Research Paper

The impact of ethnicity on clinical outcomes in COVID-19: A systematic review

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ABSTRACT

Background: The relationship between ethnicity and COVID-19 is uncertain. We performed a systematic review to assess whether ethnicity has been reported in patients with COVID-19 and its relation to clinical outcomes.

Methods: We searched EMBASE, MEDLINE, Cochrane Library and PROSPERO for English-language citations on ethnicity and COVID-19 (1st December 2019-15th May 2020). We also reviewed: COVID-19 articles in *NEJM, Lancet, BMJ, JAMA*, clinical trial protocols, grey literature, surveillance data and preprint articles on COVID-19 in *MedRxiv* to evaluate if the association between ethnicity and clinical outcomes were reported and what they showed. PROSPERO:180654.

Findings: Of 207 articles in the database search, five reported ethnicity; two reported no association between ethnicity and mortality. Of 690 articles identified from medical journals, 12 reported ethnicity; three reported no association between ethnicity and mortality. Of 209 preprints, 34 reported ethnicity – 13 found Black, Asian and Minority Ethnic (BAME) individuals had an increased risk of infection with SARS-CoV-2 and 12 reported worse clinical outcomes, including ITU admission and mortality, in BAME patients compared to White patients. Of 12 grey literature reports, seven with original data reported poorer clinical outcomes in BAME groups compared to White groups.

Interpretation: Data on ethnicity in patients with COVID-19 in the published medical literature remains limited. However, emerging data from the grey literature and preprint articles suggest BAME individuals are at an increased risk of acquiring SARS-CoV-2 infection compared to White individuals and also worse clinical outcomes from COVID-19. Further work on the role of ethnicity in the current pandemic is of urgent public health importance.

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1. Introduction

Severe acute respiratory syndrome-2 (SARS-CoV-2) is the novel coronavirus first detected in Wuhan, China, that causes coronavirus disease 2019 (COVID-19) [1]. Since initial detection of the virus, more than five million cases have been confirmed worldwide. Reports

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Panel: Research in context

Evidence before this study

There is increasing concern that COVID-19 causes adverse clinical outcomes in individuals from Black, Asian and Minority Ethnic (BAME) backgrounds.

Added value of this study

We performed a systematic review looking at evidence on the role of, and outcomes by, ethnicity in COVID-19. We found 17 published studies of patients with COVID-19 which reported data on ethnicity; 1 reported an increased risk of acquiring SARS-CoV-2 in Black compared to White patients and 5 reported no association between ethnicity and clinical outcomes. Of grey literature, 7 reported poorer clinical outcomes in BAME compared to White patients. 34 preprint articles on MedRxiv reported ethnicity; 13 reported an increased risk of acquiring infection with SARS-CoV-2 and 12 reported adverse clinical outcomes with COVID-19 in BAME compared to White patients.

Implications of all the available evidence

Increasing numbers of articles from the UK and USA in the grey literature and in preprint suggest that individuals from BAME communities are at increased risk of infection from SARS-CoV-2 and worse clinical outcomes including hospitalization, ITU admission and mortality, compared to White patients. Data on ethnicity in patients with COVID-19 in the medical literature however remains limited. Future research on this topic is of urgent public health importance.

from China and Italy suggest an associated high mortality rate, which has placed stress on intensive care unit capacity [2,3].

Ethnicity is a complex construct including genetic make-up, social/cultural identity and behavioural patterns;[4] it has been used as a crude tool to explore differences amongst populations.[5] Several studies have elucidated significant differences in clinical features, based on complex factors closely interconnected with ethnicity. For example, ethnic disparities have influenced treatment outcomes in patients with tuberculosis [6,7]. and community engagement of diverse local ethnic populations in West Africa was a key cornerstone in the response to the 2014 Ebola outbreak [8]. During the 2009/2010 influenza H1N1 pandemic, those of non-White ethnicity experienced a higher mortality rate compared to White populations in England [9]. Given these findings, we recently hypothesised that the acquisition, transmission and severity of COVID-19 might be influenced by ethnicity [10].

Older age, male gender, raised body mass index and cardiometabolic diseases have emerged as important risk factors for adverse outcomes [11]. So far, global public health responses have been focused on preventing at-risk individuals from being infected, through social distancing and self-isolation measures. Apparent differences in clinical outcomes between China and European nations may indicate that ethnicity may impact on disease severity, but data in this area is very limited.

In the United Kingdom (UK), one in seven people are from Black, Asian and Minority Ethnic (BAME) backgrounds and 14% of the population were born overseas [12,13]. Recently, the Intensive Care National Audit and Research Centre (ICNARC) released data on patients admitted to intensive care units in the UK with COVID-19 [14]. A significant proportion of critically ill patients with COVID-19 were from BAME communities. In addition, the first ten healthcare

workers in the UK who died as a result of COVID-19 were all from BAME backgrounds. This has resulted in the UK government launching a national enquiry to explore if, and why, people from BAME backgrounds appear to be disproportionately affected by COVID-19. At the time of writing, in the United States of America (USA), 39 states have released full or partial COVID-19 death data disaggregated by race and ethnicity, showing BAME residents account for over 50% of all deaths [15]. These early observations suggest a potential association between SARS-CoV-2 and ethnicity. As COVID-19 continues to spread across the world to areas with significant ethnic diversity, an understanding of ethnicity and its relation to the acquisition and transmission of SARS-CoV-2, and the clinical course of COVID-19 is important.

When a novel emerging infectious disease becomes a pandemic, there is an urgent need for evidence synthesis to inform guidelines and interventions. In these extraordinary circumstances, the World Health Organization (WHO) recommends rapid reviews (WHO) [16]. We undertook a rapid systematic review of the literature to firstly assess the extent to which ethnicity had been reported in clinical studies on COVID-19, and secondly, where applicable, evaluate the relationship between ethnicity and clinical outcomes, including intensive care admission and mortality.

2. Methods

This systematic review was conducted in line with PRISMA guidelines [17]. We searched MEDLINE, EMBASE, PROSPERO and the Cochrane Library. The database searches were drafted by an experienced librarian (PD) and refined through team discussions with co-authors. The search strategy is presented in Supplementary Methods. In brief, we used a combination of keywords and MeSH terms for "COVID-19″, "novel coronavirus", "2019-ncov", "ncov". "novel beta-cov", "novel betacoronavirus" and "ethnicity". We included articles available in English, published between 1st December 2019 and 15th May 2020 in peer-reviewed journals, which contained original clinical data (Fig. 1). We also carried out bibliographic screening to identify any additional relevant publications. Correspondence pieces and articles about predictive modelling, basic science or animal data were excluded. The quality of included citations identified through the systematic search of the databases was assessed using the Joanna Briggs Institute Critical Appraisal Tool [18]. The review has been registered on PROSPERO (ID:180,654).

We supplemented our database search with a detailed review of all studies regarding COVID-19 published between 1st December 2019 and 15th May 2020, in the four most influential general medical journals: *New England Journal of Medicine, British Medical Journal, Journal of the American Medical Association* and *The Lancet.* All studies that reported original patient data were reviewed. Correspondence pieces and articles about predictive modelling, basic science or animal data were excluded. We inspected the full text, baseline characteristics tables and any relevant supplementary materials to explore whether ethnicity was reported and whether its relation with clinical outcomes of COVID-19 patients was examined (Fig. 1). The quality of any paper that reported ethnicity or its relation to clinical outcomes was assessed using the Joanna Briggs Institute Critical Appraisal Tool [18].

We also reviewed any publications awaiting peer review in pre-print servers on *MedRxiv* as well as COVID-19 related clinical trials registered on *ClinicalTrials.gov*, published between 1st of December 2019 and 15th May 2020, to assess whether data on ethnicity are being collected and ethnicity associated clinical outcomes. We approached experts in the field of infectious diseases and critical care for grey literature. Quality checks for this literature were not undertaken as they had not yet been peer -reviewed.

Lastly, we reviewed national surveillance reports on case notifications and outcomes of COVID-19 from the ten countries with the
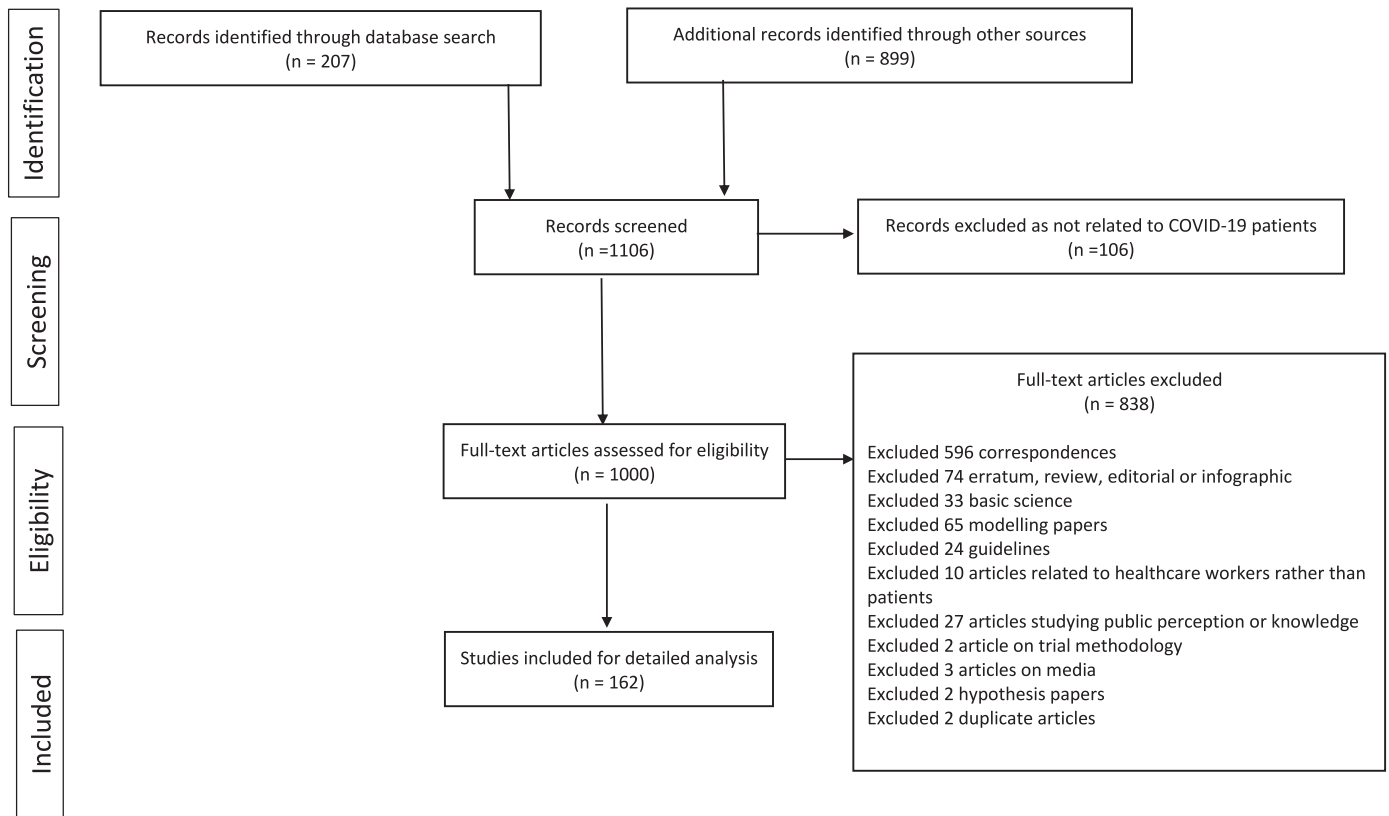
Fig. 1. PRISMA Flow Diagram.

highest COVID-19 incidence for data reported on ethnicity on, or before, 15th May 2020.

Two authors (SS and DP) duplicated title and abstract screening as well as full-text review of articles, identified through an electronic database search. Quality assessment was carried out by LN and DP. JM performed the search on *ClinicalTrials.gov*. MP and MB performed the search on *MedRxiv*. Disagreements between authors who screened articles for inclusion and quality assessment were resolved through group discussion. SS, DP, JM and MP agreed on final study inclusions.

3. Role of funding

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

4. Results

A total of 207 articles published between 1st December 2019 and 15th May 2020 were identified from the electronic database search. An additional 690 COVID-19 articles published between 1st December 2019 and 15th May 2020 were identified in the four pre-specified general medical journals and 209 preprint articles identified on *MedRxiv* – giving a total of 1106 articles. In total 106 articles were excluded as they were not related to patients with COVID-19. Of the remaining 1000 articles, 838 articles were excluded (Fig. 1) leaving 162 for detailed analysis – 10 from the electronic database search, 72 from the pre-specified medical journals which provided clinical data and 80 preprint articles on *MedRxiv* We found the majority of articles regarding ethnicity (reporting of ethnicity and outcomes by ethnicity) were in either the grey literature or on the preprint server (Table 1). We also found that there was a large increase in academic publications and grey literature investigating outcomes in relation to

ethnicity from the end of April 2020. All studies that were critically appraised were of high quality (Supplementary Table 1).

4.1. Recording of ethnicity

Five articles from the electronic database search (1 in March, 3 in April and 1 in May 2020); 12 articles published in the four most influential medical journals (2 in March, 3 in April and 7 in May 2020) and 34 preprint articles on *MedRxiv* reported ethnicity data (Supplementary Tables 2−4). Three studies; one from the database search and two from the journal search, were case reports. Of 1518 trials enlisted in *ClinicalTrials.gov*, one randomized controlled trial and five observational studies from the USA, UK and France are currently collecting data on ethnicity (Supplementary Table 5). Examining the grey literature, 12 articles reported concerns about the association between ethnicity and clinical outcomes (Supplementary Table 6). Of these 12 articles, 7 reported original clinical data. Of the ten countries with the highest incidence of COVID-19 as of 16th May 2020, only the USA and the UK report ethnicity data from national surveillance agencies (Table 2a). In the USA, 39 states reported disaggregated data on ethnicity (Table 2b).

4.2. Ethnicity and risk of infection with SARS-CoV-2

No published studies from China reported data on ethnicity. Two case-series from France and Singapore, of 5 and 17 patients respectively published in March reported only patients of Chinese or non-Chinese ethnicity (Supplementary Tables 2 and 3) [19,20]. The remaining articles, published in April and May 2020, had varying proportions of ethnic groups (Black 1.5% to 83%, Asian 0.2−19.5%, Hispanic 1%−51%). One recent article of 3802 participants reported that Black patients (1.5% of participants) were more likely to test positive for SARS-CoV-2 than other ethnic groups [21]. Within *MedRxiv*, 14 studies reported Black, 3 studies reported Asian and 3 studies reported Hispanic patients respectively to be at increased risk of

Table 1
Risk of infection with SARS-CoV-2, hospitalisation/ITU admission and mortality from COVID-19 in BAME groups.

Parameter	Country	Race/BAME group	Literature search	Major journals	Grey literature	Surveillance	Preprints
Risk of infection with SARS-COV-2	US	Black	-	-	-	-	⬆
		Hispanic	-	-	-	-	⬆
		Asian	-	-	-	-	⬆
		Mixed/Other	-	-	-	-	-
	UK	Black	-	⬆	-	-	⬆
		Asian	-	-	-	-	⬆
		Mixed/Other	-	-	-	-	⬆
Risk of hospitalisation/ITU	US	Black	↔	↔	-	-	⬆
		Hispanic	-	-	-	-	⬆
		Asian	-	-	-	-	⬆
		Mixed/Other	-	-	-	-	-
	UK	Black	-	-	⬆	-	⬆
		Asian	-	-	⬆	-	⬆
		Mixed/Other	-	-	-	-	-
Risk of mortality	US	Black	↔	↔	⬆	⬆	⬆
		Hispanic	↔	↔	-	-	⬆
		Asian	↔	↔	-	-	-
		Mixed/Other	-	↔	-	-	-
	UK	Black	-	-	⬆	⬆	⬆
		Asian	-	-	⬆	-	⬆
		Mixed/Other	-	-	⬆	-	⬆

Legend

⬆ = overall increase risk compared to White patients

↔ = no association between ethnicity and parameter studied

- = no data

Table 2a
Assessment of ethnic group data from national surveillance agencies of the ten countries with the highest incidence of COVID-19 cases as of 15th May 2020.

Country	Reporting Agency	Ethnic Group Reporting
United States of America	Centers for Disease Control and Prevention https://www.cdc.gov/	Yes
Russia	Russian Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing https://xn−80aesfpe bagmfblc0a.xn−p1ai/information/	No
United Kingdom	Public Health England https://www.gov.uk/government/organisations/public-health-england	Yes
Spain	Government of Spain https://covid19.isciii.es/	No
Italy	Dipartimento della Protezione Civile http://www.protezionecivile.gov.it/en/risk-activities/health-risk/emergencies/coronavirus	No
Brazil	Ministério da Saúde (Brazil) https://covid.saude.gov.br/	No
France	French Public Health Agency https://www.santepubliquefrance.fr/l-info-accessible-a-tous/coronavirus	No
Germany	Robert Koch-Institut https://www.rki.de/EN/Home/homepage_node.html	No
Turkey	Turkish Ministry of Health https://covid19.saglik.gov.tr/	No
Iran	Iran Health Ministry http://ird.behdasht.gov.ir/	No

testing positive for SARS-CoV-2 compared to White patients, while 1 study reported no association between ethnicity and PCR positivity (Supplementary Table 4).

Examining the grey literature, The International Severe Acute Respiratory and emerging Infection Consortium (ISARIC), led by WHO, has also developed a portfolio of resources to accelerate COVID-19 research and response. Their proposed case report form includes ethnicity but data on this is not yet available [22].

4.3. Ethnicity, hospitalization and itu admission

Two papers from the database search did not find any association between ethnicity and rates of hospitalisation or intubation [23,24]. One paper published in the *New England Journal of Medicine* also found that ethnicity was not an independent predictor of intubation [25]. One preprint article on *MedRxiv* found no association between ethnicity and ICU admission; however five found Black patients and two found Asian patients to be at increased risk of

hospitalisation and ITU admission compared to White patients (Supplementary Table 4). Examining the grey literature, ICNARC has been reporting data disaggregated by ethnicity since April 2020. As of 15th May 2020, 8699 patients were admitted to 252 critical care units in the UK with COVID-19, of which 66.8% were White, 15.2% were Asian, 9.9% were Black and 8.1% were from other ethnic groups. For comparison, in 2019, in the general UK population, 86% were White, 7.5% were Asian, 3.3% were Black and 3.2% were from other ethnic groups [26]. Furthermore in this cohort, compared to historical data on patients with non-COVID viral pneumonia, a larger proportion of patients with COVID-19 admitted to intensive care units were from BAME communities (34% vs 12%) [14].

4.4. Ethnicity and mortality

One paper from the database search did not find any association between ethnicity and mortality [24]. Three papers published in the

Table 2b
Assessment of ethnic group data from 39 states within the USA.

APM Research Lab (a member of the American Associate for Public Opinion Research's transparency initiative): https://www.apmresearchlab.org/covid/deaths-by-race#asian	Asian % of COVID-19 deaths up till 11th May 2020/% of population	Black % of COVID-19 deaths up till 11th May 2020/% of population	Latino % of COVID-19 deaths up till 11th May 2020/% of population
Alabama	0.8/1.3	46/27	2/4
Alaska	20/6.3	0/3	0/7
Arizona	1.1/3.4	4/4	17/32
Arkansas	0/1.6	38/15	3/8
California	16.3/14.5	10/6	36/39
Colorado	4.1/3.1	7/4	18/22
Connecticut	1.1/4.6	15/10	9/17
Delaware	0.5/4.1	28/22	6/10
Florida	*	22/15	22/26
Georgia	1.9/4.1	50/31	3/10
Idaho	3.1/1.7	2/1	6/13
Illinois	4.5/5.6	34/14	17/17
Indiana	0.5/2.3	18/10	2/7
Iowa	3.3/3.1	7/5	7/6
Kansas	0/2.8	32/6	7/12
Kentucky	2.2/1.5	19/8	2/4
Louisiana	0.8/1.6	57/32	2/5
Maryland	3.5/6.2	43/29	8/10
Massachusetts	3.1/6.8	9/7	11/12
Michigan	1.1/3.3	43/14	2/5
Minnesota	2.6/4.9	8/7	3/5
Mississippi	*	54/38	1/3
Missouri	*	41/11	9/4
New Hampshire	0/2.6	0/1	7/4
New Jersey	5.3/9.7	20/14	17/21
New York	7.2/8.5	27/14	27/19
North Carolina	1.2/3.0	19/8	4/10
Ohio	0.8/2.3	17/12	1/4
Oklahoma	0.8/2.2	8/7	2/11
Oregon	5.9/4.6	5/2	7/13
Pennsylvania	2.2/3.6	22/11	0/8
Rhode Island	0/3.3	6/6	13/16
South Carolina	*	56/27	0/6
Tennessee	2.5/1.8	32/17	3/6
Texas	1.6/4.9	18/12	32/40
Vermont	3.8/1.9	0/1	0/2
Virginia	0/6.5	26/19	8/10
Washington	9.4/8.7	3/4	9/13
Wisconsin	1.5/2.9	29/6	8/7

* Florida, Mississippi, Missouri and South Carolina include Asians in their "Other" category, so they cannot be shown here.

New England Journal of Medicine and *Journal of the American Medical Association* also found no association between ethnicity and mortality. [25,27,28]. Four preprint articles on *MedRxiv* found no relation between ethnicity and mortality; however, six found Black patients and three found Asian patients to be at increased risk of death compared to White patients (Supplementary Table 4).

Within the grey literature, five studies reported Black patients; three reported Asian patients and one reported Hispanic patients to be increased risk of death compared to White patients. Specifically, the Royal College of Psychiatrists and one article published in *Health Service Journal* reported that healthcare workers from BAME groups are at increased risk of mortality compared to White healthcare workers [29,30]. In the USA, of 39 states that reported ethnicity, nine states reported a higher incidence of COVID-19 related deaths in Asian residents; 33 for Black residents and five for Hispanic residents, compared to their respective proportions in national census data (Table 2b).

5. Discussion

We undertook an extensive search of the literature to identify whether ethnicity had been reported in studies relating to COVID-19 as well as the impact of ethnicity on risk of infection with SARS-CoV-2 and COVID-19 clinical outcomes. We found that the majority of literature on ethnicity has been published only recently, in April

and May 2020 with a much larger number of studies in preprint. This may be in part because studies published in China do not report data disaggregated by ethnicity, given a possible assumption of the lack of ethnic diversity in patients represented across these studies. Most studies on ethnicity, whether published, actively recording in prospective studies or in pre-print are UK or USA based, where there has been a focus on the impact of COVID-19 on BAME communities. This is reflected by the large amount of grey literature published from both countries on this issue. The UK and USA are also the only countries within the ten countries with the highest incidence of COVID-19 cases to report data disaggregated by ethnicity in national surveillance reports.

We found published evidence to suggest that those of Black ethnicity may be at higher risk of acquiring SARS-CoV-2 infection, compared to White patients. Data from preprint articles also suggest that Black, Asian and Hispanic patients are at higher risk of acquiring SARS-CoV-2 infection compared to White patients; individuals of black ethnicity appear to be at the most risk.

Whilst we were unable to find any published (through literature search and medical journal search) evidence of an association between ethnicity and clinical outcomes, this is likely to reflect the small number of studies specifically investigating this issue. By contrast, data from the grey literature and preprint articles suggest that those of Black and Asian ethnicities are at increased risk of hospitalization, admission to the intensive care unit and death.

Elucidating the role of ethnicity in the current pandemic is of urgent public health importance. Whilst there are insufficient data on the mechanisms that may contribute to increased risk of COVID-19 morbidity and mortality in ethnic minority groups, existing evidence does indicate a relationship between ethnicity and known risk factors for poor clinical outcomes in COVID-19, driven by both biological and socio-economic mechanisms.

Early reports from China and Italy identified cardiometabolic comorbidity as an important risk factor for adverse outcomes in patients with COVID-19 [31,32]. Several cardiovascular diseases are over-represented in certain ethnic groups which might place them at higher risk of infection and adverse outcomes. According to the Health Improvement Network database, of over 400,000 individuals permanently registered with general practices in London, Asian and Black ethnic groups had a higher prevalence of type 2 diabetes compared to White individuals [33]. Asian and Black ethnic groups also develop diabetes at a younger age compared to White individuals [34]. The prevalence of hypertension is considerably higher amongst Black African and Caribbean groups than in the White population, and hypertension associated risk of cardiovascular disease may be accentuated in South Asian groups [35,36]. The prevalence of left ventricular hypertrophy was three times higher amongst Black patients compared to White patients, which may contribute to their increased risk of developing heart failure [37]. In the UK, coronary artery disease associated mortality is 40% higher in South Asians, but lower in Black African or Caribbean groups [38].

One important mechanistic explanation for the association between cardiovascular disease and COVID-19 is the expression of angiotensin-converting enzyme 2 (ACE2) receptor in the respiratory tract and myocardium. ACE2 receptor has been identified as the main functional entry receptor for SARS-CoV-2 [39]. Upon binding, SARS-CoV-2 may downregulate ACE2 expression, leading to enhanced pro-fibrotic angiotensin II activity and acute respiratory distress syndrome (ARDS) [40,41]. SARS-CoV-2 may also enter the myocardium through the same receptor, resulting in myocarditis and myocardial injury [42]. ACE2 receptor expression may be elevated in patients treated with ACE-inhibitors or angiotensin receptor blockers, resulting in higher levels of viral entry and consequently more severe disease. These drugs are commonly prescribed for hypertension and diabetes in the South Asian population, but less so in the Afro-Caribbean population [43]. Individuals of Afro-Caribbean ethnicities may also express lower systemic levels of ACE2, conferring protection from infection [44,45] However, currently, the interaction between ethnicity, ACE2 activity and clinical outcome of COVID-19 remains uncertain.

The evolution of mankind has constantly been influenced by pathogens encountered. People of different ethnicities historically faced a variety of different infectious agents, resulting in local adaptations of the immune system for these populations [46]. Individuals from different ethnic groups are known to have varying immune profiles, which modulate their response to vaccination, and their risks of both autoimmunity and acquiring infections such as tuberculosis [47−49]. Therefore, people of different ethnicities may have differing immune responses after being infected with SARS-CoV-2. For example, there appears to be a trend to suggest a slower spread of the virus in countries with current national BCG vaccination policies [50]. When examining influenza, mortality was different between ethnic groups in New Zealand; in particular, the mortality rate in those of Maori and Pacific origin was double that of European and Other ethnicities [51]. Another study from the UK, which explored the relation between the risk of death and ethnicity during the 2009/2010 influenza A (H1N1) pandemic, reported that patients of non-White ethnicity experienced increased risk of mortality compared to White populations, with the highest risk observed in the South Asian population [9]. In the USA, Iwane and colleagues demonstrated that Black children of all ages had a higher rate of hospitalisation for acute respiratory infection and influenza, compared to White children, which may have been due to differences in skin tone and consequent production of endogenous Vitamin D [52].

Looking forward, the uptake, safety and immunogenicity of a SARS-CoV-2 vaccine may vary amongst different ethnicities. Lu and colleagues showed that in the USA, vaccination coverage was significantly lower amongst Blacks, Hispanics, and Asians compared with White participants [53]. Disparities in vaccination coverage may be attributed to socio-economic factors, health literacy, insurance status or entitlement to care, mobility, and social marginalisation. In the context of potential second and further waves of COVID-19, barriers to increasing immunity will be an important public health issue for industrialised societies.

Cultural, behavioural and socio-economic differences amongst ethnic groups may influence viral spread and consequently the basic reproduction number (R0) in an area. Co-habiting in inter-generational familial units, differences in educational background, professional roles, socio-economic status and health-seeking behaviours are different in BAME communities compared to White individuals. This is likely to have partly contributed to a higher prevalence of certain respiratory infectious diseases, such as tuberculosis, in migrant populations with evidence that social and economic inequalities are associated with an increased risk of these diseases [43]. Differences in local culture may also influence societal responses to governmental measures which can be seen in the different lockdown measures between countries in Asia and those in Europe and North America. As the pandemic expands to settings with less robust healthcare systems and more diverse populations, for example Sub-Saharan Africa, it will become increasingly important to ensure healthcare systems, and public health messaging, are inclusive of diverse and marginalised communities.

Our study has several limitations. Due to the rapidly evolving COVID-19 situation, we limited our electronic database search to include only publications published in English between December 2019 and May 2020. We focused our search on ethnicity and COVID-19; we did not review evidence regarding the role of ethnicity in other coronavirus outbreaks, such as MERS or SARS. These outbreaks were limited to the Middle East and Asia. However, our findings relating to COVID-19 highlight the need for published evidence relating to ethnicity and risk of infection or severe symptomatology for these viral infectious diseases. We believe our work to be the first review to comprehensively study this topic. We also supplemented our electronic database search by using alternative search strategies, such as looking through all literature published on COVID-19 in the most influential general medical journals, searching preprints, reviewing protocols of ongoing COVID-19 related clinical trials and going through the grey literature, with expert guidance. We believe our approach to be pragmatic and appropriate for an ongoing pandemic setting, aligning with PRISMA guidelines, and WHO recommendations for rapidly reviewing evidence in the context of emergencies [16].

A key question which requires urgent attention is what the predictors of mortality are in patients with COVID-19, especially in those who are young and without multiple comorbidities. The current pandemic is occurring in a highly globalized society, comprised of individuals from diverse migrant and ethnic backgrounds, with distinct social and cultural practices. There is an urgent need for more robust data on mechanisms that may contribute to increased risk of COVID-19 morbidity and mortality in ethnic minority communities, to ensure these groups are meaningfully and appropriately included in public health measures and health services.

We found that there has been an encouraging increase in the grey literature and preprints from the UK and USA on the role of ethnicity in patients with COVID-19. Further work however, still needs to be done. Scientific evaluation, for example, of outcomes of patients infected with COVID-19 of Chinese ethnic origin, between those residing in mainland

China compared to those in the West may help to tease out whether differences in clinical outcomes is primarily due to genetics or the environment. The ideal way to compare the impact of COVID-19 on clinical outcomes amongst ethnic groups would be to compare groups matched as well as possible for all factors other than ethnicity.

In conclusion, increasing numbers of articles from the UK and USA, in the grey literature as well as in preprint, suggest that individuals from BAME communities are at increased risk of infection from SARS-CoV-2 and adverse clinical outcomes including hospitalization, ITU admission and mortality. Data in the published medical literature on ethnicity in patients with COVID-19 however remains limited and should be addressed by routine reporting of disaggregated data on ethnicity as part of routine governmental surveillance data, large scale international registries and clinical trials to inform future public health interventions and mechanistic studies.

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Declaration of Competing Interest

MP received grants and personal fees from Gilead Sciences outside of the submitted work. JSM received grants from National Institute for Health Research (NIHR) during this work. WH is a Trustee of the South Asian Health Foundation. KK is Director for Centre of Black and Minority Ethnic Health, University of Leicester and lead for NIHR ARC-EM on Ethnicity and Diversity - NIHR ARC. All other authors report no conflicts of interest.

Author contributions

DP and SS contributed equally to this work. DP, SS and MP came up with the project idea. PD came up with the search strategy for database search. DP and SS performed all searches for the literature review and drafted the manuscript. JSM performed searches on *ClinicalTrials.gov*. LSN and DP critically appraised the articles identified from the database search. All other authors reviewed the manuscript drafts. All authors approved the final submitted manuscript. MP had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2020.100404.

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