NIPH
Norwegian Institute of Public Health

REPORT

2021

SYSTEMATIC REVIEW:
Incidence and severe outcomes from COVID-19 among immigrant and minority ethnic groups and among groups of different socio-economic status

Publisher Norwegian Institute of Public Health
Division for Health Services
Title Incidence and severe outcomes from COVID-19 among immigrant and minority ethnic groups and among groups of different socio-economic status: A systematic review
Norwegian title Insidens og alvorlig utfall ved covid-19 i innvandrer- og minoritetsgrupper og i grupper med ulik sosioøkonomisk status: en systematisk oversikt
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ISBN 978-82-8406-197-9

Type of report Systematic review
No. of pages 51 (84 with appendices)
Client Norwegian Institute of Public Health, Division of Infection Control and Environmental Health and Division for Health Services
Subject heading(MeSH) Emigrants and Immigrants; Ethnic Groups; Minority Groups; Socioeconomic Factors; Denmark; Finland; Iceland; Norway; Sweden; COVID-19; SARS-CoV-2; Prevalence; Severity of Illness Index; Hospitalization; Mortality; Systematic Review
Citation Vist GE, Arentz-Hansen EH, Vedøy TF, Spilker RS, Hafstad EV, Giske L. Incidence and severe outcomes from COVID-19 among immigrant and minority ethnic groups and among groups of different socio-economic status 2021. Oslo: Norwegian Institute of Public Health, 2021.

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Key messages

In this systematic review we have summarised and assessed available research from Norway and countries with similar welfare systems on the incidence of infection, rate of admission to hospital and death due to COVID-19. Populations of special interest were immigrants and minority ethnic groups as well as people with different socio-economic status. We included two studies from Norway (data up to November 2020), one study from Denmark (data up to September 2020) and nine studies from Sweden (data mainly up to May 2020).

In Norway, the highest **risk of COVID-19 infection** (measured as Relative Risk Increase (RRI)), was among people born in Somalia, Pakistan, Iraq, Afghanistan and Turkey. In Denmark, the highest RRI of COVID-19 was among people born in Somalia, Pakistan, Morocco, Lebanon and Turkey. In Sweden, among people born in Turkey, Ethiopia, Somalia, Chile and Iraq.

The occupational groups with the highest proportion of COVID-19 cases were different in the different waves of the pandemic. In the first wave in Norway, it was healthcare workers and drivers and in the second wave restaurant staff and tourist guides. In almost all occupational groups in Denmark, the proportion of COVID-19 infection was higher among people with non-Western origin than among people with Western and Danish origin.

COVID-19 related admission to hospital occurred more often among people with non-Western origin in Norway and Denmark compared to those with Norwegian and Danish origin. In Sweden the risk for admission to hospital was higher for people who were not employed, for those who had to be present at work at least 50% of the time, and for people working in the health care system compared to those working from home.

The number of **COVID-19 related deaths** in Norway and Denmark was too low to conclude about variation by country of birth. In Sweden, the results indicated that the risk of dying from COVID -19 was higher among people born in Low- or Middle-Income Countries compared to Swedish born. Also, a low socio-economic position, measured by education and net income, predicted an increased risk of death from COVID-19.

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Type of publication:
Systematic review

Publisher:
Norwegian Institute of Public Health

Updated:
Last search for studies: November 2020.

Peer review:
Liv Merete Reinar, NIPH
Else Karin Grøholt, NIPH

External peer reviewers:
Allan Krasnik, University of Copenhagen, Denmark

Executive summary (English)

Background

The current COVID-19 pandemic is affecting the whole world, including the population of Norway. There have been reports that belonging to certain minority ethnic groups and groups of low socio-economic status may increase the risk of infection and severe outcome from COVID-19.

Objective

In this systematic review we have summarised and assessed available research from Norway and countries with similar welfare systems on the incidence of COVID-19 infection, rate of admission to hospital and death during the COVID-19 pandemic. Populations of special interest were immigrants and minority ethnic group as well as people with different socioeconomic status.

Method

Our inclusion criteria were: **Population**: Minority ethnic groups, populations with different socio-economic status, people living in deprived areas. **Exposure**: The COVID-19 pandemic. **Comparison**: No limitation. **Outcome**: Incidence of COVID-19, admission to hospital for COVID-19, admission to intensive care unit for COVID-19, need for use of ventilator for COVID-19, mortality for COVID-19. **Study design**: Systematic reviews and primary studies. **Setting**: Our analysis included studies conducted in Norway and other similar Nordic welfare states: Denmark, Finland, Iceland and Sweden. We also included studies from countries with welfare systems closely resembling the Nordic model: Austria, Belgium, the Netherlands and New Zealand. Studies from countries with welfare systems with some features resembling the Nordic model was presented in tables: Australia, Germany, Great Britain and Ireland. **Literature search**: We searched for relevant literature in the End-Note database for the NIPH live map of COVID-19 evidence on November 30th 2020, and for grey literature in selected web pages in Norway, Denmark, Finland, Iceland and Sweden on December 10th 2020. Inclusion of studies were performed according to the PRISMA-rules. Due to heterogeneity in time frame of sampling, the difference in covariates adjusted for in different studies, and variation in infection, prevention and control measures implemented in the different countries, we did not consider it appropriate to conduct meta-analysis. Results are presented narratively. We used the GRADE-approach for assessing our confidence in the evidence.

Results

We included 64 publications (from 7675 identified) in this systematic review. For countries with welfare systems closely resembling the Norwegian, we included one study from Denmark (data up to September 2020) and nine from Sweden (data mainly up to May 2020) in addition to two studies from Norway (data up to November 2020). Results were reported differently, therefore we report both common features and from each country.

The studies from the Scandinavian countries provided analysis based on country of birth. In Norway, the highest **risk of COVID-19 infection** (measured as Relative Risk Increase (RRI)), was among people born in Somalia (780%), Pakistan (711%), Iraq (494%), Afghanistan (427%) and Turkey (395%). In Denmark, the highest RRI of COVID-19 was among people born in Somalia (1191%), Pakistan (899%), Morocco (603%), Lebanon (404%) and Turkey (306%). In Sweden, the RRI was highest among people born in Turkey (298%), Ethiopia (293%), Somalia (249%), Chile (230%) and Iraq (217%).

In Norway, the occupational groups with highest incidence of COVID-19 infections during the first wave of the pandemic were health care workers and drivers of busses, trams and taxies. In the second wave it was restaurant staff and tourist guides. In Denmark, the incidence of COVID-19 infection was reported by occupational group and origin combined. The occupations with the highest total number of cases per 100 000 were as follows: health and social services: 874 (for non-Western: 1931, Western: 1093 and Danish origin: 772), public administration, defence and police: 468 (non-Western 2115, Western: 1043 and Danish origin: 395), and transport: 436 (non-Western 1815, Western 405, and Danish origin: 238). In almost all occupational groups the proportion of COVID-19 infection was higher among people with non-Western origin than among people with Western and Danish origin. The occupational group with both the highest (absolute) numbers of non-Western employees and COVID-19 cases, was health and social services. Furthermore, non-western transport workers had more than seven times higher infection rate compared to Danish transport workers, and thus represented the largest relative difference.

In Norway and Denmark, **COVID-19 related rate of admissions to hospital** occurred more often among people with non-Western origin compared to those with Norwegian and Danish origin, respectively. In Norway, the number per 100 000 was significantly higher among people born in Pakistan (510), followed by Somalia (424), and Turkey (235) compared to Norwegian born (27). In Denmark, people of non-Western origin comprise 8.9% of the population, but 15.3% of the COVID-19 related hospital admissions. This is 1.7 times higher compared to people of Danish origin In Stockholm (not reported for Sweden as a whole), the risk for admission to hospital was higher for people who were not employed (Hazard Ratio (HR) 1.25 [95% CI 1.12 to 1.38]), for those who had to be present at work at least 50% of the time (HR 1.24 [95% CI 1.12 to 1.36]), and for people working in the health care system (HR 1.68 [95% CI 1.47 to 1.92]) compared to those working from home (adjusted for sex, age, country of birth, living area and education).

The number of **COVID-19 related deaths** in Norway and Denmark was too low to conclude about variation by country of birth, but it may seem that there is a higher proportion of deaths for people born in Africa and Asia than for people born in Norway. In Sweden, the results indicated that the risk of dying from COVID -19 was higher among people born in Low- or Middle-Income Countries compared to Swedish born (HR_{men}: 2.20 [95% CI 1.81 to 2.69] and HR_{women}: 1.66 [95% CI 1.32 to 2.09]). Also, low socioeconomic position, measured by education and net income, predicted an increased risk of death from COVID-19.

Discussion

The included epidemiological studies were well conducted and generally based on reliable data information sources. However, the studies for the different countries covered different follow-up periods, and the variation in infection, prevention and control measures implemented in the different countries means that the results are not directly comparable.

Incidence of COVID-19 infection were reported by country of birth in Norway, Sweden and Denmark. However, the incidence, admission to hospital and death of COVID-19 in different socio-economic groups measured by education and income was only reported for Sweden.

A strength with systematic reviews is the systematic and transparent approach used when conducting it. An inherent challenge with systematic reviews is that they may be out of date as soon as the literature search is completed, because new studies are continuously being published. For the question in this systematic review, we are aware of three new publications from Norway after our literature search. All of them confirm the results presented in this systematic review.

The theme of this review pertain to an ongoing pandemic, and there is a need for more research of good quality on many aspects of this pandemic. Especially there is a need for knowledge about targeted interventions to reduce the high incidence of infection and disease in minority ethnic groups and groups with low socioeconomic status.

Conclusion

The Scandinavian studies report an increased risk of being infected and admitted to hospital due to COVID-19 for several minority ethnic groups. The groups with the highest rates were by and large overlapping across Scandinavia. It was also found a higher risk for COVID-19 related mortality among minority ethnic groups in Sweden, whereas mortality data for Norway and Denmark was too sparse to conclude.

Furthermore, in Denmark, the proportion of COVID-19 infection was higher among people of non-Western origin than among people of Western and Danish origin in almost all occupational groups. Incidence of COVID-19 infection was not reported by education and income in Norway and Denmark, whereas for Sweden the results were unclear. However, analyses of Swedish data show that admission to hospital and death occurred more frequently in groups of lower socio-economic status.

Hovedbudskap

I denne systematiske oversikten har vi oppsummert og vurdert tilgjengelig forskning fra Norge og land med lignende velferdssystemer om insidens, covid-19 relaterte innleggelser på sykehus og død. Fokus er innvandrer- og minoritetsgrupper og grupper med ulik sosioøkonomisk status. Vi inkluderte to studier fra Norge (data til november 2020), en studie fra Danmark (data til september 2020) og ni studier fra Sverige (data hovedsakelig til mai 2020).

I Norge var relativ risikoøkning for **covid-19 infeksjon** høyest blant innbyggere som var født i Somalia, Pakistan, Irak, Afghanistan og Tyrkia. I Danmark for innbyggere født i Somalia, Pakistan, Marokko, Libanon og Tyrkia. I Sverige for innbyggere født i Tyrkia, Etiopia, Somalia, Chile og Irak.

Yrkesgruppene med høyest andel covid-19 smittede var forskjellig i de ulike bølgene av pandemien; i den første bølgen i Norge var det helsearbeidere og sjåfører, i den andre bølgen var det ansatte i serveringsbransjen og blant fly- og båtverter. For nesten alle yrker i Danmark var det en høyere andel covid-19 smittede blant personer med ikke-vestlig opprinnelse sammenlignet med de med dansk og annen vestlig opprinnelse.

Andelen **covid-19 relaterte sykehusinnleggelser** var høyere blant personer født utenfor Norge og personer med ikke-vestlig bakgrunn født i Danmark enn for personer født i Norge og Danmark. I Sverige var risikoen for sykehusinnleggelse høyere for personer uten arbeid, for dem som måtte være til stede på jobb minst halvparten av tiden og for helsearbeidere sammenlignet med dem som jobbet hjemmefra.

Covid-19 relatert død i Norge og Danmark var for lavt til å konkludere om variasjon etter fødeland. I Sverige var risiko for covid-19 relatert død høyere blant personer født i lav- og middelsinntektsland sammenlignet med svenskfødte. Lav sosioøkonomisk status målt ved utdannelse og inntekt predikerte en økt risiko for covid-19 relatert død.

Tittel: Insidens og alvorlig utfall ved covid-19 i innvandrer- og minoritetsgrupper og i grupper med ulik sosioøkonomisk status: en systematisk oversikt

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Publikasjonstype:
Systematisk oversikt

Hvem står bak denne publikasjonen?
Folkehelseinstituttet

Når ble litteratursøket utført?
Søk etter studier ble avsluttet november 2020.

Interne fagfeller
Liv Merete Reinar, FHI
Else Karin Grøholt, FHI

Eksterne fagfeller:
Allan Krasnik, Universitet i København, Danmark

Sammendrag

Innledning

Covid-19 pandemien påvirker hele verden, inkludert den norske befolkningen. Det har blitt rapportert at det å tilhøre innvandrer- og minoritetsgrupper eller grupper med lav sosioøkonomisk status kan ha sammenheng med økt risiko for infeksjon og med dårligere prognose fra covid-19.

Metode

Våre inklusjonskriterier var: Populasjon: Innvandrere og minoritetsgrupper og grupper med ulik sosioøkonomisk status. Eksponering: covid-19 pandemien. Sammenligning: Ingen begrensing. Endepunkt: covid-19 infeksjon, covid-19 relaterte innleggelser på sykehus, covid-19 relatert bruk av respirator og covid-19 relatert død. Studiedesign: Systematiske oversikter og primærstudier. Setting: Primæranalysen vår inkluderte studier fra Norge og andre land med svært likt velferdssystem: Danmark, Finland, Island og Sverige. Den utvidede analysen omfattet land med lignende velferdssystem: Belgia, Nederland, New Zealand og Østerrike. Studier fra land med velferdssystem som har likheter med den nordiske modellen ble presentert i tabell: Australia, Irland, Storbritannia og Tyskland. Vi søkte etter litteratur i EndNote-databasen til FHI sitt kart over koronaforskning den 30. november 2020, og etter grå litteratur i et utvalg websider fra Norge, Danmark, Finland, Island og Sverige den 10. desember 2020. Vi fulgte PRISMA-reglene for inklusjon av studier. Grunnet heterogenitet i tidsperioder for datainnsamling, forskjellige justeringer for covariater og stor variasjon i innførte smitteverntiltak har vi vurdert at det ikke er fornuftig med meta-analyser. Resultatene er deskriptivt presentert og vi har brukt GRADE til å vurdere vår tillit til resultatene.

Resultater

Vi inkluderte 64 publikasjoner (fra 7675 identifiserte) i denne systematiske oversikten. For land med velferdssystem som i stor grad ligner på det norske inkluderte vi én studie fra Danmark (med data til september 2020) og ni studier fra Sverige (med data hovedsakelig til mai 2020) i tillegg til to studier fra Norge (data frem til november 2020).

Studiene fra de skandinaviske landene hadde utført analysene etter fødeland. I Norge var relativ risikoøkning (RRI) for **covid-19 infeksjon** høyest blant innbyggere som var født i Somalia (780 %), Pakistan (711 %), Irak (494 %), Afghanistan (427 %) og Tyrkia (395 %). I Danmark var RRI høyest for innbyggere født i Somalia (1191 %), Pakistan (899 %), Marokko (603 %), Libanon (404 %) og Tyrkia (306 %). I Sverige var RRI for

COVID-19 høyest for innbyggere født i Tyrkia (298 %), Etiopia (293 %), Somalia (249 %), Chile (230 %) og Irak (217 %).

Yrkesgruppene med høyest andel covid-19 smittede var forskjellig i de ulike bølgene av pandemien. I den første bølgen i Norge var det helsearbeidere og sjåfører, i den andre bølgen var det ansatte i serveringsbransjen og blant ansatte i passasjertrafikk. Fra Danmark ble COVID-19 insidensen rapportert for yrke og opprinnelsesland kombinert. Yrkene med flest antall tilfeller per 100 000 var som følger: helse- og sosialarbeidere: 874 (for ikke-vestlig 1931, vestlige 1093 og for danske 7729), offentlig administrasjon, forsvar og politi: 468 (for ikke-vestlige 2115, vestlige 1043 og danske 395) og for transport: 436 (ikke-vestlige 1815, vestlige 405 og danske 238). For nesten alle yrkesgrupper i Danmark var det en høyere andel covid-19 smittede blant personer med ikke-vestlig fødeland enn med dansk og annet vestlig fødeland. Yrkesgruppen med høyest (absolutt) antall både ikke-vestlige ansatte og covid-19 smittede var helse- og sosialtjenesten. I tillegg hadde ikke-vestlige transportarbeidere syv ganger høyere infeksjonsrate sammenlignet med danske transportarbeidere, og var den yrkesgruppen som sto for den største relative forskjellen mellom gruppene.

I Norge og Danmark var andelen **covid-19 relaterte sykehusinnleggelser** høyere for personer med ikke-vestlig fødeland enn for personer med norsk- og dansk opprinnelse. I Norge var antall sykehusinnleggelser per 100 000 høyest for personer født i Pakistan (510) etterfulgt av Somalia (424) og Tyrkia (235) sammenlignet med personer født i Norge (27). I Danmark, der personer født i ikke-vestlige land utgjør 8,9 % av befolkningen, utgjorde disse gruppene 15,3 % av covid-19 relaterte innleggelser på sykehus. Det er 1,7 ganger flere innleggelser enn for personer født i Danmark. I Stockholm (det var ikke rapportert for Sverige) var risikoen for sykehusinnleggelse høyere for folk som ikke var i arbeid (Hazard Ratio (HR) 1,25 [95 % CI 1,12 til 1,38]), for folk som måtte være til stede på jobb minst 50 % av tiden (HR 1,24 [95 % CI 1,12 til 1,36]) og for ansatte i helsevesenet (HR 1,68 [95 % CI 1,47 til 1,92]) sammenlignet med folk som kunne jobbe hjemmefra (juserter for kjønn, alder, fødeland, bosted og utdanning).

Antall **covid-19 relaterte dødsfall** i Norge og Danmark var for lavt til å konkludere om variasjon etter fødeland, men det kan se ut som det i Norge var høyere risiko for død blant personer født i Afrika og Asia enn for norskfødte. I Sverige var risiko for covid-19 relatert død høyere blant folk født i lav- og middelsinntektsland sammenlignet med svenskfødte (HR_{menn}: 2.20 [95 % CI 1.81 til 2.69] and $HR_{kvinner}$: 1.66 [95 % CI 1.32 til 2.09]). Lav sosioøkonomisk status målt ved utdannelse og inntekt predikerte en mulig økt risiko for covid-19 relatert død.

Diskusjon

De inkluderte epidemiologiske studiene var metodisk godt utført og basert på pålitelige datakilder. Studiene fra de ulike landene hadde forskjellige data-innsamlingsperioder, og det var stor forskjell på hvilke smitteverntiltak som ble gjennomført i de forskjellige landene og til hvilken tid. Dette betyr at resultatene ikke er direkte overførbare mellom landene.

Insidensen av covid-19 infeksjon var rapportert for hvert fødeland i de skandinaviske landene. men kun Sverige hadde studier som inkluderte opplysninger om ulike sosioøkonomiske grupper målt ved utdanning og inntekt.

En styrke ved systematiske oversikter generelt er den systematiske og transparente tilnærmingen til arbeidet. En iboende svakhet er derimot at de kan bli utdaterte så snart litteratursøket er utført, fordi nye studier kontinuerlig blir publisert. Det har blitt publisert tre nye studier fra Norge etter at vårt søk ble utført. De nye studiene rapporterer resultater som pekte i samme retning som resultatene i denne systematiske oversikten.

Problemstillingene i denne oversikten omhandler en pågående pandemi, og det er fremdeles behov for mer forskning av god kvalitet om mange aspekter ved denne pandemien. Særlig vil det være behov for kunnskap om tiltak som kan bidra til å redusere den høye insidensen av covid-19 smitte blant innvandrer- og mioritetsgrupper og grupper med lav sosioøkonomisk status.

Konklusjon

Alle de skandinaviske studiene finner en økt risiko for covid-19 smitte og sykehusinnleggelse i flere innvandre- og etniske minoritetsgrupper. Gruppene med høyest risiko var i stor grad de samme på tvers av landene. Disse gruppene hadde også høyere risiko for covid-19 relatert død i Sverige, tallmateriale fra Norge og Danmark var for lite til at det kunne konkluderes.

I Danmark var det for nesten alle yrkesgrupper en høyere andel av covid-19 smittede blant personer med ikke-vestlig fødeland enn for danske og personer med annen vestlig opprinnelse. Kun Sverige hadde studier som inkluderte opplysninger om ulike sosioøkonomiske grupper målt ved utdanning og inntekt. Resultater fra disse studiene viste økt risiko for covid-19 relatert sykehusinnleggelse og død i grupper med lav sosioøkonomisk status, mens insidensen av covid-19 smitte ikke hadde en tydelig sammenheng med utdanning og inntekt.

Preface

This systematic review was commissioned by the Division of Infection Control and Environmental Health and the Division for Health Services at the Norwegian Institute of Public Health. We were asked to assess and systematically summarize evidence on the prevalence of COVID-19 and the severity of the disease (COVID-19) in immigrants and minority ethnic groups and in populations with different socio-economic status. The studies should be from Scandinavia and other countries with similar welfare systems as in Norway.

This review will be used to inform discussions and decisions regarding infection prevention and control measures in Norway about the current COVID-19 pandemic. We thank Ellen Furuseth and Thor Indseth for sharing their expertise with us during this project.

The project group consisted of:
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We thank Kjetil Gundro Brurberg and Liv Merete Reinar, both at NIPH for methodological peer review of this systematic review. We thank Else Karin Grøholt at NIPH and Allan Krasnik at the University of Copenhagen, Denmark for their expert peer review of this review. We thank Vigdis Underland at NIPH for collecting information about the studies and population according to the PROGRESS equity lens for the included studies table (appendix 4) of studies from countries with a welfare system closely resembling the Norwegian welfare system, and for help with quality control of Appendix 5.

Kåre Birger Hagen	Kjetil Gundro Brurberg	Gunn Elisabeth Vist
Research director	*Unit director*	*Project coordinator*

Introduction

Background on immigrant and minority ethnic groups and socio-economic status relating to the current COVID-19 pandemic

Consecutively published data from national registers in Norway show a higher prevalence of detected cases of COVID-19 infection among immigrant groups and there is also an overrepresentation of immigrants among patients hospitalized due to this disease. Similar data has been reported from several European countries including our neighboring countries Sweden and Denmark as well as from the UK (1-3).

In Norway nearly 800.000 persons or 14.7% of the population are immigrants and 3.8% are Norwegian born to immigrant parents. In 2020, 238 281 persons, or more than 25% of immigrants in Norway, were refugees (4;5).

Refugee families often live in difficult conditions with poor economy, crowded housing, labour uncertainty and lack of social networks. These conditions could increase their susceptibility to infection exposure and in general make them more vulnerable to the consequences of the pandemic (6). Labor-immigrants are exposed to similar difficulties (7-9).

There is different use of concepts in different countries when referring to immigrant or minority ethnic groups. In Norway the most common terms are immigrants and Norwegian born to immigrant parents which is the terminology used by Statistics Norway and defined as "Persons born abroad of two foreign-born parents and four foreign-born grandparents" (4) This is the most commonly used term in both academic and public discourse and also indicates that we are not referring to our indigenous population, the Saami people, or the Kvens, a minority ethnic group that started to migrate to Norway (Finnish origin) as early as the 15th century.

In other countries the term minority ethnic groups are more commonly used as a concept in research and data collection. The term BAME (Black and Asian minority groups) is for example used by Public Health England and encompasses both recently arrived immigrants and English born persons of African, Caribbean or Asian background). Whereas in the USA, the term race is commonly used.

Some countries use country of birth (and country of birth of parents) as proxy for minority ethnic groups, others use self-identified ethnicity or race.

Socio-economic status (SES), or socio-economic position (SEP), is related to many different health outcomes, including non-communicable diseases, chronic diseases, infectious diseases, and mortality (10-14). Structural factors associated with social inequality may enable or hamper a society's response to an epidemic. For example, in a study by Elgar et al., social trust, a mark of societies with low(er) social inequality, was related to lower COVID-19 mortality: *"The results indicate that societies that are more economically unequal and lack capacity in some dimensions of social capital experienced more COVID-19 deaths"* (15). Another example may be the role sick leave can have on the spread of COVID-19 as sick leave is more common and more accessible in countries with lower income/wealth inequality. Another example may be the role sick leave can have on the spread of COVID-19 as sick leave is more common and more accessible in countries with lower income/wealth inequality.

Most often, socio-economic position is measured by an individual's education, occupation (or labour market participation) or income. However, different measures of socio-economic position affect different health outcomes through different mechanisms. If there is political interest and will to close or minimize the gap in morbidity and mortality between socio-economic groups, the mechanism producing inequality must be described.

Education is the most common measure of SES in health research and, if other measures are omitted, function as a proxy for SES. Education is a measure of knowledge and information processing ability. The idea is that education is not only a set of facts and procedures, but also a set of behaviours and social relations that may affect health related actions and behaviours later in life. For example, smoking is less common among people with university education, even after controlling for work and income, and even among students of subjects that do not concern themselves with the biological or chemical causes of disease (e.g. sociology). One explanation is that by taking part in an institution of higher learning, students acquire certain ideas about whether smoking is an acceptable/desirable behaviour or not. To some degree, education also measure family background and other forms of social capital.

In contrast, income measure material resources that may both promote and hinder healthy life choices, for example access to health care or products and services that increase health or help avoid loss of health. Lastly, occupation measure exposure to working conditions that may affect health, but may, in certain contexts, also provide access to (affordable) health care and social resources that promote health.

It is likely that both likelihood of becoming infected by COVID-19 and the severity of the infection is related to SES. However, to effectively address a possible SES gap in COVID-19, it is necessary to assess to what degree differences are related to individual factors such as knowledge and risk perception related to COVID-19 or structural factors such as social and economic resources or work situation.

An earlier rapid review from the Norwegian Institute of Public Health (NIPH) reported on associations between increased severity of COVID-19 disease, and infection rates in populations postulated to be socially or economically vulnerable (16). The literature

search of Lauvrak & Juvet 2020 was from May 2020 and they included 32 primary studies where only one Swedish study represented Scandinavia.

Another recently published rapid review from NIPH concluded that older persons are the main group at risk of hospital admission, severe illness, and death if infected by COVID-19 (17). Most comorbidities appeared to increase the risk, and an increasing number and severity of comorbidities contributed to further increase the overall risk. Himmels et al 2020 note that male sex, obesity, non-white ethnicity and deprivation were associated with increased risk. One of the included studies were Danish.

Inclusion of studies from countries that may have transferable results
Our immediate goal with this systematic review was to inform health care decision makers in Norway, hence our primary analysis will include studies conducted in Norway and other similar Nordic welfare states: Denmark, Finland, Iceland and Sweden (18).

Acknowledging that this strategy may result in very little information, we expanded the scope to also include additional studies from countries with welfare systems closely resembling the Nordic model: Austria, Belgium, the Netherlands and New Zealand (19).

The third layer was further expanded to include presentation of studies from countries with welfare systems with some features resembling the Nordic model: Australia, Germany, Great Britain and Ireland (20).

Why is it important to do this systematic review?

This systematic review will systematically present information on the incidence of COVID-19 and severity of the disease in populations of immigrant and minority ethnic groups and populations with different socio-economic status. Hence, this systematic review may provide:

- A better evidence base for targeted and reinforced measures to fight COVID-19 based on knowledge from comparable settings/ countries
- Knowledge/ information to better identify vulnerable socio-economic and immigrant and minority ethnic groups
- A better understanding of independent social factors influencing incidence, morbidity and mortality of COVID-19
- Important information when developing a strategy for vaccination against COVID-19
- Useful information when designing communication strategies and other interventions to help fight the COVID-19 pandemic

Objectives

The objectives of this systematic review are to identify studies from Scandinavia and other countries with similar welfare system, to assess and systematically summarize evidence about immigrant and minority ethnic groups and populations with different socio-economic status on the

- Incidence of COVID-19 in these populations
- Severity of the disease (COVID-19) in these populations

Method

We conducted this systematic review in accordance with our pre published protocol (https://www.fhi.no/cristin-prosjekter/aktiv/prevalence-and-severe-outcomes-from-covid-19-among-immigrant-and-minority-e/). Our scope was primarily studies with relevance for the Norwegian context. We conducted analysis by geographic origin, and pooled results from countries where we considered results may be applicable and transferable to a Norwegian setting. Hence, in this systematic review we included and analysed studies conducted in Norway, Denmark, Finland, Iceland and Sweden. Studies conducted in Austria, Belgium, the Netherlands and New Zealand were included in secondary analysis. We restricted risk of bias assessment and analysis to the above-mentioned studies.

Study results from the following countries was presented in tables: Australia, Germany, Great Britain and Ireland. Studies from other countries and continents were excluded.

There were 55 studies conducted in the UK fulfilling our inclusion criteria. In accordance with the protocol where we stated that if there were more than 15 studies, we only included studies with 100 participants or more from the UK.

Inclusion criteria

Population:	Immigrant and minority ethnic groups Populations with different socio-economic status People living in deprived areas
Exposure:	The COVID-19 pandemic
Comparison:	No limitations
Outcome:	Incidence of COVID-19 Admission to hospital for COVID-19 Admission to intensive care unit for COVID-19 Need for use of ventilator for COVID-19 Mortality for COVID-19
Study design:	Systematic reviews (reviews including literature search, clear inclusion criteria and risk of bias assessment of included studies)

	Primary studies that assess the incidence and/ or severity of COVID-19 infection in immigrant and minority ethnic groups and populations with different socio-economic status
Setting:	Our primary analysis aimed to include studies conducted in Norway and other similar Nordic welfare states: Denmark, Finland, Iceland and Sweden Secondary analysis aimed to include studies from countries with welfare systems closely resembling the Nordic model: Austria, Belgium, the Netherlands and New Zealand Studies from countries with welfare systems with some features resembling the Nordic model were presented in tables: Australia, Germany, Great Britain and Ireland
Publication year:	2020
Language:	Danish, English, Norwegian and Swedish

Exclusion criteria

- We did not include rapid reviews, but screened their reference lists for potential relevant studies.
- Groups other than those specifically mentioned above
- First nations and indigenous populations

Literature search

We used two main approaches to identify relevant data/research for our review:

1. a search in the EndNote database containing all the COVID-19 references on (and off) the NIPH Live map of COVID-19 evidence – at the time approximately 85000 records, mostly journal articles retrieved from searches in MEDLINE and Embase. A detailed description on how the map is populated, can be found at the COVID-19 evidence map home page(21).
2. a search for non-journal documents, often named grey literature, for our purpose restricted to publication type reports - in a broad sense. We did not search for preprints.

In collaboration with our commissioner, we compiled a list of about 110 words and expressions describing the characteristics of the population of interest. (Appendix 1) On November 30th 2020, we searched the EndNote database using the words from the list in groups of ten, the maximum number of allowed items in one search, continuously adding the resulting hits to an EndNote group. The 6278 records retrieved in this

process were then exported to a separate EndNote library for deduplication and then again exported to Rayyan for screening.

To identify relevant reports (grey literature), we used three different approaches. The last two were added after the protocol was published.

- For a start, we searched selected websites of the Norwegian (2), Danish (4) and Swedish (3) national health and public health authorities as well as one research institute each in Sweden and Denmark for reports or papers containing data on prevalence and morbidity among the population groups of interest for this review.
- We then searched open research repositories of Norway (cristin.no and NORA), Denmark (Danish National Research Database), Sweden (DiVA portal), and Finland (Juuli Julkaisutietoportaali). We also used Bielefeld Academic Search Engine, a source harvesting documents from open repositories in many countries, restricting the search to Nordic countries. Only documents of publication types report or working paper were considered for inclusion.
- Finally, we ran Google searches in Norwegian, Danish, Swedish and English restricted to filetype ".pdf" and sites ".no", ".dk", ".se", ".fi" and ".is" respectively.

The grey literature searches were conducted on December 10th 2020. For a list of visited websites, search words, limitations and more – see appendix 1. Librarian EVH screened the search results online and listed potentially relevant reports with hyperlinks in a table. Researchers GEV and EHAH then made the final selection for inclusion from this pre-selected list.

Article selection

Two persons, independent of each other, assessed title and abstract for all the search results according to our inclusion criteria. We used Rayyan (22) for this process. References considered relevant were read in full text. Similarly, the full text publications were assessed for relevance by two review authors independent of each other according to our inclusion criteria.

When there were several publications on the same participants, we only included the publication with the longest follow-up time. The intention was to avoid double counting. This resulted in us excluding studies that actually fulfilled the inclusion criteria, but we considered it most important to not count the same participants twice (or more times) for the same outcome.

Assessment of included studies / reviews

We used the AMSTAR checklist to assess the methodological quality of the included systematic review (23). If we had found a systematic review that was both up-to-date,

of high quality and that answered our questions, we would have stopped our review process and communicated those results.

Assessing risk of bias in included studies

Two review authors assessed independently of each other the risk of bias of included studies. Any disagreement was solved by discussion or involvement of a third review author. Cohort studies, cross-sectional studies, and prevalence studies were assessed using the JBI cohort checklist, the JBI cross-sectional checklist and the JBI prevalence checklist respectively (24).

Data extraction

From each included study we noted the full reference, the study design and method of analysis, including adjustments for age and comorbidities that has been conducted in the studies.

Related to the population, we extracted information, as presented in the publications, about exposure to COVID-19, and other information about the population according to the PROGRESS equity lens (25) and recorded the available information in data extraction tables on:
Place of residence, including country, setting and if reported the infection rate at the time of the study
Race, ethnicity, culture and language; country of birth if recorded
Occupation
Gender/sex
Religion
Education
Socio-economic status
Social capital

We noted if and which of these components that were adjusted for in analysis.

The following outcomes were recorded: prevalence of COVID-19 infection, COVID-19 related admission to hospital, COVID-19 related admission to intensive care unit, COVID-19 related use of ventilator and COVID-19 related mortality.

One review author extracted the data and another checked that the data extraction was correct and complete.

Analyses

Dichotomous outcomes are presented as adjusted risk ratios (RRs), adjusted odds ratios (ORs) and adjusted hazard ratios (HRs) with 95% confidence intervals (CIs)

as they were reported in the studies. Due to relative sparsity of data, heterogeneity in time frame of data sampling, differences in analysis and adjustments and variation in infection, prevention and control measures implemented in the different countries we did not consider it appropriate to conduct meta-analysis on the available data. However, we presented prevalence results from Norway, Denmark and Sweden in the same table (Table 7).

Assessment of confidence in the findings

We used the Grading of Recommendations Assessment, Development and Evaluation method (GRADE) (26) to assess our confidence in the evidence for the main outcomes in this systematic review.

Ethics

We have not analysed or discussed ethical challenges related to the COVID-19 pandemic in this systematic review.

Results

Our literature searches in databases were conducted on November 30th 2020, the grey literature search on the December 10th 2020. The search strategies, both for the electronic search in databases and the grey literature search on websites of Nordic institutions are presented in Appendix 1. The literature searches in databases found 6246 references and the grey literature searched 1429 publications.

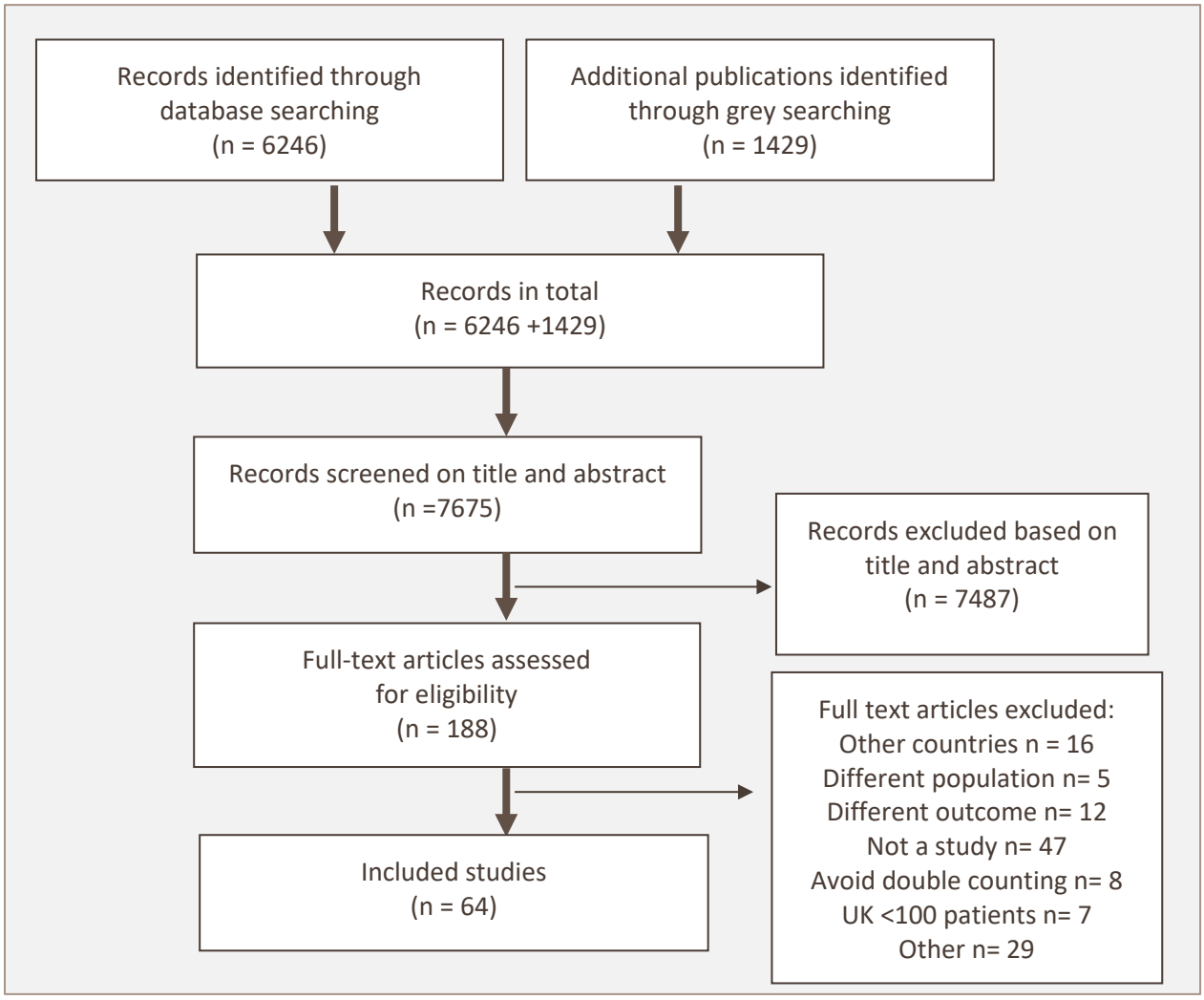

Figure 1. Results of the literature search

All titles and abstracts were assessed against our inclusion criteria by two authors independently of each other. One hundred and eighty eight references were considered potentially relevant and were assessed in full text, again by two people independent of each other and against the same inclusion criteria. Sixty-four studies were included and 124 were excluded.

Excluded studies

The excluded studies are presented together with their reason for exclusion in the Excluded studies table in Appendix 2. The most used reasons for full text exclusion was that the publication was not a study with own primary data (n=47) or that the study was conducted in another country than the pre-specified countries for our review (n= 16). We excluded seven review articles that had not presented a risk of bias assessment of their included studies. We identified one review that had assessed the risk of bias of its included studies (27)**.** Pan et al 2020 systematically reviewed whether ethnicity had been reported in patients with COVID-19 and its relation to clinical outcomes. Pan et al 2020 conducted their literature search on May 15th 2020. However, the review is of low quality according to the AMSTAR-2 assessment we conducted (Appendix 3) and was excluded. The results presented in the review by Pan et al 2020 are from the US and UK only.

We excluded eight studies from the Nordic countries (four from Sweden and two each from Denmark and Norway) that fulfilled the inclusion criteria but where the participants and related outcome were also included in another study with a longer follow up period and more participants. This was done to avoid double counting of the participants in these studies. A further seven studies from the UK that fulfilled the inclusion criteria were excluded because they had fewer than 100 participants.

Included studies

For countries with **welfare systems closely resembling the Norwegian welfare system**, we conducted an electronic literature search in databases and a manual search in grey literature for Norway, Denmark, Finland, Iceland and Sweden. The literature search in databases identified seven potentially relevant publications from Sweden, but none from Norway, Denmark, Finland or Iceland. The manual search identified 11 potentially relevant studies from Norway, three from Denmark and nine from Sweden. Seven of the potentially relevant studies from Norway and three from Sweden did not fulfil all of our inclusion criteria. We included two studies from Norway (28;29), one study from Denmark (30) and nine from Sweden (1;31-38).

For countries with **welfare systems closely resembling the Nordic model**, we only searched through electronic databases. The literature search in databases identified one relevant publication from New Zealand (39), but none from Austria, Belgium or the Netherlands.

For countries with **welfare systems similar to the Nordic model**, we only searched through electronic databases. The literature search in databases identified two relevant

publication from Germany, one from Ireland and 50 from the UK, but none from Australia.

Figure 2 illustrate the three welfare systems and show the countries represented with included studies in bold.

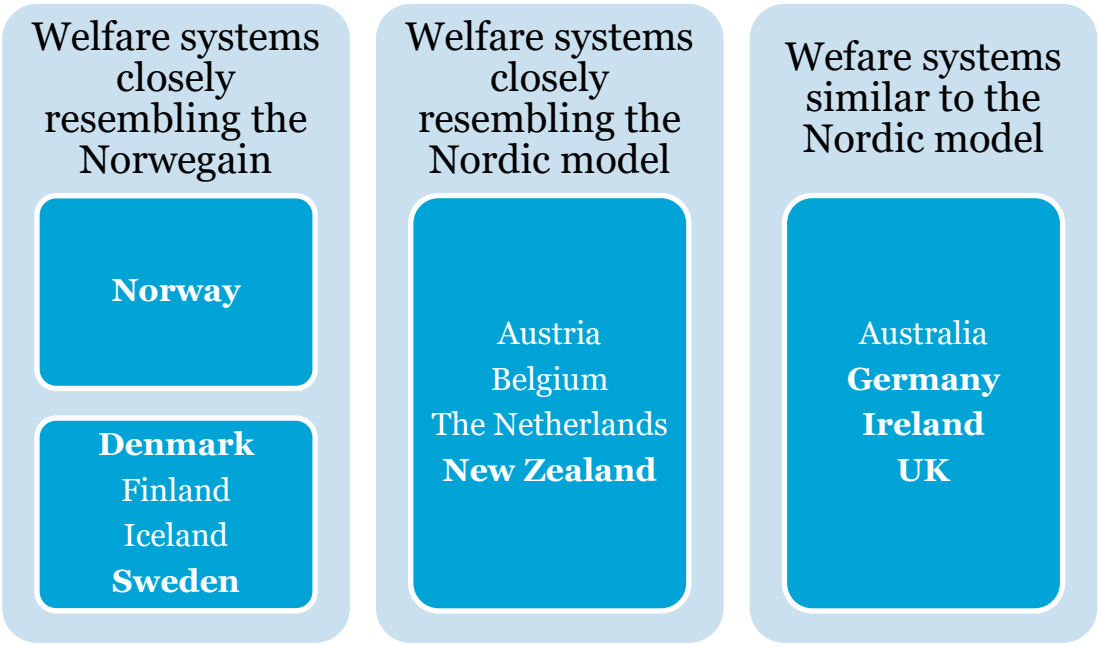

Figure 2. The relevant welfare systems with countries considered

Risk of bias in included studies

Risk of bias of the included studies was assessed from countries with welfare systems closely resembling the Norwegian and for studies from countries with welfare systems closely resembling the Nordic model.

Our assessments indicate that the included studies are well conducted. The quality assessment for the included cross sectional studies are shown in Table 1. The quality assessment for the included retrospective cohort studies are shown in Table 2.

Table 1. Critical Appraisal of included cross sectional studies (JBI)

	Indseth et al 2020a (28)	SSI October 2020 (30)	Bartelink et al 2020 (36) Stockholm	Billingsley et al 2020 (33)	Drefahl et al 2020 (34)	Folkhelsomyndigheten 2020(32)	Florida & Mellander 2020 (31)	Lager et al 2020 (1) Stockholm	Jefferies et al 2020 (39)
1. Were the criteria for inclusion in the sample clearly defined?	+	+	+	+	+	+	+	+	+
2. Were the study subjects and the setting described in detail?	+	+	+	+	+	+	+	+	+
3. Was the exposure measured in a valid and reliable way?	+	+	+	+	+	+	+	+	?[d]
4. Were objective, standard criteria used for measurement of the condition?	+	+	+	+	+	+	+	+	-[d]
5. Were confounding factors identified?	+	+	+	+	+	+	+	+	+
6. Were strategies to deal with confounding factors stated?	+	+	+	+	+	NA	+	+	+
7. Were the outcomes measured in a valid and reliable way?	+	+[a]	+	+	+	+	+	+	+
8. Was appropriate statistical analysis used?	+	+	+	?[b]	+	+	?[c]	+	+
Methodological quality	**High**	**High**	**High**	**Moderate**	**High**	**High**	**High**	**High**	**High**

[a]Two calculation errors in table B2. The cells with errors are omitted
[b]Wide confinence intervals and few events
[c]A high number of correlations and regressions. No protocol.
[d]Confirmed and probable cases of Covid-19. Probable: close contacts of confirmed cases with clinically compatible presentations where SARS-CoV-2 testing was inconclusive and other causes excluded.

Table 2. Critical appraisal of included retrospective cohort studies

	Calderón-Larrañaga et al 2020 (38) Stockholm	Hansson et al 2020 (35)	Lundkvist et al 2020 (37) Stockholm
1. Were the two groups similar and recruited from the same population?	+	+	—[a]
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	NA	NA	NA
3. Was the exposure measured in a valid and reliable way?	+	+	+
4. Were confounding factors identified?	+	+	—[a]
5. Were strategies to deal with confounding factors stated?	NA	NA	—[a]
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	+	+	+
7. Were the outcomes measured in a valid and reliable way?	+	+	+
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?	+	+	+
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	+	+	+
10. Were strategies to address incomplete follow up utilized?	+	+	NA
11. Was appropriate statistical analysis used?	+	+	?
Methodological quality	**High**	**High**	**Moderate/ Low**

[a] Incomplete description of recruitment of study participants. Differences in age and sex

Population information according to the PROGRESS equity lens (25) were collected from the studies conducted in Norway or countries with welfare systems closely resembling the Norwegian system. The PROGRESS information is presented together with other information about these studies in the Included studies tables in Appendix 4.

Prevalence and severe outcomes from the COVID-19 pandemic

The results presented in this systematic review are about a still ongoing pandemic, the final results of the pandemic may be different. The countries from which data are collected were affected at different time points and phases of the pandemic. Interventions to prevent, treat and constrain the disease were different in the different countries, which might have had considerable influence on the prevalence and severity of the disease. Additionally, studies collected data at different time periods and with different lengths of follow up.

First, we describe results from the included studies from countries of most direct relevance: Norway, Denmark and Sweden. Then we describe results from New Zealand. Lastly, we shortly present results from Germany, Ireland and the UK in a separate table.

Welfare systems closely resembling the Norwegian system

Most of the relevant outcomes were reported in several studies. We have used the results from the study with the longest follow-up time. However, sometimes the outcome is reported differently in different studies, for instance numbers per 100 000 from each country of birth or by income group level by country of birth (High Income Countries (HIC), Low and Middle Income Countries (LMIC)), in these cases we have shown both. Regarding the capital cities, for Norway and Denmark, the results from the capitals (Oslo and Copenhagen) were reported with the same time frame as the results from the countries as a whole and were therefore not reported. For Sweden, the results from Stockholm were for several outcomes reported for a much longer time frame than for the country as a whole. We therefore decided to show the results from Stockholm as well. An overview of the outcomes reported and time periods in the included studies are shown in Table 3.

Table 3. Outcomes reported during time periods for the included studies

Follow up period (all dates are in 2020)	Prevalence of COVID-19	Admission to hospital for COVID-19	Admission to intensive care unit for COVID-19	Need for use of ventilator for COVID-19	Mortality for COVID-19	Excess mortality	Minority ethnic groups	Socioeconomic factors	Reference
Norway									
March to 26th Nov	■	■	■	■	■		■		Indseth et al 2020a (28) Norway
26th Feb to 20th October	■							■	Folkehelseinstituttet 5 Nov (29) Norway
Denmark									
Week 9 to week 36	■	■			■		■	■	Statens Serum Institute October 2020 (30) Denmark
Sweden									
Up to 2nd August	■				■		■	■	Florida & Mellander 2020 (31) Sweden
Up to 7th May	■				■		■		Folkhälsomyndigheten 2020 (32) Sweden
Up to 7th May					■			■	Billingsley et al 2020 (33) Sweden
Up to 7th May					■			■	Drefahl et al 2020 (34) Sweden
Up to 7th May						■	■		Hansson et al 2020 (35) Sweden
Stockholm									
Up to 30th June		■			HR		■	■	Bartelink et al 2020 (36) Stockholm
Up to 22nd June					OR		■	■	Lager et al 2020 (1) Stockholm
17th and 18th June	Anti-body							■	Lundkvist et al 2020 (37) Stockholm
Up to 17th May						■		■	Calderón-Larrañaga et al 2020 Stockholm

Norway

Indseth et al have analysed Covid-19 infection among immigrants in Norway (28). Included in the analyses were people from countries with more than 10 000 inhabitants in Norway, in total 26 countries.

COVID-19 infection

In the period from March to 26th November the number of people with confirmed COVID-19 infection per 100 000 tested was 468 for people born in Norway and 1173 for those who were born abroad (28). The number was highest among people born in Somalia (4120), followed by Pakistan (3795), Iraq (2782), Afghanistan (2468), Turkey (2316), Eritrea (2112), Serbia and Montenegro (1973), Ethiopia (1862), and Iran (1498). We note that the results from Oslo concur well with the data reported here (40).

The proportion of COVID-19 cases among those who were tested was higher for people born abroad (3.8%) compared to people born in Norway (1.2 %) (28).

A report from the Norwegian Institute of Public Health (29) analysed prevalence of COVID-19 infection by occupation. The report included 3.5 million workers and the results from the first wave (February 26th to July 17th) and the second wave (18th July to October 20th) were presented separately. During the first wave, health care workers (doctors, nurses, dentists, and physiotherapists) and drivers of busses, trams, and taxies had the highest rate of confirmed COVID-19 infection. During the second wave, bartenders, waiters, and travel guides had the highest rate of COVID-19 infections.

COVID-19 related admission to hospital

The number of COVID-19 related admission to hospital was 27 per 100 000 for people born in Norway and 85 for people born abroad (28). The number was highest among those born in Pakistan (510), followed by Somalia (424), Turkey (235), Iraq (222), Serbia and Montenegro (221), Afghanistan (145), Iran (143), Ethiopia (112), and Bosnia-Herzegovina (100).

COVID-19 related use of ventilator and COVID-19 related deaths

The number of COVID-19 related use of ventilator and COVID-19 related deaths are very low, and the results must be interpreted with caution. COVID-19 related use of ventilator per 100 000 born in Norway was 2.3, and 8.6 for people born abroad (28). The number of COVID-19 related use of ventilator was largest for people born in Africa (16.4) followed by Asia (13.7), Latin America (9) and Europe (4.7). The number of COVID-19 related deaths was 6 per 100 000 born in Norway and 5 for people born abroad (28). The number of COVID-19 related deaths was largest for people born in Africa (10.6) followed by Asia (7.4), Europe (3) and Latin America (2).

Denmark

Statens Serum Institute (30) has analysed COVID-19 confirmed infection, COVID-19 related admission to hospital and COVID-19 related mortality among minority ethnic groups either born abroad in a non-Western country or born in Denmark with both parents born in a non-western country. The analyses also included COVID-19 confirmed infection by occupational groups. The report covers week 9 to week 36 in 2020, and only results from countries where more than 100 COVID-19 cases per country were shown.

Additionally, SSI October 2020 report on COVID-19 confirmed infection based on living conditions defined such as living with > 4 persons per household or living with < 40m^2 per person in the household. However, since they counted a household as one unit regardless of whether one or several persons in the household were infected, we cannot use this information to assess the risk of COVID-19 infection based on size of household or number of persons per household. Therefore, we do not include these numbers in our review.

COVID-19 infection

During the period from week 9 to week 36 in 2020, 18 113 persons of the 5.8 million people living in Denmark had confirmed COVID-19 infection, 69.2% were of Danish descent (86.2% of the population), 5.1% were from another western-country (4.9 % of the population) and 25.7% had a non-western country origin (8.9 % of the population).

The number of people with confirmed COVID-19 infection was 312 per 100 000 in Denmark. For people born in Denmark and of Danish heritage 248 per 100 000 had confirmed COVID-19 infection (30). The number of people per 100 000 with confirmed COVID-19 infection was largest among people born in Somalia (3202), followed by Pakistan (2477), Morocco (1743), Lebanon (1251), Turkey (1006), Iraq (992), Afghanistan (819) and ex-Yugoslavia (833).

The prevalence of COVID-19 infection by occupational group include in total 2.7 million workers and was reported by occupational group and origin combined (table 4). The occupations with highest total number of cases per 100 000 were as follows: health and social services: 874 (for non-Western: 1931, Western: 1093 and Danish origin: 772) public administration, defence and police: 468 (for non-Western: 2115, Western: 1043 and Danish origin: 395), transport: 436 (for non-Western: 1815, Western: 405 and Danish origin: 238), and travel agencies, cleaning and other operational services: 405 (for non-Western: 1046, Western: 212 and Danish: 286). In almost all occupational groups the proportion of COVID-19 infection was higher among people with non-Western origin than among people with Western and Danish origin (Table 4). The occupational group with both, the highest (absolute) numbers of non-Western employees and COVID-19 cases, was health and social services. Furthermore, non-western transport workers had more than seven times higher infection rate compared to Danish transport workers, and thus represented the largest relative difference.

Table 4. Number of COVID-19 cases per 100 000 by occupation and origin (N total = 2 715 069 workers).

Occupation	Total no. employed	Total infected	**Infected per 100000**	**Danish origin**		**Western origin**		**Non-western origin**	
				No. infected / no. employed	**Infected per 100000**	No. infected / no. employed	**Infected per 100000**	No. infected / no. employed	**Infected per 100000**
Agriculture, forestry, & fishing	38130	52	136	33 / 26491	**125**	6 / 5931	**101**	13 / 5708	**228**
Raw material extraction	4180	4	96	3 / 3411	**(—) ***	1 / 501	**(—) ***	0 / 268	**(—) ***
Industry	302012	745	247	483 / 260316	**186**	115 / 21071	**546**	147 / 20625	**713**
Energy supply	11044	25	226	23 / 9972	**231**	0 / 601	**(—) *-**	2 / 471	**(—) ***
Water supply and renovation	11555	27	234	25 / 10846	**230**	0 / 318	**(—) ***	2 / 391	**(—) ***
Construction	159981	326	204	278 / 145634	**191**	12 / 9168	**131**	36 / 5179	**695**
Trading	429972	1297	302	867 / 379334	**229**	73 / 18192	**401**	357 / 32446	**1100**
Transport	128332	560	**436**	251 / 105366	**238**	31 / 7649	**405**	278 / 15317	**1815**
Hotels and restaurants	109596	389	355	202 / 75644	**267**	45 / 12103	**372**	142 / 21849	**650**
Information and communication	110195	367	333	280 / 94092	**298**	26 / 8164	**318**	61 / 7939	**768**
Finance and insurance	82438	263	319	231 / 75434	**306**	10 / 3259	**307**	22 / 3745	**587**
Real estate and rentals	40072	104	260	85/ 36732	**231**	2 / 1457	**(—) ***	17 / 1883	**903**
Knowledge service	150827	454	301	361/ 132876	**272**	29 / 9908	**293**	64 / 8043	**796**
Travel agencies, cleaning and other operational services	144305	585	**405**	298 / 104084	**286**	34 / 16023	**212**	253 / 24198	**1046**
Public administration, defence and police	146745	687	**468**	549 / 139006	**395**	25 / 2396	**1043**	113 / 5343	**2115**
Teaching	224278	585	261	472 / 201725	**234**	32 / 11336	**282**	81 / 11217	**722**
Health and social services	505075	4414	**874**	3466 / 449116	**772**	173 / 15829	**1093**	775 / 40130	**1931**
Culture and leisure time	54130	145	268	108 / 48930	**221**	13 / 2756	**472**	24 / 2444	**982**
Other services	61923	164	265	125 / 55380	**226**	7 / 2594	**270**	32 / 3949	**810**
Occupation not reported	279#			—	—	—	—	—	—

*In cases where the number of infected (the numerator) was less than 5, or the number of employed (the denominator) was less 1000, they were not included in the calculations.
#irregularities in reporting of numbers in this row

The number of COVID-19 cases by type of public service include in total 1 115 716 tested recipients (Table 5). For people of non-Western origin, recipients of sick pay had highest number of cases per 100 000 tested; (i.e. 7300) compared to those with Western (4180) and Danish (3594) origin. This was followed by recipients of early retirement, national pension and adult education, see Table 5.

Table 5. Number of infected persons per 100 000 tested by type of public welfare service received and origin (N total = 1 115 716).

			Danish origin		Western origin		non-Western origin	
	Total tested	Total infected	No. infected / no. tested	Infected per 100000	No. infected / no. tested	Infected per 100000	No. infected / no. tested	Infected per 100000
Employment-oriented activities and financial assistance	54226	380	184 / 46237	398	7 / 1581	(—)*	189 / 6408	2949
Severance pay	13343	81	69 / 12719	542	1 / 327	(—)*	11 / 297	(—)*
National pension	284312	2928	2588 / 268033	966	96 / 8710	1102	244 / 7569	3224
Early retirement	61516	587	232 / 49843	465	3 / 1333	(—)*	352 / 10340	3404
Integration benefit	3798	69	1 / 192	(—)*	1 / 127	(—)*	67 / 3479	1926
Public welfare	90890	838	374 / 69525	538	55 / 7116	773	409 / 14249	2870
Leave of absence	43660	254	153 / 36661	417	23 / 2907	791	78 / 4092	1906
Self sufficient	**321401**	2058	1137 / 271594	419	117 / 16905	692	804 / 32902	2444
Sick pay	73166	2879	2292 / 63765	3594	133 / 3182	4180	454 / 6219	7300
Educational support	165941	1650	1024 / 135792	754	75 / 9046	829	551 / 21103	2611
Adult education	3463	39	20 / 2635	759	1 / 229	437	18 / 599	3005
Total	1 115 716	11763	8074 / 956996		512 / 51463		3177 / 107257	

*When the number of infected persons (the numerator) was less than 5, or the number of tested persons (the denominator) was less 1000, they were not included in the calculations.

COVID-19 related admission to hospital

For COVID-19 related admission to hospital, people of Danish heritage comprise 80.9% of the admissions to hospital (they are 86.2% of the population). People of non-Western origin comprise 8.9% of the Danish population, but 15.3% of the COVID-19 related hospital admissions (30). This is 1.7 times higher compared to people of Danish origin. People of Western origin (excluding Danish) compromise 4.9% of the Danish population, and 3.8% of the COVID-19 related hospital admissions.

COVID-19 related deaths

COVID-19 related case fatality rate (i.e. percent of people who died among people who tested positive for COVID-19) for people between 60 and 79 years old was higher for people of Danish origin than for people of non-Western origin (8.6% for Danish and 5% for non-western origin). Corresponding numbers for people over 80 years of age were even larger (32.2% for Danish and 15.4% for non-western origin). For people under 60 years of age, there were so few deaths that it was concluded (by SSI) not to make the calculations (30).

Sweden

Although our searches were conducted in November 2020, the report from Sweden with the longest follow-up period lasted until August 2nd (31), see Table 3 for an overview of the outcome reporting.

COVID-19 infection

By May 2020, the number of people with confirmed COVID-19 infection was 189 per 100 000 for people born in Sweden (32). The number was largest among people born in Turkey (753) followed by Ethiopia (742), Somalia (660), Chile (624), Iraq (600) and Lebanon (533).

The number of COVID-19 cases per capita up to August 2nd was positively correlated with being foreign born (0.123) and for first or second generation foreign born (0.144) (31). In a regression analysis, they found that immigration status was positively and significantly associated with COVID-19 cases, but not deaths.

Lundkvist et al 2020 (37) investigated the prevalence of COVID-19 antibodies in two different residential areas in Stockholm on the 17th and 18th June. Correspondingly, of 123 tested residents in an upper-and –middle- class area (Norra Djurgårdstaden), 4% had antibodies for COVID-19. Of 90 residents tested in a highly segregated low-income area (Tensta), 30% tested positive for antibodies.

COVID-19 related admission to hospital

Bartelink et al 2020 (36) reported on the risk of COVID-19 related admissions to hospital in Stockholm by type of occupation in relation to the possibility of working from home. The analysis included people between 25 and 64 years of age and was adjusted for age, gender, country of birth, neighbourhood and educational level. Compared to working from home, there was a higher risk of admission to hospital for people who were not employed (HR 1.25 [95% CI 1.12 to 1.38]), for those who had to be present at work at least 50% of the time (HR 1.24 [95% CI 1.12 to 1.36]) and for people who worked in the health care system (HR 1.68 [95% CI 1.47 to 1.92]).

COVID-19 related deaths

We consider that the COVID-19 related deaths in Stockholm are included in the COVID-19 related deaths in Sweden. However, since COVID-19 related deaths in Stockholm are measured until June 22nd (1) and June 30th (36), we present results from both data sets from Stockholm in addition to the data from Sweden until May 7th (32). See also Table 6 below.

COVID-19 related death for Sweden based on country of birth or immigration status are presented in three reports, in three different ways. Folkhälsomyndigheten 2020 (32) report COVID-19 related deaths up to May 7th per 100 000 population. The number of deaths among people born in Sweden was 32 deaths per 100 000 population. The number of deaths was largest among people born in Finland (145), followed by Turkey (97),

Somalia (74), Chile (64), Lebanon (63), Germany (62), Iran (56), ex-Yugoslavia (56) and Norway (55).

Drefahl et al 2020 (34) calculated the hazard ratios for the risk of dying from COVID-19 in Sweden between January 1st and May 7th. Only adults were included, and men and women were reported separately. The calculations were adjusted for age. Using Swedish born as the comparator, male immigrants from High Income Countries (HIC) had a slightly higher mortality (HR 1.19 [95% CI 1.01 to 1.39]) whereas men from Low or Middle Income Countries (LMIC) from the Middle East and Northern Africa had a much higher mortality (HR:3.13 [95% CI: 2.51 to 3.90]). Men from other LMIC had more than twice as high mortality (HR 2.20 [95% CI 1.81 to 2.69]) compared to Swedish men. For women from HIC, the mortality rate was not significantly different from that of Swedish women (HR 1.08 [95% CI 0.92 to 1.26]). The mortality among women from LMIC was higher compared to women from Sweden (HR 1.66 [95% CI 1.32 to 2.09]).

Drefahl et al also analysed the association between COVID-19 mortality and socio-economic position measured by education and net income. Individuals with secondary education had higher mortality, 25% higher for men (HR 1.25 [95%CI 1.09 to 1.43]) and 38% higher for women (HR 1.38 [95% CI 1.17 to 1.62]) than individuals with post-secondary education (reference group). Men with primary education had 24% higher mortality (HR 1.24 [95% CI: 1.07 to 1.43]) and women 51% (HR 1.51 [95% CI 1.13 to 1.79]) higher mortality relative to the same reference group (34).

Drefahl et al 2020 (34) found an income gradient for men, but not for women. Men in the first and second tertiles of individual net income had 76% (HR: 1.76 [95% CI1.49 to 2.09]) and 51% (HR 1.51 [95% CI 1.29 to 1.78]) higher mortality, respectively, than men in the top tertile. Women in the first tertile had 26% higher mortality (HR 1.26 [95% CI 1.01 to 1.58]), while for women in the second tertile, the mortality rate was not significantly different from those in the top tertile (HR 0.99 [95% CI 0.78 to 1.25]).

Florida & Mellander 2020 (31) reported COVID-19 related deaths per capita up to August 2nd. For the population of Sweden it was 0.121 deaths per capita. For people who were born abroad it was 0.228 and for first or second generation foreign born it was 0.232 deaths per capita.

Table 6. COVID-19 related deaths per 100 000 population by country of birth. Results from Sweden and Stockholm. Note the difference in time and measure of reporting.

COVID-19 related deaths **Deaths per 100 000 by country of birth for Sweden, adjusted OR and adjusted HR for Stockholm**			
Country of birth	**Sweden, #/100 000** **Up to May 7th** (Folkhälsomyn-digheten 2020)(32)	**Stockholm, adjusted OR*** **Up to June 22nd** (Lager et al 2020) (1)	**Stockholm, adjusted HR**** **Up to June 30th** (Bartelink et al 020)(36)
Bosnia-Herzegovina	35	-	-
Chile	**64**	1.4 (0.9 to 2.3)	1.63 (0.95 to 2.79)
Estonia	-	**1.8 (1.1 to 2.8)**	**2.04 (1.09 to 3.82)**
Finland	**145**	**1.5 (1.2 to 1.7)**	1.04 (0.80 to 1.35)
Germany	62	0.8 (0.5 to 1.2)	1.03 (0.59 to 1.78)
Greece	-	1.5 (0.5 to 2.4)	1.60 (0.93 to 2.76)
Iraq	45	**1.6 (1.1 to 2.3)**	1.42 (0.96 to 2.11)
Iran	56	1.2 (0.8 to 1.9)	0.81 (0.43 to 1.53)
Lebanon	**63**	**2.6 (1.4 to 4.8)**	**2.47 (1.34 to 4.56)**
Norway	55	1.0 (0.6 to 1.7)	-
Poland	18	1.1 (0.7 to 1.7)	0.89 (0.47 to 1.67)
Somalia	**74**	**3.7 (2.3 to 6.0)**	**3.63 (2.14 to 6.18)**
Sweden	32	1 (reference)	1 (reference)
Syria	35	**2.9 (2.0 to 4.1)**	**2.32 (1.55 to 3.48)**
Turkey	**97**	**2.1 (1.5 to 2.9)**	**2.06 (1-43 to 2.97)**
Ex-Yugoslavia	56	-	-
Countries with fewer than 10 deaths per country	-	1.1 (0.9 to 1.3)	1.11 (0.93 to 1.32)

*Analysis adjusted for age, gender and neighbourhood

**Analysis adjusted for age, gender, neighbourhood, education, occupation, income, size of household, household density, and pre-existing chronic disease

-numbers were not available for these countries

Bartelink 2020 (36) reported risk for Covid-19 related deaths in Stockholm by educational level up to June 30th 2020. The absolute number of deaths (deaths per 10 000 population) were 354 (18.8) for people with pre-college education, 487 (7.1) for people with college education, and 234 (3.3) for people with post college education. Compared to people with post-college education there were an increased HR for death, both for people with college education (1.49 [95% CI 1.27 to 1.75]) and pre-college education (1.93 [95% CI 1.63 to 2.3]) when adjusted for sex, age, and country of birth. When adjusted for living area in addition to sex, age and country of birth, there were a similar increased HR for death both for college (1.51 [95% CI 1.29 to 1.77]) and pre-college education (1.79 [95% CI 1.50 to 2.13]).

Billingsley et al 2020 (33) investigated mortality risk ratios for frontline occupations and essential workers in Sweden. Both the risk for the workers and the risk for older occupants in the household of these workers. IT technicians are the reference group as they were an occupational group who can work from home. Billingsley et al 2020 have information up to May 7th 2020 and adjusted for age, sex, country of birth, living in

Stockholm, highest achieved educational degree, and individual net income. The occupations included were care workers, taxi- and bus drivers, meat packers, teachers, service sector, police and security guards, postal workers and delivery, cleaners and others. There were no deaths among meat packers, police or postal/delivery workers. None of the adjusted mortality risk ratios were significantly different from that of the IT technicians. All the confidence intervals to the adjusted analysis were very wide.

Florida & Mellander 2020 (31) analysed Swedish data from February to August 2nd 2020 and present results both from correlation and regression analyses. Generally, results from the analyses show that the geographic variation in COVID-19 in Sweden was significantly but modestly associated with variables like density, population size (people per km^2), and the socio-economic characteristics (disposable income, Gini coefficient, occupation, unemployment), and somewhat more associated with variables for household size (number per household, and share of single household). The results from the analyses show that up to August 2nd 2020 about two thirds (73%) of COVID-19 deaths in Sweden had been among individuals who had either lived in nursing homes or had been in need of special help in their own homes. There was a significant difference in the number of cases per capita across Swedish municipalities. In week 32 of the pandemic, the most impacted municipality had 40 plus times as many cases as the least affected municipality.

Even so, all these analyses by Florida & Mellander 2020 explain little of the geographic variation in COVID-19 across Sweden. There appears to be a high degree of randomness in the geographic variation of COVID-19.

Excess mortality

Hansson et al 2020 (35) presented information about **excess mortality in Sweden**. The number of deaths (all-cause mortality), age, living area and country of birth were obtained per month from February to May 2020. This information was compared with the corresponding information during the same months in 2016 to 2019. They used three comparison groups based on how long, and thence how well established the population from different countries were. The group called “low level of establishment” include people from countries where the majority had arrived since the millennium such as Syria, Iraq and Somalia. “High level of establishment” are those born in Sweden, other Nordic countries, EU, and North America. Everyone else are in the “intermediary group”.

For people in the low level of establishment in the age group 40 to 64 years, there were 122 deaths. This, compared with an average of 39 deaths in 2016 to 2019, indicates an excess mortality of 220%. Similar rate of excess mortality was seen for people over 65 years. For people with high level of establishment there was 1% lower mortality for those between 40 and 64 years of age, but 19% excess mortality for those over 65 years of age in the same time period (35).

Calderón-Larrañaga et al 2020 (38) compared **weekly all-cause mortality in areas of Stockholm** from January 1st to May 17th 2020 with the average weekly mortality estimates recorded for the corresponding weeks during the years 2015 to 2019 (the same population was also included in the study by Hansson et al 2020 (35). Excess mortality variation by socioeconomic status (tertiles of income, education, Swedish-born, gainful employment) and age distribution (share of 70+-year-old persons) was explored based on Demographic Statistics Area (DeSO) data. During the peak week of the epidemic (week 15) Calderón-Larrañaga et al observed the highest excess mortality for DeSOs with lowest income (171%), lowest education (162%), lowest share of Swedish-born (178%) and lowest share of gainfully employed residents (174%).

Prevalence and incidence across the Nordic countries

The cumulative numbers of COVID-19 infected people by country are presented in Table 7. Only information from Norway, Denmark and Sweden were available. Note that the time span of data collected is very different in the three countries. The numbers from Norway are collected to the end of November 2020, Denmark until September 2020, whereas the numbers from Sweden, with more than twice the population, are only collected until early May. This explains the large difference in numbers of infected people and a direct comparison is inappropriate.

In Norway, the highest risk of COVID-19 infection (measured as Relative Risk Increase (RRI)), was among people born in Somalia (780%), Pakistan (711%), Iraq (494%), Afghanistan (427%) and Turkey (395%). In Denmark, the highest RRI of COVID-19 was among people born in Somalia (1191%), Pakistan (899%), Morocco (603%), Lebanon (404%) and Turkey (306%). In Sweden, the RRI was highest among people born in Turkey (298%), Ethiopia (293%), Somalia (249%), Chile (230%) and Iraq (217%).

Table 7. COVID-19 infection per 100 000 by country of birth. Results from Norway, Denmark and Sweden. Note the large difference in data-collection-periods.

-results not available

COVID-19 infection per 100 000 by country of birth The five with the highest rate for each country are coloured						
Country of birth	**Norway to November 2020** (Indseth et al 2020a) (28)		**Denmark to September 2020** (SSI October 2020) (30)		**Sweden to May 2020** (Folkhälsomyndigheten 2020) (32)	
	Per 100 000	RRI*	Per 100 000	RRI*	Per 100 000	RRI*
Afghanistan	2468	427%	819	230%	364	93%
Bosnia-Herzegovina	1063	127%	-		343	81%
Chile	-		-		624	230%
Denmark	604	29%	248	reference	-	
Eritrea	2112	351%	-		477	152%
Ethiopia	1862	298%	-		742	293%
Finland	-		-		515	172%
Germany	560	20%	-		266	41%
Great Britain	542	16%	-		-	
India	678	45%	781	215%	-	
Iraq	2782	494%	993	300%	600	217%
Iran	1498	220%	505	104%	522	176%
Latvia	209	-55%	-		-	
Lebanon	-		1251	404%	533	182%
Lithuania	384	-18%	-		-	
Morocco	-		1743	603%	-	
Norway	468	reference	-		253	34%
Pakistan	3795	711%	2477	899%	-	
The Pilipines	825	76%	-		-	
Poland	1081	131%	369	49%	181	-4%
Romania	1090	133%	-		-	
Russia	1109	137%	-		-	
Serbia & Montenegro	1973	322%	-		-	
Somalia	4120	780%	3202	1191%	660	249%
Sweden	653	40%	628	153%	189	reference
Syria	948	103%	281	13%	310	64%
Thailand	404	-14%	-		243	29%
Turkey	2316	395%	1006	306%	753	298%
USA	510	9%	-		-	
Vietnam	672	44%	-		-	
Ex-Yugoslavia	-		833	236%	446	136%

*RRI- relative risk increase

Welfare systems closely resembling the Nordic model

From the pre-classified countries in this group: Austria, Belgium, the Netherlands and New Zealand, there was one study from New Zealand (39).

New Zealand
Jefferies et al followed a cohort of 1503 people with COVID-19 (1153 were confirmed and 350 probably infected) from February 2nd to May 13th 2020 in New Zealand. The majority, 1034 of the COVID-19 cases, were imported.

The incidence (cases/100 000) of COVID-19 was highest for people of European descent (35), followed by Pacific (25), Asian (24) and Māori populations (17) in New Zealand. Comparison analysis for COVID-19 infection using the European population as a reference found a lower risk ratio for the Māori (RR 0.49 [95% CI 0.41 to 0.58]), the Asian (RR 0.68 [95% CI 0.58 to 0.79]) and the Pacific populations (RR 0.70 [95% CI 0.55 to 0.88]).

Comparison analysis for COVID-19 infection using lowest social deprivation scale as reference found the lowest risk ratio for people in the most deprived population (RR 0.52 [95% CI 0.43 to 0.62]). Overall, the highest number of cases tended to be in young adults of European ethnicity, and with higher socioeconomic status.

Of the 1503 persons with COVID-19 infection, 95 were hospitalised, 10 were admitted to intensive care and 22 died. Compared to the European population, the risk of severe outcome (hospitalisation and or death) was highest for the Pacific (OR 2.76 [95% CI 1.14 to 6.68]) and Asian population (OR 2.15 [95% CI 1.10 to 4.29]) (Jefferies et al 2020). However, none of the 22 who died were of Pacific or Asian ethnicity.

Welfare systems similar to the Nordic model

The pre-specified countries in this group were Australia, Germany, Ireland and the UK. We included two studies from Germany, one from Ireland and 50 from the UK. The studies from countries with a welfare system similar to the Nordic model are briefly presented in Appendix 5. The table include information on time frame, outcomes and main conclusions.

GRADEing of our confidence in the findings

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) method to assess our confidence in the prevalence and severity of outcomes from the COVID-19 pandemic in Norway. The result of our GRADE assessment is shown in the Summary of Findings table, Table 8.

Table 8. GRADE Summary of Findings table.

Minority ethnic groups during COVID-19 pandemic and their prevalence and severity of outcome

Patient or population: Immigrant and minority ethnic groups in Norway
Setting: Norway, a population of 5.45 million persons, where 0.89 million are registered as born outside of Norway.
Exposure: COVID-19 pandemic

Outcomes	Absolute measure (individuals per 100 000)		No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Norwegian born	Born abroad			
COVID-19 infection	468	1173	5.45 million (1 observational study)	⊕⊕⊕◯ MODERATE[a]	Only one study but similar trends are reported in Denmark and Sweden
COVID-19 related admission to hospital	27	85	5.45 million (1 observational study)	⊕⊕◯◯ LOW	Only one study but similar trends are reported in Denmark and Sweden
COVID-19 related use of ventilator	2.3	8.6	5.45 million (1 observational study)	⊕⊕◯◯ LOW	Only one study but similar trends are reported in Denmark and Sweden
COVID-19 related death	6	Africa 11 Asia 7 Europe 3 Latin America 2	5.45 million (1 observational study)	⊕⊕◯◯ LOW	Only one study but similar trends are reported in Sweden

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[a] Upgraded due to large effect

The studies from Norway were of high quality so we did not downgrade for risk of bias. Since the studies were conducted in Norway, there is good level of directness. Additionally, the fact that the results from Denmark and Sweden report similar results prevented us from downgrading for only one study. Since the reported incidence for many of the immigrant and minority ethnic groups were many times higher than for Norwegian born, we upgraded for large effect.

Discussion

Key findings of this systematic review

The objectives of this systematic review were to assess and systematically summarize evidence on the prevalence of COVID-19 and the severity of the disease (COVID-19) among immigrant and minority ethnic groups and in populations with different socio-economic status. The studies of most interest are those from Scandinavia and other countries with welfare systems closely resembling the Norwegian system.

We included two studies from Norway covering the period up to the end of November 2020. For countries with welfare systems closely resembling the Norwegian, we included one study from Denmark covering the period up to the start of September 2020, and five studies from Sweden covering the period up to early May and early August 2020.

COVID-19 infection. Studies from all three countries provided analysis based on country of birth. For all three countries (Norway, Denmark and Sweden), the number of people per 100 000 population with confirmed COVID-19 infection was larger for people born abroad than for people born in the country.

Occupation was the only measure of socioeconomic status reported from Norway. Results from analyses of the association between COVID-19 infection and occupation showed that the prevalence of Covid-19 infection was highest amongst health care workers and drivers during the first wave (February to July) in Norway. During the second wave (July to October), bartenders, waiters, and travel guides had the highest rate of COVID-19 infections. In Denmark, prevalence of COVID-19 infection was reported by occupational group and origin combined. The occupational groups with highest total number of cases per 100 000 were “health and social services”, “public administration, defence and police”, “transport”, and “travel agencies, cleaning and other operational services”. In almost all occupational groups (including the above mentioned) the proportion of COVID-19 infection was higher among people with non-Western origin than among people with Western and Danish origin. In Denmark, recipients of public services such as sick pay, early retirement and adult education who were of non-Western origin had a higher rate of COVID-19 infections.

Admission to hospital per 100 000 population was larger for people born abroad than for people born in Norway. In Denmark the rate of admission to hospital was larger for people of non-Western origin compared to people with Danish origin.

In Norway, **COVID-19 related deaths** per 100 000 was higher for people born in Africa and Asia than for people born in Norway, but lower for people born in Europe and Latin America compared to people born in Norway. However, the numbers were very low, and the results must be interpreted with caution. In Sweden, it was reported a higher number of COVID-19 related deaths per 100 000 for people born in Low and Middle income countries compared to Swedish born. In Denmark, COVID-19 related case fatality rate for people between 60 and 79 years old was higher for people of Danish origin than for people of non-Western origin. This was even more pronounced for people over 80 years of age. No calculation was made for people below 60 years of age due to few deaths.

In Sweden, a higher mortality rate was found for people with secondary education than for people with post-secondary education, and a higher mortality rate for people in the third and second tertile of income than for those in the first tertile. Corresponding results were found in studies from Stockholm where the number of COVID-19- related deaths decreased by increasing level of education.

The quality of the evidence presented in this systematic review

Two of the included studies in this systematic review provided evidence that is directly relevant to the Norwegian setting as they were conducted in Norway during the COVID-19 pandemic. The Norwegian evidence was supported by results from Denmark and Sweden, countries with welfare systems closely resembling the Norwegian system.

The included epidemiological studies were well conducted, and they are based on relatively reliable data information sources.

The number of people with confirmed COVID-19 infection is dependent on who and how many people that is tested. If the rates of testing are very different between different groups of people, results may end up misleading. However, in Norway, the rate of testing was rather similar between people born in Norway (23%) and people born outside of Norway (21%). Among the people who were tested for COVID-19, the proportion of people who had a positive COVID-19 test was higher for people born abroad compared to people born in Norway (28). The number of people with COVID-19 related admission to hospital and the number of COVID-19 related deaths are more reliable but still rely on some judgements.

Older people have the highest risk of being admitted to hospital admission, for severe illness, and death if infected by COVID-19 (17). Hence, age is a major risk factor. This is adjusted for in most analysis in the included studies. It is useful to keep in mind that the age distribution among people born in Norway and people born abroad are different, with more older people among the Norwegian-born population.

The GRADE Summary of findings table summarise our assessments of available evidence regarding COVID-19 infection, COVID-19 related admission to hospital, use of ventilator and COVID-19 related death for Norway. Our GRADE assessments reflect that of well conducted epidemiological studies with results that are consistent with other studies in very similar settings (Denmark and Sweden).

Strengths and weaknesses of this systematic review

A strength with systematic reviews is the systematic and transparent approach used when conducting it. The use of a pre-published and peer reviewed protocol, help to standardize methods and to reduce bias. We conducted dual assessments where each reference, both for title and abstract screening and for full text assessment were conducted by two people independent of each other, thus reducing the risk of errors and bias. The checking of assessments, data collection and descriptions by a second person for all the information presented in this review also reduce the risk of errors and bias. As do the peer review of the full report.

An inherent challenge with systematic reviews is that they may be outdated as soon as the literature search is completed, because new studies are continuously being published. For the question in this systematic review, we are aware of three new publications from Norway.

Indseth et al 2021 (41) report on the prevalence of COVID-19, admission to hospital, use of ventilator and number of deaths presented by country of birth from March 2020 to February 2021. This new study is an update of the main study included in this systematic review (28). Their main finding was that the differences between Norwegian born and people born abroad on COVID-19 infection persisted. There was a large variation between the different countries of birth in both reports. For both periods of data collection, people born in Pakistan, Somalia, Iraq, Turkey and Afghanistan were at high risk for COVID-19.

Magnusson et al 2021 (42) report on updated prevalence of COVID-19 infection by occupation in Norway. New numbers also include November and December 2020. Bartenders, waiters and people working in cafes and with fast food are still the occupational groups with the highest prevalence of COVID-19 infection.

The newly published report from Indseth et al 2021 (43) report on SARS-CoV-2 infections and COVID-19 related admission to hospital separate for people born abroad and children of people born abroad compared to people born in Norway for the time period 15th June 2020 to 31st March 2021. People born abroad have, also for this extended time period, a higher risk of COVID-19 infection and admission to hospital than people born in Norway. They found the highest risk of COVOD-19 infection to be among the children of people born abroad.

Indseth et al 2021 (43) conducted regression models adjusted for age, sex, municipality of residence, occupation, overcrowded housing (overcrowding),

education, household income and medical risk group for severe COVID-19. Municipality of residence explained the most. Occupation, overcrowding, medical risk group, education and household income explained relatively little of the differences in infection and hospitalizations between foreign-born and Norwegian-born persons. After adjusting for all these factors together, it had a certain effect, but the overrepresentation among foreign-born was still significant.

A wide literature search was conducted for this systematic review, including the searches of many web pages for institutions and organisations in the Nordic countries. Almost all the included studies are from the grey literature, which is more difficult to search systematically and complete and hence, may increase the risk of overlooking some relevant publications.

Generalisability of findings

The results from Norway is directly generalisable to the Norwegian setting. The similarities of results from Norway, Denmark and Sweden indicate that these results may potentially be generalisable to the Scandinavian countries.

The COVID-19 pandemic is occurring in waves, different groups of people are therefore affected at different time points. This implies that results may vary depending on time of testing and time period of measuring. Hence, it is important to interpret all of these results with care. Results from Norway and from Denmark are relatively sparse with few numbers of people admitted to hospital and few deaths although measured over a longer time period. Results from Sweden are based on many more people over a shorter time period. Measures implemented in these three countries to prevent and control infection of COVID-19 differed and varied over time. Nonetheless, it appears that across Norway, Denmark and Sweden, similar immigrant groups are at higher risk of COVID-19 infection.

COVID-19 related mortality can, like many other causes of death, be difficult to ascertain. Definitions and practices may vary, both between countries and between different institutions (for instance between specialised hospitals and nursing homes) within the same country. With low numbers like in the studies from Norway and Denmark and with a new disease, differences may be exaggerated, and any comparisons should be conducted with caution.

We aimed to collect information on how different minority ethnic groups were affected by the COVID-19 pandemic. However, the included studies from Scandinavia generally reported results categorised by country of birth. Hence, we cannot comment on potential influence from religious or cultural factors from these studies. Differences between country of birth and belonging to a minority ethnic group would. This difference would be especially important to keep in mind when comparing results with other countries such as the US or UK.

In this systematic review, the studies from the UK were briefly presented in a table. We did not closely compare the studies to look for overlap in population and time period of data collection. Hence, there may be (and probably are) several studies that include the same population in time. Even so, we consider that the results from the UK confirm general trends as seen in the Scandinavian studies with results from Norway, Denmark and Sweden.

Consistency with other reviews

Our results appear to be in agreement with results of the earlier rapid review from NIPH by Lauvrak & Juvet 2020 (44). Their results suggested that low income, poverty, living in deprived areas, and certain ethnic backgrounds were associated with an increased risk of COVID-19 related death compared to the general population.

We are aware of an ongoing systematic review by Mamelund et al (45) regarding the association between socioeconomic status and pandemic influenza.

Implication of results on practice

The results of this systematic review will be used to inform discussions and decisions regarding interventions to prevent COVID-19 infection, including vaccination strategies.

Need for further research

The questions of this review pertains to an ongoing pandemic, and there is an unquestionable need for more research of good quality on most aspects of this pandemic.

Conclusion

The Scandinavian studies report an increased risk of being infected and admitted to hospital due to COVID-19 for several immigrant and minority ethnic groups. The groups with the highest rates were by and large overlapping across Scandinavia. These immigrant and minority ethnic groups were also at higher risk for COVID-19 related mortality in Sweden, whereas mortality data for Norway and Denmark were too sparse to conclude.

Furthermore, results from Danish studies show that in almost all occupational groups the proportion of COVID-19 infection was higher among people of non-Western origin compared to people of Western and Danish origin. Finally, Swedish analyses show that groups with low socio-economic status had higher rates of admission to hospital and death compared to groups with high socio-economic status.

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Appendix 1 Search strategies

1. Words searched in EndNote database

Socio-economic status:				
accultur		medium educat		socioeconomic
cramped quarter		middle educat		socio-economic
deprived		moderate educat		tight quarter
disadvantaged		noneducated		undergraduate education
economic capital		non-educated		underprivileged
economic constraint		nonprivileged		under-privileged
economic determinant		non-privileged		uneducat
economic disparit		out of work		unemploy
economic equality		out-of-work		unequal
economic equity		poor people		unprivileged
economic hardship		poverty		unskilled
economic justice		primary educat		vulnerable communit
economic position		privileged		vulnerable group
economic resilien		professional education		without education
economic status		psycho-social stress		work condition
economic stressor		psychosocial stress		
economic vulnerab		schooling		
education factor		seasonal employment		
education level		seasonal labor		
education status		seasonal labour		**Immigrant status:**
employment		seasonal work		asylum
graduate education		short educat		country of birth
health disparit		social capital		ethnic
health justice		social class		foreign citizen
high educat		social constraint		immigrant
homeless		social depriv		immigration
housing		social determin		migrant
illiteracy		social disparit		migration
illiterate		social equality		minorities
income		social equity		minority group
inequalit		social justice		minority population
inequit		social network		nationalit
injustice		social risk factor		non-citizen
jobless		social status		noncitizen
least educat		social stratification		non-national
less educat		social vulnerab		non-permanent resident

long educat		sociocultural		nonpermanent resident
low educat		socio-cultural		racial
marginalis		sociodemographic		racism
marginaliz		socio-demographic		refugee

As the EndNote search engine recognizes combinations of letters independent of whether they appear in the beginning, in the middle or at the end of a word, truncation is not neither possible nor necessary.

2. Grey literature search

Resource; Search date; Search strategy	**No. of hits (possibly relevant after preliminary screening by EVH)**
Norway	
Folkehelseinstituttet - Publikasjoner Folkehelseinstituttet - Covid-19: Faglige notater som grunnlag for nasjonale beslutninger 2020-12-10 Search: COVID-19	63 (5)
Helsedirektoratet 2020-12-10 Faglig grunnlag til Helse- og omsorgsdepartementet (covid-19)	47 (6)
BASE (Bielefeld Academic Search Engine) 2020-12-10 (covid-19 sars-cov-2 coronavirus koronavirus koronasmitte pandemi koronapandemi) countr y:no doctype:14 country:no doctype:14 [= Reports]	39 (0)
Cristin.no (Current Research Information System in Norway) 2020-12-10 Search: "COVID-19" Category: Report	40 (0)
NORA - Alt i norske vitenarkiv i én tjeneste 2020-12-10 Search: covid-19 OR korona* OR coronavirus OR "corona virus" OR pandemi* OR SARS-COV-2 Type publikasjon: Rapporter: 39; Arbeidsnotat (Working paper): 8	47 (1)
Google 2020-12-20 (screened first 50 hits x3) covid- 19|koronavirus|koronasmitte|koronasmittet|koronasmittede|koronas ykdom|koronasyk|koronasyke minoriteter|minoritetsgrupper|innvandrere|innvandrergrupper|flyktni nger|migranter|asylsøkere|fødeland|"sosial ulikhet"|sosioøkonomisk| sosioøkonomi|"lav inntekt"|lavinntektsgrupper|fattigdom|trangboddh et|trangbodd|boforhold|utdanningsbakgrunn|utdanningsnivå filetype: pdf site:.no covid-19|sars-cov- 2|coronavirus|pandemic immigrant|immigrants|ethnicity|ethnic|mino rities|"minority group"|"minority groups"|refugees|demographic|dem	150 (3)

ography|socio-demographic|sociodemographic|socioeconomic|socio-economic filetype:pdf site:.no covid-19|sars-cov-2|coronavirus|pandemic "living conditions"|"working conditions"|"social stratification"|"social class"|education|income|deprived|"vulnerable population"|"vulnerable groups"|disparities|inequality|inequalities|injustice filetype:pdf site:.no	
Sweden	
Folkhälsomyndigheten Publikation; Engelska, Svenska	119 (1)
Socialstyrelsen Search: COVID-19	23 (0)
Centrum för epidemiologi och samhällsmedicin / Folkhälsoguiden 2020-12-10 Rapporter om COVID-19	10 (3)
Demographic Unit, Department of Sociology, University of Stockholm 2020-12-10 Working paper series; screened all published in 2020	51 (4)
BASE (Bielefeld Academic Search Engine) 2020-12-10 Search: (covid-19 sars-cov-2 coronavirus coronasmitta pandemi coronapandemi) country:se doctype:14 [= Reports]	45 (4)
Digitala Vetenskapliga Arkivet 2020-12-10 Advanced search – Research publications Search: COVID-19 Publication type: Report	19 (0)
Google 2020-12-10 (screened first 50 hits x3) covid-19|coronavirus|coronasmitta|coronasmittad|coronasmittade|coronapandemin minoriteter|minoritetsgrupper|invandrare|invandrargrupper|flyktingar|migranter|asylsökare|etnicitet|födelseland|"social olikhet"|socioekonomisk|socioekonomi|"låg inkomst"|låginkomsttagare|fattigdom|trångboddhet|trångbodd|boförhållanden|utbildningsnivå|utbildningsbakgrund|lågutbildade filetype:pdf site:.se + repeat the Google searches x2 in English (see Norway above) with site:.se	150 (3)
Denmark	
Statens Serum Institut 2020-12-10 Fokusrapporter	17 (2)
Sundhedsstyrelsen 2020-12-10 Search: "COVID-19" Limits: Udgivelser: Publikation	93 (0)
Statens Institut for Folkesundhed 2020-12-10 Rapporter 2020	36 (0)
VIVE – Det Nationale Forsknings- og Analysecenter for Velfærd 2020-12-10 Search: "COVID-19"	8 (0)
BASE (Bielefeld Academic Search Engine) 2020-12-10	15 (0)

Search: (covid-19 sars-cov-2 coronavirus coronasmitte pandemi coronapandemi) country:dk doctyp e:14 [= Reports]	
Danish National Research Database 2020-12-10 Publication: Report Search: covid-19 OR pandemi* OR corona*	77 (0)
Google 2020-12-10 (screened first 50 hits x3) covid- 19|coronavirus|coronasmitte|coronasmittet|coronasmittede|pandem i|pandemien|coronapandemien socioøkonomi|socioøkonomisk|minori teter|etnicitet|etnisk|minoriteter|minoritetsgruppe|minoritetsgruppe r|herkomst|indvandrere|indvandrergrupper|flygtninge|asylansøgere| beboelsesforhold|indkomst|uddannelsesniveau|uddannelsesbaggrunn filetype:pdf site:.dk + repeat the Google searches x2 in English (see Norway above) with site:.dk	150 (3)
Finland	
BASE (Bielefeld Academic Search Engine) 2020-12-10 Search: (covid-19 sars-cov-2 coronavirus coronasmitta pandemi coronapandemi) country:fi doctype: 14 [= Reports]	8 (0)
Juuli Julkaisutietoportaali 2020-12-10 Type of publication: D4 Published development or research report Language: English	2 (0)
Google 2020-12-10 (screened first 50 hits x3) covid- 19|coronavirus|coronasmitta|coronasmittad|coronasmittade|coronap andemin minoriteter|minoritetsgrupper|invandrare|invandrargrupper |flyktingar|migranter|asylsökare|etnicitet|födelseland|"social olikhet" |socioekonomisk|socioekonomi|"låg inkomst"|låginkomsttagare|fattig dom|trångboddhet|trångbodd|boförhållanden|utbildningsnivå|utbild ningsbakgrund|lågutbildade filetype:pdf site:.fi + repeat the Google searches x2 in English (see Norway above) with site:.fi	150 (0)
Iceland	
BASE (Bielefeld Academic Search Engine) 2020-12-10 Search: (covid-19 sars-cov-2 coronavirus pandemic) country:is doctype:14 [= Reports]	0 (0)
Google 2020-12-20 (screened first 50 hits x2) Google searches x2 in English (see Norway above) with site:.is	100 (0)

Appendix 2. Excluded studies

Excluded studies table with reason for exclusion

Reference	Excluded with reason
Review will assess whether ethnicity is a COVID-19 risk factor. Nursing Standard. 2020;35(5):7.	Exclude, news report that is retracted
Coronavirus research updates: High risk of COVID-19 death for minority ethnic groups is a troubling mystery. Nature. 2020.	Exclude, news report
Abbas A. COVID-19 Risk Assessments: Shortcomings in the protection of Black, Asian and Minority Ethnic healthcare workers. Journal of Hospital Infection. 2020;15:15.	Exclude, not a study
Abrams EM, Szefler SJ. COVID-19 and the impact of social determinants of health. The Lancet Respiratory Medicine. 2020;18:18.	Exclude, not a study
Ahmed F, Ahmed N, Pissarides C, Stiglitz J. Why inequality could spread COVID-19. Lancet Public Health. 2020.	Exclude, not a study
Ahmed MH. Black and Minority Ethnic (BAME) Alliance Against COVID-19: One Step Forward. Journal of Racial & Ethnic Health Disparities. 2020;12:12.	Exclude, not a study
Albon D, Soper M, Haro A. Potential implications of COVID-19 pandemic on the homeless population. Chest. 2020.	Exclude, USA
Alemi Q, Stempel C, Siddiq H, Kim E. Refugees and covid-19: Achieving a comprehensive public health response. Bulletin of the World Health Organization. 2020;98:510-A.	Exclude, not a study
Alnababteh M, Drescher G, Jayaram L, Kohli A, Hashmi M, Hayat F, et al. Investigating the Relationship between Race/Ethnicity and Clinical Outcomes in Covid-19. Chest. 2020;158:A2477-A8.	Exclude, USA
Amasamy R, Milne KM, Stoneham SM, Chevassut TJ. Molecular mechanisms for thrombosis risk in black people: a role in excess mortality from Covid-19. British Journal of Haematology. 2020;21:21.	Exclude, comment on another article
Anderez DO, Kanjo E, Pogrebna G, Kaiwartya O, Johnson SD, Hunt JA. A COVID-19-Based Modified Epidemiological Model and Technological Approaches to Help Vulnerable Individuals Emerge from the Lockdown in the UK. Sensors. 2020;20:02.	Exclude, different population
Anonymous. Tackle coronavirus in vulnerable communities. Nature. 2020;581:239-40.	Exclude, not a study
Aquino-Canchari CR, Quispe-Arrieta RDC, Huaman Castillon KM. COVID-19 and its relationship with vulnerable populations. Revista Habanera de Ciencias Medicas. 2020;19.	Exclude, review without risk of bias assessment of included studies and vulnerability on medical reasons
Aradhya, Siddartha; Brandén, Maria; Drefahl, Sven; Obućina, Ognjen; Andersson, Gunnar; Rostila, Mikael; et al. (2020): Lack of acculturation does not explain excess COVID-19 mortality among immigrants. A population-based cohort study.	Exclude, this study otherwise fulfil inclusion criteria, but participants already included in

Stockholm Research Reports in Demography. Preprint. https://doi.org/10.17045/sthlmuni.13110365.v2	Calderón-Larrañaga et al 2020
Arsalan M, Mubin O, Alnajjar F, Alsinglawi B. COVID-19 Global Risk: Expectation vs. Reality. International Journal of Environmental Research & Public Health [Electronic Resource]. 2020;17:03.	Exclude, results presented on country level. Include Sweden, Belgium, Netherlands, Ireland and UK
Asfahan S, Shahul A, Chawla G, Dutt N, Niwas R, Gupta N. Early trends of socio-economic and health indicators influencing case fatality rate of COVID-19 pandemic. Monaldi Archives for Chest Disease. 2020;90:22.	Exclude, results presented by country (whole population)
Atar S, Atar I. An Invited Commentary on "The Socio-Economic Implications of the Coronavirus and COVID-19 Pandemic: A Review". International Journal of Surgery (London, England). 2020.	Exclude, not a study
Atkins JL, Masoli JAH, Delgado J, Pilling LC, Kuo CL, Kuchel GA, et al. Preexisting Comorbidities Predicting COVID-19 and Mortality in the UK Biobank Community Cohort. Journals of Gerontology Series A Biological Sciences & Medical Sciences. 2020;20:20.	Exclude, different population
Baptist AP, Lowe D, Sarsour N, Jaffee H, Eftekhari S, Carpenter LM, et al. Asthma disparities during the COVID-19 pandemic: a survey of patients and physicians. The Journal of Allergy & Clinical Immunology in Practice. 2020;24:24.	Exclude, USA
Baumer T, Phillips E, Dhadda A, Szakmany T, Gwent C-G. Epidemiology of the First Wave of COVID-19 ICU Admissions in South Wales—The Interplay Between Ethnicity and Deprivation. Frontiers in Medicine. 2020;7.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients
Bentley GR. Don't blame the BAME: Ethnic and structural inequalities in susceptibilities to COVID-19. American Journal of Human Biology. 2020:e23478.	Exclude, not a study
Bhala N, Curry G, Martineau AR, Agyemang C, Bhopal R. Sharpening the global focus on ethnicity and race in the time of COVID-19. Lancet. 2020.	Exclude, not a study
Bhargava A, Fukushima EA, Levine M, Zhao W, Tanveer F, Szpunar SM, et al. Predictors for Severe COVID-19 Infection. Clinical Infectious Diseases. 2020;30:30.	Exclude, USA
Bhattacharjee A, Lisauskaite E. COVID-19 IMPACTS on DESTITUTION in the UK. National Institute Economic Review. 2020;253:R77-R85.	Exclude, different outcome
Blundell R, Costa D, Joyce R, Xu X. COVID-19 and Inequalities. Fiscal Studies. 2020;14:14.	Exclude, different outcomes
Brandenberger J, Baauw A, Kruse A, Ritz N. The global COVID-19 response must include refugees and migrants. Swiss Med Wkly. 2020;150:w20263.	Exclude, not a study
Brandt EB, Beck AF, Mersha TB. Air pollution, racial disparities and COVID-19 mortality. Journal of Allergy and Clinical Immunology. 2020.	Exclude, USA
Brown EG, Chahine LM, Goldman SM, Korell M, Mann E, Kinel DR, et al. The Effect of the COVID-19 Pandemic on People with Parkinson's Disease. Journal of Parkinsons Disease Print. 2020;10:10.	Exclude, USA
Bulmer M, Solomos J. From the Editors: Covid-19 and race and Ethnic Studies. Ethnic and Racial Studies. 2020;43(9):1541.	Exclude, not a study
Burstrom B, Tao W. Social determinants of health and inequalities in COVID-19. European Journal of Public Health. 2020;8:08.	Exclude, not a study

Calderón-Larrañaga A, Dekhtyar S, Vetrano DL, Bellander T, Fratiglioni L. COVID-19: risk accumulation among biologically and socially vulnerable older populations. Ageing Research Reviews. 2020:101149.	Exclude, this study otherwise fulfil inclusion criteria, but participants already included in Calderón-Larrañaga et al 2020
Centrum för epidemiologi och samhällsmedicin. Coronapandemin och socioekonomiska skillnader. Centrum för epidemiologi och samhällsmedicin. April 2020.	Exclude, not a study
Chaudhry R, Dranitsaris G, Mubashir T, Bartoszko J, Riazi S. A country level analysis measuring the impact of government actions, country preparedness and socioeconomic factors on COVID-19 mortality and related health outcomes. EClinicalMedicine. 2020:100464.	Exclude, results presented on global level
Chedid Y, Ubaide H, Sani I, Hamza Y. What about BAME? A letter to the editor on "The socio-economic implications of the coronavirus pandemic (COVID-19): A review. International Journal Of Surgery. 2020;31:31.	Exclude, not a study
Cheudjeu A. Correlation of D-xylose with severity and morbidity-related factors of COVID-19 and possible therapeutic use of D-xylose and antibiotics for COVID-19. Life Sciences. 2020;260:118335.	Exclude, not a study
Chidiac C, Feuer D, Flatley M, Rodgerson A, Grayson K, Preston N. The need for early referral to palliative care especially for Black, Asian and minority ethnic groups in a COVID-19 pandemic: Findings from a service evaluation. Palliative Medicine. 2020:269216320946688.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients during the pandemic
Chin-Hong P, Alexander KM, Haynes N, Albert MA, Association of B, Cardiologists. Pulling at the heart: COVID-19, race/ethnicity and ongoing disparities. Nature Reviews Cardiology. 2020;27:27.	Exclude, not a study
Clementi R. Structural racism remains a primary public health risk amidst COVID and beyond in the United Kingdom. Journal of Public Health. 2020;10:10.	Exclude, not a study
Cleveland Manchanda E, Couillard C, Sivashanker K. Inequity in Crisis Standards of Care. New England Journal of Medicine. 2020:NEJMp2011359-NEJMp.	Exclude, not a study
Clift AK, Coupland CAC, Keogh RH, Diaz-Ordaz K, Williamson E, Harrison EM, et al. Living risk prediction algorithm (QCOVID) for risk of hospital admission and mortality from coronavirus 19 in adults: national derivation and validation cohort study. BMJ. 2020;371:m3731	Exclude, results are model generated
Cook M. Potential factors linked to high COVID-19 death rates in British minority ethnic groups. The Lancet Infectious Diseases. 2020;17:17.	Exclude, not a study
Davies P, Evans C, Kanthimathinathan HK, Lillie J, Brierley J, Waters G, et al. Intensive care admissions of children with paediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS) in the UK: a multicentre observational study. The Lancet Child & Adolescent Health. 2020;9:09.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients
de Havenon A, Yaghi S, Mistry EA, Delic A, Hohmann S, Shippey E, et al. Endovascular thrombectomy in acute ischemic stroke patients with COVID-19: prevalence, demographics, and outcomes. Journal of Neurointerventional Surgery. 2020;28:28.	Exclude, USA
de Lusignan S, Joy M, Oke J, McGagh D, Nicholson B, Sheppard J, et al. Disparities in the excess risk of mortality in the first wave of COVID-19: cross sectional study of the English sentinel network. Journal of Infection. 2020;25:25.	Exclude, same information as in the other publication by de Lusignan that is included

Drefahl, Sven; Wallace, Matthew; Mussino, Eleonora; Aradhya, Siddartha; Kolk, Martin; Brandén, Maria; et al. (2020): Socio-demographic risk factors of COVID-19 deaths in Sweden: A nationwide register study. Stockholm Research Reports in Demography. Preprint.	Exclude, preprint of the included Drefahl et al 2020
Elgar FJ, Stefaniak A, Wohl MJA. The trouble with trust: Time-series analysis of social capital, income inequality, and COVID-19 deaths in 84 countries. Social Science & Medicine. 2020:113365.	Exclude, Canada
El-Khatib Z, Jacobs GB, Ikomey GM, Neogi U. The disproportionate effect of COVID-19 mortality on ethnic minorities: Genetics or health inequalities? EClinicalMedicine. 2020;23:100430.	Exclude, not a study
Emeruwa UN, Spiegelman J, Ona S, Kahe K, Miller RS, Fuchs KM, et al. Influence of Race and Ethnicity on Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection Rates and Clinical Outcomes in Pregnancy. Obstetrics & Gynecology. 2020;21:21.	Exclude, USA
Esegbona-Adeigbe S. COVID-19 and the risk to black, Asian and minority ethnic women during pregnancy. British Journal of Midwifery. 2020;28(10):718-23.	Exclude, review without a search or RoB
Estrela FM, Soares C, Cruz MAD, Silva AFD, Santos JRL, Moreira TMO, et al. Covid-19 Pandemic: reflecting vulnerabilities in the light of gender, race and class. Ciencia & Saude Coletiva. 2020;25:3431-6.	Exclude, review article without risk of bias assessments
Evans S. BAME excess deaths: Chronic stress and constant hostility. British Journal of General Practice. 2020;70:395.	Exclude, not a study
Felsenstein S, Willis E, Lythgoe H, McCann L, Cleary A, Mahmood K, et al. Presentation, Treatment Response and Short-Term Outcomes in Paediatric Multisystem Inflammatory Syndrome Temporally Associated with SARS-CoV-2 (PIMS-TS). Journal of Clinical Medicine. 2020;9:14.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients
Folkehelseinstituttet, 30. november 2020. COVID-19-EPIDEMIEN: Kunnskap, situasjon, prognose, risiko og respons i Norge etter uke 48. FHI 2020	Exclude, different outcome
Folkehelseinstituttet, Oppdrag fra HOD nr. 197 om nasjonale tiltak. FHI Oktober.	Exclude, this study otherwise fulfil inclusion criteria, but population included in Indseth et al 2020.
Folkehelseinstituttet, Oppdrag fra HOD nr. 208 om forberedelse av innstramminger	Exclude, different outcomes
Flodgren G, Vestrheim D, Brurberg K. COVID-19 and risk factors for severe disease: a rapid review, 2nd update. Oslo: Norwegian Institute of Public Health; 2020 2020.	Exclude, rapid review without risk of bias assessment of included studies
Germain S, Yong A. COVID-19 Highlighting Inequalities in Access to Healthcare in England: A Case Study of Ethnic Minority and Migrant Women. Feminist Legal Studies. 2020:1-10.	Exclude, not a study
Goyal MK, Simpson JN, Boyle MD, Badolato GM, Delaney M, McCarter R, et al. Racial and/or ethnic and socioeconomic disparities of SARS-CoV-2 infection among children. Pediatrics. 2020;146.	Exclude, USA
Gray DM, nd, Anyane-Yeboa A, Balzora S, Issaka RB, May FP. COVID-19 and the other pandemic: populations made vulnerable by systemic inequity. Nature Reviews Gastroenterology & Hepatology. 2020;15:15.	Exclude, not a study
Greenaway C, Hargreaves S, Barkati S, Coyle CM, Gobbi F, Veizis A, et al. COVID-19: Exposing and addressing health disparities	Exclude, not a study

among ethnic minorities and migrants. Journal of Travel Medicine. 2020;24:24.	
Gross CP, Essien UR, Pasha S, Gross JR, Wang SY, Nunez-Smith M. Racial and Ethnic Disparities in Population-Level Covid-19 Mortality. Journal of General Internal Medicine. 2020;4:04.	Exclude, USA
Harman K, Verma A, Cook J, Radia T, Zuckerman M, Deep A, et al. Ethnicity and COVID-19 in children with comorbidities. The Lancet Child & Adolescent Health. 2020;28:28.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients
Hastie CE, Mackay DF, Ho F, Celis-Morales CA, Katikireddi SV, Niedzwiedz CL, et al. Vitamin D concentrations and COVID-19 infection in UK Biobank. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2020.	Exclude, this study is not about ethnicity or socioeconomic factors by themselves
Helsedirektoratet. Svar på covid-19 oppdrag fra HOD 188 - Om innreisekarantene, reiseråd mv - Frist 23. oktober 2020	Exclude, different outcome
Helsedirektoratets svar på covid-19-oppdrag 208 fra Helse- og omsorgsdepartementet. 4. november 2020.	Exclude, different outcome
Helsedirektoratets svar på covid-19-oppdrag 221 fra Helse- og omsorgsdepartementet. 10. desember 2020.	Exclude, different outcome
Helsedirektoratets svar på covid-19-oppdrag 240 fra Helse- og omsorgsdepartementet. 26. november 2020.	Exclude, different outcome
Henning-Smith C, Tuttle M, Kozhimannil KB. Unequal Distribution of COVID-19 Risk among Rural Residents by Race and Ethnicity. Journal of Rural Health. 2020;12:12.	Exclude, not a study
Holst H, Fessler A, Niehoff S. Covid-19, social class and work experience in Germany: inequalities in work-related health and economic risks. European Societies. 2020.	Exclude, different outcomes (Germany)
Iacobucci G. Covid-19: Racism may be linked to ethnic minorities' raised death risk, says PHE. BMJ. 2020;369:m2421.	Exclude, not a study
Indseth T, Kjøllesdal MK, Calero CJ, Nygård KM, Godøy A 2020. "Covid-19 i Oslo etter fødeland: Personer testet, bekreftet smittet og relaterte innleggelser [Covid-19 by country of birth in Oslo: Persons tested, confirmed infections and associated hospitalizations], Rapport 2020. Oslo: Folkehelseinstituttet, 2020	Exclude, this study otherwise fulfil inclusion criteria, but all the participants are already included in Indseth et al 2020a
Islam N, Khunti K, Dambha-Miller H, Kawachi I, Marmot M. COVID-19 mortality: A complex interplay of sex, gender, and ethnicity. European Journal of Public Health. 2020;3:03.	Exclude, not a study
Iyengar KP, Ish P, Upadhyaya GK, Malhotra N, Vaishya R, Jain VK. COVID-19 and mortality in doctors. Diabetes & Metabolic Syndrome. 2020;14:1743-6.	Exclude, review without RoB of studies in India
Jaspal R, Fino E, Breakwell GM. The COVID-19 Own Risk Appraisal Scale (CORAS): Development and validation in two samples from the United Kingdom. Journal of Health Psychology. 2020.	Excluded, different outcomes
Joseph NP, Reid NJ, Som A, Li MD, Hyle EP, Dugdale CM, et al. Racial/Ethnic Disparities in Disease Severity on Admission Chest Radiographs among Patients Admitted with Confirmed COVID-19: A Retrospective Cohort Study. Radiology. 2020:202602.	Exclude, USA
Karan A, Ali K, Rambaran K, Del C, Sakhamuri S, Teelucksingh S. COVID-19 and ethnicity: Does reduced responsiveness to glucocorticoids explain the more aggressive nature of disease among minorities? Medical Hypotheses. 2020;144.	Exclude, not a study
Khonyongwa K, Taori SK, Soares A, Desai N, Sudhanva M, Bernal W, et al. Incidence and outcomes of healthcare-associated COVID-19 infections: significance of delayed	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients

diagnosis and correlation with staff absence. Journal of Hospital Infection. 2020;13:13.	
Khunti K, Singh AK, Pareek M, Hanif W. Is ethnicity linked to incidence or outcomes of covid-19? BMJ. 2020;369.	Exclude, not a study
Kirby T. Evidence mounts on the disproportionate effect of COVID-19 on ethnic minorities. Lancet Respiratory Medicine. 2020.	Exclude, not a study
Kluge HHP, Jakab Z, Bartovic J, D'Anna V, Severoni S. Refugee and migrant health in the COVID-19 response. Lancet. 2020.	Exclude, not a study
Kmietowicz Z. Covid-19: Half of pregnant women in UK hospitals are from ethnic minorities. BMJ. 2020;369:m2266.	Exclude, comment on Knight 2020
Kopel J, Perisetti A, Roghani A, Aziz M, Gajendran M, Goyal H. Racial and Gender-Based Differences in COVID-19. Frontiers in Public Health. 2020;8.	Exclude, not a study
Lassale C, Gaye B, Hamer M, Gale CR, Batty GD. Ethnic Disparities in Hospitalization for COVID-19: a Community-Based Cohort Study in the UK. MedRxiv : the Preprint Server for Health Sciences. 2020;26:26.	Exclude, preprint of the included Lassale et al 2020
Lauvrak V, Juvet L. Social and economic vulnerable groups during the COVID-19 pandemic: a rapid review. Oslo: Norwegian Institute of Public Health; 2020 2020.	Exclude, Rapid review without RoB
Livingston G, Rostamipour H, Gallagher P, Kalafatis C, Shastri A, Huzzey L, et al. Prevalence, management, and outcomes of SARS-CoV-2 infections in older people and those with dementia in mental health wards in London, UK: a retrospective observational study. The Lancet Psychiatry. 2020;5:05.	Exclude, different population
Lynn R, Meisenberg G. Race differences in deaths from coronavirus in england and Wales: Demographics, poverty, pre-existing conditions, or intelligence? Mankind Quarterly. 2020;60(4):511-24.	Exclude, this study is not about ethnicity or socioeconomic factors by themselves
Mahil SK, Dand N, Mason KJ, Yiu ZZ, Tsakok T, Meynell F, et al. Factors associated with adverse COVID-19 outcomes in patients with psoriasis - insights from a global registry-based study. Journal of Allergy & Clinical Immunology. 2020;16:16.	Exclude, ethnicity presented together with treatment effect
Mamelund SE, Ingelsrud MH, Steen AH. Arbeidslivsbarometerets koronaundersøkelse Preliminære funn per 6. april 2020. ARBEIDSFORSKNINGSINSTITUTTET AFI. 2020	Exclude, different outcomes
Nguyen LH, Drew DA, Graham MS, Joshi AD, Guo CG, Ma W, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. The lancet Public Health. 2020;30:30.	Exclude, USA and UK presented with one results (not separate results)
O'Dowd A. Covid-19: People in most deprived areas of England and Wales twice as likely to die. BMJ. 2020;369:m2389.	Exclude, not a study
Pal R, Banerjee M, Yadav U, Bhattacharjee S. Clinical profile and outcomes in COVID-19 patients with diabetic ketoacidosis: A systematic review of literature. Diabetes & Metabolic Syndrome. 2020;14:1563-9.	Exclude, different population
Pan D, Sze S, Minhas JS, Bangash MN, Pareek N, Divall P, et al. The impact of ethnicity on clinical outcomes in COVID-19: A systematic review. EClinicalMedicine. 2020;23:100404.	Exclude, systematic review but of low quality as assessed using AMSTAR
Patel AP, Paranjpe MD, Kathiresan NP, Rivas MA, Khera AV. Race, Socioeconomic Deprivation, and Hospitalization for COVID-19 in English participants of a National Biobank. MedRxiv : the Preprint Server for Health Sciences. 2020;2:02.	Exclude, preprint of the included Patel et al 2020
Patel JA, Nielsen FBH, Badiani AA, Assi S, Unadkat V, Patel B, et al. Poverty, Inequality & COVID-19: The Forgotten Vulnerable. Public Health. 2020.	Exclude, not a study but letter to the other Patel references

Patel P, Hiam L, Sowemimo A, Devakumar D, McKee M. Ethnicity and covid-19. BMJ. 2020;369:m2282.	Exclude, not a study
Price CC, Altice FL, Shyr Y, Koff A, Pischel L, Goshua G, et al. Tocilizumab treatment for Cytokine Release Syndrome in hospitalized COVID-19 patients: survival and clinical outcomes. Chest. 2020;15:15.	Exclude, USA
Rahman M, Islam M, Shimanto MH, Ferdous J, Rahman AAS, Sagor PS, et al. A global analysis on the effect of temperature, socio-economic and environmental factors on the spread and mortality rate of the COVID-19 pandemic. Environment, Development and Sustainability. 2020:1-15.	Exclude, results presented on too high meta-level
Raifman M, Raifman J. Disparities in the Population at Risk of Severe Illness From COVID-19 by Race/Ethnicity and Income. American Journal of Preventive Medicine. 2020.	Exclude, USA
Ramcharan T, Nolan O, Lai CY, Prabhu N, Krishnamurthy R, Richter AG, et al. Paediatric Inflammatory Multisystem Syndrome: Temporally Associated with SARS-CoV-2 (PIMS-TS): Cardiac Features, Management and Short-Term Outcomes at a UK Tertiary Paediatric Hospital. Pediatric Cardiology. 2020;12:12.	Excluded, this study otherwise fulfil inclusion criteria, but have fewer than 100 patients
Razaq A, Harrison D, Karunanithi S, Barr B, Asaria M, Routen A, et al. BAME COVID-19 DEATHS – What do we know? Rapid Data & Evidence Review. Oxford, UK: Centre for Evidence-Based Medicine; 2020 2020.	Exclude, Rapid review without risk of bias assessment
Reza N, DeFilippis EM, Jessup M. Secondary Impact of the COVID-19 Pandemic on Patients With Heart Failure. Circ Heart Fail. 2020;13(5):e007219.	Exclude, not a study
Rimmer A. Covid-19: Two thirds of healthcare workers who have died were from ethnic minorities. BMJ. 2020;369.	Exclude, comment on another paper
Riphagen S. Understanding Covid and the associated post-infectious hyper-inflammatory state (PIMS-TS) in children. Medical Hypotheses. 2020;144.	Exclude, different focus (cause)
Roger Yat-Nork C, Dong D, Li MM. Socioeconomic gradient in health and the covid-19 outbreak. BMJ. 2020;369.	Exclude, not a study
Rollston R, Galea S. COVID-19 and the Social Determinants of Health. American Journal of Health Promotion. 2020;34:687-9.	Exclude, not a study
Rostila, Mikael; Cederström, Agneta; Wallace, Matthew; Brandén, Maria; Malmberg, Bo; Andersson, Gunnar (2020): Disparities in covid-19 deaths by country of birth in Stockholm, Sweden: A total population based cohort study. Stockholm Research Reports in Demography. Preprint. https://doi.org/10.17045/sthlmuni.12852854.v1	Exclude, this study otherwise fulfil inclusion criteria, but participants already included in Bartelink et al 2020
Rousseau P. Immigrant COVID. Annals of Internal Medicine. 2020;4:04.	Exclude, not a study
Sannigrahi S, Pilla F, Basu B, Basu AS, Molter A. Examining the association between socio-demographic composition and COVID-19 fatalities in the European region using spatial regression approach. Sustainable Cities and Society. 2020;62.	Exclude, results modelled and presented on country level
Schrooyen L, Delforge M, Lebout F, Vanbaelen T, Lecompte A, Dauby N. Homeless people hospitalized with COVID-19 in Brussels. Clinical Microbiology & Infection. 2020;7:07.	Exclude, different population Belgium
Shahbazi F, Khazaei S. Socioeconomic inequality in global incidence and mortality rates from COVID-19: an Ecological study. New Microbes & New Infections. 2020:100762.	Exclude, cross-country level reporting
Singh I, Chand K, Singh A, Kandadi KR. Time for a culture change: understanding and reducing risk, morbidity and mortality from COVID-19 in those of black and minority ethnicity. British Journal of Hospital Medicine. 2020;81:1-4.	Exclude, not a study

Slot LV, Søndergaard JK, Zaken S. CORONA RAMMER SKÆVT – ETNICITET OG SMITTE Ligebehandlingsafdelingen, Institut for Menneskerettigheder, 2020.	Exclude, this study otherwise fulfil inclusion criteria, but participants in Statens Serum Institute, October 2020
Soiné H, Kriegel L, Dollmann J. The impact of the COVID-19 pandemic on risk perceptions: differences between ethnic groups in Germany. European Societies. 2020.	Exclude, different outcome
Souch JM, Cossman JS. A Commentary on Rural-Urban Disparities in COVID-19 Testing Rates per 100,000 and Risk Factors. Journal of Rural Health. 2020.	Exclude, USA
Statens Serum Institute, May 2020	Exclude, this study otherwise fulfil inclusion criteria, but participants included in Statens Serum Institute, October 2020
Steyn N, Binny RN, Hannah K, Hendy SC, James A, Kukutai T, et al. Estimated inequities in COVID-19 infection fatality rates by ethnicity for Aotearoa New Zealand. New Zealand Medical Journal. 2020;133:28-39.	Exclude, a model
Strang P, Fürst P, Schultz T. Excess deaths from COVID-19 correlate with age and socio-economic status. A database study in the Stockholm region. Upsala Journal of Medical Sciences. 2020;125(4):297-304.	Exclude, this study otherwise fulfil inclusion criteria, but participants already included in Calderón-Larrañaga et al 2020
Townsend MJ, Kyle TK, Stanford FC. Outcomes of COVID-19: disparities in obesity and by ethnicity/race. International Journal of Obesity. 2020;9:09.	Exclude, not a study
Travaglio M, Yu Y, Popovic R, Selley L, Leal NS, Martins LM. Links between air pollution and COVID-19 in England. Environmental Pollution. 2021;268.	Exclude, analysis by large geographical areas, not possible to isolate low socioeconomic areas.
Tukpah AM, Moll M, Gay EB. COVID-19 Racial/Ethnic Inequities in Acute Care and Critical Illness Survivorship. Annals of the American Thoracic Society. 2020;25:25.	Exclude, USA
Valeriani G, Vukovic IS, Mollica R. Unconventional Answers to Unprecedented Challenges: The Swedish Experience During the COVID-19 Outbreak. Journal of Preventive Medicine & Public Health / Yebang Uihakhoe Chi. 2020;53:233-5.	Exclude, not a study
Wise J. Covid-19: Known risk factors fail to explain the increased risk of death among people from ethnic minorities. BMJ. 2020;369:m1873.	Exclude, comment on a study, Williamson
Wood LCN, Devakumar D. Healthcare access for migrant children in England during the COVID-19 pandemic. BMJ Paediatrics Open. 2020;4.	Exclude, do not present data
Wu A, Sng CCT, Benafif S, Chopra N, Galazi M, Lee AJX, et al. COVID-19 mortality in patients receiving anti-cancer therapy in a UK national cancer centre. Annals of Oncology. 2020;31:S1004.	Exclude, different comparison

Appendix 3. AMSTAR assessment

Pan D, Sze S, Minhas JS, Bangash MN, Pareek N, Divall P, et al. The impact of ethnicity on clinical outcomes in COVID-19: A systematic review. EClinicalMedicine. 2020;23:100404.	Assessments		
Questions:	**Yes**	**Partially yes**	**No**
1.Did the research questions and inclusion criteria for the review include the components of PICO?	Yes		
2.Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol? *Prospero protocol published in April*	Yes		
3.Did the review authors explain their selection of the study designs for inclusion in the review?	Ok		
4.Did the review authors use a comprehensive literature search strategy?	Yes		
5.Did the review authors perform study selection in duplicate?	Yes		
6.Did the review authors perform data extraction in duplicate?	Yes		
7.Did the review authors provide a list of excluded studies and justify the exclusions?			No
8.Did the review authors describe the included studies in adequate detail?			No
9.Did the review authors use a satisfactory technique for assessing the risk of bias in individual studies that were included in the review?	Yes		
10.Did the review authors report on the sources of funding for the studies included in the review?	Yes		
11.If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results? *Vote counting*			No
12.If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?			No
13.Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review? *Pan et al assessed all included studies to be of good quality*	Yes		
14.Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?			No
15.If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?		Not conducted	
16.Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?			no
AMSTAR score: Low quality score (https://amstar.ca/Amstar_Checklist.php)			

Appendix 4. Included studies tables

Norwegian studies

<table>
<tr><td colspan="2">Indseth et al 2020
Indseth T, Godøy A, Kjøllesdal M, Arnesen T, Jacobsen C, Grøsland M, Telle K. Covid-19 etter fødeland: Personer testet, bekreftet smittet og relaterte innleggelser og dødsfall. [Covid-19 by country of birth: Persons tested, confirmed infected and associated hospitalizations and deaths], Rapport 2020. Oslo: Folkehelseinstituttet, 2020.</td></tr>
<tr><td>Study design</td><td>Register study</td></tr>
<tr><td>Source of information</td><td>The Norwegian Institute of Public Health established an emergency register in April 2020, BeredtC19. This register includes the entire population in Norway with data from the MSIS/laboratory database, the National Population Register, the AA register (Employer and Employee Register) and data from the Norwegian Patient Register (NPR).</td></tr>
<tr><td>Population</td><td>All persons living in Norway 1st March 2020 and who have a Norwegian birth number; 5,45 million persons with 0,89 million who are registered as born abroad.</td></tr>
<tr><td>Time period of data collection</td><td>1st March 2020 to end of November 2020</td></tr>
<tr><td>Key description of population studied</td><td>Focus on people born abroad, the 26 countries where more than 10 000 people living in Norway were born.</td></tr>
<tr><td colspan="2">Outcomes reported:<table>
<tr><td>Prevalence of COVID-19 infection</td><td>Yes by country of birth</td></tr>
<tr><td>COVID-19 related admission to hospital</td><td>Yes by country of birth</td></tr>
<tr><td>COVID-19 related admission to intensive care unit</td><td>No</td></tr>
<tr><td>COVID-19 related use of ventilator</td><td>Yes by continent of birth</td></tr>
<tr><td>COVID-19 related mortality</td><td>Yes by continent of birth</td></tr>
</table></td></tr>
<tr><td>Method of analysis, including which factors the analysis were adjusted for</td><td>From BeredtC19, data were extracted for descriptive statistics and rates per 100,000 were calculated. Only residents in Norway are included in the material.
Analysis were adjusted for age, sex, place of residence and occupation.</td></tr>
<tr><td colspan="2">Population information according to the PROGRESS equity lens (O'Neil et al 2014):</td></tr>
<tr><td>Place of residence, including country, setting and if reported also the infection rate at the time of the study</td><td>Norway</td></tr>
<tr><td>Race, ethnicity, culture and language, note country of birth if recorded</td><td>Countries of birth: Afghanistan, Bosnia-Hercegovina, China, Denmark, Eritrea, Ethiopia, the Fillipines Germany, India, Iraq, Iran, Latvia, Lithauen, Pakistan, Polen, Romania, Russia, Serbia</td></tr>
</table>

	and Montenegro, Somalia, Sweden Syria, Thailand, UK, USA, Vietnam
Occupation	Not reported
Gender/sex	Not reported
Religion	Not reported
Education	Not reported
Socio-economic status	Income, % with low level of education, % trangbodd and % living in Norway >5 years
Social capital	Not reported
Other	

COVID-19-EPIDEMIEN: Kunnskap, situasjon, prognose, risiko og respons i Norge etter uke 45 (Covid-19-pandemic: Knowledge, situation, prognosis, risk and respons in Norway after week 45). Folkehelseinstituttet (NIPH) Oslo. 5 November 2020	
Study design	Register study, modelling
Source of information	NIPH
Time period of data collection	February to 4th of November
Key description of population studied	Norwegian population.
Outcomes reported: Prevalence of COVID-19 infection: Yes COVID-19 related admission to hospital: Yes (modelling) COVID-19 related admission to intensive care unit: Yes (modelling) COVID-19 related use of ventilator: No COVID-19 related mortality: Yes (modelling)	
Method of analysis, including which factors the analysis were adjusted for	Analysis of insidence of Covid-19 in people born outside of Norway, compared to people born in Norway. This analysis was adjusted for age, sex, place of residence and occupation. This study also included a model for calculating R.
Population	Norwegian population.
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Norway
Race, ethnicity, culture and language, note country of birth if recorded	People born in other western and non-western countries
Occupation	Yes
Gender/sex	No
Religion	No
Education	No
Socio-economic status	No
Social capital	No
Other	

Danish studies

Statens Serum Insitut. COVID-19 og herkomst. October 2020. (SSI October 2020)	
Study design	Register study
Source of information	SSI, data collected 7th September 2020
Time period of data collection	Week 9 to week 36, 2020
Key description of population studied	Danish population 5.8 mill people, with focus on immigrants and families with non-western origin.

	Danish population living with >4 persons per household and persons living with <40m^2 per person. Occupational groups and recipients of public services are reported.

Outcomes reported:

Prevalence of COVID-19 infection	Yes
COVID-19 related admission to hospital	Yes
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Not mentioned
Population	Danish population. COVID-19 related outcomes reported from populations with >100 000 persons living in Denmark
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Denmark
Race, ethnicity, culture and language, note country of birth if recorded	Afghanistan, India, Iran, Iraq, Lebanon, Morocco, Pakistan, Poland, Somalia, Sweden, Syria, Turkey, ex-Yugoslavia
Occupation	Yes
Gender/sex	No
Religion	No
Education	No
Socio-economic status	Recipients of benefit noted
Social capital	not mentioned
Other	

Swedish studies

Florida R and Mellander C. No 487: The Geography of COVID-19 in Sweden. Working paper series in economics and institutions of innovation, Royal Institute of Technology, CESIS-Centre of Excellence for Science and Innovative Studies	
Study design	Registry
Source of information	Weekly data on cases of COVID-19 infections were released from Folkälsomyndigheten Data on COVID-19 deaths came from Socialstyrelsen. Two levels of geography, by municipality (Sweden has 290 municipalities), and by neighbourhood using the 34 neighbourhoods of the three largest cities in Sweden (Stockholm, Gothenburg and Malmö). Most of the data regarding variables for the analysis were collected from Statistics Sweden.
Time period of data collection	25 weeks from February 3rd to August 2nd
Key description of population studied	The whole population of Sweden, reports on both minority ethnic and socio economic indicators

Outcomes reported:

Prevalence of COVID-19 infection	Yes
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No

COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Both a correlation and a regression analysis Independent variables: Population size, density (people per km^2), air connectivity (airport access and traffic level at the airport), age, income (disposable income), income inequality (Gini coefficient), household size (number per household, and share of single household), multi-generational households (includes both person over 70 years and under 15 years), immigration status (share of population born outside Sweden, or share of people who are either born abroad or one or both parents are born abroad), education (share with BA or above), occupation, unemployment (for people 20 to 64 years old, temperature/climate (average yearly temperature in the municipality), nursing homes (by two level of language skills of the staff, average education level and share of foreign born staff), week of first infection.
Population	The whole population of Sweden
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	People who live in Sweden, Population size, density (people per km^2) per municipality. Week of first infection. Presence of nursing homes and staff variable (by two level of language skills of the staff, average education level and share of foreign born staff
Race, ethnicity, culture and language, note country of birth if recorded	Immigration status by share of population born outside Sweden, or share of people who are either born abroad or one or both parents are born abroad
Occupation	Adjusted for in analysis, but not reported for different occupations
Gender/sex	Yes
Religion	No
Education	Share with BA or above
Socio-economic status	income (disposable income), income inequality (Gini coefficient), unemployment (for people 20 to 64 years old.
Social capital	Household size (number per household, and share of single household), multi-generational households (includes both person over 70 years and under 15 years).
Other	Air connectivity and average temperature of the municipality

Folkhälsomyndigheten. Covid-19 Demografisk beskrivning av bekräftade covid-19 fall i Sverige 13 mars-7 maj 2020. Folkhälsomyndigheten 20096.	
Study design	Register study
Source of information	Statistics Sweden (SCB)
Time period of data collection	13th March to 7th of May
Key description of population studied	Inhabitants registered in Sweden.

Outcomes reported:

Prevalence of COVID-19 infection	Yes
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No

COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Insidence and mortality presented as number of cases per 100,000 by birth country.
Population	Population data from Statistics Sweden from 2019. All inhabitants, place of birth and gender.
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	Western and non-western countries of birth.
Occupation	No
Gender/sex	Yes
Religion	No
Education	No
Socio-economic status	No
Social capital	No
Other	

Billingsley S, Brandén M, Aradhya S, Drefahl S, Andersson G, Mussino E, (2020). Deaths in the frontline: Occupation-specific COVID-19 mortality risks in Sweden. Stockholm Research Reports in Demography. Preprint.	
Study design	Register study
Source of information	"Swedish administrative and population registers", Swedish National Board of Health and Welfare, the agency responsible for the cause of death register
Time period of data collection	Up to 8th of May 2020
Key description of population studied	

Outcomes reported:

Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Poisson regressions with COVID-19 death as an event. Analyses adjusted for age, sex, country of birth, living in Stockholm (measured at the end of 2019), highest achieved educational degree, and individual net income (measured at the end of 2018).
Population	The study population is municipalities in Sweden in which there had been at least one COVID-19 related death by May 8, 2020.
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	
Race, ethnicity, culture and language, note country of birth if recorded	Not mentioned
Occupation	Yes
Gender/sex	No
Religion	No
Education	No
Socio-economic status	Yes
Social capital	

Other	Exposure in occupation

Drefahl S, Wallace M, Mussino E, Aradhya S, Kolk M, Branden M, et al. A population-based cohort study of socio-demographic risk factors for COVID-19 deaths in Sweden. Nature communications. 2020;11:5097.	
Study design	Register study
Source of information	«Data from Swedish authorities». «Administrative registers». Not specified.
Time period of data collection	Up to 7th of May 2020
Key description of population studied	Entire population of Sweden
Outcomes reported:	
Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes
Method of analysis, including which factors the analysis were adjusted for	Multivariate Cox survival analysis
Population	7,8 mill inhabitants of Sweden
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	Population grouped into HIC: high-income countries, LMIC MENA: low-middle-income countries from Northern Africa and the Middle East, LMIC other: other low-middle-income countries.
Occupation	No
Gender/sex	Yes
Religion	No
Education	No
Socio-economic status	Yes
Social capital	
Other	Country of birth, civil status

Hansson E, Albin M, Rasmussen M, Jakobsson K. [Large differences in excess mortality in March-May 2020 by country of birth in Sweden]. Stora skillnader i överdödlighet våren 2020 utifrån födelseland. Lakartidningen. 2020;117:29.	
Study design	Register study and modelling study
Source of information	Statistics Sweden (SCB)
Time period of data collection	February to May 2020
Key description of population studied	People residing in Sweden, not specified.
Outcomes reported:	
Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes
Method of analysis, including which factors the analysis were adjusted for	Total number of deaths per month, place of birth and age group for 2020 is related to the average number for the same group and the same month for 2016-2019. (Det totala antalet avlidna per månad, födelseland och åldersgrupp 2020

	relaterades till medelvärdet i samma grupp under samma månad 2016–2019).
Population	People residing in Sweden, not specified.
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	Countries of birth were grouped in categories of possible degree of being established depending on work opportunities, housing opportunities and language knowledge. (utifrån antagande om etableringsgrad i samhället i stort (arbetsmarknad, bostadsmarknad, språkkunskap), en variabel hädanefter kallad etableringsgrad). Somalian, Syrian and Irakian countries of birth were incuded in the lowest category. Sweden, EU-countries, Scandinavia and north America were of the highest category.
Occupation	No
Gender/sex	No
Religion	No
Education	No
Socio-economic status	Yes
Social capital	
Other	

Bartelink V, Tynelius P, Walander A, Burström B, Ponce de Leon A, Nederby Öhd J, Hergens MP, Lager A. Socioekonomiska faktorer och covid-19 i Stockholms län. November 2020. Stockholm: Centrum för epidemiologi och samhällsmedicin, Region Stockholm; 2020. Rapport 2020:10.	
Study design	Register
Source of information	Statistics Sweden (SCB)
Time period of data collection	Up to 30th of June 2020
Key description of population studied	Residents registered in the total of 170 areas of Stockholm during 2019 and up to 1st of March 2020.

Outcomes reported:

Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	no
COVID-19 related admission to intensive care unit	Yes
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Multivariate cox regression. The results are presented as Hazard ratios (HR). Analyses were adjusted for age, gender, size of area of Stockholm, number of people living in the household, occupation, and country of birth.
Population	
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	All countries with more than ten COVID-19 related deaths are specified in the results. All other countries are presented as "other".
Occupation	Yes
Gender/sex	Yes

Religion	No
Education	Yes
Socio-economic status	Yes
Social capital	Yes
Other	Size of region in Stockholm

Lager A, Tynelius P, Walander A, Nederby Öhd J, Ponce de Leon A, Zhou M, Burström B, Yacamán Méndez D, Fischer M, Hergens MP, Bartelink V. Covid-19 i Stockholms län till och med mitten av juni 2020. Förloppet och den geodemografiska spridningen. Stockholm: Centrum för epidemiologi och samhällsmedicin, Region Stockholm; 2020. Rapport 2020:6.	
Study design	Register
Source of information	Statistics Sweden (SCB)
Time period of data collection	Up to June 12th 2020
Key description of population studied	Residents registered in Stockholm 2018

Outcomes reported:

Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Not mentioned. Presents number of deaths per 10.000 inhabitants. Results on country of birth are presented as OR with Sweden as reference country.
Population	
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	All countries with more than ten COVID-19 related deaths are specified in the results. All other countries are presented as "other".
Occupation	No
Gender/sex	No
Religion	No
Education	No
Socio-economic status	Yes
Social capital	No
Other	Age and region of Stockholm

Lundkvist A, Hanson S, Olsen B. Pronounced difference in Covid-19 antibody prevalence indicates cluster transmission in Stockholm, Sweden. Infection Ecology and Epidemiology. 2020;10.	
Study design	Case control study
Source of information	This study
Time period of data collection	17th and 18th of June 2020
Key description of population studied	213 randomly selected residents of two areas in Stockholm with different socio-economic conditions, one area with a mainly middle- to high-income population, and one lower income highly segregated suburban area

Outcomes reported:

Prevalence of COVID-19 infection	Yes
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No

COVID-19 related use of ventilator	No
COVID-19 related mortality	No

Method of analysis, including which factors the analysis were adjusted for	Country of origin described as % of participants with Sweden as country of origin.
Population	113 persons residing in Stockholm at the data collection days
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Two regions of Stockholm. Ethnicity other than Sweden as country of origin not specified.
Race, ethnicity, culture and language, note country of birth if recorded	Yes
Occupation	No
Gender/sex	Yes
Religion	No
Education	No
Socio-economic status	No
Social capital	No
Other	

Calderón-Larrañaga A, Dekhtyar S, Vetrano DL, Bellander T, Fratiglioni L. COVID-19: risk accumulation among biologically and socially vulnerable older populations. Ageing Research Reviews. 2020:101149.	
Study design	Register
Source of information	Statistics Sweden (SCB)
Time period of data collection	1st to 10th April 2020
Key description of population studied	Population in 26 municipalities in Stockholm

Outcomes reported:

Prevalence of COVID-19 infection	No
COVID-19 related admission to hospital	No
COVID-19 related admission to intensive care unit	No
COVID-19 related use of ventilator	No
COVID-19 related mortality	Yes

Method of analysis, including which factors the analysis were adjusted for	Excess mortality calculated comparing the mortality rate between 1-10 April 2020 with the average mortality rate recorded for the corresponding 10-day period during the two previous years.
Population	All inhabitants
Population information according to the PROGRESS equity lens (O'Neil et al 2014):	
Place of residence, including country, setting and if reported also the infection rate at the time of the study	Sweden
Race, ethnicity, culture and language, note country of birth if recorded	% of Swedish born. No other information.
Occupation	No
Gender/sex	No
Religion	No
Education	Yes
Socio-economic status	Yes
Social capital	
Other	

Appendix 5. Studies from countries with welfare systems similar to the Nordic model

The table include information on time frame, outcomes and main conclusions. First presented are studies from Germany and Ireland. The UK studies are separated so that those under the heading of the UK comprise results from two or more of the UK countries, then for England, Northern Ireland, Scotland and Wales.

Reference	Place & population Variables	Time period	Outcome	Main conclusion by authors
Germany				
Plumper T, Neumayer E. The Pandemic Predominantly Hits Poor Neighbourhoods? SARS-CoV-2 Infections and Covid-19 Fatalities in German Districts. European Journal of Public Health. 2020;20:20.	Germany (the whole population) divided into income groups and areas	Up to April 13th and April14th to May 19th 2020.	Prevalence Fatality	First wave had positive correlation with income. Second wave predominantly hit poorer neighbourhoods
Scarpone C, Brinkmann ST, Grose T, Sonnenwald D, Fuchs M, Walker BB. A multimethod approach for county-scale geospatial analysis of emerging infectious diseases: a cross-sectional case study of COVID-19 incidence in Germany. International Journal of Health Geographics 2020;19:32.	Germany, the 401 counties by socio economic and build density variables	Up to April 1st 2020	COVID-19 incidence	"Modelling indicated that geographical configuration, built environment densities, socioeconomic characteristics, and infrastructure all exhibit associations with COVID-19 incidence"
Ireland				
Farrell RJ, O'Regan R, O'Neill E, Bowens G, Maclellan A, Gileece A, et al. Sociodemographic variables as predictors of adverse	257 patients hospitalised with COVID-19. Dublin.	From March 13th to May 1st	Severe outcomes and death	"Being overweight/obese, a care home resident, socioeconomically deprived and older were significantly associated

outcome in SARS-CoV-2 infection: an Irish hospital experience. Irish Journal of Medical Science. 2020.	Minority ethnicity and socio economic markers			with death, while ethnicity and being overweight/obese were significantly associated with ICU admission."
The UK				
Richards-Belle A, Orzechowska I, Gould DW, Thomas K, Doidge JC, Mouncey PR, et al. COVID-19 in critical care: epidemiology of the first epidemic wave across England, Wales and Northern Ireland. Intensive Care Medicine. 2020;9:09.	10 834 patients with COVID-19 in hospitals in England, Wales and Northern Ireland. Variables were age, sex, ethnicity, indexes of multiple deprivation and BMI	1st February to 31st August 2020	Admission to ICU, use of ventilator, mortality	"Critical care patients with COVID-19 were disproportionally non-white, from more deprived areas and more likely to be male and obese."
Swann OV, Holden KA, Turtle L, Pollock L, Fairfield CJ, Drake TM, et al. Clinical characteristics of children and young people admitted to hospital with covid-19 in United Kingdom: Prospective multicentre observational cohort study. The BMJ. 2020;370.	651 children enrolled in 138 hospitals across England, Wales and Scotland. Variables were age, ethnicity and comorbidity	17th January to 17th July 2020	Admission to ICU, in-hospital mortality	"Ethnicity seems to be a factor in both critical care admission and MIS-C."
Raisi-Estabragh Z, McCracken C, Ardissino M, Bethell MS, Cooper J, Cooper C, et al. Renin-Angiotensin-Aldosterone System Blockers Are Not Associated With Coronavirus Disease 2019 (COVID-19) Hospitalization: Study of 1,439 UK Biobank Cases. Frontiers in Cardiovascular Medicine. 2020;7:138.	7099 participants in UK Biobank who tested for COVID-19. Variables were age, gender, ethnicity, BMI and clinical measures	16th March to 14th June 2020	COVID-19 infection	"Among participants tested for COVID-19 with presumed moderate to severe symptoms in a hospital setting, BAME ethnicity, male sex, and higher BMI are associated with a positive result."
Raisi-Estabragh Z, McCracken C, Bethell MS, Cooper J, Cooper C, Caulfield MJ, et al. Greater risk of severe COVID-19 in Black, Asian and Minority Ethnic populations is not explained by cardiometabolic, socioeconomic or behavioural factors, or by 25(OH)-vitamin D status: study of 1326 cases from the UK Biobank. Journal of Public Health. 2020;19:19.	4510 participants in UK Biobank who tested for COVID-19. Sorted by age, gender, ethnicity, BMI, Townsend deprivation score and household overcrowding	16th March to 18th May 2020	COVID-19 infection	"Male sex, BAME ethnicity, higher BMI, higher Townsend deprivation score and household overcrowding were independently associated with significantly greater odds of COVID-19."
Jackson SE, Brown J, Shahab L, Steptoe A, Fancourt D. COVID-19, smoking and inequalities: a study of 53	UK survey of 53 002 participants. Sorted by smoking	21st March to 20th April 2020	COVID-19 infection	"There were socio-economic disparities, with the association only apparent among those

002 adults in the UK. Tobacco Control. 2020;21:21.	status, socio-demographic variables and health conditions			without post-16 qualifications."
Knight M, Bunch K, Vousden N, Morris E, Simpson N, Gale C, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study. BMJ. 2020;369:m2107.	427 pregnant women in the UK. Sorted by ethnicity, BMI, regions.	1st March to 14th April 2020	COVID-19 infection, admission to hospital and transmission to infant, and death	"More than half of pregnant women admitted to hospital with SARS-CoV-2 infection in pregnancy were from black or other ethnic minority groups."
Trivedy C, Mills I, Dhanoya O. The impact of the risk of COVID-19 on Black, Asian and Minority Ethnic (BAME) members of the UK dental profession. British Dental Journal. 2020;228:919-22.	243 health and social care workers in the UK. No adjustments mentioned	25th March to 2nd June 2020	Mortality	"The date confirms that, even in the health sector, BAME HCWs appear to be at a higher risk of a COVID-19 related death."
Ferrando-Vivas P, Doidge J, Thomas K, Gould Doug W, Mouncey P, Shankar-Hari M, et al. Prognostic Factors for 30-Day Mortality in Critically Ill Patients With Coronavirus Disease 2019: An Observational Cohort Study. Critical Care Medicine. 2020.	England, Wales and Northern Ireland. 9990 intensive care patients from the 258 adult critical care units participating. Sorted by age, gender, ethnicity, deprivation quintile, medical and physiological measures.	1st March to 22nd June 2020	30-day mortality	Results show factors that predict 30-day mortality include prior dependency and Asian ethnicity, as well as the medical and physiological measures.
Wise J. Covid-19: Low skilled men have highest death rate of working age adults. BMJ. 2020;369.	2494 COVID-19-related deaths among 20 to 64 year olds in England and Wales. Adjustments not mentioned	Up to 20th April 2020	Mortality	"Men working in the lowest skilled jobs had the highest rate of death involving covid-19 among working age people"
Platt L, Warwick R. COVID-19 and Ethnic Inequalities in England and Wales*. Fiscal Studies. 2020;41(2):259-89.	England and Wales. Sorted by age, gender, ethnic group, underlying health condition, occupation, employment status, household structure, social care groups	Up to 15th May 2020	Mortality	"After accounting for differences in population structure and regional concentration, we show that most minority groups suffered excess mortality compared with the white British majority group."
Iacobucci G. Covid-19: Deprived areas have the highest death rates in England and Wales. BMJ. 2020;369.	England and Wales. Sorted by level of deprivation	1st March to 17th April 2020	Death	Deprived areas have the highest death rates

England				
Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, et al. OpenSAFELY: factors associated with COVID-19 death in 17 million patients. Nature. 2020;8:08.	17 278 392adults in NHS England. Variables age, sex, ethnicity, comorbidity, level of deprivation	Up to 6th May 2020	Mortality	"The underlying causes of the higher risk of COVID-19-related death among BAME individuals, and among people from deprived areas, require further investigation."
Tammes P. Social distancing, population density, and spread of COVID-19 in England: a longitudinal study. Bjgp Open. 2020;7:07	Incidence rates per 100 000 in England. Variables age, density of population, ethnicity, occupational class, health	16th March to 19th April 2020	Incidence of COVID-19	"After the introduction of social distancing measures, the incidence rate per 100 000 people dropped stronger in most densly populated ULTAs."
Joy M, Hobbs FR, Bernal JL, Sherlock J, Amirthalingam G, McGagh D, et al. Excess mortality in the first COVID pandemic peak: cross-sectional analyses of the impact of age, sex, ethnicity, household size, and long-term conditions in people of known SARS-Cov-2 status in England. British Journal of General Practice. 2020;19:19.	4.4 mill people in England. People were grouped into household variables, socio-economy, ethnicity, disabilities	6th January to 18th May 2020	Mortality	"Male sex, population density, black ethnicity (compared to white), and people with long term conditions, including learning disability (…) had higher odds of mortality.
McQueenie R, Foster HME, Jani BD, Katikireddi SV, Sattar N, Pell JP, et al. Multimorbidity, polypharmacy, and COVID-19 infection within the UK Biobank cohort. PLoS ONE [Electronic Resource]. 2020;15:e0238091.	428 199 participants from 16 assessment centres in England registered in the UK Biobank. Sorted by demographic, lifestyle and health conditions	16th March to 18th May 2020	COVID-19 infection	"Importantly, those from non-white ethnicities with multimorbidity had nearly three times the risk of having COVID-19 infection compared to those of white ethnicity, suggesting that those from minority ethnic groups with multimorbidity are at particular risk."
Patel AP, Paranjpe MD, Kathiresan NP, Rivas MA, Khera AV. Race, socioeconomic deprivation, and hospitalization for COVID-19 in English participants of a national biobank. International Journal for Equity in Health. 2020;19:114.	418 794 English patients from the UK Biobank. Variables were age, gender, ethnicity, Townsend deprivation index, household income, geographic region and clinical measures	Unclear timing	COVID-19 hospitalisation	"Both Black participants (…) and Asian participants (…) were at substantially increased risk as compared to White participants. We further observed a striking gradient in COVID-19 hospitalization rates according to the Townsend Deprivation Index-a composite measure of socioeconomic deprivation-and household income."
Lassale C, Gaye B, Hamer M, Gale CR, David B. Ethnic Disparities in Hospitalisation for COVID-19 in England: The Role of	340 966 patients from the UK Biobank and tested in England. Variables were	16th March to 26th April 2020	COVID-19 hospitalisation	"There were clear ethnic differences in the risk of COVID-19 hospitalisation and these do not appear to

Socioeconomic Factors, Mental Health, and Inflammatory and Pro-inflammatory Factors in a Community-based Cohort Study. Brain, Behavior, & Immunity. 2020;1:01.	ethnicity, socio-economic factors, lifestyle measures and comorbidities			be fully explained by measured factors."
Kolin DA, Kulm S, Elemento O. Clinical and Genetic Characteristics of Covid-19 Patients from UK Biobank. MedRxiv : the Preprint Server for Health Sciences. 2020;5:05.	1474 patients from the UK Biobank who were tested in England. Variables were age, gender, BMI, race, Townsend deprivation index and blood pressure.	Unclear timing	COVID-19 infection	"In this study, we found that black and Asian participants were at increased risk of Covid-19, even after adjusting for confounders."
Holman N, Knighton P, Kar P, O'Keefe J, Curley M, Weaver A, et al. Risk factors for COVID-19-related mortality in people with type 1 and type 2 diabetes in England: a population-based cohort study. The Lancet Diabetes & Endocrinology. 2020;13:13.	People in England with diabetes type 1 (n=264 390) and diabetes type 2 (n=2 874 020). Sorted by gender, age, deprivation quartile, region ethnicity, and medical variables	16th February to 11th May 2020	Mortality	"Male sex, older age, renal impairment, non-white ethnicity, socioeconomic deprivation, and pervious stroke and heart failure were associated with increased COVID-19-related mortality in both type 1 and type 2 diabetes."
de Lusignan S, Dorward J, Correa A, Jones N, Akinyemi O, Amirthalingam G, et al. Risk factors for SARS-CoV-2 among patients in the Oxford Royal College of General Practitioners Research and Surveillance Centre primary care network: a cross-sectional study. The Lancet Infectious Diseases. 2020;15:15.	3802 people registered in RCGP RSC. Sorted by gender, age, ethnicity, household size, socio economic status and medical variables	28th January to 4th April 2020	COVID-19 infection	"We provide evidence of potential sociodemographic factors associated with a positive test, including deprivation, population density, ethnicity, and chronic kidney disease."
Razieh C, Zaccardi F, Davies MJ, Khunti K, Yates T. Body mass index and risk of COVID-19 across ethnic groups: analysis of UK Biobank study. Diabetes, Obesity & Metabolism. 2020;29:29.	5623 people registered in the UK Biobank and laboratory test data in Public Health England. Variables were ethnicity and BMI	16th March to 14th June 2020	COVID-19 infection	"BMI was associated with the risk of a positive test for COVID-19 in both BME and WE individuals. However, the dose response association differed by ethnic group (P for interaction = .05) (Figure 1): in WE individuals, there was no additional higher risk of COVID-19 beyond a BMI of 25 kg/m^2, whereas in BME individuals the risk was greater for higher BMI values." BME- Black and Minority Ethnic groups WE- White Europeans
Kakkar DN, Dunphy DJ, Raza DM. Ethnicity profiles of COVID-19 admissions	3018 adult patients at Sheffield teaching	21st March to 25th April 2020	COVID-19 infection, admission to	"BAME patients were significantly more likely to test positive than the White

and outcomes. Journal of Infection. 2020;27:27.	hospitals. Grouped by ethnicity		hospital and mortality	cohort". "There was no significant difference between BAME and White groups in terms of overall admissions". "Whilst the odds of death were decreased in Black and Sub-continent groups compared to the White population, this difference was not significant"
Chadeau-Hyam M, Bodinier B, Elliott J, Whitaker MD, Tzoulaki I, Vermeulen R, et al. Risk factors for positive and negative COVID-19 tests: a cautious and in-depth analysis of UK biobank data. International Journal of Epidemiology. 2020;20:20.	UK Biobank linked to 4509 English individuals tested. Sorted by variables of demographic (including ethnicity), social, health risk, medical factors and environmental exposures	16th March to 18th May 2020	Testing for COVID-19, and testing positive for COVID-19	"We found that male sex, non-White ethnicity, and lower educational attainment were independently associated with testing positive among tested individuals."
Niedzwiedz CL, O'Donnell CA, Jani BD, Demou E, Ho FK, Celis-Morales C, et al. Ethnic and socioeconomic differences in SARS-CoV-2 infection: prospective cohort study using UK Biobank. BMC Medicine. 2020;18:160.	UK Biobank linked to 2658 English persons tested. Sorted by age, gender, socioeconomic conditions, baseline self-reported health and behavioural risk factors	16th March to 3rd May 2020	COVID-19 infection	"Some minority ethnic groups have a higher risk of confirmed SARS-CoV-2 infection in the UK Biobankstudy, which was not accounted for by differences in socioeconomic conditions, baseline self-reported health or behavioural risk factors."
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;185:261-3.	310 of the 317 English local authorities. Analysis by the variables ethnicity, overweight and obesity, population density, deprivation and pollution	1st March to 17th April 2020	COVID-19 mortality	"Despite our initial hypothesis, our findings suggest that individual factors, such as ethnicity, and structural factors, such as population density, are stronger predictors of COVID-19 mortality than deprivation."
Batty GD, Deary IJ, Luciano M, Altschul DM, Kivimaki M, Gale CR. Psychosocial factors and hospitalisations for COVID-19: Prospective cohort study based on a community sample. Brain, Behavior, & Immunity. 2020;16:16.	UK biobank with around half a million people between 40 to 69 years old. Sorted by disadvantage level	16th March to 26th April 2020	Hospitalisation for COVID-19	Elevated risk of COVID-19 was related to disadvantaged levels of education, income, area deprivation, occupation, psychological distress, mental health, neuroticsm, and performance on two tests of cognitive function (age-and sex adjusted analysis).
Aldridge RW, Lewer D, Srinivasa Vittal K, Mathur R, Pathak N, Burns R, et al. Black, Asian and Minority	England. NHS data on 16 272 people who died in	1st March to 21st April 2020	In-hospital death	".. BAME people are at increased risk of death from COVID-19 even after

Ethnic groups in England are at increased risk of death from COVID-19: indirect standardisation of NHS mortality data [version 1; peer review: awaiting peer review]. Wellcome Open Research. 2020.	hospital, sorted by ethnicity, BAME			adjusting for geographical region.."
Zheng C, Hafezi-Bakhtiari N, Cooper V, Davidson H, Habibi M, Riley P, et al. Characteristics and transmission dynamics of COVID-19 in healthcare workers at a London teaching hospital. Journal of Hospital Infection. 2020;27:27.	1045 hospital staff in a University teaching hospital in London were tested. Comparison with staff professional groups, department and ethnicity	March to April 2020	COVID-19 infection	"White and non-white ethnic groups among our HCWs had similar rates of infection."
Zakeri R, Bendayan R, Ashworth M, Bean DM, Dodhia H, Durbaba S, et al. A case-control and cohort study to determine the relationship between ethnic background and severe COVID-19. EClinicalMedicine. 2020:100574.	872 in-hospital patients inner city London compared with 3488 matched primary care patients in the same area. Variables were ethnicity, sociodemographic and clinical variables	1st March to 2nd June 2020	Hospital admission, severity and mortality	"Black and mixed ethnicity are independently associated with greater admission risk with COVID-19 and may be risk factors for development of severe disease, but do not affect in-hospital mortality risk. Comorbidities and socioeconomic factors only partly account for this and additional ethnicity-related factors may play a large role. The impact of COVID-19 may be different in Asians."
Patel A, Abdulaal A, Ariyanayagam D, Killington K, Denny Sarah J, Mughal N, et al. Investigating the association between ethnicity and health outcomes in SARS-CoV-2 in a London secondary care population. Plos One. 2020;15(10).	645 patients in 2 London hospitals and 173 community managed patients. Variables age, gender, ethnic group and comorbidities	1st March to 30th April 2020	Rate of admission to ICU and mortality	"BAME patients were more likely to be admitted younger, and to die at a younger age with SARS-CoV-2. Within the BAME cohort, Asian patients were more likely to die, but despite this, there was no difference in the rates of admission to ICU."
Perez-Guzman PN, Daunt A, Mukherjee S, Crook P, Forlano R, Kont MD, et al. Clinical characteristics and predictors of outcomes of hospitalized patients with COVID-19 in a multi-ethnic London NHS Trust: a retrospective cohort study. Clinical Infectious Diseases. 2020;7:07.	614 patients in 3 London hospitals. Variables age, gender, ethnicity and if they were health care worker and clinical observations	25th February to 5th April 2020	Mortality	"BAME patients were overrepresented in our cohort; when accounting for demographic and clinical profile of admission, black patients were at increased odds of death."
Perkin MR, Heap S, Crerar-Gilbert A, Albuquerque W, Haywood S, Avila Z, et al. Deaths in people from Black, Asian and minority	243 deaths in one London hospital. Variables were age, gender, ethnicity,	Up to 12th March 2020	Mortality	"Deaths in the BAME communities were overrepresented in both COVID-19 and non-COVID-19 groups,"

ethnic communities from both COVID-19 and non-COVID causes in the first weeks of the pandemic in London: a hospital case note review. BMJ Open. 2020;10:e040638.	comorbidities and deprivation.			
Moody WE, Mahmoud-Elsayed HM, Senior J, Gul U, Khan-Kheil AM, Horne S, et al. Impact of Right Ventricular Dysfunction on Mortality in Patients Hospitalized with COVID-19 according to Race. CJC Open. 2020;20:20.	164 people admitted to 3 hospitals in the Birmingham area. Variables ethnicity, baseline demographics, clinical risk factors, biomarkers and echocardiogram results	16th March to 9th May 2020	Mortality	"There is, however, no racial variation in the early findings on echocardiography, biomarkers, or mortality.
Hull SA, Williams C, Ashworth M, Carvalho C, Boomla K. Prevalence of suspected COVID-19 infection in patients from ethnic minority populations: a cross-sectional study in primary care. British Journal of General Practice. 2020;7:07.	Approximately 1.2 mill adults in east London, 55% ethnic minorities and top decile of social deprivation in England. Sorted by age, gender, ethnicity, measures of social deprivation and clinical variables	10th February to 30th April 2020	COVID-19 infection	"Univariate analysis showed a two-fold increase in the odds of suspected COVID-19 for South Asian and black adults compared with white adults."
Sattar N, Ho FK, Gill JM, Ghouri N, Gray SR, Celis-Morales CA, et al. BMI and future risk for COVID-19 infection and death across sex, age and ethnicity: Preliminary findings from UK biobank. Diabetes & Metabolic Syndrome. 2020;14:1149-51.	839 patients with positive COVID-19 tests of the 4855 tested. Variables were age, sex, ethnicity and BMI	16th March to 31st May 2020	Mortality	"These data add support for adiposity being more strongly linked to COVID-19-realted deaths in younger people and non-white ethnicities."
Martin CA, Jenkins DR, Minhas JS, Gray LJ, Tang J, Williams C, et al. Socio-demographic heterogeneity in the prevalence of COVID-19 during lockdown is associated with ethnicity and household size: Results from an observational cohort study. EClinicalMedicine. 2020.	4051 patients in the University hospital of Leicester. Sorted by age, gender, ethnicity, deprivation level, household size, clinical variables and comorbidities	1st March to 28th April 2020	COVID-19 infection	"In individuals presenting with suspected COVID-19, those from ethnic minority communities and larger households had an increased likelihood of SARS-CoV-2 PCR positivity."
Razvi S, Oliver R, Moore J, Beeby A. Exposure of hospital healthcare workers to the novel coronavirus (SARS-CoV-2). Clinical Medicine. 2020;22:22.	2521 NHS staff at Gateshead had their COVID-19 antibody status tested. Sorted by age, gender, ethnicity, working	Up to 8th June 2020	COVID-19 antibody status	"Reassuringly, workers from BAME backgrounds had a similar risk of COVID-19 exposure to their white colleagues."

	with patient-facing roles			
Sapey E, Gallier S, Mainey C, Nightingale P, McNulty D, Crothers H, et al. Ethnicity and risk of death in patients hospitalised for COVID-19 infection in the UK: an observational cohort study in an urban catchment area. BMJ open respiratory research. 2020;7.	2217 patients admitted to University Hospitals Birmingham. Variables were age, sex, deprivation, ethnicity and comorbidities	10th March to 17th April 2020	Mortality	"Those of South Asian ethnicity appear at risk of worse COVID-19 outcomes."
Leeds JS, Raviprakash V, Jacques T, Scanlon N, Cundall J, Leeds CM. Risk factors for detection of SARS-CoV-2 in healthcare workers during April 2020 in a UK hospital testing programme. EClinicalMedicine. 2020:100513.	991 health care workers in County Durham and Darlington. Variables age, gender, ethnicity and occupation	From 1st April and for 4 weeks	COVID-19 infection	"No specific variables were identified that altered the risk of SATS-CoV-2RNA detection including age, sex, occupation and ethnicity."
Santorelli G, Sheldon T, West J, Cartwright C, Wright J. COVID-19 in-patient hospital mortality by ethnicity [version 1; peer review: awaiting peer review]. Wellcome Open Research. 2020.	1276 inpatients in Bradford. Variables age, sex, ethnicity	18th March to 27th April 2020	Mortality	"They also suggest that this increased risk is not greater in people of South Asian (mainly Pakistani) ethnicity.
Galloway JB, Norton S, Barker RD, Brookes A, Carey I, Clarke BD, et al. A clinical risk score to identify patients with COVID-19 at high risk of critical care admission or death: an observational cohort study. Journal of Infection. 2020;29:29.	1157 patients admitted to two London hospitals. Sorted by ethnicity, postal code (index of multiple deprivation), socio economic position as well as medical variables.	1st March to 17th April 2020	Admission to ICU, death	"Non-white ethnicity predicted critical care admission but not death. Social deprivation was not predictive of outcome."
Shields A, Faustini SE, Perez-Toledo M, Jossi S, Aldera E, Allen JD, et al. SARS-CoV-2 seroprevalence and asymptomatic viral carriage in healthcare workers: a cross-sectional study. Thorax. 2020;11:11.	545 health care workers in Birmingham. Variable age, sex, ethnicity and ward	Invitation to test 24 to 25 April 2020	SARS-CoV-2 antibodies	"This study identifies differences in the risk of exposure of healthcare workers to SARS-CoV-2 between ethnic groups and between hospital departments; these findings may inform future infection control and occupational health policy."
Brill SE, Jarvis HC, Ozcan E, Burns TLP, Warraich RA, Amani LJ, et al. COVID-19: a retrospective cohort study with focus on the over-80s and hospital-onset disease. BMC Medicine. 2020;18:194.	The first 450 COVID-19 patients admitted to Barnet hospital in London. Sorted by age and ethnic white or BAME	10th March to 8th April 2020	Death	"The ethnic composition of our caseload was similar to the underlying population."

Bannaga AS, Tabuso M, Farrugia A, Chandrapalan S, Somal K, Lim VK, et al. C-reactive protein and albumin association with mortality of hospitalised SARS-CoV-2 patients: A tertiary hospital experience. Clinical Medicine. 2020;20:463-7.	321 hospitalised patients in Coventry and Warwickshire NHS trust. Sorted by age, gender, ethnicity and admission laboratory findings	24th January to 13th April 2020	ICU admission and in-hospital death	"COVID-19 has high mortality. BAME and male patients were associated with ICU admission."
Sng CCT, Wu A, Wong YNS, Soosaipillai GB, Ottaviani D, Lee AJX, et al. Do cancer patients really do worse? A study in a UK tertiary hospital within a COVID-19 epicentre. Annals of Oncology. 2020;31:S1015.	94 patients with cancer and 226 patients without cancer, all with confirmed COVID-19 in London. Variables age, ethnicity and comorbidity	1st March to 31st May 2020	Mortality	South Asian ethnicity was an independent predictor of mortality
Russell B, Moss C, Papa S, Irshad S, Ross P, Spicer J, et al. Factors Affecting COVID-19 Outcomes in Cancer Patients: A First Report From Guy's Cancer Center in London. Frontiers in Oncology. 2020;10.	156 cancer patients with confirmed COVID-19, of the 1507 patients who tested, at Guy's cancer centre, London. Variables were socioeconomic status, ethnicity, age, sex and clinical status	29th February to 12th May 2020	Mortality	"Asian ethnicity and palliative treatment were also associated with COVID-19 death in cancer patients."
Northern Ireland				
None identified				
Scotland				
Khan KS, Torpiano G, McLellan M, Mahmud S. The impact of socioeconomic status on 30-day mortality in hospitalised patients with COVID-19 infection. Journal of Medical Virology. 2020;30:30.	172 patients in 3 acute hospitals in Scotland. Sorted by high and low socioeconomic status	From 9th April 2020 for at least 30 days	Need for intubation or death	".., our study suggests that the SES does not have any impact on outcome of hospitalized patients with COVID-19, however it negatively impacts length of stay."
Bell S, Campbell J, McDonald J, O'Neill M, Watters C, Buck K, et al. COVID-19 in patients undergoing chronic kidney replacement therapy and kidney transplant recipients in Scotland: findings and experience from the Scottish renal registry. BMC Nephrology. 2020;21:419.	110 COVID-19 positive tested patients of the 876 who tested in the Scottish renal registry, sorted by postcode for deprived area	1st March to 31st May 2020	COVID-19 infection and mortality	"Patients who tested positive were older and more likely to reside in more deprived postcodes. Mortality was high…"

Wales				
None identified				

Published by the Norwegian Institute of Public Health
April 2021
P.O.B 4404 Nydalen
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