



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

COVID-19 mortality and deprivation: pandemic, syndemic, and endemic health inequalities

Victoria J McGowan, Clare Bamba



Lancet Public Health 2022;
7: e966–75

Population Health Sciences
Institute, Newcastle
University, Newcastle upon
Tyne, UK (V J McGowan PhD,
Prof C Bamba PhD);
Fuse-The Centre for
Translational Research in Public
Health, Newcastle Upon Tyne,
UK (V J McGowan,
Prof C Bamba)

Correspondence to:
Prof Clare Bamba, Population
Health Sciences Institute,
Newcastle University,
Newcastle upon Tyne NE1 4LP, UK
clare.bamba@ncl.ac.uk

For more on Rayyan QCRI see
<https://www.rayyan.ai/>

See Online for appendix

COVID-19 has exacerbated endemic health inequalities resulting in a syndemic pandemic of higher mortality and morbidity rates among the most socially disadvantaged. We did a scoping review to identify and synthesise published evidence on geographical inequalities in COVID-19 mortality rates globally. We included peer-reviewed studies, from any country, written in English that showed any area-level (eg, neighbourhood, town, city, municipality, or region) inequalities in mortality by socioeconomic deprivation (ie, measured via indices of multiple deprivation: the percentage of people living in poverty or proxy factors including the Gini coefficient, employment rates, or housing tenure). 95 papers from five WHO global regions were included in the final synthesis. A large majority of the studies (n=86) found that COVID-19 mortality rates were higher in areas of socioeconomic disadvantage than in affluent areas. The subsequent discussion reflects on how the unequal nature of the pandemic has resulted from a syndemic of COVID-19 and endemic inequalities in chronic disease burden.

Introduction

The COVID-19 pandemic has occurred against a backdrop of existing social and economic inequalities in non-communicable diseases.¹ Although the effects of COVID-19 have been examined across various dimensions of health inequalities such as age,^{2–5} disability,⁶ gender,^{7–10} race and ethnicity,^{5,9,11–16} sexuality,¹⁷ occupation,¹⁸ and socioeconomic status,^{16,19} geographical inequalities by area-level deprivation have been relatively less explored (yet notable early exceptions include work in the USA by Chen and Krieger²⁰ or in Europe such as by Daras and colleagues²¹ or by Niedzwiedz and colleagues²²). The links between place and health have been long established in the scientific literature,^{23,24} and endemic geographical inequalities in health have been widely documented—eg, in England,^{25,26} and in other European countries.^{27,28} There are also notable geographical inequalities in health within low-income and middle-income countries—in Chile,²⁹ in India,^{30,31} and in Malawi, South Africa, Eswatini, Zambia, and Zimbabwe.³² These health inequalities are entrenched and in some countries are increasing over time.³³

Given these marked, endemic health inequalities, we sought to examine whether COVID-19 mortality rates also showed similar geographical patterns. Research in England, for example, has found large regional inequalities with high rates of COVID-19 deaths in the most deprived northern regions.³⁴ However, there has been no assessment of whether there is an association between COVID-19 mortality and deprivation across different countries, in different stages of the pandemic, or at different geographical scales. Therefore, this Review explores what is known about geographical inequalities in COVID-19 mortality rates. It aims to identify and analyse the association between deprivation and COVID-19 mortality rates globally by reviewing studies from any country, at any stage of the pandemic, and at any geographical scale. The discussion draws on these findings and the wider place and health literature to reflect on how the unequal nature of the pandemic

has resulted from a syndemic of COVID-19 and endemic inequalities in chronic disease burden.

Methods

The protocol has been published elsewhere.³⁵ Our inclusion and exclusion criteria was ordered by population, concept, and context.

All titles and abstracts were screened by VJM, using Rayyan QCRI,³⁶ and relevant papers were retrieved and assessed for inclusion. Ambiguous studies were discussed with CB. Following guidance for conducting scoping reviews by Peters and colleagues,³⁷ data pertaining to population, location, and outcomes were extracted from full-text versions of included studies using standardised extraction forms. A formal assessment of study quality and risk of bias was not done.^{38–40}

A process of charting the results was done, in which a descriptive summary of the study characteristics and findings pertaining to the Review topic were tabulated (appendix pp 8–47). Studies were tabulated by WHO region and their findings narratively synthesised (on the basis of the direction of effect determined by whether studies showed significant results, dichotomised into a positive significant association vs no or a negative association) to summarise the global evidence base on geographical inequalities in COVID-19 mortality.

COVID-19 mortality and deprivation

Overview of the findings

95 primary studies were included in this Review. Initially, 22190 citations were retrieved from the four databases searched. All records were uploaded to Rayyan and after deduplication, a total of 13930 unique citations were subject to title and abstract screening. This process resulted in 360 full texts being screened for inclusion of which 145 were selected for full-text review, and 50 of those were excluded with reasons provided (appendix pp 48–52). The process of study inclusion and exclusion is depicted in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart⁴¹ (appendix p 53).

Included studies were in the following five WHO regions: the Americas (n=72); Europe (n=20); Africa (n=1); South-East Asia (n=1); and the Western Pacific (n=1). No studies were identified from the Eastern Mediterranean region. The results and locations of the different studies are summarised in the appendix (pp 8–47) and a map of the global distribution of included studies is also provided (appendix p 54).

Although study outcomes (ie, COVID-19 mortality) were homogeneous, measures of socioeconomic disadvantage varied across the studies (including poverty, income, education, [un]employment, deprivation, social vulnerability, and car and computer ownership). There was also great variation in the timepoints for data used in the studies ranging from a few weeks in the early stages of the pandemic to the whole first year. Considering these variations in socioeconomic measures and time periods is important when interpreting the results of the studies.

91% (86 of 95) of the studies^{20,21,42–125} found that COVID-19 mortality was significantly higher in areas of social disadvantage than in affluent areas. Only a small minority of studies (n=9)^{126–134} showed mixed results. Three studies^{126–128} showed high mortality rates regardless of deprivation and one of these studies¹²⁷ noted that mortality rates shifted back and forth between deprived and affluent areas over time. Four studies^{129–132} showed no association between markers of economic disadvantage and COVID-19 mortality; however, two of these studies^{129,130} found higher rates among areas with high minority ethnic populations than in areas with low ethnic minority populations, one study found a substantial relationship between COVID-19 case fatalities and poverty,¹³¹ and one found greater area income inequality was associated with higher infections but not deaths.¹³² Two studies^{133,134} showed higher COVID-19 mortality rates in more advantaged areas.

Region of the Americas

72 studies were from the WHO region of the Americas, of which 55 studies^{20,42–92,127,129,130} were from the USA. 52 of the US studies showed that COVID-19 mortality rates were higher in areas of social disadvantage than in affluent areas. For example, Oronce and colleagues⁷⁹ examined the relationship between state-level COVID-19 mortality and the Gini index in the early phase of the pandemic (ie, from Jan 22 to April 13, 2020), observing that states with higher income inequality had higher deaths than states with lower income inequality. At the county level, Al Rifat and Liu⁴² found a positive correlation between social vulnerability and COVID-19 mortality during the first year of the pandemic (ie, from Jan 20, 2020, to Jan 20, 2021). Chen and Krieger²⁰ found that COVID-19 death rates were consistently higher in the most disadvantaged counties and neighbourhoods (up to May 5, 2020). Three US studies showed mixed results.^{127,129,130} For example, Neelon and colleagues¹²⁷ examined mortality rates from March 15 to Dec 31, 2020 and found that, although more socially

vulnerable counties had higher death rates early in the pandemic (ie, up to May, 2020), less socially vulnerable areas had higher rates later (ie, by October, 2020).

In Brazil, positive associations were found between social disadvantage and COVID-19 mortality rates in all 12 studies conducted at different timepoints.^{93–103,126} For example, de Souza and colleagues⁹⁷ (up to May 6, 2020) and Silva and Ribeiro-Alves¹⁰¹ (up to May 23, 2020) found that people living in high-income areas were more at risk of COVID-19 infection, but those living in more deprived areas had higher death rates. Studies from Chile,¹⁰⁴ Columbia,¹⁰⁵ and Mexico^{106,107} all observed positive associations between indicators of social disadvantage and COVID-19 mortality rates. For example, Benita and Gasca-Sanchez¹⁰⁶ examined COVID-19 deaths at the municipality level in Mexico from June 1 to Aug 22, 2020, and found that income inequality was strongly associated with mortality. In Peru however, Dorregaray-Farge and colleagues¹³¹ did not observe a significant association between poverty and mortality at the district level in Metropolitan Lima from March 18 to Sept 30, 2020, but found a significant correlation between COVID-19 case fatalities and poverty.

European region

There were 20 studies conducted within the WHO European region. All studies from the UK (n=9),^{20,108–115} Germany (n=3),^{116–118} France (n=1),¹¹⁹ Hungary (n=1),¹²⁰ Italy (n=1),¹²¹ and Switzerland (n=1)¹²² showed positive associations between area-level indicators of socioeconomic disadvantage and COVID-19 mortality rates. For example, Chaudhuri and colleagues¹¹² examined inequalities in COVID-19 mortality rates at the local authority level in England from March 1 to April 16, 2020, and found that the most deprived areas had significantly higher COVID-19 mortality compared with the least deprived areas. In Germany, Hoebel and colleagues¹¹⁶ found that COVID-19 mortality rates increased faster in more deprived districts between September, 2020, and March, 2021, than in less deprived districts. Ginsburgh and colleagues¹¹⁹ observed more deaths in departments with greater income inequality in France, from March 1 to Sept 3, 2020, than in departments with less income inequality. In Hungary, Oroszi and colleagues¹²⁰ found a strong positive relationship between mortality and deprivation at the municipality level up to April 13, 2021. Di Girolamo and colleagues¹²¹ found that in the Emilia-Romagna region of northern Italy, COVID-19 mortality rates were high in the most disadvantaged census blocks from March 1 to April 31, 2020. In Switzerland, Riou and colleagues¹²² found that COVID-19 mortality was high in neighbourhoods with a low socioeconomic status up to April 14, 2021.

Two studies from Spain,^{133,134} however, showed that COVID-19 mortality was associated with socioeconomic advantage and one showed increased area-level income inequality was associated with high infections but not deaths.¹³² For example, Garcia¹³⁴ examined COVID-19

mortality rates across the 17 autonomous communities of Spain up to May 23, 2020, and found that a 1% increase in the gross domestic product per capita was associated with a 3·1% increase in COVID-19 mortality. One study from Sweden¹²³ found no significant association between COVID-19 mortality and area-level income or education.

African region

Only one study from the WHO Africa region was found. This South African study by Hussey and colleagues¹²⁴ identified a socioeconomic gradient in COVID-19 mortality at the subdistrict level in Cape Town up to Feb 24, 2021.

South-East Asia region

Only one study from the WHO South-East Asia region was included.¹²⁸ This study by Middy and Roy¹²⁸ examined geographical inequalities in COVID-19 deaths at the district level in India up to Feb 24, 2021. They found mixed results with high mortality rates in affluent areas in the COVID-19 death hotspots of eastern and western India, but a strong negative relationship between COVID-19 death rates and education in hotspots of eastern, central, and southern regions of India.

Western Pacific region

One study from the WHO Western Pacific region was included. Yoshikawa and Kawachi¹²⁵ observed high COVID-19 mortality rates in areas with the greatest socioeconomic disadvantage at the prefecture (ie, regional) level in Japan for the first year of the pandemic up to February, 2021.

Pandemic, syndemic, and endemic health inequalities

Overall, the vast majority of studies showed inequalities by various measures of area-level deprivation at differing geographical scales, from neighbourhood to region. Evidence of area-level socioeconomic inequalities in COVID-19 mortality rates were found in four of the six WHO world regions (ie, the Americas, Europe, Africa, and the Western Pacific). Most of the studies were conducted in the Americas and Europe with only some from other WHO regions; no studies were found for the Eastern Mediterranean region and the single study for South-East Asia had mixed results. The scarcity of studies on the association between area-level deprivation and COVID-19 mortality outcomes from most of the countries on the planet speaks to our lack of knowledge about inequalities in most places, and the poor investment in researching this topic.

Our findings are broadly in keeping with extensive data on area-level inequalities in other pandemics. For example, area-level inequalities were documented in the 2009 H1N1 influenza pandemic in England¹³⁵ and there are well documented inequalities by deprivation in seasonal winter influenza among both adults and children.^{136,137} Research into the Ebola virus disease outbreaks in west Africa and

the Democratic Republic of the Congo has also found that transmission was high in the most impoverished communities and that most of the spread originated in low socioeconomic status areas.¹³⁸ Similarly for the congenital Zika syndrome pandemic in Brazil, there is evidence of a strong association between prevalence rates and living conditions.¹³⁹ Even historical research into the 1918 Spanish influenza pandemic has documented area-level inequalities in mortality related to deprivation (eg, household size and income).¹⁴⁰⁻¹⁴² Similarly, our results reflect the findings of reviews of socioeconomic inequalities in COVID-19 at the individual level. For example, an international systematic review of inequalities in COVID-19 outcomes found that ethnic minorities and low socioeconomic groups had high risks of COVID-19 infection, hospitalisation, confirmed diagnosis, and death.¹⁴³ The long-term increases in health inequalities, already under way in some countries (for example in mortality), might be exacerbated by the pandemic.³³

Understanding the relationship between deprivation and COVID-19 mortality rates is multifaceted. The COVID-19 pandemic has been described as a syndemic pandemic.¹⁴⁴ Originating in anthropology, a syndemic describes “a set of closely intertwined and mutual enhancing health problems that significantly affect the overall health status of a population within the context of a perpetuating configuration of noxious social conditions”.¹⁴⁵ Deprivation—which is an area measure of poverty, low income, and a reflection of the wider social determinants of health (such as housing, working conditions, unemployment, health-care access, etc)—results in multiple, interacting, and additive adverse risk factors for COVID-19 mortality.¹ These can be summarised by way of four inter-related pathways: unequal exposure, unequal transmission, unequal vulnerability, and unequal susceptibility.^{144,146}

Unequal exposure results from variations in the ability to shield from infection. For example, people in more deprived areas are more often in jobs that are less amenable to remote working and so they benefit less from lockdown restrictions than those able to work from home.¹⁴⁴ Unequal transmission is the increased risk of infection spreading within the community for people living in more deprived areas. For example, self-isolation if infected is hard in overcrowded houses and in more urban areas and areas of high population density.¹⁴⁷ Unequal vulnerability is the increased risk of mortality from the high burden of non-communicable diseases in socioeconomically disadvantaged areas. For example, key clinical risk factors for adverse COVID-19 outcomes such as respiratory disease, obesity, or heart diseases are all higher in more deprived areas.¹⁴⁸ Unequal susceptibility arises from the increased risk of more severe disease for people from disadvantaged backgrounds, due to weakened resilience from chronic exposure to the social determinants of health. For example, studies have found that adverse psychosocial circumstances increase

immunosuppression—influencing the onset, course, and outcome of disease.¹⁴⁹

Also, of potential relevance to understanding our findings is the health inequalities framework—originally proposed by Diderichsen and colleagues¹⁵⁰ and elaborated on by Katikireddi and colleagues¹⁵¹ in relation to ethnic inequalities in the COVID-19 pandemic. This approach articulates an additional three pathways to inequality in the pandemic including: (1) the differential social consequences of COVID-19 (eg, disability that results in job loss and future loss of earnings due to poor health), (2) the differential effectiveness of pandemic control measures (eg, their effect on risk of exposure, vulnerability, and consequences might be different for different communities), and (3) the differential adverse consequences of control measures (eg, the economic effects of pandemic control measures [such as loss of income] might also disproportionately affect disadvantaged groups more). These could all also apply when considering the potential causes of area-level inequalities in the pandemic that our Review has summarised.

Our Review was limited to studies showing data from the first 2 years of the pandemic (2020–21) and most of the data comes from the first 18 months. As such, we have not been able to capture the extent of inequalities in COVID-19 mortality rates by deprivation after the start of vaccination programmes. This information could be particularly important in high-income countries in which vaccines have been widely distributed. However, despite vaccines often being provided in these contexts at no or low cost, there have been clear inequalities by deprivation in rates of uptake.¹⁵² Indeed, vaccine uptake and unequal health-care treatment more generally (eg, hospital care, respirators, and antivirals) can be considered to be an additional pathway leading to pandemic inequalities.¹⁴⁶ The unequal distribution of vaccine uptake means that future COVID-19 outbreaks can be expected to be geographically concentrated in areas and regions of high deprivation (and low uptake). In countries with low vaccine coverage (including the majority of low-income and middle-income countries) we can also expect inequalities in COVID-19 mortality to continue—albeit with a lower overall death rate given the current dominance of the omicron strand. New variants could of course further exacerbate the unequal pandemic.

The inequalities by deprivation in COVID-19 mortality that we have summarised in this Review reflect wider patterns of endemic geographical inequalities in health.²⁴ There are well documented, long-standing health inequalities within and between places, operating at different scales: from the life expectancy gap of 9 years between men living in the most and least deprived neighbourhoods of England, to the excess mortality in the west of Scotland, the US mortality disadvantage, or regional inequalities in life expectancy across India.^{31,153} These endemic health inequalities arise from a mixture of the nature of the places themselves and the characteristics of the populations

living within them (sometimes referred to as compositional and contextual factors).²⁴ Health inequalities by place arise from differences in compositional risk factors such as demographics (eg, age, sex, and ethnicity), health-related practices (eg, smoking, alcohol consumption, physical activity, diet, drug use, and gambling), and socioeconomic characteristics (eg, income, education, and occupation) of the people living within the area (ie, neighbourhood, town, city, or region).²⁴ They are also influenced by the contextual nature of the place in terms of the socio-spatial determinants of health including the economic (eg, area-level poverty rates, unemployment rates, wages, types and quality of work, and job availability), social (eg, services such as childcare, food supply, health care, housing or schools, and social cohesion), and physical (eg, air pollution, access to green spaces, and the built environment) environments.²⁴ These factors are also influenced by the macro political, economic, and policy conditions operating at national and, increasingly, international levels.¹⁵³ The fact that patterns of COVID-19 follow these endemic health inequalities is unfortunately no surprise as they too reflect these underpinning pathways.

Although there are various immediate tools available to public health policy makers for reducing inequalities in COVID-19—most notably increasing vaccine availability and uptake in more deprived global regions and areas (eg, via mobile vans, door-to-door outreach, and overcoming reasons for hesitancy among more disadvantaged communities such as low social trust or cultural norms, via education, etc)^{154,155}—ultimately improving our future pandemic preparedness requires long-term solutions to health inequalities through tackling the social determinants of health. Reducing inequalities in pandemics requires reducing inequalities in the underpinning endemic inequalities in chronic disease and the social determinants of health. This task is not straightforward or quickly achieved but there is evidence of effective policy actions in different global contexts—from the expansion of civil rights in the USA in the 1960s to the democratisation of Brazil in the 1980s as well as the English Health Inequalities strategy of the 2000s and the reunification of Germany in the 1990s.¹⁵⁶

Strengths and limitations

We followed established scoping review methods and carried out a systematic, international, and wide-ranging search for studies of inequalities by area-level deprivation in COVID-19 mortality during the first 2 years of the pandemic. We included studies from any country, at any geographical scale, and used a broad and inclusive measure of deprivation. However, our study is also subject to some important limitations.

Firstly, although our Review examined studies published up to July, 2022, the majority of studies used data from 2020. As such they relate to the first-known variant, alpha, beta, and delta variants only. They do not examine inequalities in the more recent omicron

variant, nor do they capture post-vaccine mortality rates.

Secondly, we used COVID-19-specific mortality, as opposed to a measure of excess mortality, and this approach could have underestimated the effects of area-level deprivation on mortality especially in countries with less established testing and reporting processes. Similarly, we did not examine other measures of adverse COVID-19 outcomes such as case rates, hospitalisations, or symptom severity. There was also potential heterogeneity in the COVID-19 mortality metrics used by different countries (eg, differences in the criteria for attributing a death to COVID-19). This discrepancy might also have been affected by different testing capacities or reporting policies between countries. Moreover, some differences in the mortality monitoring systems between countries could affect the availability of studies in the period covered by this Review.

Thirdly, this paper is a scoping review, not a full systematic review, and as such no critical appraisal was conducted, and screening and data extraction was done by only one reviewer. We have found a large evidence base (at least for some regions) and therefore recommend a full systematic review with meta-analysis to be conducted soon. Our Review also had other methodological limitations such as only including papers published in English, papers published as full papers, and papers of full populations (thereby excluding those studies based on random samples, which could have inadvertently excluded studies from some countries more than others). We also made some small refinements to the inclusion criteria originally set out in our protocol: (1) studies were required to include data from whole populations rather than just subsections (eg, women, children, and ethnic minorities); (2) case fatality rates were excluded due to concerns over inequalities in testing;^{46,109,111,157} and (3) studies had to show a measure of socioeconomic deprivation (eg, indices of multiple deprivation, percentage living in poverty, proxy factors [including the Gini coefficient as deprivation tends to be highly correlated with income inequality], employment rates, or housing tenure).¹⁵⁸ Notably, another limitation is that in our summary of effect direction, we relied on whether the authors reported significant findings. Any full systematic review could also use other approaches.¹⁵⁹

Fourthly, although we have identified relationships at the area level we cannot assume that our findings hold true at the individual level: the ecological fallacy.¹⁶⁰ However, we make no claims to causality within this Review.

Fifthly, the included studies did not show the intersectional relationship between area-level deprivation and gender (or other axes of inequalities such as ethnicity). So, we were unable to report on additional subgroup differences (eg, whether mortality rates differed between men and women in more or less deprived areas). This lack of intersectionality in geographical studies has been noted previously and is further highlighted in our Review.¹⁶¹

Search strategy and selection criteria

Searches were conducted in four databases (host sites): MEDLINE (Ovid), Embase (Ovid), Science Citation Index Expanded, and Social Science Citation Index (Web of Science) from July 11 to July 15, 2022. The inclusion criteria were guided by the population, concept, and context mnemonic. The population was the total population of the study location; the concept was geographical inequalities in COVID-19 mortality within countries; and the context was any country at any geographical level (eg, neighbourhood, town, city, municipality, or region). Only peer-reviewed studies, from any country, written in English, and published during the first two and a half years of the COVID-19 pandemic (ie, from Jan 1, 2020, to July 11, 2022) were included. Our full search strategy is listed in the appendix (pp 3–7).

Search terms included (SARS-Cov-2 or 2019-nCoV or COVID-19 or coronavirus or exp COVID-19/) and (fatalit* or death* or mortalit* or exp death/ or exp mortality/) and (socioeconomic or SES or education* or employment or income or occupation* or poverty or class or depriv* or disadvantage* or social class or social factors or economic or unemployment or ethnic* or rac* or minorit* or exp socioeconomic factors/) and (area* or geo* or place* or neighbourhood* or region* or count* or ward* or cit* or district* or municipal* or province* or state* or communit* or count* or town* or district* or census or post* or zip or spatial or metropolitan or depriv* or environ*).

Inclusion criteria:

- The publication is a peer-reviewed empirical study published in English
- Population; the publication focuses on COVID-19 deaths or mortality rates from the total population of the study location
- Concept, the publication disaggregates COVID-19 mortality rates by measures of the area's socioeconomic deprivation (eg, Gini index, poverty, income, education, unemployment and employment, deprivation, social vulnerability, and car and computer ownership)
- Context, the publication covers concepts at any geographical level (eg, neighbourhood, town, city, municipality, and region)

Exclusion criteria:

- The publication is a conference proceeding, editorial, letter, comment, erratum, survey, note, or doctoral thesis; or does not meet one or more of the key elements of population, concept, and context
- The publication focuses on COVID-19 hospitalisations, incidences, cases, case fatalities, symptoms and severity, or infection rates
- The publication does not include COVID-19 mortality disaggregated by an area measure of socioeconomic deprivation

Finally, there are also limits to the evidence base itself: the vast majority of studies were from the USA and so generalisability to other countries might be limited. There was a clear dearth of studies conducted in other regions especially those outside high-income regions. Further, many of the included studies were conducted at a large geographical scale (eg, region, county, or municipality) when analysis of smaller-level geographies (ie, neighbourhoods) might allow a more precise estimation of the extent of area-level inequalities in COVID-19 mortality. However, large units can help in considering the way different institutions and services might be contributing to inequalities whereas small areas, because they are potentially a better proxy for individual-level exposures, might provide insight into more proximal pathways.

Conclusion

This Review has found extensive evidence of inequalities in COVID-19 mortality rates by area-level deprivation across the world. The pandemic has been an unequal experience with high mortality rates in the most deprived places and communities. These inequalities can be understood as a syndemic, arising from endemic inequalities in the social determinants of health. Reducing these inequalities—and those that might arise from future pandemics—requires long-term action to reduce inequalities in health and wealth. Future research and data collection should focus on improving surveillance systems by, for example, integrating measures of inequalities into the WHO Mortality Database.

Contributors

CB and VJM conceived the study idea and jointly developed the study methodology. VJM conducted searches, screening, and data extraction with support from CB. CB and VJM analysed and synthesised the findings. VJM led the write-up of the Methods and Results sections, CB led the write-up of the Introduction, Discussion, and Conclusion. Both authors read the draft, provided comments, revised, and agreed on the final version.

Declaration of interests

We declare no competing interests.

Acknowledgments

The authors gratefully acknowledge the information specialist expertise and support from Katie Thomson, who reviewed and refined our search strategy. We would also like to thank our reviewers for their valuable comments and suggestions, which helped us strengthen this manuscript. CB is funded by the Health Foundation (2211473) and the Norwegian Research Council (288638). CB and VJM are both funded by the National Institute for Health Research (NIHR) School for Public Health Research (PD-SPH-2015) and the Wellcome Trust (221266/Z/20/Z). CB is also an NIHR Senior Investigator. The views expressed here are those of the authors and not necessarily those of the NIHR, or the UK Department of Health and Social Care. The funders had no role in the development, conduct, or writing of this Review.

References

- Bambra C, Riordan R, Ford J, Matthews F. The COVID-19 pandemic and health inequalities. *J Epidemiol Community Health* 2020; **74**: 964–68.
- Tyler CM, McKee GB, Alzueta E, et al. A study of older adults' mental health across 33 countries during the covid-19 pandemic. *Int J Environ Res Public Health* 2021; **18**: 5090.
- Scott S, McGowan VJ, Visram S. 'I'm gonna tell you about how Mrs Rona has affected me'. Exploring young people's experiences of the COVID-19 pandemic in north-east England: a qualitative diary-based study. *Int J Environ Res Public Health* 2021; **18**: 3837.
- Babulal GM, Torres VL, Acosta D, et al. The impact of COVID-19 on the well-being and cognition of older adults living in the United States and Latin America. *EClinicalMedicine* 2021; **35**: 100848.
- Pennington AF, Kompaniyets L, Summers AD, et al. Risk of clinical severity by age and race/ethnicity among adults hospitalized for COVID-19—United States, March–September 2020. *Open Forum Infect Dis* 2020; **8**: ofaa638.
- Salter A, Fox RJ, Newsome SD, et al. Outcomes and risk factors associated with SARS-CoV-2 infection in a North American registry of patients with multiple sclerosis. *JAMA Neurol* 2021; **78**: 699–708.
- Bambra C, Albani V, Franklin P. COVID-19 and the gender health paradox. *Scand J Public Health* 2021; **49**: 17–26.
- White A. Men and COVID-19: the aftermath. *Postgrad Med* 2020; **132** (suppl 4): 18–27.
- Rushovich T, Boulicault M, Chen JT, et al. Sex disparities in COVID-19 mortality vary across US racial groups. *J Gen Intern Med* 2021; **36**: 1696–701.
- Vahidy FS, Pan AP, Ahnstedt H, et al. Sex differences in susceptibility, severity, and outcomes of coronavirus disease 2019: cross-sectional analysis from a diverse US metropolitan area. *PLoS One* 2021; **16**: e0245556.
- Bassett MT, Chen JT, Krieger N. Variation in racial/ethnic disparities in COVID-19 mortality by age in the United States: a cross-sectional study. *PLoS Med* 2020; **17**: e1003402.
- Machado S, Goldenberg S. Sharpening our public health lens: advancing im/migrant health equity during COVID-19 and beyond. *Int J Equity Health* 2021; **20**: 57.
- Gillispie-Bell V. The contrast of color: why the black community continues to suffer health disparities. *Obstet Gynecol* 2021; **137**: 220–24.
- Dickinson KL, Roberts JD, Banacos N, et al. Structural racism and the COVID-19 experience in the United States. *Health Secur* 2021; **19**: S14–26.
- Mathur R, Rentsch CT, Morton CE, et al. Ethnic differences in SARS-CoV-2 infection and COVID-19-related hospitalisation, intensive care unit admission, and death in 17 million adults in England: an observational cohort study using the OpenSAFELY platform. *Lancet* 2021; **397**: 1711–24.
- Quan D, Luna Wong L, Shallal A, et al. Impact of race and socioeconomic status on outcomes in patients hospitalized with COVID-19. *J Gen Intern Med* 2021; **36**: 1302–09.
- McGowan VJ, Lowther HJ, Meads C. Life under COVID-19 for LGBT+ people in the UK: systematic review of UK research on the impact of COVID-19 on sexual and gender minority populations. *BMJ Open* 2021; **11**: e050092.
- Chen YH, Glymour M, Riley A, et al. Excess mortality associated with the COVID-19 pandemic among Californians 18–65 years of age, by occupational sector and occupation: March through November 2020. *PLoS One* 2021; **16**: e0252454.
- Politi J, Martín-Sánchez M, Mercuriali L, et al. Epidemiological characteristics and outcomes of COVID-19 cases: mortality inequalities by socio-economic status, Barcelona, Spain, February 24 to 4 May 2020. *Euro Surveill* 2021; **26**: 2001138.
- Chen JT, Krieger N. Revealing the unequal burden of COVID-19 by income, race/ethnicity, and household crowding: US county versus zip code analyses. *J Public Health Manag Pract* 2021; **27** (suppl 1): S43–56.
- Daras K, Alexiou A, Rose TC, Buchan I, Taylor-Robinson D, Barr B. How does vulnerability to COVID-19 vary between communities in England? Developing a Small Area Vulnerability Index (SAVI). *J Epidemiol Community Health* 2021; **75**: 729–34.
- Niedzwiedz CL, O'Donnell CA, Jani BD, et al. Ethnic and socioeconomic differences in SARS-CoV-2 infection: prospective cohort study using UK Biobank. *BMC Med* 2020; **18**: 160.
- Arcaya MC, Tucker-Seeley RD, Kim R, Schnake-Mahl A, So M, Subramanian SV. Research on neighborhood effects on health in the United States: a systematic review of study characteristics. *Soc Sci Med* 2016; **168**: 16–29.
- Bambra C. Health divides: where you live can kill you. Bristol: Policy Press, 2016.
- Office of National Statistics. Health state life expectancies, UK: 2015 to 2017. 2018. <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/bulletins/healthstatelifeexpectanciesuk/2015to2017> (accessed Aug 22, 2022).
- González S. The north/south divide in Italy and England: discursive construction of regional inequality. *Eur Urban Reg Stud* 2011; **18**: 62–76.
- Gutiérrez-Fisac JL, Gispert R, Solà J. Factors explaining the geographical differences in disability free life expectancy in Spain. *J Epidemiol Community Health* 2000; **54**: 451–55.
- Thomson KH, Renneberg AC, McNamara CL, Akhter N, Reibling N, Bambra C. Regional inequalities in self-reported conditions and non-communicable diseases in European countries: findings from the European Social Survey (2014) special module on the social determinants of health. *Eur J Public Health* 2017; **27** (suppl 1): 14–21.
- Olmos C, Stuardo V. Distribución de la COVID-19 y tuberculosis en la Región Metropolitana de Chile: diferentes enfermedades, similares desigualdades. *Rev Med Chil* 2020; **148**: 963–69.
- Das A, Ghosh S, Das K, Basu T, Dutta I, Das M. Living environment matters: unravelling the spatial clustering of COVID-19 hotspots in Kolkata megacity, India. *Sustain Cities Soc* 2021; **65**: 102577.

- 31 Sauvaget C, Ramadas K, Fayette JM, Thomas G, Thara S, Sankaranarayanan R. Socio-economic factors & longevity in a cohort of Kerala State, India. *Indian J Med Res* 2011; **133**: 479–86.
- 32 Umuhoza SM, Ataguba JE. Inequalities in health and health risk factors in the Southern African Development Community: evidence from world health surveys. *Int J Equity Health* 2018; **17**: 52.
- 33 Steel N, Ford JA, Newton JN, et al. Changes in health in the countries of the UK and 150 English Local Authority areas 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2018; **392**: 1647–61.
- 34 Munford L, Khavandi S, Bamba C, et al. A year of COVID-19 in the north: regional inequalities in health and economic outcomes. Newcastle: Northern Health Science Alliance, 2021.
- 35 Bamba C, McGowan VJ. Geographical inequalities in COVID-19 mortality: a scoping review protocol. *Research Square* 2021; published online Nov 16. <https://doi.org/10.21203/rs.3.rs-1086250/v1> (preprint).
- 36 Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 2016; **5**: 210.
- 37 Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid-Based Healthc* 2015; **13**: 141–46.
- 38 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005; **8**: 19–32.
- 39 Peters MDJ, Marnie C, Tricco AC, et al. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth* 2020; **18**: 2119–26.
- 40 Tricco AC, Lillie E, Zarin W, et al. A scoping review on the conduct and reporting of scoping reviews. *BMC Med Res Methodol* 2016; **16**: 15.
- 41 Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021; **372**: n71.
- 42 Al Rifat SA, Liu W. One year into the pandemic: the impacts of social vulnerability on COVID-19 outcomes and urban–rural differences in the conterminous United States. *Int J Environ Health Res* 2021; published online Sept 23. <https://doi.org/10.1080/09603123.2021.1979196>.
- 43 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.
- 44 Adjei-Fremah S, Lara N, Anwar A, et al. The effects of race/ethnicity, age, and area deprivation index (ADI) on COVID-19 disease early dynamics: Washington, D.C. case study. *J Racial Ethn Health Disparities* 2022; published online Feb 15. <https://doi.org/10.1007/s40615-022-01238-1>.
- 45 Akinwumiju AS, Oluwafemi O, Mohammed YD, Mobolaji JW. Geospatial evaluation of COVID-19 mortality: influence of socio-economic status and underlying health conditions in contiguous USA. *Appl Geogr* 2022; **141**: 102671.
- 46 Backer S, Rezene A, Kahar P, Khanna D. Socioeconomic determinants of COVID-19 incidence and mortality in Florida. *Cureus* 2022; **14**: e22491.
- 47 Baltrus PT, Douglas M, Li C, et al. Percentage of black population and primary care shortage areas associated with higher COVID-19 case and death rates in Georgia counties. *South Med J* 2021; **114**: 57–62.
- 48 Bilal U, Tabb LP, Barber S, Diez Roux AV. Spatial inequities in COVID-19 testing, positivity, confirmed cases, and mortality in 3 U.S. cities: an ecological study. *Ann Intern Med* 2021; **174**: 936–44.
- 49 Scannell Bryan M, Sun J, Jagai J, et al. Coronavirus disease 2019 (COVID-19) mortality and neighborhood characteristics in Chicago. *Ann Epidemiol* 2021; **56**: 47–54.e5.
- 50 Carrión D, Colicino E, Pedretti NF, et al. Neighborhood-level disparities and subway utilization during the COVID-19 pandemic in New York City. *Nat Commun* 2021; **12**: 3692.
- 51 Clouston SAP, Natale G, Link BG. Socioeconomic inequalities in the spread of coronavirus-19 in the United States: a examination of the emergence of social inequalities. *Soc Sci Med* 2021; **268**: 113554.
- 52 Dalsania AK, Fastiggi MJ, Kahlam A, et al. The relationship between social determinants of health and racial disparities in COVID-19 mortality. *J Racial Ethn Health Disparities* 2022; **9**: 288–95.
- 53 De PK, Price T. Pre-existing economic conditions and COVID-19 infections and mortality in New York City. *J Health Care Poor Underserved* 2021; **32**: 1978–94.
- 54 De Jesus M, Ramachandra SS, Jaffin Z, et al. The environmental and social determinants of health matter in a pandemic: predictors of COVID-19 case and death rates in New York City. *Int J Environ Res Public Health* 2021; **18**: 8416.
- 55 Do DP, Frank R. Unequal burdens: assessing the determinants of elevated COVID-19 case and death rates in New York City's racial/ethnic minority neighbourhoods. *J Epidemiol Community Health* 2020; **75**: 321–26.
- 56 Doti JL. Examining the impact of socioeconomic variables on COVID-19 death rates at the state level. *J Bioeconomics* 2021; **23**: 15–53.
- 57 Dukhovnov D, Barbieri M. County-level socio-economic disparities in COVID-19 mortality in the USA. *Int J Epidemiol* 2022; **51**: 418–28.
- 58 Fielding-Miller RK, Sundaram ME, Brouwer K. Social determinants of COVID-19 mortality at the county level. *PLoS ONE* 2020; **15**: e0240151.
- 59 Figueroa JF, Wadhwa RK, Mehtsun WT, Riley K, Phelan J, Jha AK. Association of race, ethnicity, and community-level factors with COVID-19 cases and deaths across U.S. counties. *Healthc (Amst)* 2021; **9**: 100495.
- 60 Finch H, Hernández Finch ME, Mytych K. Not one pandemic: a multilevel mixture model investigation of the relationship between poverty and the course of the COVID-19 pandemic death rate in the United States. *Front Sociol* 2021; **6**: 629042.
- 61 Finch WH, Hernández Finch ME. Poverty and COVID-19: rates of incidence and deaths in the United States during the first 10 weeks of the pandemic. *Front Sociol* 2020; **5**: 47.
- 62 Grekousis G, Wang R, Liu Y. Mapping the geodemographics of racial, economic, health, and COVID-19 deaths inequalities in the conterminous US. *Appl Geogr* 2021; **135**: 102558.
- 63 Hawkins RB, Charles EJ, Mehaffey JH. Socio-economic status and COVID-19-related cases and fatalities. *Public Health* 2020; **189**: 129–34.
- 64 Huang Y, Li R. The lockdown, mobility, and spatial health disparities in COVID-19 pandemic: a case study of New York City. *Cities* 2022; **122**: 103549.
- 65 Islam N, Lacey B, Shabnam S, et al. Social inequality and the syndemic of chronic disease and COVID-19: county-level analysis in the USA. *J Epidemiol Community Health* 2021; **75**: 496–500.
- 66 Itzhak N, Shahar T, Moskovich R, Shahar Y. The impact of US county-level factors on COVID-19 morbidity and mortality. *J Urban Health* 2022; **99**: 562–70.
- 67 Jackson SL, Derakhshan S, Blackwood L, et al. Spatial disparities of COVID-19 cases and fatalities in United States counties. *Int J Environ Res Public Health* 2021; **18**: 8259.
- 68 Karmakar M, Lantz PM, Tipirneni R. Association of social and demographic factors with COVID-19 incidence and death rates in the US. *JAMA Netw Open* 2021; **4**: e2036462.
- 69 Khan SS, Krefman AE, McCabe ME, et al. Association between county-level risk groups and COVID-19 outcomes in the United States: a socioecological study. *BMC Public Health* 2022; **22**: 81.
- 70 Khanijahani A. Racial, ethnic, and socioeconomic disparities in confirmed COVID-19 cases and deaths in the United States: a county-level analysis as of November 2020. *Ethn Health* 2021; **26**: 22–35.
- 71 Khanijahani A, Tomassoni L. Socioeconomic and racial segregation and COVID-19: concentrated disadvantage and Black concentration in association with COVID-19 deaths in the USA. *J Racial Ethn Health Disparities* 2022; **9**: 367–75.
- 72 Kim SJ, Bostwick W. Social vulnerability and racial inequality in COVID-19 deaths in Chicago. *Health Educ Behav* 2020; **47**: 509–13.
- 73 Kandula S, Shaman J. Investigating associations between COVID-19 mortality and population-level health and socioeconomic indicators in the United States: a modeling study. *PLoS Med* 2021; **18**: e1003693.
- 74 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.
- 75 Luo Y, Yan J, McClure S. Distribution of the environmental and socioeconomic risk factors on COVID-19 death rate across continental USA: a spatial nonlinear analysis. *Environ Sci Pollut Res Int* 2021; **28**: 6587–99.

- 76 McLaughlin JM, Khan F, Pugh S, et al. County-level predictors of coronavirus disease 2019 (COVID-19) cases and deaths in the United States: what happened, and where do we go from here? *Clin Infect Dis* 2021; **73**: e1814–21.
- 77 Nguyen TH, Shah GH, Schwind JS, Richmond HL. Community characteristics and COVID-19 outcomes: a study of 159 counties in Georgia, United States. *J Public Health Manag Pract* 2021; **27**: 251–57.
- 78 Oishi S, Cha YJ, Schimmack U. The social ecology of COVID-19 cases and deaths in New York City: the role of walkability, wealth, and race. *Soc Psychol Personal Sci* 2021; **12**: 1457–66.
- 79 Oronce CIA, Scannell CA, Kawachi I, Tsugawa Y. Association between state-level income inequality and COVID-19 cases and mortality in the USA. *J Gen Intern Med* 2020; **35**: 2791–93.
- 80 Ossimetha A, Ossimetha A, Kosar CM, Rahman M. Socioeconomic disparities in community mobility reduction and COVID-19 growth. *Mayo Clin Proc* 2021; **96**: 78–85.
- 81 Pan W, Miyazaki Y, Tsumura H, Miyazaki E, Yang W. Identification of county-level health factors associated with COVID-19 mortality in the United States. *J Biomed Res* 2020; **34**: 437–45.
- 82 Paul R, Arif A, Pokhrel K, Ghosh S. The association of social determinants of health with COVID-19 mortality in rural and urban counties. *J Rural Health* 2021; **37**: 278–86.
- 83 Pierce JB, Harrington K, McCabe ME, et al. Racial/ethnic minority and neighborhood disadvantage leads to disproportionate mortality burden and years of potential life lost due to COVID-19 in Chicago, Illinois. *Health Place* 2021; **68**: 102540.
- 84 Robertson LS. Predictors of COVID-19-confirmed cases and fatalities in 883 US counties with a population of 50 000 or more: estimated effect of initial prevention policies. *J Urban Health* 2021; **98**: 205–10.
- 85 Russette H, Graham J, Holden Z, Semmens EO, Williams E, Landguth EL. Greenspace exposure and COVID-19 mortality in the United States: January–July 2020. *Environ Res* 2021; **198**: 111195.
- 86 Samuel LJ, Gaskin DJ, Trujillo AJ, Szanton SL, Samuel A, Slade E. Race, ethnicity, poverty and the social determinants of the coronavirus divide: U.S. county-level disparities and risk factors. *BMC Public Health* 2021; **21**: 1250.
- 87 Sung B. A spatial analysis of the association between social vulnerability and the cumulative number of confirmed deaths from COVID-19 in United States counties through November 14, 2020. *Osong Public Health Res Perspect* 2021; **12**: 149–57.
- 88 Tan AX, Hinman JA, Abdel Magid HS, Nelson LM, Odden MC. Association between income inequality and county-level COVID-19 cases and deaths in the US. *JAMA Netw Open* 2021; **4**: e218799.
- 89 Unruh LH, Dharmapuri S, Xia Y, Soyemi K. Health disparities and COVID-19: a retrospective study examining individual and community factors causing disproportionate COVID-19 outcomes in Cook County, Illinois. *PLoS One* 2022; **17**: e0268317.
- 90 Wrigley-Field E, Garcia S, Leider JP, Van Riper D. COVID-19 mortality at the neighborhood level: racial and ethnic inequalities deepened in Minnesota in 2020. *Health Aff (Millwood)* 2021; **40**: 1644–53.
- 91 Zhang CH, Schwartz GG. Spatial disparities in coronavirus incidence and mortality in the United States: an ecological analysis as of May 2020. *J Rural Health* 2020; **36**: 433–45.
- 92 Zhong X, Zhou Z, Li G, Kwizera MH, Muennig P, Chen Q. Neighborhood disparities in COVID-19 outcomes in New York City over the first two waves of the outbreak. *Ann Epidemiol* 2022; **70**: 45–52.
- 93 Almeida Andrade L, Silva da Paz W, Fontes Lima AGC, et al. Spatiotemporal pattern of COVID-19-related mortality during the first year of the pandemic in Brazil: a population-based study in a region of high social vulnerability. *Am J Trop Med Hyg* 2021; **106**: 132–41.
- 94 Bermudi PMM, Lorenz C, Aguiar BS, Failla MA, Barrozo LV, Chiaravalloti-Neto F. Spatiotemporal ecological study of COVID-19 mortality in the city of São Paulo, Brazil: shifting of the high mortality risk from areas with the best to those with the worst socio-economic conditions. *Travel Med Infect Dis* 2021; **39**: 101945.
- 95 Castro RR, Santos RSC, Sousa GJB, et al. Spatial dynamics of the COVID-19 pandemic in Brazil. *Epidemiol Infect* 2021; **149**: e60.
- 96 Demenech LM, Dumith SC, Vieira MEC, Neiva-Silva L. Income inequality and risk of infection and death by COVID-19 in Brazil. *Epidemiol Infect* 2021; **149**: e60.
- 97 de Souza CDF, Machado MF, do Carmo RF. Human development, social vulnerability and COVID-19 in Brazil: a study of the social determinants of health. *Infect Dis Poverty* 2020; **9**: 124.
- 98 Souza RC, Almeida ERM, Fortaleza CMCB, Miot HA. Factors associated with COVID-19 mortality in municipalities in the state of São Paulo (Brazil): an ecological study. *Rev Soc Bras Med Trop* 2022; **55**: e04472021.
- 99 Ribeiro KB, Ribeiro AF, Veras MASM, de Castro MC. Social inequalities and COVID-19 mortality in the city of São Paulo, Brazil. *Int J Epidemiol* 2021; **50**: 732–42.
- 100 Sanhueza-Sanzana C, Aguiar IWO, Almeida RLF, Kendall C, Mendes A, Kerr LRFS. Social inequalities associated with COVID-19 case fatality rate in Fortaleza, Ceará state, Brazil, 2020. *Epidemiol Serv Saude* 2021; **30**: e2020743.
- 101 Silva J, Ribeiro-Alves M. Social inequalities and the pandemic of COVID-19: the case of Rio de Janeiro. *J Epidemiol Community Health* 2021; **75**: 975–79.
- 102 Viezzer J, Biondi D. The influence of urban, socio-economic, and eco-environmental aspects on COVID-19 cases, deaths and mortality: a multi-city case in the Atlantic Forest, Brazil. *Sustain Cities Soc* 2021; **69**: 102859.
- 103 Figueiredo AM, Figueiredo DCMM, Gomes LB, et al. Social determinants of health and COVID-19 infection in Brazil: an analysis of the pandemic. *Rev Bras Enferm* 2020; **73** (suppl 2): e20200673.
- 104 Villalobos Dintrans P, Castillo C, de la Fuente F, Maddaleno M. COVID-19 incidence and mortality in the Metropolitan Region, Chile: time, space, and structural factors. *PLoS One* 2021; **16**: e0250707.
- 105 Rodriguez-Villamizar LA, Belalcázar-Ceron LC, Fernández-Niño JA, et al. Air pollution, sociodemographic and health conditions effects on COVID-19 mortality in Colombia: an ecological study. *Sci Total Environ* 2021; **756**: 144020.
- 106 Benita F, Gasca-Sanchez F. The main factors influencing COVID-19 spread and deaths in Mexico: a comparison between phases I and II. *Appl Geogr* 2021; **134**: 102523.
- 107 Chávez-Almazán LA, Díaz-González L, Rosales-Rivera M. Socioeconomic determinants of health and COVID-19 in Mexico. *Gac Med Mex* 2022; **158**: 3–10.
- 108 Sun Y, Hu X, Xie J. Spatial inequalities of COVID-19 mortality rate in relation to socioeconomic and environmental factors across England. *Sci Total Environ* 2021; **758**: 143595.
- 109 Bray I, Gibson A, White J. Coronavirus disease 2019 mortality: a multivariate ecological analysis in relation to ethnicity, population density, obesity, deprivation and pollution. *Public Health* 2020; **185**: 261–63.
- 110 Breen R, Ermisch J. The distributional impact of COVID-19: geographic variation in mortality in England. *Demogr Res* 2021; **44**: 397–414.
- 111 Brown AE, Heinsbroek E, Kall MM, et al. Epidemiology of confirmed COVID-19 deaths in adults, England, March–December 2020. *Emerg Infect Dis* 2021; **27**: 1468–71.
- 112 Chaudhuri K, Chakrabarti A, Lima JM, Chandan JS, Bandyopadhyay S. The interaction of ethnicity and deprivation on COVID-19 mortality risk: a retrospective ecological study. *Sci Rep* 2021; **11**: 11555.
- 113 Harris R. Exploring the neighbourhood-level correlates of COVID-19 deaths in London using a difference across spatial boundaries method. *Health Place* 2020; **66**: 102446.
- 114 Griffith GJ, Davey Smith G, Manley D, Howe LD, Owen G. Interrogating structural inequalities in COVID-19 mortality in England and Wales. *J Epidemiol Community Health* 2021; **75**: 1165–71.
- 115 Griffith GJ, Owen G, Manley D, Howe LD, Davey Smith G. Continuing inequalities in COVID-19 mortality in England and Wales, and the changing importance of regional, over local, deprivation. *Health Place* 2022; **76**: 102848.

- 116 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**: 344–46.
- 117 Doblhammer G, Kreft D, Reinke C. Regional characteristics of the second wave of SARS-CoV-2 infections and COVID-19 deaths in Germany. *Int J Environ Res Public Health* 2021; **18**: 10663.
- 118 Plümper T, Neumayer E. The pandemic predominantly hits poor neighbourhoods? SARS-CoV-2 infections and COVID-19 fatalities in German districts. *Eur J Public Health* 2020; **30**: 1176–80.
- 119 Ginsburgh V, Magerman G, Natali I. COVID-19 and the role of inequality in French regional departments. *Eur J Health Econ* 2021; **22**: 311–27.
- 120 Oroszi B, Juhász A, Nagy C, Horváth JK, McKee M, Ádány R. Unequal burden of COVID-19 in Hungary: a geographical and socioeconomic analysis of the second wave of the pandemic. *BMJ Glob Health* 2021; **6**: e006427.
- 121 Di Girolamo C, Bartolini L, Caranci N, Moro ML. Socioeconomic inequalities in overall and COVID-19 mortality during the first outbreak peak in Emilia-Romagna Region (Northern Italy). *Epidemiol Prev* 2020; **44** (suppl 2): 288–96.
- 122 Riou J, Panczak R, Althaus CL, et al. Socioeconomic position and the COVID-19 care cascade from testing to mortality in Switzerland: a population-based analysis. *Lancet Public Health* 2021; **6**: e683–91.
- 123 Fonseca-Rodríguez O, Gustafsson PE, San Sebastián M, Connolly AF. Spatial clustering and contextual factors associated with hospitalisation and deaths due to COVID-19 in Sweden: a geospatial nationwide ecological study. *BMJ Glob Health* 2021; **6**: e006247.
- 124 Hussey H, Zinyakatira N, Morden E, et al. Higher COVID-19 mortality in low-income communities in the city of Cape Town—a descriptive ecological study. *Gates Open Res* 2021; **5**: 90.
- 125 Yoshikawa Y, Kawachi I. Association of socioeconomic characteristics with disparities in COVID-19 outcomes in Japan. *JAMA Netw Open* 2021; **4**: e2117060.
- 126 Baggio JAO, Machado MF, Carmo RFD, Armstrong ADC, Santos ADD, Souza CDF. COVID-19 in Brazil: spatial risk, social vulnerability, human development, clinical manifestations, and predictors of mortality—a retrospective study with data from 59 695 individuals. *Epidemiol Infect* 2021; **149**: e100.
- 127 Neelon B, Mutiso F, Mueller NT, Pearce JL, Benjamin-Neelon SE. Spatial and temporal trends in social vulnerability and COVID-19 incidence and death rates in the United States. *PLoS One* 2021; **16**: e0248702.
- 128 Middy AI, Roy S. Geographically varying relationships of COVID-19 mortality with different factors in India. *Sci Rep* 2021; **11**: 7890.
- 129 DuPre NC, Karimi S, Zhang CH, et al. County-level demographic, social, economic, and lifestyle correlates of COVID-19 infection and death trajectories during the first wave of the pandemic in the United States. *Sci Total Environ* 2021; **786**: 147495.
- 130 Pekmezaris R, Zhu X, Hentz R, Lesser ML, Wang JJ, Jelavic M. Sociodemographic predictors and transportation patterns of COVID-19 infection and mortality. *J Public Health (Oxf)* 2021; **43**: e438–45.
- 131 Dorregaray-Farge ZE, de la Cruz Vargas J, Soto A. Correlation between mortality due to COVID-19, wealth index, human development and population density in districts of Metropolitan Lima during 2020. *Revista de la Facultad de Medicina Humana* 2021; **21**: 780–89.
- 132 Amate-Fortes I, Guarnido-Rueda A. Inequality, public health, and COVID-19: an analysis of the Spanish case by municipalities. *Eur J Health Econ* 2022; published online March 9. <https://doi.org/10.1007/s10198-022-01455-9>.
- 133 Zaldo-Aubanell Q, Campillo I, López F, Bach A, et al. Community risk factors in the COVID-19 incidence and mortality in Catalonia (Spain). A population-based study. *Int J Environ Res Public Health* 2021; **18**: 3768.
- 134 García CN. Socioeconomic, demographic and healthcare determinants of the COVID-19 pandemic: an ecological study of Spain. *BMC Public Health* 2021; **21**: 606.
- 135 Rutter PD, Mytton OT, Mak M, Donaldson LJ. Socio-economic disparities in mortality due to pandemic influenza in England. *Int J Public Health* 2012; **57**: 745–50.
- 136 Crighton EJ, Elliott SJ, Moineddin R, Kanaroglou P, Upshur R. A spatial analysis of the determinants of pneumonia and influenza hospitalizations in Ontario (1992–2001). *Soc Sci Med* 2007; **64**: 1636–50.
- 137 Tam K, Yousey-Hindes K, Hadler JL. Influenza-related hospitalization of adults associated with low census tract socioeconomic status and female sex in New Haven County, Connecticut, 2007–2011. *Influenza Other Respir Viruses* 2014; **8**: 274–81.
- 138 Fallah MP, Skrip LA, Gertler S, Yamin D, Galvani AP. Quantifying poverty as a driver of Ebola transmission. *PLoS Negl Trop Dis* 2015; **9**: e0004260.
- 139 Souza WV, Albuquerque MFP, Vazquez E, et al. Microcephaly epidemic related to the Zika virus and living conditions in Recife, Northeast Brazil. *BMC Public Health* 2018; **18**: 130.
- 140 Mamelund SE. A socially neutral disease? Individual social class, household wealth and mortality from Spanish influenza in two socially contrasting parishes in Kristiania 1918–19. *Soc Sci Med* 2006; **62**: 923–40.
- 141 Bamba C, Norman P, Johnson NPAS. Visualising regional inequalities in the 1918 Spanish flu pandemic in England and Wales. *Environ Plann A* 2021; **53**: 607–11.
- 142 Mamelund SE, Shelley-Egan C, Rogeberg O. The association between socioeconomic status and pandemic influenza: systematic review and meta-analysis. *PLoS One* 2021; **16**: e0244346.
- 143 Khanijahani A, Iezadi S, Gholipour K, Azami-Aghdash S, Naghibi D. A systematic review of racial/ethnic and socioeconomic disparities in COVID-19. *Int J Equity Health* 2021; **20**: 248.
- 144 Bamba C, Smith K, Lynch J. The unequal pandemic: COVID-19 and health inequalities. Bristol: Policy Press, 2021.
- 145 Singer M. A dose of drugs, a touch of violence, a case of Aids: conceptualizing the Sava Syndemic. *Free Inq Creat Sociol* 1996; **24**: 99–110.
- 146 Bamba C. Pandemic inequalities: emerging infectious diseases and health equity. *Int J Equity Health* 2022; **21**: 6.
- 147 Gibson M, Petticrew M, Bamba C, Sowden AJ, Wright KE, Whitehead M. Housing and health inequalities: a synthesis of systematic reviews of interventions aimed at different pathways linking housing and health. *Health Place* 2011; **17**: 175–84.
- 148 Collins PF, Stratton RJ, Kurukulaaratchy RJ, Elia M. Influence of deprivation on health care use, health care costs, and mortality in COPD. *Int J Chron Obstruct Pulmon Dis* 2018; **13**: 1289–96.
- 149 Biondi M, Zannino LG. Psychological stress, neuroimmunomodulation, and susceptibility to infectious diseases in animals and man: a review. *Psychother Psychosom* 1997; **66**: 3–26.
- 150 Diderichsen F, Andersen I, Manuel C, et al. Health inequality—determinants and policies. *Scand J Public Health* 2012; **40** (suppl 8): 12–105.
- 151 Katikireddi SV, Lal S, Carrol ED, et al. Unequal impact of the COVID-19 crisis on minority ethnic groups: a framework for understanding and addressing inequalities. *J Epidemiol Community Health* 2021; **75**: 970–74.
- 152 Perry M, Akbari A, Cottrell S, et al. Inequalities in coverage of COVID-19 vaccination: a population register based cross-sectional study in Wales, UK. *Vaccine* 2021; **39**: 6256–61.
- 153 Bamba C, Smith KE, Pearce J. Scaling up: the politics of health and place. *Soc Sci Med* 2019; **232**: 36–42.
- 154 Todd A, Bamba C. Learning from past mistakes? The COVID-19 vaccine and the inverse equity hypothesis. *Eur J Public Health* 2021; **31**: 2.
- 155 Goffe L, Antonopoulou V, Meyer CJ, et al. Factors associated with vaccine intention in adults living in England who either did not want or had not yet decided to be vaccinated against COVID-19. *Hum Vaccin Immunother* 2021; **17**: 5242–54.
- 156 Bamba C. Levelling up: global examples of reducing health inequalities. *Scand J Public Health* 2021; published online June 19. <https://doi.org/10.1177/14034948211022428>.
- 157 Parker DM, Bruckner T, Vieira VM, et al. Predictors of test positivity, mortality, and seropositivity during the early coronavirus disease epidemic, Orange County, California, USA. *Emerg Infect Dis* 2021; **27**: 2604–18.
- 158 Cairns JM, Graham E, Bamba C. Area-level socioeconomic disadvantage and suicidal behaviour in Europe: a systematic review. *Soc Sci Med* 2017; **192**: 102–11.

- 159 McKenzie JE, Brennan SE, Ryan RE, Thomson HJ, Johnston RV. Chapter 9: summarizing study characteristics and preparing for synthesis. In: Higgins J, Thomas J, Chandler J, et al, eds. *Cochrane handbook for systematic reviews of interventions*. Chichester: John Wiley & Sons, 2019: 229–40.
- 160 Fieldhouse EA, Tye R. Deprived people or deprived places? Exploring the ecological fallacy in studies of deprivation with the samples of anonymised records. *Environ Plann A* 1996; **28**: 237–59.
- 161 Bamba C. Placing intersectional inequalities in health. *Health Place* 2022; **75**: 102761.

Copyright © 2022 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.