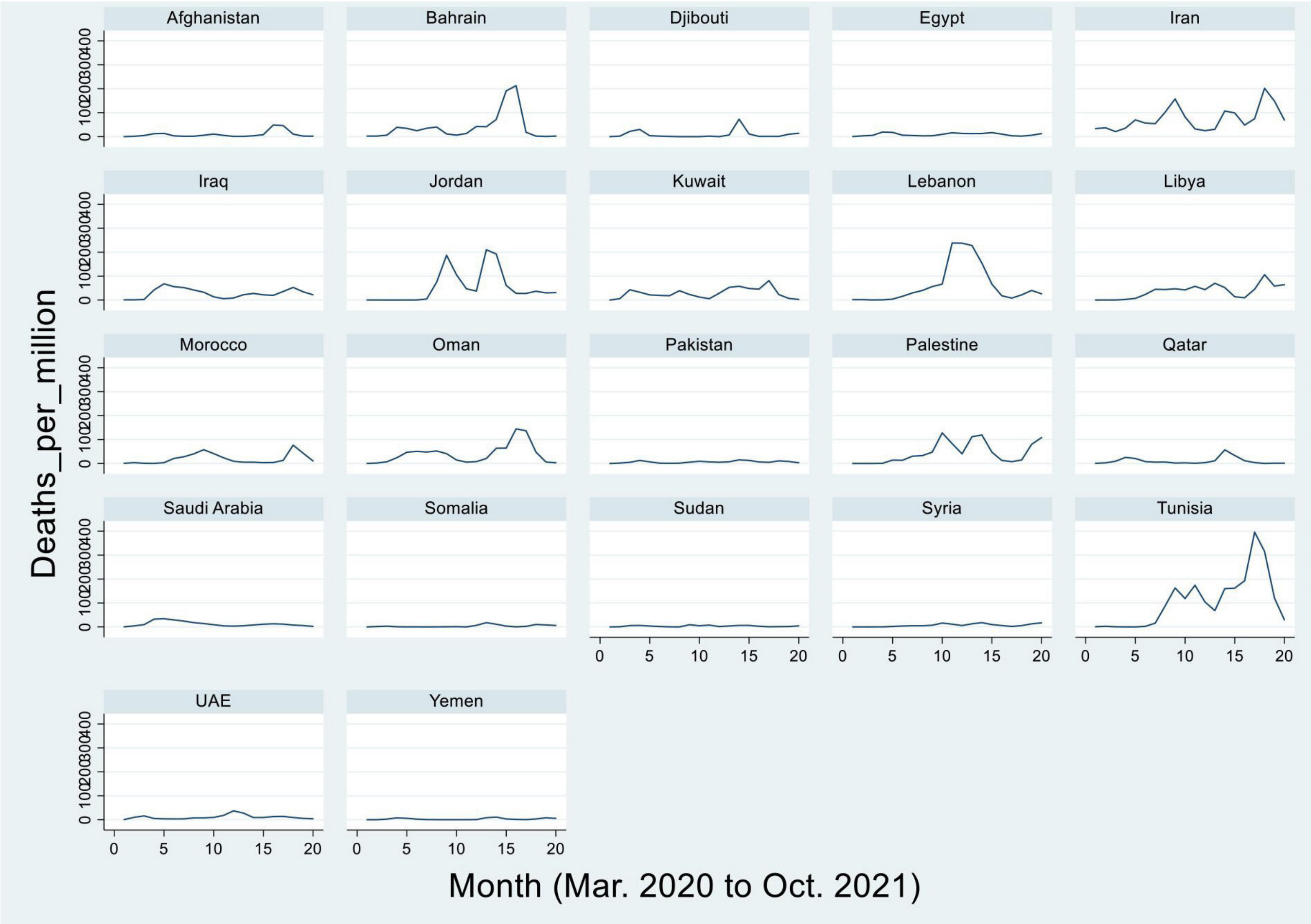

Figure 2 Monthly COVID-19 deaths per million population during March 2020 to October 2021 in the Eastern Mediterranean region, by country.

population (reduced from 8.1% for all 22 countries, p value=0.013). A similar positive association was observed between Gini coefficient and COVID-19 deaths (the increase in mortality was 5.1% per-million population; p value ≤0.001). Overall, regression results from sensitivity analyses for both COVID-19 cases and deaths per million remain almost similar to the base case analysis involving all 22 countries.

DISCUSSION

Main findings

This is the first study investigating the association between pre-existing income inequalities across countries in the EMR and COVID-19 cases and mortality. Our study findings add to the emerging evidence in the literature that suggests a strong positive association between economic disparities and the incidence of COVID-19 cases and deaths. The study demonstrates that a greater level of income inequalities in Eastern Mediterranean countries corresponds to a higher rate of COVID-19 infections and deaths during the study period. That is, a one unit increase in income inequality via the Gini coefficient is associated with an increase in COVID-19 infection and death rates by approximately 7.2% and 3.9% per million population, respectively, in the region. The magnitude of the association for COVID-19 deaths per-million population remains consistent in the sensitivity analysis, by excluding data for four warzone countries in the region.

COVID-19 cases and deaths are likely to be higher in countries with high income inequality, because these countries might have better records of incidence and mortality than countries with low income inequality.[74] For example, high-income countries in the GCC and a number of other countries in the region have better healthcare systems in terms of contact tracing and testing.[85 86] And, some of these countries (eg, Bahrain, Kuwait, Saudi Arabia, Iran) have higher income inequalities in the region. However, after adjusting for GDP, there is no valid reason to agree that higher income inequality reflects a better recording of COVID-19 cases and deaths.[74] Following a number of initial lockdowns, many countries including those in the Eastern Mediterranean have come out from government restrictions and strict measures during the first wave of virus, and started to have a systematic and accurate recording of COVID-19 data.

The observed positive association between income inequality and harm to the population health, via

Table 2 Mixed-effect negative binomial regression for COVID-19 cases and deaths per-million population

	Cases per-million population			Deaths per-million population		
Covariates	IRR	95% CI	P value	IRR	95% CI	P value
Gini coefficient	1.072	1.006 to 1.142	0.031	1.039	1.001 to 1.079	0.031
Stringency index	1.033	1.025 to 1.041	<0.001	1.030	1.022 to 1.038	<0.001
GDP per capita	1.000	0.999 to 1.000	0.411	0.999	0.999 to 0.999	0.031
Percentage of population over 65	0.829	0.647 to 1.061	0.136	0.942	0.815 to 1.087	0.419
Life expectancy at birth	1.205	1.087 to 1.337	<0.001	1.126	1.058 to 1.198	<0.001
No of physicians per 100 000 population	1.000	0.995 to 1.006	0.855	1.000	0.997 to 1.004	0.752
Diabetes_Prevalence	0.853	0.761 to 0.958	0.007	0.940	0.877 to 1.007	0.068
No. of days since first case detected	1.051	1.021 to 1.081	0.001	1.019	1.002 to 1.037	0.026
Time trend	1.127	1.101 to 1.154	<0.001	1.123	1.097 to 1.149	<0.001
Q1 (January to March)	Reference			Reference		
Q2 (April to June)	1.004	0.516 to 1.815	0.976	1.047	0.771 to 1.423	0.662
Q3 (July to September)	0.893	0.452 to 1.348	0.448	0.908	0.674 to 1.224	0.377
Q4 (October to December)	1.323	0.459 to 1.382	0.091	1.331	0.963 to 1.839	0.723
Dispersion parameter—alpha	1.103	0.978 to 1.243		1.024	0.888 to 1.181	
Var (country-level intercepts)	0.423	0.214 to 0.834		0.110	0.044 to 0.277	
Model χ^2 value (d.f.)	231.13 (12)		<0.001	209.33(12)		<0.001
N	440			440		
LR test χ^2 value (d.f.)	78.79 (12)		<0.001	14.23 (12)		0.0001

IRR, incidence rate ratio; LR, likelihood ratio.

COVID-19 cases and deaths, reflects what the inequality researchers link to the failure of critical social and public infrastructure; including education, transportation and healthcare.[61 77] This may be the case in many Eastern Mediterranean countries where there are significant social and economic disparities, which means that people from disadvantaged group are likely to be deprived from necessary healthcare services during the pandemic. Another reasonable argument lies with the fact that, many Eastern Mediterranean countries, including those in the GCC, have a large expatriate population, who are predominantly socioeconomically disadvantaged and low earners, compared with the native population.[87] For example, of the total non-nationals in the labour force in the GCC countries, approximately only 10%–22% foreigners were covering high-skilled jobs.[88]

People with longer life expectancy generally represent a healthy population with a low probability of death at a younger age.[74] However, higher life expectancy indicates that more elderly people in the community who are appeared to be at a greater risk of COVID-19 cases and deaths, especially those who have underlying comorbidities such as CVD and diabetes. Our study showed that a unit increase in average life expectancy in EMR countries is associated with a 21.7% and 13% increase in COVID-19 cases and deaths, respectively. The importance of this result lies in that, after including life expectancy in the model the estimated Gini coefficient still remains as sufficiently large and statistically significant. Unlike life expectancy, the prevalence of diabetes showed a negative association with COVID-19 cases, which was not in the expected direction. Although the inclusion of this parameter into the model produced a spurious estimate, it does not change the main Gini coefficient. This could be attributable to a data issue.

Our findings are consistent with evidence from the literature. Based on a study for OECD countries, Wildman showed that a 1% increase in Gini coefficient is associated with approximately 4% and 5% increase in COVID-19 cases and deaths per-million, respectively.[74] However, these findings were based on aggregated data without accounting for the impact of time. Income inequality was also found to be positively associated with county-level COVID-19 cases and deaths in the USA.[71 72] A 1.0% increase in a county's income inequality is associated with an increase in adjusted RR of 1.020 and 1.030 for COVID-19 cases and deaths.[72]

The Middle East persistently represents the highest income inequality worldwide—with the top 1% of income earners' sharing almost double (23%) the income of the bottom 50% (12%) in 2019.[87] There is also a clear difference in distribution of income and wealth between oil-rich Gulf countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE) and more populous non-Gulf

Table 3 Mixed-effect negative binomial regression for COVID-19 cases and deaths per-million population, excluding four warzone countries

	Cases per-million population			Deaths per-million population		
Covariates	IRR	95% CI	P value	IRR	95% CI	P value
Gini coefficient	1.059	1.012 to 1.109	0.013	1.051	1.023 to 1.080	<0.001
Stringency index	1.032	1.023 to 1.041	<0.001	1.026	1.018 to 1.035	<0.001
GDP per capita	0.999	0.999 to 1.000	0.735	0.999	0.999 to 0.999	<0.001
Percentage of population over 65	0.671	0.547 to 0.823	<0.001	0.790	0.701 to 0.889	<0.001
Life expectancy at birth	1.285	1.192 to 1.386	<0.001	1.151	1.098 to 1.205	<0.001
No. of physicians per 100 000 population	1.000	0.996 to 1.004	0.876	1.001	0.998 to 1.003	0.329
Diabetes_Prevalence	0.854	0.789 to 0.925	<0.001	0.934	0.889 to 0.981	0.006
No. of days since first case detected	1.003	0.971 to 1.038	0.834	1.022	1.002 to 1.043	0.030
Time Trend	1.118	1.089 to 1.148	<0.001	1.109	1.082 to 1.137	<0.001
Q1 (January to March)	Reference			Reference		
Q2 (April to June)	1.124	0.806 to 1.567	0.492	1.174	0.837 to 1.645	0.353
Q3 (July to September)	0.923	0.669 to 1.274	0.628	0.954	0.681 to 1.336	0.784
Q4 (October to December)	1.377	0.964 to 1.968	0.078	1.334	0.925 to 1.924	0.123
Dispersion parameter—alpha	1.079	0.945 to 1.231		1.055	0.903 to 1.234	
Var (country-level intercepts)	0.155	0.063 to 0.379		0.014	0.0002 to 1.030	
Model χ^2 value (d.f.)	274.09 (12)		<0.001	263.52 (12)		<0.001
N	360			360		
LR test χ^2 value (d.f.)	22.87 (12)		<0.001	0.24 (12)		0.312

IRR, incidence rate ratio; LR, likelihood ratio.

countries. Non-Gulf countries are little less unequal, where 49% (as opposed to 56% in Gulf countries) of national income is concentrated among the top 10% of earners.[87] The sheer amount of income inequality in the Gulf and some EMR countries exhibits important features of their political economy, where low-paid expatriate workers generally live in labour camps under unhealthy and poor living conditions, and do not enjoy similar privileges as national citizens. Although there is a decreasing trend in overall income inequality in the region, within-country inequality remains persistently high in a number of Middle-Eastern countries.[30] Underprivileged people, those who are already in poor health, living with low income or poverty, or working and living in crowded or unhealthy conditions, are at greater risk of COVID-19 infections or deaths. Declining income can also likely lead to poorer living conditions and deprivation with worse accommodation, hygiene and basic healthcare access—factors that are associated with an increased risk of infections and deaths from COVID-19. Across the globe, the pandemic negatively affected those people who were already poor the most, especially those with ill health or insecure income.[89]

Although COVID-19 has led significant increases in healthcare needs across the globe, a large number of people in EMR countries or geographical areas have been living with under-resourced healthcare services, partly due to inadequate investment in health systems and infrastructure. For people living in areas of conflict or those receiving humanitarian and emergency support in the EMR, the pandemic has worsened the conditions of already overwhelmed, weakened and fragile healthcare systems. Access to healthcare services has been reduced substantially in the region during the COVID-19 pandemic. In Syria, only approximately half of the 113 public health hospitals and facilities were functional.[90] Three-quarters of primary care clinics in Libya were not in service prior to the pandemic due to the shortage of staff, medicine, supplies and equipment.[47] Doctors in Somalia reported that there were no ventilators and only two intensive care units with a total of 31 beds available in the country in April 2020.[91] Similarly, limited access to much needed healthcare facilities during the COVID-19 pandemic has also been observed in the Gaza strip, Yemen, Somalia and Pakistan.[3] People from low-income groups such as expatriate migrant workers sometimes even declined to seek healthcare or testing for COVID-19 due to the risk of being quarantined or losing income.[92]

Limitations

As common in most of the cross-sectional studies, our study faces some limitations. First, confirmed incidence of COVID-19 cases significantly may vary between countries due to different starting times of the outbreak in different countries, method used and variability in testing, and likely differences in implementing stringency measures. This is not clear how well stringency measures were enforced in these countries; however, it gives an indication about what was happening in terms of governments' COVID-19 actions and measures in EMR countries. It is possible that countries with lower income had less resources for a nuanced or graded response (eg, partial lockdowns) and implemented stringent measures across the board instead (eg, Jordan). Also, compliance to measures depends to an extent on governance in a country and on the duration of measures.[93] It could also be the fact that countries with high-income inequality may have enough resources to implement the strictest stringency measures, leading a high stringency index. Countries with high-income inequalities may also have populations who simply do not follow COVID-19 rules and restrictions, suggesting a likely increase in cases and fatalities. Although, most of the countries had been easing lockdowns and restrictions, and their daily cases were falling, COVID-19 data reporting cannot be directly comparable between countries. The study did not cover the period during which COVID-19 vaccination programmes rolled out globally; hence, it could not investigate the impact of the vaccination on COVID-19 disease and mortality. For a number of countries, Gini coefficients were not available from the WB database; hence, data for these countries were captured from a relevant published article or report, which can also be seen as a limitation of the study.

Given this is a cross-country study which faces a challenge of heterogeneity across counties in the EMR in terms of reporting COVID-19 cases and recording of mortality data, the source of variations could also be related to varied socioeconomic, demographic, medical and hospital capacity, and other healthcare system-level factors. Although we acknowledge that this could lead to bias in analyses, we have conducted a sensitivity analysis by excluding four warzone countries to reduce uncertainty in results. Essentially, this is a common phenomenon and limitation of a cross-country study like the one presented in this manuscript. Due to variation in reporting COVID-19 mortality statistics and underestimation of cases, a cross-country comparison of these data remains as a challenge.[94]

CONCLUSION

In line with the growing number of studies in the literature, our study reveals that income inequality, as measured by Gini coefficients, in the EMR has a positive and significant association with country-level infection and mortality rates from COVID-19. Based on the study findings and discussions, it is likely that income inequality leads to an increase in COVID-19 infections and mortality, partly because a large proportion of population in the region are living in poverty, poor housing, with comorbidities, or with limited or virtually no access to essential healthcare services. Healthcare policy-makers across the region need to adopt and implement targeted and effective interventions in areas of income inequality to both flatten the curve and lessen the burden of socioeconomic inequality in the region.

Contributors MFA conceived and led the study design, data collection, statistical analysis, interpretation of results and made the first draft of the manuscript. JW contributed to the statistical analysis, revised results and reviewed the initial draft manuscript. HAR critically reviewed and contributed to revising the manuscript. All authors critically reviewed and approved the final version of the manuscript. MFA is a senior author and guarantor of all contents in the manuscript.

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REFERENCES

1 Swann T. "'anarchist Technologies': anarchism, cybernetics and mutual aid in community responses to the COVID-19 crisis". *Organization (Lond)* 2023;30:193–209. 10.1177/13505084221090632 Available: https://COVID-19.who.int/
2 Islam S, Islam T, Islam MR. New Coronavirus variants are creating more challenges to global Healthcare system: A brief report on the current knowledge. *Clin Pathol* 2022;15:2632010X221075584.
3 Bello-Chavolla OY, González-Díaz A, Antonio-Villa NE, *et al*. Unequal impact of structural health determinants and Comorbidity on COVID-19 severity and lethality in older Mexican adults: considerations beyond chronological aging. *J Gerontol A Biol Sci Med Sci* 2021;76:e52–9.
4 Hawkins D. Social determinants of COVID-19 in Massachusetts, United States: an ecological study. *J Prev Med Public Health* 2020;53:220–7.
5 Kim SJ, Bostwick W. Social vulnerability and racial inequality in COVID-19 deaths in Chicago. *Health Educ Behav* 2020;47:509–13.
6 Tai DBG, Shah A, Doubeni CA, *et al*. The disproportionate impact of COVID-19 on racial and ethnic minorities in the United States. *Clin Infect Dis* 2021;72:703–6.
7 Krieger N, Waterman PD, Chen JT. COVID-19 and overall mortality inequities in the surge in death rates by zip code characteristics. *Am J Public Health* 2020;110:1850–2.
8 World Health Organization. *Build back fairer: achieving health equity in the Eastern Mediterranean Region: report of the commission on social determinants of health in the Eastern Mediterranean Region, Cairo: World Health Organization. Regional Office for the Eastern Mediterranean, ISBN 978-92-9022-868-4*. 2021.

9 Burström B, Tao W. Social determinants of health and inequalities in COVID-19. *Eur J Public Health* 2020;30:617–8. 10.1093/eurpub/ckaa095 Available: https://doi.org/10.1093/eurpub/ckaa095
10 Hawkins RB, Charles EJ, Mehaffey JH. Socio-economic status and COVID-19-related cases and fatalities. *Public Health* 2020;189:129–34.
11 Wachtler B, Michalski N, Nowossadeck E, *et al*. Socioeconomic inequalities and COVID-19 - A review of the current international literature. *J Health Monit* 2020;5:3–17.
12 Khan A, Althunayyan S, Alsofayan Y, *et al*. Risk factors associated with worse outcomes in COVID-19: a retrospective study in Saudi Arabia. *East Mediterr Health J* 2020;26:1371–80.
13 Wu Z, McGoogan JM. Characteristics of and important lessons from the Coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese center for disease control and prevention. *JAMA* 2020;323:1239–42.
14 Dalton JE, Gunzler DD, Jain V, *et al*. Mechanisms of socioeconomic differences in COVID-19 screening and hospitalizations. *PLoS ONE* 2021;16:e0255343. 10.1371/journal.pone.0255343 Available: https://doi.org/10.1371/journal.pone.0255343
15 Alhasan KA, Shalaby MA, Temsah M-H, *et al*. Factors that influence mortality in critically ill patients with SARS-Cov-2 infection: A multicenter study in the kingdom of Saudi Arabia. *Healthcare* 2021;9:1608. 10.3390/healthcare9121608 Available: https://doi.org/10.3390/healthcare9121608
16 Nguyen NT, Chinn J, De Ferrante M, *et al*. Male gender is a Predictor of higher mortality in hospitalized adults with COVID-19. *PLoS ONE* 2021;16:e0254066.
17 Hoebel J, Michalski N, Diercke M, *et al*. Emerging socio-economic disparities in COVID-19-related deaths during the second pandemic wave in Germany. *Int J Infect Dis* 2021;113:344–6.
18 Ozyilmaz A, Bayraktar Y, Toprak M, *et al*. Demographic and health determinants of the COVID-19 outbreak. *Healthcare* 2022;10:748. 10.3390/healthcare10040748 Available: https://doi.org/10.3390/healthcare10040748
19 Moosa IA, Khatatbeh IN. Robust and fragile determinants of the infection and case fatality rates of COVID-19: International cross-sectional evidence. *Applied Economics* 2021;53:1225–34. 10.1080/00036846.2020.1827139 Available: https://doi.org/10.1080/00
20 Stojkoski V, Utkovski Z, Jolakoski P, *et al*. n.d. The socio-economic determinants of the Coronavirus disease (COVID-19) pandemic. *SSRN Journal* 10.2139/ssrn.3576037 Available: https://www.medrxiv.org/content/10.1101/2020.04.15.20066068v1.full.pdf
21 Cao Y, Hiyoshi A, Montgomery S. COVID-19 case-fatality rate and demographic and socioeconomic Influencers: worldwide spatial regression analysis based on country-level data. *BMJ Open* 2020;10:e043560. 10.1136/bmjopen-2020-043560 Available: https://doi.org/10.1136/bmjopen-2020-043560
22 International Monetary Fund. COVID-19 in Latin America and the Caribbean: A high toll on lives and livelihoods. In: *Regional Economic Outlook for Western Hemisphere*. Washington, DC: International Monetary Fund, 2020. Available: https://www.imf.org/en/Publications/REO/ WH/Issues/2020/10/13/regional-economic-outlookwestern-hemisphere
23 Sorci G, Faivre B, Morand S. Explaining amongCountry variation in COVID-19 case fatality rate. *Sci Rep* 2020;10:18909. 10.1038/s41598-020-75848-2 Available: https://doi. org/10.1038/s41598-020-75848-2
24 Deaton A. Health, inequality and economic development. *Journal of Economic Literature* 2003;41:113–58.
25 Gertler P, Gruber J. Insuring consumption against illness. *Am Econ Rev* 2002;92:51–70.
26 Wagstaff A. Poverty and health. *Bull World Health Org* 2002;80:97–105.
27 World Bank Group and UNHCR. *Compounding misfortunes: changes in poverty since the onset of Covid-19 on Syrian refugees and host communities in Jordan, the Kurdistan region of Iraq and Lebanon*. Washington, DC: World Bank, 2020. Available: http://documents1.worldbank.org/curated/en/878321608148278305/pdf/CompoundingMisfortunes-Changes-in-Poverty-Since-the-Onset-of-COVID-19.pdf
28 OECD. *COVID-19 crisis response in MENA countries*. Paris: Organisation for Economic Co-operation and Development, 2020. Available: https://www.oecd.org/coronavirus/policy-responses/covid-19-crisis-response-in-menacountries-4b366396/#annex-d1e2136
29 United Nations Lebanon. *Rapid socio-economic impact assessment*. New York, NY: United Nations, 2020. Available: https://www.arabstates.undp.org/content/rbas/en/home/library/crisis-response0/rapid-socio-economicimpact-assessment-lebanon.html
30 Akmal M, Crawfurd L, Hares S, *et al*. CGD policy paper 188. *COVID-19 in Pakistan: a phone survey to assess education, economic, and health-related outcomes*. Washington, DC: Center for Global Development, 2020. Available: https://www.cgdev.org/publication/covid-19-pakistan-phone-survey-assess-educationeconomic-and-health-related-outcomes
31 Alvaredo F, Assouad L, Piketty T. Measuring Lnequality in the Middle East 1990–2016: the world's most unequal region *Review of Income and Wealth* 2019;65:685–711. 10.1111/roiw.12385 Available: https://onlinelibrary.wiley.com/toc/14754991/65/4
32 World Bank. MENA: trade and regional integration are critical to economic recovery in the post-Covid era. 2020. Available: https://www.worldbank.org/en/news/press-release/2020/10/19/mena-trade-and-regionalintegration-are-critical-to-economic-recovery-in-the-post-covid-era
33 World Bank. *Poverty and shared prosperity 2020: reversals of fortune*. Washington, DC, 2020.
34 Arezki R, Moreno-Dodson B, Yuting Fan R, *et al*. Trading together: reviving Middle East and North Africa regional integration in the post-COVID era. In: *Middle East and North Africa Economic Update*. Washington, DC: World Bank, 2020.
35 United Nations Office for the Coordination of Humanitarian Affairs (OCHA). *Humanitarian needs overview Afghanistan*. New York, NY: UN OCHA, 2020. Available: https://reliefweb.int/sites/reliefweb.int/files/resources/afghanistan_humanitarian_needs_overview_2021_0.pdf
36 Chetty R, Stepner M, Abraham S, *et al*. The association between income and life expectancy in the United States. *JAMA* 2016;315:1750–66. 10.1001/jama.2016.4226 Available: 1750-1766
37 Senghore M, Savi MK, Gnangnon B, *et al*. Leveraging Africa's preparedness towards the next phase of the COVID-19 pandemic. *Lancet Glob Health* 2020;8:e884–5.
38 United Nations High Commission for Refugees (UNHCR). COVID-19: water, sanitation and hygiene in schools: a safe return to schools for refugee children and youth. Geneva: United Nations high Commissioner for refugees. 2020. Available: https://www.unhcr.org/5fbfdc674.pdf
39 The Economist. *COVID-19 in the camps: migrant workers in cramped Gulf dorms fear infection*. Beirut: The Economist, 2020. Available: https://www.economist.com/middle-east-and-africa/2020/04/23/migrant-workers-in-cramped-gulfdorms-fear-infection
40 Bond J. COVID-19, migrant labor, and the case for labor recruitment reform. *Council on Foreign Relations* 2020. Available: https://www.cfr.org/blog/covid-19-migrant-labor-and-case-labor-recruitment-reform
41 Pan D, Sze S, Minhas JS, *et al*. The impact of Ethnicity on clinical outcomes in COVID-19: a systematic review. *EClinicalMedicine* 2020;23:100404.
42 Bor J, Cohen GH, Galea S. Population health in an era of rising income inequality: USA, 1980-2015. *Lancet* 2017;389:1475–90.
43 International Organization for Migration (IOM). Somalia responds: together we can fight COVID-19 in Somalia. 2022. Available: https://www.iom.int/donate/campaigns/somalia-responds
44 Alkire S, Dirksen J, Nogales R, *et al*. *Multidimensional poverty and COVID-19 risk factors: a rapid overview of interlinked deprivations across 5.7 billion people*. Oxford Poverty and Human Development Initiative, University of Oxford, 2020. Available: https://ophi.org.uk/b53
45 Alahmad B, Kurdi H, Colonna K, *et al*. COVID-19 stressors on migrant workers in Kuwait: cumulative risk considerations. *BMJ Glob Health* 2020;5:e002995.
46 Koh D. Migrant workers and COVID-19. *Occup Environ Med* 2020;77:634–6.
47 World Health Organization (WHO). COVID-19 research and innovation: powering the world's pandemic response – now and in the future. 2022.
48 Campbell BMS. The great transition. In: *Climate, Disease and Society in the Late-Medieval World*. Cambridge: Cambridge University Press, 2016.
49 Snowden FM. *Epidemics and society: from the Black death to the present*. New Haven: Yale University Press, 2019.
50 Furceri D, Loungani P, Ostry JD, *et al*. Will COVID-19 affect inequality? evidence from past Pandemics. *Covid Economics* 2020;12:138–57.
51 Anbarci N, Escaleras M, Register CA. From cholera outbreaks to Pandemics: the role of poverty and inequality. *The American Economist* 2012;57:21–31.
52 Farmer P. Social inequalities and emerging infectious diseases. *Emerg Infect Dis* 1996;2:259–69.
53 Farmer P. *Infections and inequalities: the modern plagues*. Berkeley, CA: University of California Press, 2001.

54 Pickett KE, Wilkinson RG. *The Spirit Level*. New York, London, New Delhi, Sydney: Bloomsbury Press, 2009.
55 Pickett KE, Wilkinson RG. Income inequality and health: a causal review. *Soc Sci Med* 2015;128:316–26.
56 Wagstaff A, van Doorslaer E. Income inequality and health: what does the literature tell us *Annu Rev Public Health* 2000;21:543–67.
57 Gravelle H, Wildman J, Sutton M. Income, income inequality and health: what can we learn from aggregate data *Soc Sci Med* 2002;54:577–89.
58 Jones AM, Wildman J. Health, income and income inequality. *J Health Econ* 2008;27:308–24.
59 Wilkinson RG. Income distribution and life expectancy. *BMJ* 1992;304:165–8.
60 Gravelle H. How much of the relation between population mortality and unequal distribution of income is a statistical Artefact *BMJ* 1998;316:382–5.
61 Elgar FJ, Stefaniak A, Wohl MJA. The trouble with trust: time-series analysis of social capital, income inequality, and COVID-19 deaths in 84 countries. *Social Science & Medicine* 2020;263:113365.
62 Rutter PD, Mytton OT, Mak M, *et al*. Socio-economic disparities in mortality due to pandemic influenza in England. *Int J Public Health* 2012;57:745–50. 10.1007/s00038-012-0337-1 Available: https://doi.org/10.1007/s00038-012-0337-1
63 Ahmed F, Ahmed N, Pissarides C, *et al*. Why inequality could spread COVID-19. *Lancet Public Health* 2020;5:S2468-2667(20)30085-2.
64 Takian A, Kiani MM, Khanjankhani K. COVID-19 and the need to Prioritize health equity and social determinants of health. *Int J Public Health* 2020;65:521–3.
65 Mollalo A, Vahedi B, Rivera KM. GIS-based spatial modeling of COVID-19 incidence rate in the Continental United States. *Sci Total Environ* 2020;728:S0048-9697(20)32401-3.
66 Oronce CIA, Scannell CA, Kawachi I, *et al*. Association between Statelevel income inequality and COVID-19 cases and mortality in the USA. *J Gen Intern Med* 2020;35:2791–3. 10.1007/s11606-020-05971-3 Available: https://doi.org/10.1007/s11606-020-05971-3
67 Abedi V, Olulana O, Avula V, *et al*. Racial, economic, and health inequality and COVID-19 infection in the United States. *J Racial Ethn Health Disparities* 2021;8:732–42.
68 Bucchianeri GW. Is SARS a poor man's disease? socioeconomic status and risk factors for SARS transmission. *Forum Health Econ Policy* 2010;13:1–29.
69 Elgar FJ, Stefaniak A, Wohl MJA. The trouble with trust: time-series analysis of social capital, income inequality, and COVID-19 deaths in 84 countries. *Soc Sci Med* 2020;263:113365. 10.1016/j.socscimed.2020.113365 Available: https://doi.org/10.1016/j.socscimed.2020.113365
70 Chakrabarty D, Bhatia B, Jayasinghe M, *et al*. Relative deprivation, inequality and the COVID-19 pandemic. *Social Science & Medicine* 2023;324:115858.
71 Tan AX, Hinman JA, Abdel Magid HS, *et al*. Association between income inequality and county-level COVID-19 cases and deaths in the US. *JAMA Netw Open* 2021;4:e218799.
72 Liao TF, De Maio F. Association of social and economic inequality with Coronavirus disease 2019 incidence and mortality across US counties. *JAMA Netw Open* 2021;4:e2034578.
73 Oronce CIA, Scannell CA, Kawachi I, *et al*. Association between state-level income inequality and COVID-19 cases and mortality in the USA. *J GEN INTERN MED* 2020;35:2791–3.
74 Wildman J. COVID-19 and income inequality in OECD countries. *Eur J Health Econ* 2021;22:455–62.
75 Davies JB. Economic inequality and COVID-19 death rates in the first wave, a cross-country analysis. *SSRN Journal* 2021:8957.
76 World O meter. n.d. Available: https://www.worldometers.info/coronavirus/
77 Maio FD. *Health and Social Theory*. Palgrave Macmillan, 2009.
78 World Bank. The World Bank, Middle East and North Africa. 2021. Available: https://www.worldbank.org/en/region/mena
79 Haldar A, Sethi N. The effect of country-level factors and government intervention on the incidence of COVID-19. *Asian Economics Letters* 2020;1.
80 Hale T, Angrist N, Goldszmidt R, *et al*. A global panel database of pandemic policies (Oxford COVID-19 government response Tracker). *Nat Hum Behav* 2021;5:529–38.
81 Burbidge JB, Magee L, Robb AL. Alternative transformations to handle extreme values of the dependent variable. *Journal of the American Statistical Association* 1988;83:123–7.
82 Friedline T, Masa RD, Chowa GAN. Transforming wealth: using the inverse hyperbolic sine (IHS) and Splines to predict youth's math achievement. *Soc Sci Res* 2015;49:264–87.
83 Daw MA. The impact of armed conflict on the Epidemiological situation of Coronavirus disease (COVID-19) in Libya, Syria, and Yemen. *Front Public Health* 2021;9:9. 10.3389/fpubh.2021.667364 Available: https://doi.org/10.3389/fpubh.2021.667364
84 Statacorp LLC. STATA (statistical data analysis) version 15.1. Statacorp LLC, Texas, USA.
85 Salameh P. COVID-19 in the Eastern Mediterranean region: testing frequency, cumulative cases and mortality analysis. *East Mediterr Health J* 2020;26:1005–10.
86 Moradi L. COVID-19 in Eastern Mediterranean region countries. *J Arch Mil Med* 2020;8:e112671.
87 Moshrif R. Income inequality in the Middle East; the world inequality lab, issue brief 2020-06. 2020.
88 Khadri SA. High skilled professionals in the GCC: migration policies and government outlook. Fargues P, Shah NM, eds. Qatar Foundation Annual Research Conference Proceedings; Qatar National Convention Center (QNCC), Doha, Qatar.Gulf Migration Center Cambridge, 2018
89 Bambra C, Riordan R, Ford J, *et al*. The COVID-19 pandemic and health inequalities. *J Epidemiol Community Health* 2020;74:964–8.
90 United Nations Development Programme. Syrian Arab Republic UN country team. framework for the immediate socio-economic response to COVID-19 for Syrian Arab Republic. 2020. Available: https://unsdg.un.org/resources/ framework-immediate-socio-economic-response-covid-19-syrian-arab-republic
91 International Organization for Migration. Somalia responds: together we can fight COVID-19 in Somalia. 2022. Available: https://www.iom.int/donate/campaigns/somalia-responds
92 Asi YM. *Migrant workers' health and COVID-19 in GCC countries*. Washington, DC: Arab Center Washington DC, 2020. Available: http://arabcenterdc.org/policy_analyses/migrant-workers-health-and-covid-19-in-gcc-countries
93 Makki F, Sedas PS, Kontar J, *et al*. Compliance and Stringency measures in response to COVID-19: a regional study. *J Behav Econ Policy* 2020;4:15–24.
94 Chen YY, Assefa Y. The heterogeneity of the COVID-19 pandemic and national responses: an explanatory mixed-methods study. *BMC Public Health* 2021;21:835. 10.1186/s12889-021-10885-8 Available: https://doi.org/10.1186/s12889-021-10885-8