Health Inequalities and Infectious Diseases: A Rapid Review of Reviews

Abimbola Ayorinde[1], Iman Ghosh[1], Benjamin Barr[2], Noel McCarthy[3], Oyinlola Oyebode[1]

[1]Warwick Medical School, University of Warwick

[2]Institute of Population Health, University of Liverpool

[3]School of Medicine, Trinity College Dublin

Supported by: Ifra Ali, Iram Zahair, Olajumoke Olarewaju, Suzanne Rotheram, Seun Anjorin, Megha Singh, Edward Meehan, Samantha Johnson and Yen-Fu Chen

Funding

This project was funded by Public Health England

Acknowledgements

We would like to acknowledge Ines Campos-Matos, Rebecca Wilkinson and Katy Sinka from Public Health England for their input. Iman Ghosh is funded by Warwick Evidence, University of Warwick. Abimbola Ayorinde is funded by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. The views expressed are those of the author(s) and not necessarily those of the NIHR, the Department of Health and Social Care or Public Health England.

Executive summary

Public Health England (PHE) commissioned a team, led from University of Warwick, to conduct a review to describe the existing health inequalities presented in the academic literature, relating to key infectious disease topics in the United Kingdom (UK). For this work, PHE had specific interest in three dimensions of inequalities: protected characteristics, socioeconomic inequalities, and inclusion health groups (specifically, vulnerable migrants, people experiencing homelessness and rough sleeping, people who engage in sex work, and Gypsy Roma and Traveller communities). The infectious disease topics of interest were tuberculosis, human immunodeficiency virus (HIV), sexually transmitted infections (STIs), Hepatitis C (HCV), vaccination, and antimicrobial resistance (AMR).

We conducted a rapid overview of reviews to identify and synthesise existing reviews which have explored inequalities in the topics of interest, relevant to the UK.

Key findings

We identified 84 reviews that explored inequalities in at least one of the three dimensions of interest. The reviews spanned through all the specified infectious diseases and more (Figure E1). The methodological quality of the included reviews varied significantly based on the Assessment of Multiple Systematic Reviews version 2 (AMSTAR2) criteria. Only 14% explicitly reported pre-registered protocol, 22% had a comprehensive literature search strategy, 29% performed risk of bias of included studies, 46% accounted for risk of bias while interpreting the results of the review and 69% provided satisfactory explanation for and discussion of heterogeneity observed in the findings of the review. Only about 49% of the reviews performed meta-analysis. However, 98% of those that performed meta-analyses used appropriate methods, 54% assessed the impact of risk of bias on the results of meta-analysis and 46% performed adequate assessment of the presence and likely impact of publication bias.

Dimension of inequalities	Variables	Tuberculosis	HIV	STI	Hepatitis C	Vaccination	AMR/multi-drug resistance	Others
Protected characteristics	Age	2	2	2	2	10	2	12
	Sex	2	5	2	3	3	2	9
	Marriage and civil partnership	0	0	0	0	4	0	0
	Pregnancy and maternity	0	0	0	2	0	0	1
	Race (or ethnicity)	3	2	1	0	10	1	0
	Religion or belief	0	0	0	0	5	0	1
	Sexual orientation	0	4	0	2	0	1	2
	Gender reassignment	0	1	0	0	0	0	0
	Disability	0	0	0	0	0	0	1
Inclusion Health Groups	Vulnerable migrants	0	1	1	2	2	1	3
	General migrants	4	5	3	5	5	1	6
	People experiencing homelessness and rough sleeping	3	1	0	1	0	1	2
	People who engage in sex work	0	3	1	0	1	0	1
	Gypsy Roma/ Traveller communities/Indigenous people	2	0	0	0	1	0	0
Socioeconomic inequalities	Level of education/income	1	3	1	0	15	2	7
	Employment/occupation	1	2	2	1	8	0	5
	Social class/Area level socioeconomic status	0	1	0	0	9	0	1
	Deprivation	1	0	1	0	4	0	2
	Residence/living situation (e.g living in a home environment with moisture damage, house tenure)	2	0	0	0	5	1	7

Figure E1: Matrix showing the number of reviews identified for each dimension of inequality and infectious disease topic. Colour ranges from red which indicates where no review was identified, up to green for a maximum number of reviews (15).

Inclusion Health Groups

Although the magnitude of the association varies for different geographical regions and different infectious diseases, migrants generally have higher risk of infectious diseases than the host population, especially for the diseases that are prevalent in their country of origin. Evidence also suggests that the higher prevalence of infectious diseases among migrants is not limited to pre-migration infection. Evidence shows an increasing number of migrants contracting HIV after arriving in the UK between 2002 and 2011. In addition to infectious disease prevalence, vaccination rates are also lower among migrants when compared to non-migrants. Furthermore, the two reviews on AMR suggest higher prevalence of AMR among migrants. The evidence shows that not only are migrants generally at higher risk of infectious diseases, lower vaccine uptake and higher risk of AMR carriage compared to non-migrants, vulnerable migrants (such as refugees and trafficked persons) are at greater risk compared to general migrants.

We identified only three reviews regarding inequalities in infectious diseases based on being from a Gypsy Roma, or Traveller community. These were on three different topics and only one of the reviews included at least one UK study. The available evidence suggests that Roma and Irish Travellers in the UK are often under vaccinated, and in other countries, people in this population have greater risk of infectious diseases (specifically, TB and HIV).

Although the number of reviews within the homeless population is limited, all six reviews identified reported much higher risk of various infectious diseases and AMR among people experiencing homelessness compared to those who are not. In one of the reviews, a series of meta-analyses were conducted including 13 factors which are potentially associated with recent TB transmission, homelessness was the third strongest association observed, following belonging to an ethnic minority group and drug use. Homelessness surpassed factors such as migration, age, sex and area of residence. This suggests that experiencing homelessness is an important risk factor for TB.

Overall, there is a paucity of evidence on the prevalence of infectious diseases among sex workers compared to the general population in the UK and high-income countries. We only identified five reviews which compared sex workers to other populations, and among those only one explicitly included at least one UK study. Overall, the available evidence suggests there are higher risks of sexually transmitted diseases such as HIV and STIs among sex workers. It is not clear if vaccine uptake is lower or if AMR is more prevalent among sex workers.

Generally, the available evidence suggests that migrants, Gypsy Roma and Travellers, people experiencing homelessness and sex workers are important groups to target for interventions to reduce the burden of infectious disease.

Protected Characteristics

Of the nine protected characteristics, the review only found clear synthesised evidence for inequalities by ethnicity and sexual orientation. Synthesised evidence on the association of infectious disease topics with other protected characteristics, such as age and sex are mixed, while for other protected characteristics (such as disability) the synthesised evidence is sparse and inconclusive.

The available evidence suggests a higher prevalence of TB, HIV, and STIs and a lower vaccine uptake among those from ethnic minority groups. There is no strong evidence to suggest higher risk

of AMR incidence among those from ethnic minority groups. The reviews on sexual orientation focussed on men who have sex with men (MSM). The evidence suggests higher prevalence of infectious diseases (specifically Hepatitis B (HBV), HCV, Hepatitis D (HDV) and HIV) and AMR among MSM compared to the general population. No review examined vaccination uptake by sexual orientation. We identified only one review on gender reassignment which showed that HIV is more prevalent among transgender women sex workers compared to biologically female sex workers.

Generally, the association of age with infectious disease risk varies between different diseases and is most likely to be patterned due to biology. Vaccination uptake also varies between age groups depending on the type of vaccination. Similarly, AMR may be associated with age, but there is no clear pattern. The evidence regarding association of sex with the risk of infectious diseases in high income countries, including the UK, also varied depending on the specific infectious disease. Overall, evidence in the reviews show that for some infectious diseases sex is not important, for others it is important with sexes differentially affected in a way that varies across diseases.

We did not identify any review which reported the association of disability with any of the infectious disease topics that we have focused on. However, we identified one review which reported that disability was associated with higher incidence of listeriosis. All four reviews which examined the association with being married focussed on vaccination and the available evidence suggests that those who were married were generally more likely to have higher vaccination uptake and children of married parents were also more likely to be vaccinated. We did not identify any reviews reporting on the association of marital status with prevalence of infection or AMR. We also found limited evidence relating to the association of infectious diseases with pregnancy. Two of the reviews suggest that pregnancy was associated with lower risk of HCV while one suggests higher risk of HBV among pregnant women compared with the general population. None of the included reviews reported on association of pregnancy with vaccination or AMR. Also, there is a paucity of synthesised evidence on the association between religion and vaccination. One of the reviews reported that there is high incomplete vaccination among children from certain religious groups, such as Orthodox Jewish. We did not identify any reviews exploring the association of religion with infectious disease risk or AMR, although one review suggested that attendance at religious events was associated with decreased risk of meningococcal disease. It is, therefore, not clear if marital status, pregnancy, or religion have significant association with infectious diseases, vaccination, or AMR.

Overall, there is evidence for inequalities by ethnicity and sexual orientation but for other protected characteristics, the evidence is inconclusive.

Socioeconomic inequalities

We identified several reviews highlighting the association of socioeconomic factors with infectious disease prevalence, AMR, and vaccination. Many reviews show that lower level of income, lower educational attainment and higher unemployment are associated with higher risk of infectious diseases, AMR and lower vaccination uptake. Higher area level deprivation, lower socioeconomic status, and poor living situations (such as overcrowding, living in a home with moisture damage) are also associated with higher risk of infectious diseases, AMR, and lower vaccine uptake. Overall, the evidence suggests that targeting those of lower socioeconomic status is important.

Conclusion

The available literature provides strong evidence that people in inclusion health groups and lower socio-economic status are consistently at higher risk of infectious diseases, AMR, and lower vaccination rates. There is also evidence that ethnicity and sexual orientation are important factors contributing to inequalities. Based on the findings of this work, developing targeted interventions for these groups would contribute to reducing infectious disease burden.

Contents

Abbreviations

AIDS	Acquired immunodeficiency syndrome
AMR	Antimicrobial resistance
AMSTAR2	Assessment of Multiple Systematic Reviews version 2
CHC	Chronic hepatitis C
CI	Confidence interval
HBV	Hepatitis B
HCV	Hepatitis C
HDV	Hepatitis D
HEV	Hepatitis E
HIV	Human Immunodeficiency Virus
HPV	Human papillomavirus infection
HTLV-1	Human T-cell lymphotropic virus type 1
MDR	Multi-drug resistance
MMR	Measles, mumps, and rubella
MRSA	Methicillin-resistant Staphylococcus Aureus
MSM	Men who have sex with men
NG	Neisseria gonorrhoea
OR	Odds Ratio
PHE	Public Health England
PICOS	Participants, Intervention, Comparator, Outcome and Study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
RR	Risk Ratio
SES	Socioeconomic status
STIs	Sexually transmitted infections
TB	Tuberculosis
TV	Trichomonas vaginalis
UK	United Kingdom
USA	United States of America

1. Introduction

Experiencing the highest possible standard of health is a fundamental and universal human right regardless of one's personal or social circumstances.[1] However, systematic and avoidable inequalities in health status, access to health care and the prevalence of diseases and illness between various social groups exist.[2] Increased vulnerability to poorer health among particular social groups is rooted in a complex interaction between structural (for example, income and wealth distribution) and individual-level (for example, health behaviours and living conditions) determinants of health.[3, 4]

Infectious diseases constitute 7% of deaths in the United Kingdom (UK) alongside 4% of lost life years, thus posing a substantial health burden.[5] Economically, the burden of infectious diseases in the UK is estimated at a significant £30 billion per year.[5] In the UK, significant disparities in the exposure, prevalence and consequences of infectious diseases such as tuberculosis (TB), hepatitis C (HCV), human immunodeficiency virus (HIV) and sexually transmitted diseases (STIs) have been documented.[6, 7] In particular, these inequalities have been observed across the dimensions of protected characteristics, socioeconomic status (a measure of one's social and economic position) and inclusion health groups (socially excluded and vulnerable populations).[8, 9] For example, the prevalence of TB in the most socioeconomically deprived groups is seven times higher than the least deprived.[9] Socially excluded groups, those experiencing homelessness and migrant populations are also at an increased risk of TB relative to the general population.[9] Similarly, a significantly higher prevalence of HCV has been noted among marginalised groups in the UK, including migrants and men who have sex with men (MSM).[10] Regarding ethnic inequalities, higher rates of STIs such as gonorrhoea have been noted among Black Caribbean individuals relative to other ethnic groups in the UK.[11]

Whilst infectious diseases impose substantial, negative health and economic consequences within populations, it is key to note, many infectious diseases are vaccine-preventable or avoidable via adequate control measures.[12] However, some groups remain under vaccinated[13] and other control measures may be difficult or impossible to implement for some, depending on living circumstances, for example, crowded homes with fewer washing and toilet facilities or inflexible employment.[14] In efforts to remedy the observed disparities and to reduce the wider burden of infectious diseases in the UK, a strategic approach that tackles the high burden of infectious diseases among high-risk groups is required.[15] To effectively devise public health policies tailored to needs and initiatives to achieve

this goal, a comprehensive synthesis of evidence that highlights inequalities in infectious diseases according to varying personal and social characteristics is required.

Public Health England (PHE) commissioned this project to gain a broad overview of the available evidence on the existing health inequalities relating to key infectious disease topics in the UK. These are TB, HIV, STIs, HCV, vaccination, and antimicrobial resistance (AMR). It does not cover COVID-19 which is covered in other reviews. The review covered three dimensions of inequalities; protected characteristics (such as age, sex, ethnicity, sexual orientation, and others), socioeconomic inequalities, and inclusion health groups (specifically, vulnerable migrants, people experiencing homelessness and rough sleeping, people who engage in sex work, and Gypsy Roma and Traveller communities). We therefore conducted an overview of reviews with specific focus on those that reported inequalities in the prevalence/incidence of these key infectious diseases, inequalities in vaccination as well as AMR as specified by PHE.

2. Methods

We conducted a rapid review of reviews. The review was pre-registered in PROSPERO, an international prospective register of systematic reviews (2020 CRD42020220203 https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020220203).

Search strategy and study selection

We searched four electronic databases; MEDLINE (inception to October 2020), EMBASE (inception to October 2020), Web of Science (inception to January 2021) and to identify relevant grey literature we searched Open Grey database (http://www.opengrey.eu/) in February 2021 and contacted experts. We developed a search strategy with the support of an information specialist and used a wide range of synonyms and MeSH terms for inequalities, inclusion health groups, protected characteristics, socioeconomic factors combined with synonyms and MeSH terms for infectious diseases and reviews. The search strategy for the databases is provided in Appendix 1.

Citations were exported into Endnote and duplicates removed. After this, citations were exported onto Rayyan to facilitate screening. Titles and abstracts were screened by a single reviewer and 10%

were double screened by a second reviewer. All full texts of selected articles were double screened independently by two reviewers. Discrepancies were resolved by discussion between the reviewers.

Eligibility Criteria

Inclusion criteria

Population: Any review relevant to the UK population

Exposure:

- Socioeconomic status at individual or aggregated level. This includes education, income, occupation, social class and deprivation
- Protected characteristics: age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex and sexual orientation
- Inclusion health groups: vulnerable migrants, people experiencing homelessness and rough sleeping, people who engage in sex work, and Gypsy Roma and Traveller communities.

Comparators/controls: Any

Outcome: inequalities relating to exposure, incidence and prevalence and consequences of infectious diseases. PHE have specific interest in TB, HIV, STIs, HCV, immunisation, and AMR. However, we included reviews relating to any infectious diseases at this point, except reviews focused on COVID-19.

Types of reviews: We included systematic reviews. Systematic reviews were defined as any literature review which reports all the following (a) explicit objectives, (b) clear search strategies and (c) eligibility criteria. We initially required reviews to have included quality appraisal of included studies, however, during the review process we realised some potentially informative reviews did not include quality appraisal. We, therefore, removed this criterion from our definition of reviews. The quality appraisal of included reviews highlights those reviews for which quality appraisal of included studies were not reported.

Publication date: Only reviews published from the year 2000 onwards were included

Exclusion criteria

We excluded systematic reviews of qualitative studies and articles that are not systematic reviews, such as topical reviews, essays, expert opinions, comments, letters etc. Review protocols were excluded but the titles were searched to identify any publication of associated results. Reviews on COVID-19 were excluded. We also excluded articles that focus on factors associated with travel-

related infections. Reviews which excluded the UK in their eligibility criteria or have not included populations relevant to the UK population (for example, papers where all results are from low-income countries) were excluded. We excluded reviews published before year 2000 to focus on recent evidence synthesis.

Data extraction

We designed and piloted a data extraction form in Microsoft Excel. The information extracted from each review includes: first author's last name, publication year, corresponding author's country, review methodology, inclusion and exclusion criteria, infectious disease(s), population(s) included, dimension(s) of inequality, outcomes, conclusions, and strengths and limitations. Data extraction was performed by one reviewer and checked by a second reviewer.

Quality assessment

Assessment of Multiple Systematic Reviews version 2 (AMSTAR2) checklist was used to assess the quality of each review.[16] AMSTAR2 is a 16-item checklist that was designed to appraise the quality of systematic reviews that contain randomised controlled trials and/or non-randomised controlled trials. Although it was originally designed for systematic reviews of studies of interventions, it is widely used for various types of systematic reviews. It covers various aspects of the systematic review process such as pre-registration of protocol, adequacy of literature search, justification of excluded studies, risk of bias assessment for individual included studies, appropriateness of meta-analysis methods, use of risk of bias findings in results interpretation and consideration publication bias. Quality assessment was performed independently by two reviewers and disagreements were resolved by discussion.

Data synthesis

We performed a narrative synthesis to highlight the findings of different systematic reviews and highlighted the strengths and limitations of existing evidence. To do this, we created an evidence matrix by tabulating the dimension of inequalities covered against the infectious disease topic. This shows areas where reviews already exist and highlights where there are gaps in the literature. The evidence matrix was also used to facilitate summarization of findings of reviews across different dimension of inequalities. We identified connections between different systematic reviews based on similarities in the population studied and the dimensions of inequalities addressed across different

infectious diseases. We described the findings of the reviews based on the dimensions of inequalities of interest.

3. Results

As shown in the PRISMA flow diagram (Figure 1), the electronic database searches retrieved 12808 citations. After removal of duplicates, we screened 9431 titles and abstracts and subsequently 379 full texts. We excluded 296 full text articles, of which one was a commentary on another review which we subsequently retrieved and included. We received a grey literature article through our contact with experts which highlights UK based evidence for several inclusion health groups, but the article did not fulfil the criterial for inclusion in the current review.[17] Ultimately, we included 84 reviews in our synthesis.

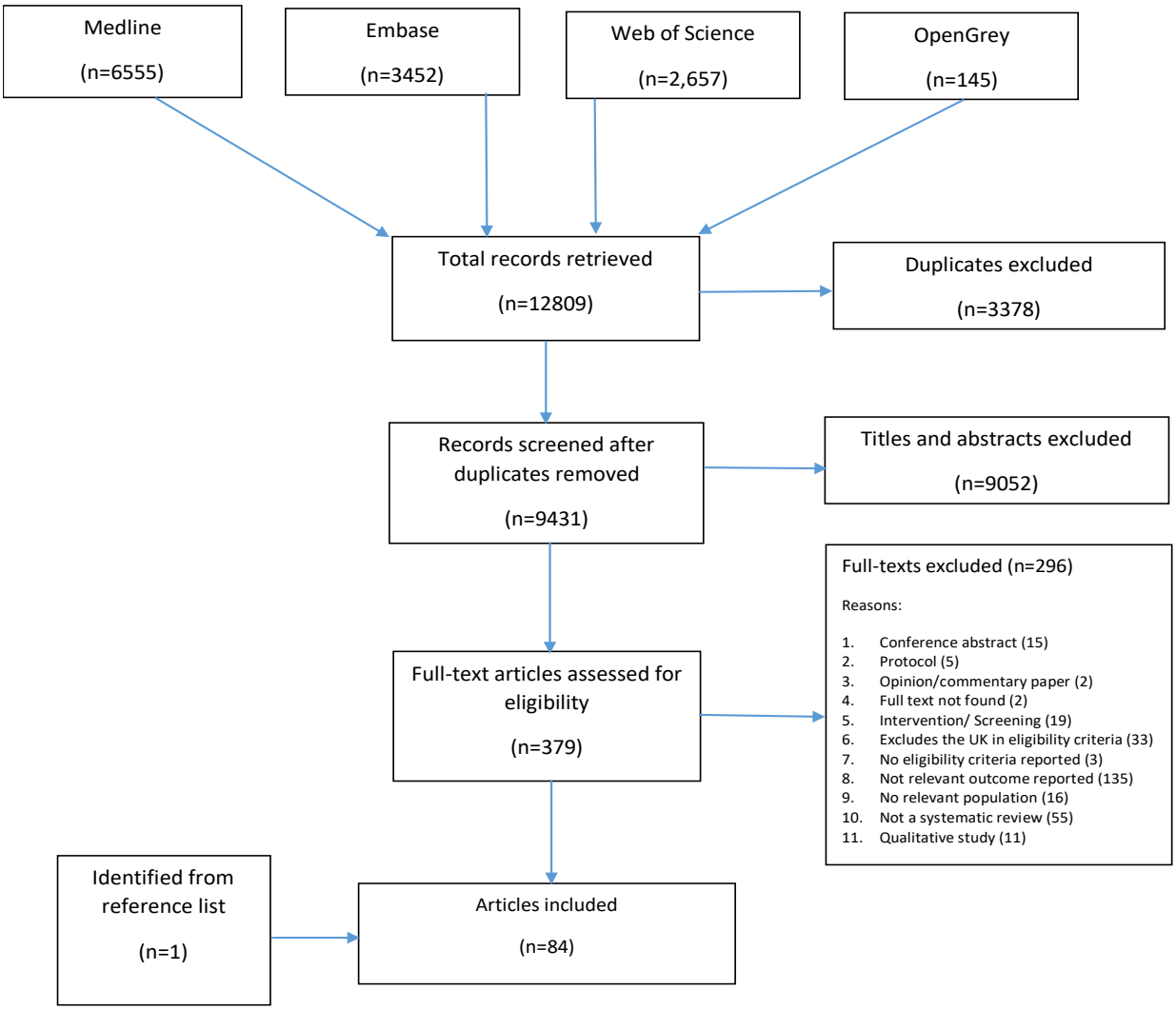

Figure 1: PRISMA flow diagram for study selection.

The characteristics of included reviews are presented in Table 1 and Appendix 2. The included reviews were published between 2005-2020 with majority (95%) published after 2010. Literature search coverage for the included reviews ranged from 1946 to 2019; 10 reviews (11%) searched databases from inception, whereas 24 studies (28%) did not clearly report the dates covered. The publication year for the primary studies included in the reviews ranged from 1964-2019; 34 of the included reviews (40%) have studies published before 2000 and 27 reviews (32%) do not clearly report the publication range. Out of 84 included reviews, 21 corresponding authors were from the UK, eight each from the United States of America (USA) and Canada, seven each from Australia and Italy, six form the Netherlands, five from Iran, three from Switzerland, two each from Portugal, Spain, Sweden, Greece and Denmark, one each from Japan, India, Sri Lanka, Mozambique, Mexico, China, Belgium, Brazil and France. More than half of the reviews (64%) clearly mentioned at least one UK-based primary study in their analysis. Seventeen reviews (20%) do not include any UK-based primary study. Forty-one of the 84 reviews (49%) included meta-analysis while the remaining studies used narrative/descriptive synthesis approach. The evidence matrix showing which review reported on different dimensions of inequalities and the infectious diseases covered is presented in Appendix 3.

Table 1: Characteristics of included reviews

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Abraha, 2018[18]	Switzerland	AMR-Gonorrhoea	1946-2017	No	24 (unclear)	1989-2017	Age, sex, ethnicity, sexual orientation	Socioeconomic position	
Adams, 2018[19]	UK	Gastrointestinal Infection	1980 - 2015	Yes	77 (unclear)	1995-2015	Age	SES, measured at the individual or aggregate level by income, education, occupation, employment or area-level deprivation.	
Aldridge, 2018[20]	UK	Not specified	2005- 2015	Yes	337 (unclear)	not reported	Sex		Homeless individuals, sex workers
Alividza,2018[21]	UK	AMR	no date limit	No	19 (at least 2)	1998 to 2015		Poverty, crowding, homelessness, and living environment, income inequalities, water and sanitation, education level	

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Arat, 2019[22]	Sweden	Vaccination	not reported	No	15 (2)	2007-2017,		Income, education, occupation, area level socioeconomic status	
Behera, 2018[23]	India	HIV	Not reported	No	Not reported	1989 - 2017	Age		
Beijer, 2012[24]	UK	Tuberculosis, hepatitis C virus, and HIV	1980 - 2012.	Yes	TB - 17 (4) HCV - 12 (1) HIV - 22 (0)	1984 - 2011	Sex	Homelessness	Homeless people
Bocquier, 2017[25]	France	Vaccination	2000 - 2016	No	43 (5)	Not reported		Education, occupation, income	
Bonten, 2020[26]	Netherlands	*Escherichia coli bacteraemia*	2007- 2018	Yes	210 (21)	2007-2018	Age and Sex		
Chan, 2017[27]	Australia	Tuberculosis	Inception- 2017	Yes	20 (1)	1990-2015			Migrants
Chen, 2019[28]	China	HIV disease	unclear - 2019	Yes	101 (1)	1984-2017	Sexual orientation		
Chernet,2017[29]	Switzerland	Six selected infectious diseases	not reported	Yes	96 (unclear)	2000-2017			Migrants and refugees

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Coffey, 2018[30]	Australia	Group A Streptococcal infection, acute rheumatic fever	Unclear - 2016	No	91 (unclear)	1944 - 2016		Living condition, education, employment, socio-economic status	
Colledge, 2020[31]	Australia	HCV (antibody)	not reported	No	223 (16)	2008 -2017	Gender, Age	Country-level ecological indicators of health, development, and inequality (income inequality)	
Cormier 2019[32]	Canada	Tuberculosis (HIV as one of the proximate determinants of tuberculosis)	1980 - 2017.	No	475 (0)	1984-2017	not reported	Living condition, malnutrition & food insecurity	Indigenous people
Crichton, 2015[33]	UK	Genital Chlamydia infection	Inception - 2014	Yes	36 (3)	not reported	Age, gender	educational, income, occupation/employment, neighbourhood measure of deprivation	
De Vito, 2017[34]	Denmark	Vaccination	2007- 2017	No	35 +21 (4)	not reported		Socio-culture, Socio-economic	Migrants and refugee
Denning, 2018[35]	UK	Vulvovaginal candidiasis	1985 - 2016	Yes	8 (2)	2000-2013	Age		

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Di Gennaro, 2017[36]	Mozambique	Therapy failure and multi drug resistance among people with tuberculosis	Inception - 2016	Yes	50 (1)	1997 - 2016		Education, income	
Eilami, 2019[37]	Iran	HIV/AIDS	2010 - 2017	Yes	37 (1) for meta-analysis 54 (unclear) for qualitative synthesis	2010-2017	Sex		
Fakoya, 2015[38]	UK	HIV	2002- 2014	No	27 (9)	2003-2014	sexual orientation		
Falagas, 2008[39]	Greece	Vaccination Compliance for several diseases.	Not reported	No	39 (1)	1979-2005	Age, ethnicity, and religion	Socioeconomic status, residence, insurance, transportation/ access	
Falla, 2018[40]	Netherlands	Chronic Hepatitis C virus (CHC)	2000-2015	No	Part 1: 18 (unclear) Part 2: 56 (1)				Migrants
Fauroux, 2017[41]	Spain	Respiratory Syncytial Virus Infection	1995 - 2015	No	74 (8)	Unclear	Sex	Living condition	
Faustini, 2005[42]	Italy	Tuberculosis (MDR)	1993-2003	Yes	29 (3)	1995-2005 (meta-analysis studies)	Age, Gender		Migrants
Fernández, 2015[43]	Denmark	Vaccination: HPV	not reported	No	23(8)	2008-2014	Age, ethnicity	education level, SES, Area of residence	

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Fisher, 2013[44]	UK	Vaccination (HPV)	inception- 2012	Yes	27(1)	2008-2012	Ethnicity, Religion	Income and are level deprivation	
Forshaw, 2017[45]	UK	Vaccination	1990 - 2016	Yes	37(0)	1990- 2015	Age	Education level, area of residence	
Fournet, 2018[13]	Netherlands	vaccination	1950- 2013	No	1st review-48 (at least 1) 2nd review-15 (at least 1)	not reported	Religion or belief		Gypsy Roma and Traveller communities.
Ghiasvand, 2020[46]	Iran	HIV/AIDS	Inception - 2017	Yes	19 (0)	2005 - 2017	Age	Poverty, education	
Gorjana, 2017[47]	Australia	HPV Vaccination	Unclear - 2015	No	18 (1)	2010 - 2015	Age, Ethnicity		
Greenaway, 2015[48]	Canada	HCV (antibody)	not reported	Yes	50(0)	1990-2013	Age	Pregnant women	Migrants, Refugee,
Hahne, 2013[49]	The Netherlands	HBV and HCV	2000 - 2009	No	124 (9)	Unclear	Pregnancy, sexual orientation		Migrants
Hermann, 2019[50]	Canada	Vaccination-Mostly childhood immunisation coverage	2000- 2017	No	33 (15)	2001-2016	Age		
Jain, 2017[51]	UK	Vaccine	not reported	Yes	35 (5)	1997 and 2015	Religion, marital status	Education, income, insurance, area socio-economic status, social class	Migrants

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Jin, 2020[52]	Australia	HCV	2000 - 2019	Yes	194 (at least 14)	Unclear			MSM
Kawatsu, 2014[53]	Japan	TB	Not reported	No	18 (1)	1997 - 2012	Ethnicity	Employment, education, income, occupation	Homeless, Migrants
Kentikelenis, 2015[54]	UK	HIV, HBV, HCV, Syphilis, Gonorrhoea	2007 - 2014	No	21 (unclear)	not reported		Employment, education, income, occupation	Migrants
Larson, 2014[55]	UK	Vaccination (Vaccine hesitancy)	unclear - 2012	No	1164 (at least one)	2007–2012		Education, income	
Leung,2019[56]	Australia	HIV, HBV, HCV	2008 - 2017	Yes	104(unclear)	not reported	Gender		
Li, P. 2020[57]	Netherlands	HEV	inception - 2019	Yes	419(7)	not reported	Age, Gender	occupation	
Lindsay,2015[58]	Belgium	Norovirous disease	2003 - 2013	No	39 (4)	not reported	Age		
Lucyk, 2019[59]	Canada	Vaccination-Influenza	2012 - 2017	No	42 (1)	2012- 2017		Social class, socioeconomic status, socioeconomic position, occupational class, educational, income, poverty,	

Study ID (Author, Year)	Corresponding Author's Country	Infectious diseases	Search period	Includes meta-analysis (Yes/No)	Number of studies included *(Number of UK studies)*	Publication year range for included studies	Protected characteristics	Socioeconomic inequalities	Inclusion health groups
								deprivation index, neighbourhood-based measures	
Malerba, 2015[60]	Italy	Pneumococcal and Meningococcal vaccination	2000 - 2014	No	Meningococcal=7 (1) Pneumococcal =4 (0)	2003-2014	Age, ethnicity, religion	Residence, accommodation type, education, employment, income	
Millett, 2012[61]	USA	HIV disease	1981 - 2011	Yes	194 (13)	1981-2011	Race	Employment, income, incarceration, education	
Mipatrini, 2017[62]	Italy	Vaccination and various infectious diseases	2005-2016	No	58 (7)	not reported			Migrants and refugee
Morais, 2017[63]	Portugal	*Helicobacter pylori*	inception - 2015	No	28 (unclear)	1988-2014			Migrants
Nagata, 2013[64]	Switzerland	vaccination-Influenza	1980 - 2011	No	80 (7)	not reported	Age, sex, marital status, Race-ethnicity	income, occupation, social class, area level deprivation	
Nava-Aguilera, 2009[65]	Mexico	TB	unclear - 2005	Yes	30 (1)	1994 - 2008	Age, Sex	Area of residence (urban vs rural)	Homelessness Ethnic minority
Nellums, 2018*b*[66]	UK	AMR	2000- 2017	Yes	23 (0)	2006-2016			Migrants-refugee, asylum seeker
Newman, 2015[67]	USA	Foodborne infectious diseases	1980 - 2013	No	16 (3)	not reported	Disability	Home ownership, education, indexes of	

Study ID (Author, Year)	Corresponding Author's Country	Infectious diseases	Search period	Includes meta-analysis (Yes/No)	Number of studies included *(Number of UK studies)*	Publication year range for included studies	Protected characteristics	Socioeconomic inequalities	Inclusion health groups
								deprivation or income	
Offer, 2015[68]	UK	TB	1990 - unclear	No	18 (18)	1999-2013	Race-ethnicity	Socio-economic deprivation	
Okoli, 2020[69]	Canada	Influenza vaccination	Unclear - 2020	Yes	34 (1)	2004 - 2019	Age, Ethnicity, Marital status, Sex	Education, income, Social class, Living situation	Immigration
Oldenburg, 2014[70]	USA	HIV	2004 - 2013	Yes	88 (1)	not reported	Sexual orientation		People who engage in sex work
Oldenburg, 2015[71]	USA	HIV	2004 - 2013,	Yes	33 (0)	2004-2013			People who engage in sex work,
Operario, 2008[72]	UK	HIV	1980 -2007	Yes	25 (0)	1988- 2006.	sex and sexual orientation		People who engage in sex work,
Platt, 2013a[73]	UK	HIV, STIs	Not reported	No	26 (1)	Not reported			Migrants
Platt, 2013b[74]	UK	HIV, STIs	2005 - 2011	No	73 (5)	Not reported			Migrants
Possenti, 2016[75]	Italy	Cystic Echinococcosis	not reported	Yes	37(0)	1964-2014	Age, sex	Income, education, living conditions and living in rural areas	

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Prost, 2007[76]	UK	HIV	Unknown - 2005	No	138 (unclear)	1996 -2005	Race		Migrants
Pulver, 2016[77]	Canada	Vaccination	1980 - 2014	No	12 (1)	1993 - 2013	Sex		Migrants
Richterman, 2018[78]	USA	Cholera	not reported	Yes	110 (0)	1974-2017	Age, sex	Income, asset ownership or composite wealth index, household building materials, surrounding household density, household member, education and literacy	
Rodrigo, 2010[79]	Sri Lanka	HIV	1999 -2009	No	98 (unclear)	not reported		Poverty	
Rossi, 2012[80]	Canada	Chronic hepatitis B virus (HBV) infection	Inception - 2011	Yes	110 (2)	1977 - 2011			Migrants, refugee
Rostami, 2019a[81]	Iran	Toxocariasis	1980 - 2019	Yes	250 (2)	1980 -2019	Age, Sex	Residence (urban vs Rural)	
Rostami, 2019b[82]	Iran	Acute Toxoplasma infection	1988 - 2018	Yes	217 (3)	1988 - 2018	Age (maternal age)		

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
Salgado-Barreira, 2014[83]	Spain	HIV, Infection and parasitic disease,	unclear -2012	No	24 (1)	1983- 2010		Deprivation	
Sandgren, 2014[84]	Sweden	Tuberculosis	1990- 2012	Yes	15 (1)	not reported			Migrants
Schepisi, 2018[85]	Italy	Tuberculosis	unclear - 2017	Yes	74 (13)	1950-2017	Age		
Schierhout, 2020[86]	Australia	Human T-cell lymphotropic virus type 1 (HTLV-1)	1910 - 2018	Yes	39 (0)	1991 - 2018	Age, Sex		
Spyromitrou-Xioufi, 2020[87]	Greece	Meningococcal Infection	2008 - 2018	Yes	6 (0)	1999-2017	Age, sex, religion	Crowding, Smoking exposure, IMD contacts, Income	
Stockdale, 2020[88]	UK	Hepatitis D	1998 - 2019	Yes	282 (at least 1)	not reported			MSM, People who engage in sex work
Strifler, 2015[89]	Canada	Meningococcal Disease	inception - 2013	No	17 (6)	1982-2012	Age		
Suhrcke, 2011[90]	UK	various infectious disease- such as Parasitic disease, HIV, TB, salmonella, Tick-bone encephalitis, Influenza, Pneumonia.	1947 - 2010	No	37 (2)	not reported		Economic crisis	Homeless populations, migrants (especially minors)

Study ID (Author, Year)	Corresponding Author's Country	Infectious diseases	Search period	Includes meta-analysis (Yes/No)	Number of studies included *(Number of UK studies)*	Publication year range for included studies	Protected characteristics	Socioeconomic inequalities	Inclusion health groups
Tabacchi, 2016[91]	Italy	Vaccination-MMR	not reported	Yes	26 meta-analysis, 45 qualitative synthesis (19)	2000-2014	Ethnicity, age, sex, marital status	Income, education, employment and house tenure	
Tauli, 2016[92]	Brazil	Vaccination	1992- 2014	No	23(0)	not reported	Age, ethnicity	employment rate, literacy and wealth index, living in a rural area,	Migrants
Tavares, 2017[93]	Portugal	HIV-TB	2000 - 2016	No	27 (2)	2003 - 2016			Migrants
Tollefson, 2013[94]	USA	Tuberculosis	1990 – 2011	No	91 (0)	1990 - 2012			Indigenous people (Roma are considered an indigenous group in some regions)
Van Gerwen, 2020[95]	USA	STI/HIV	1968 - 2018	Yes	25 (0)	not reported	sex		
Vet, 2015[96]	The Netherlands	Hep B Vaccination	inception-2014	No	18 (0)	not reported	Age, Race	Socioeconomic status	People who engage in sex work
Vukovic,2019[97]	Italy	Influenza vaccination	unknown - 2017	No	12 (6)	2004 - 2017		Deprivation	
Wayal, 2018[98]	UK	bacterial sexually transmitted infections and	Unclear - 2016	No	15 (15)	2000 - 2017	Ethnicity		

Study ID (Author, Year)	**Corresponding Author's Country**	**Infectious diseases**	**Search period**	**Includes meta-analysis (Yes/No)**	**Number of studies included** *(Number of UK studies)*	**Publication year range for included studies**	**Protected characteristics**	**Socioeconomic inequalities**	**Inclusion health groups**
		Trichomonas vaginalis							
Yu, 2020[99]	USA	HIV/STI	Unclear - 2019	No	21 (0)	2008 -2017			Trafficked women Sex workers
Zamani, 2018[100]	Iran	*Helicobacter pylori*	2000 - 2017	Yes	183 (2)	not reported	Age		

Methodological quality of included reviews

Figure 2 shows the proportion of included reviews which met each AMSTAR2 Criteria. Between 61% to 85% of the reviews fulfilled criteria such as including components of PICOS in their research questions and inclusion criteria, performing duplicate data extraction, providing discussion of heterogeneity and disclosure of conflicts of interest. Only 14% provided clear indication that the review methods were established a priori and 48% explained their selection of study design. Although only 23% of the reviews fully fulfilled the AMSTAR2 criteria for a comprehensive search, 63% of them were classed as "partial yes" which was often due to lack of grey literature searches. About half of the reviews performed duplicate study selection. The included studies are not often described in adequate detail and the quality appraisal of the included studies are not often performed using satisfactory techniques. Appropriate meta-analyses were performed in about half of the included reviews and about half accounted for risk of bias in the meta-analysis (where conducted) and in the interpretation of results. Nearly half of the reviews that performed meta-analysis carried out investigation of publication bias. None of the reviews provided a list of excluded studies with justification of the exclusions and none reported funding sources for included studies. It is worth noting that these two criteria are more common among Cochrane reviews of interventions and generally, most published non-Cochrane reviews do not include these. Assessment of the methodological qualities of included reviews are presented in Appendix 4.

Figure 2: AMSTAR2 results for included reviews

Evidence Relating to Inclusion Health Groups

Of the 84 included reviews, 35 (42%) reported on inclusion health groups in terms of general migrants (21;25%),[27, 29, 34, 40, 42, 48, 49, 51, 53, 54, 62, 63, 69, 73, 74, 76, 80, 84, 90, 92, 93] vulnerable migrants (7; 8%),[29, 34, 48, 62, 66, 80, 99] homelessness and rough sleeping (6; 7%),[20, 21, 24, 53, 65, 90] people who engage in sex work (5; 5%),[71, 72, 88, 96, 99] and Gypsy, Roma and Traveller community (3;3%).[13, 32, 94] The evidence is generally consistent across groups showing that people who belong to inclusion health groups are often at higher risk of infectious diseases, AMR and under vaccination. The findings of the reviews are reported below.

Migrants

We identified several reviews on migrants covering general migrants and vulnerable migrants such as asylum seekers, refugees, and trafficked sex workers. One review reported higher prevalence of vaccine preventable diseases among migrants and refugees in Europe.[62] The prevalence may vary by country of origin. For example, in the review, authors reported that in the UK, the prevalence of current hepatitis B (HBV) infection positivity was 11.8% among Yugoslavian patients, 9.3% among asylum seekers and refugees, 8.7% among people born in China, 5.7% in a Somali community, 1.8% for people born in Pakistan, 1.5% in people born in Bangladesh and 0.1% among those born in India.[62] Other reviewers also reported that prevalence of HBV among first time blood donors in the UK was 0.04% in the general population and 1.0% among pregnant women but 5.7% among migrants from Somalia.[49] In the UK, migrants compose about 35% of chronic HCV infection even though migrants only form 9% of the population.[40] In another review of the prevalence of six infectious diseases (syphilis, helminthiasis, schistosomiasis, intestinal protozoa infection, HBV, and HCV) among African migrants and refugees, the authors reported relatively high prevalence of some of the infectious diseases.[29] The authors also reported that there may be differences in prevalence among migrants from Sub-Saharan Africa compared to North Africa but they were unable to investigate this further due to significant heterogeneity between studies for all the infectious diseases investigated.[29] This heterogeneity could be due to variation in the sample sizes and the migrant/refugee study population may be different for different host countries. A previous review had also reported higher prevalence of HCV in migrants from intermediate or high HCV prevalence countries.[48] Some potential regional variations were also reported with the highest prevalence observed among those from Sub-Saharan Africa, Asia and Eastern Europe. Similarly, a review of chronic HBV among migrants arriving in low HBV prevalence countries also showed that migrants

from Latin America and Caribbean had the lowest risk of chronic HBV while migrants from East Asia and Sub-Saharan Africa had the highest risk.[80] The pooled estimate also showed that refugees were more likely to have chronic HBV compared to general immigrants (OR 1.42 95% CI 1.01 to 1.99).[80] A recent review of global literature showed that trafficked sex workers are at higher risk of HIV and STIs compared to female sex workers in general.[99] Although no UK studies were included in the review, the findings were consistent across North America, India and Nepal.[99] In another review, the prevalence of *Helicobacter pylori* among immigrants was reported to be higher than that of the destination country, but lower than that of the country of origin.[63] When the first-generation migrants were compared to second or more generation, they observed lower prevalence among the latter group. The authors also reported that the rates varied according to continent of origin.[63]

The incidence of TB in post-migration populations is higher than the host country,[27, 84] especially those identified to be at high risk in pre-migration screening.[27] Other reviews also showed that HIV and STIs are more prevalent among migrants.[73, 74] For example, in the UK HIV prevalence was 1.2% in migrants and 0.9% in non-migrants, chlamydia was 5% in migrants and 3% in non-migrants and Gonorrhoea was 4% in migrants and 0% in non-migrants.[73] Migrant female sex workers were generally at higher risk of HIV and STIs compared to non-migrants, although the association are not statistically significant in some studies.[73, 74] The prevalence of HIV-TB co-infection was reported to be higher among immigrants compared to nationals in various countries including England and Wales.[93] The reviewers identified four studies that measured mortality and survival; three of the studies (from Italy and Spain) reported slightly better survival/lower mortality among migrants. They attributed this observation to possible healthy migrant effect.[93] In another review, migrants are reported to be at higher risk of TB death.[53]

Authors have reported high proportion of undiagnosed HIV infection among Sub-Saharan Africans in Western Europe, including the UK.[76] The reviewers also highlighted evidence relating to various factors which contribute to the underdiagnosis, such as some African's not considering themselves at risk of HIV, lack of information, being deterred to test due to immigration status and psychological pressures triggered by immigration concerns and poverty.[76] Existing higher risk of various infectious diseases among migrants can worsen by economic crises and responses to such crises.[54, 90] Evidence from the United Kingdom also show an increasing number of migrants contracted HIV after they arrived in the UK between year 2002 and 2011.[54]

With regards to vaccination, several reviews have reported lower vaccination rates (including delayed and incomplete vaccination) among migrants and refugees in Europe.[51, 62, 69, 92] For example, a recent meta-analysis of three studies showed that among older adults in Europe, migrants were less likely to report seasonal influenza vaccine uptake, although the association was not statistically significant (OR 0.69, 95% CI 0.34 – 1.40). The meta-analysis included only three studies and there was significant heterogeneity between studies so the effect estimate should be interpreted with caution. Lower vaccination rates among migrants were also reported for other infectious diseases such as tetanus, MMR, and polio.[62] The association may also vary based on the migrant group. For example, some authors have reported that the uptake of vaccination among refugees is lower compared with asylum seekers.[34] Migrants who are not documented are often not covered within the national health services and this is likely to contribute to lower vaccination uptake among migrants.[34]

Two reviews showed that AMR carriage and infection are more prevalent among migrants in Europe.[42, 66] One of the reviews reported that multidrug resistant (MDR) TB was higher among foreign born patients (pooled OR of 2.46 95% CI 1.86 – 3.24 and for the UK study included in the sub-group analysis it was 1.97 95%CI 1.41 to 2.75).[42] In another review, the pooled prevalence of AMR among refugees and asylum seekers was higher (33·0%, 95% CI 18·3–47·6) compared to other migrant groups (6·6%, 95% CI 1·8–11·3).[66] Authors reported significant heterogeneity between studies because of issues such as variation in the definition of outcomes and sample size.

Gypsy Roma and Traveller communities

Three of the included reviews examined Gypsy Roma and Traveller communities.[13, 32, 94] Fournet and colleagues examined under-vaccinated groups in Europe and reported that Roma and Irish Traveller populations in the UK are often under-vaccinated.[13] Another review identified one study conducted among Roma communities, which found the Roma in Barcelona to have a TB incidence 5.3 times greater than Spain's national TB incidence.[94] The third review explored proximate determinants of TB in indigenous peoples globally. The authors reported a higher prevalence of HIV among Iranian, Roma, and Peruvian Indigenous populations compared to the general population.[32] However, they questioned the representativeness of the findings because there were only a few studies identified and the majority involved convenience samples. We did not identify any reviews that examined the association between being from this population and AMR.

People experiencing homelessness

We identified six reviews which examined association of homelessness with infectious diseases.[20, 21, 24, 53, 65, 90] In a meta-analysis of 15 studies, recent TB transmission was significantly associated with homelessness with an OR of 2.87, 95%CI 2.04– 4.02.[65] Although there was significant heterogeneity observed, homelessness was one of the strongest risk factors observed among 13 factors examined in the series of meta-analyses conducted in the review, preceded only by ethnicity and drug use. In another review, the prevalence of TB, HCV and HIV infection in homeless people was compared with the estimated prevalence in the general population, the prevalence ratios ranged from 34 to 452 for TB, 4 to 70 for HCV infection, and one to 77 for HIV infection.[24] Homelessness has also been reported to increase the risk of mortality associated with various infectious diseases including TB, HIV, HBV, HCV among others.[20, 53] In a review of studies that examined the impact of previous economic crises on infectious disease burden, people experiencing homelessness were identified as a high-risk group.[90] Homelessness was also associated with AMR (MRSA) in community and hospital patients.[21] We did not identify any reviews that examined the association between homelessness and vaccination.

People who engage in sex work

Five reviews explored infectious diseases risks associated with engaging in sex work.[71, 72, 88, 96, 99] A recent meta-analysis showed that HDV seroprevalence was higher among commercial sex workers compared to with the general population asymptomatic HBsAg-positive people (OR 18.7, 95% CI 6.7, 52.2).[88] However, there was considerable heterogeneity between studies due to issues such as variations in risk factors relating to geographical settings as well as methodological issues. In one meta-analysis, men who engage in transactional sex (considered a subset of MSM) had a higher risk of HIV compared to the general male population with a prevalence ratio of 20.7 (95% CI 16.8 to 25.5).[70] A meta-analysis of 33 studies (from 17 countries) comparing HIV prevalence among MSM with history of transactional sex to those who did not have history of transactional sex, showed that those who engaged in transactional sex were more likely be HIV infected (OR 1.34, 95% CI 1.11-1.62).[71] The studies covered South Asia, East Asia, Southeast Asia, Latin America, Sub-Saharan Africa, Middle East and North America but no UK or European countries were included. The reviewers reported geographical variations with the association only noted in Sub-Saharan Africa (OR=1.72, 95%CI=1.02-2.91) and Latin America (OR=2.28, 95%CI=1.87-2.78). As the other

regions did not show significant association, it is not clear if the result is generalisable to European or UK population.

In another review, transgender women who engage in sex work had higher HIV prevalence (pooled crude prevalence 27.3%) compared with transgender women who do not engage in sex work (14.7%). When the risks were compared in a meta-analysis, there was no significant association observed (RR = 1.06, 95% CI: 0.69 to 1.55).[72] The reviewers noted that the findings of the meta-analysis should be interpreted with caution due to significant heterogeneity between studies. One of the reviews explored factors associated with immunisation among MSM, one of the included studies showed that those who trade sex for drugs/money were less likely to have obtained hepatitis vaccination at Gay Pride events, although the association was not statistically significant and it is not clear if this is also true in other settings.[96] We identified other reviews on infectious diseases prevalence in sex workers, but they did not compare to non sex-worker population.[37, 73, 74, 99] We did not identify any reviews exploring the association of being a sex worker with AMR or vaccination.

Evidence Relating to Protected Characteristics

We identified 55 reviews (65%) that reported on protected characteristics, however, many of the reviews reported on the association with age (32;38%),[18, 19, 23, 26, 31, 33, 35, 39, 42, 43, 46-48, 50, 57, 58, 60, 64, 65, 69, 75, 78, 81, 82, 85-87, 89, 91, 92, 96, 100] sex (21; 25%),[18, 20, 24, 31, 33, 37, 41, 42, 56, 57, 64, 65, 72, 75, 77, 78, 81, 86, 87, 91, 95] race (17; 20%),[18, 39, 43, 44, 46, 53, 60, 61, 64, 65, 68, 69, 76, 91, 92, 96, 98] and sexual orientation (8; 9%).[18, 28, 38, 49, 52, 70, 72, 88] As described below, race and sexual orientation showed generally consistent association but the evidence relating to the association of age and sex with infectious diseases often varied depending on the specific infectious disease. The evidence on other protected characteristics is sparse and also inconsistent, this includes religion (6; 7%),[13, 39, 44, 51, 60, 87] marriage and civil partnership (4; 4%),[51, 64, 69, 91] pregnancy maternity (2; 2%),[48, 49] gender reassignment (1; 1%),[72] and disability (1; 1%).[67]

Race/ethnicity

We identified 17 reviews that explored inequalities relating to race and ethnicity.[18, 39, 43, 44, 47, 53, 60, 61, 64, 65, 68, 69, 76, 91, 92, 96, 98] Reviewers generally report higher infectious disease rates among people who belong to an ethnic minority group. For example, a meta-analysis found that recent transmission of

TB was associated with being of ethnic minority background (OR 3.03, 95% CI 2.21- 4.16).[65] The only UK study included in that review also reported similar findings (OR 3.25 95% CI 1.815 -5.811). Two reviews focussed on UK studies only.[68, 98] Of these two, one aimed to summarise factors associated with higher rates of TB among South Asian communities in the UK. The review included 18 studies and reported higher risk of TB infection among the South Asian communities, but it is not clear if this association was independent of deprivation.[68] The other UK focused review examined evidence on the association between bacterial STIs/ trichomonas vaginalis (TV) and ethnicity (Black Caribbean compared to White/White British) accounting for other risk factors.[98] Reviewers reported that compared to the White/White British ethnic group, there was a greater STI/TV risk among people from Black Caribbean background which was not fully explained by variations in socio-demographic factors, sexual behaviours, and recreational drug use. Another review reported higher proportion of HIV among Black and minority MSM compared to White MSM.[76] When young Black MSM were compared to other young men in a meta-analysis of five studies, they were almost five times as like to be HIV seropositive (OR 4.95, 95% CI 3.79 – 6.53).[61]

Although we identified 10 reviews that assessed racial inequalities in immunisation, the majority of those reviews included one (n=4 reviews) or no UK studies (n=4 reviews). One of the reviews included eight UK[43] and another included 19 UK studies.[91] In a review examining the determinants of human papillomavirus (HPV) vaccine uptake in Europe, three studies conducted in the UK showed that non-White girls were less likely to be vaccinated compared to White girls.[43] In addition, a meta-analysis indicated that on average Black young women were less likely to initiate HPV vaccination than White young women (combined OR: 0.89, 95% CI: 0.82–0.97).[44] In a meta-analysis examining the determinants of European parents' decision to vaccinate their children against measles, mumps and rubella (MMR), children from parents of ethnic minorities (compared to the majority) were less likely to be vaccinated (OR 0.89, CI 0.86–0.93 in a fixed effect model).[91] However, in the random effects model the effect disappeared (OR 1.03, 95% CI 0.79–1.34), which may be due to heterogeneity between studies.[91] In subgroup analysis there was significant association between vaccination status and ethnicity in Northern (higher vaccination uptake among those who belong to ethnic minority groups, OR 1.74, 95% CI 1.25 – 2.42) and Southern Europe (lower vaccination uptake among those who belong to ethnic minority groups, OR 0.44, 95% CI 0.31 – 0.61) but not in Western Europe (OR 0.96, 95% CI 0.74 – 1.24). In a review examining factors associated with HBV vaccination among MSM, there was no association between HBV vaccination and race/ethnicity in five of seven studies but the remaining two studies reported significant association; with those of White ethnicity being more likely to be vaccinated.[96] A meta-analysis also showed that seasonal

influenza vaccine uptake was associated with being White among older people (OR 1.30, 95% CI 1.14–1.49 [10 studies]).[69] Non-White race was reported to be associated with suboptimal compliance with vaccination among children and adolescents in developed countries.[39]

There was only one review on race and AMR which shows that people from some Black ethnic groups in the USA and Europe, and Aboriginal ethnic groups living in Canada and Australia are less likely to have AMR-Neisseria gonorrhoea (NG) than the White majority population.[18]

Age

Various reviews have reported the association of infectious diseases with age.[18, 19, 23, 26, 31, 33, 35, 39, 42, 43, 46-48, 50, 57, 58, 60, 64, 65, 69, 75, 78, 81, 82, 85-87, 89, 91, 92, 96, 100] However, the association varies depending on other factors such as the type of diseases and population studied. Regarding STIs, for example, gonorrhoea is more prevalent among younger people and a study in England showed a peak at age 20-24 in women and 25-35 in men.[18] In a multivariable meta-regression analysis, chlamydia was 1.1% (95% CI 0.0% – 2.2%) higher in young people age 20-24 years compared to under 20 years.[33] In a review of the global prevalence of recurrent vulvovaginal candidiasis, the authors reported that the prevalence peaked in the 25-34 age group.[35] This was based on findings from a telephone survey involving women from the UK, France, Germany, Italy, Spain and USA as well as seven other studies[35]. Other authors have also described disproportionately high prevalence of HIV with among younger people, particularly those age 15 -24 years.[23] Another review showed that younger people living with HIV may have better quality of life compared to those who are older.[46]

As with STIs, younger age groups appear to be more vulnerable to TB. In a meta-analysis, TB transmission was associated with younger age (OR 2.09, 95%CI 1.69–2.59).[65] In another meta-analysis that assessed the transmission of mycobacterium TB among children and adolescent in schools/childcare settings, the prevalence of TB decreased progressively with age.[85] For Hepatitis, older ages are at greater risk. Age was significantly associated with HCV seroprevalence in 35 of 50 studies which examined the association and the meta-regression analysis showed that individuals who were age ≥30 years were more likely to be HCV seropositive (OR 8.6, 95% CI 3.1-24.7).[48] Hepatitis E (HEV) rates were reported to increase significantly with increase in age.[57]

Other authors have also highlighted the association of age with various infectious diseases such as Toxocariasis,[82] Acute Toxoplasma infection,[81] Human T-cell lymphotropic virus type 1,[86] gastrointestinal infections,[19, 58, 75, 78, 100] meningococcal Disease,[87, 89] *Escherichia coli bacteremia*.[26]

A meta-analysis of factors associated with MMR vaccine uptake in European parents showed that vaccination uptake decreased with child's age (OR 0.80, 95% CI 0.76–0.85 in both fixed and random effect models).[91] Another review highlighted four studies, including two UK studies, which showed decreased vaccination coverage with increases in child's age.[50] In a review of determinants of suboptimal vaccination compliance (covering various vaccines) in children and adolescents in developed countries, authors reported that mother's younger age was associated with suboptimal compliance.[39] Similarly, in another review of pneumococcal and meningococcal vaccination, vaccination compliance was higher in older parents (>25 years: OR 2.60; 95%CI 1.03-6.83).[60] Other authors also highlighted that incomplete or delayed vaccination was associated with mother being under 20 years of age.[92] In a meta-analysis of determinants of seasonal influenza vaccine uptake among older people, older age was associated with uptake in the pooled analysis of 21 studies (OR 1.52, 95%CI 1.38–1.67) as well as the UK study included (OR 1.49 (95% CI 0.91, 2.42).[69] In a review which assessed the determinants of seasonal influenza vaccine uptake in adults ≥65 years, vaccination uptake was higher in older age groups.[64]

Furthermore, a review reported that 10 out of 14 studies which examined the association between HBV vaccination and younger age showed statistically significant association, only one found opposite association while the remaining three found no association.[96] In another review, of determinant of HPV vaccination in Europe, authors identified seven studies which compared HPV vaccine initiation in different age groups of girls within age 12 – 24 years.[43] The authors reported that three of the seven studies showed highest vaccination initiation among girls aged 16-18 years and those aged 14-15 years, one showed similar initiation rates across age 12-17 years while two studies among older girls showed not significant association.[43] In another review, HPV vaccine intention and initiation were positively associated with younger parent's age[47] in contrast to the 3 reviews highlighted above in which younger parents were associated with lower vaccination rates.

We identified two reviews which examined the association of AMR with age of participants.[18, 42] MDR TB was also associated with being younger than 65 years (pooled OR 2.53, 95% CI 1.74 – 4.83).[42] The association reported in the UK study included was similar (OR 2.62, 95% CI 1.81 to 3.92). In contrast, the other review found studies from several European countries (including UK,

Spain, Netherlands among others) which showed that AMR-NG was more common in those 25 years or older than in younger adults.[18] The authors also highlighted that the risk factors associated with gonorrhoea are not necessary associated with AMR gonorrhoea.

Sex

Twenty-one reviews exploring inequalities based on sex were identified.[18, 20, 24, 31, 33, 37, 41, 42, 56, 57, 64, 65, 72, 75, 77, 78, 81, 86, 87, 91, 95] In a meta-analysis, TB transmission was associated with being a male (OR 1.37, 95%CI 1.19–1.58).[65] In another meta-analysis, the pooled estimate for the prevalence of TB among people experiencing homelessness was 1% (95% CI 1% - 2%) in males and 0.1% (95% CI 0% - 1%) in females.[24] However, the prevalence reported in UK studies ranged from 1% to 3% in homeless males but 8% among homeless females but this was based on only one UK study which reported prevalence of TB in the review. The same review also reported pooled prevalence showing higher prevalence of HIV in homeless males (5%, 95% CI 3% - 6%) than in homeless females (3%, 95% CI 2% - 5%), but no UK studies were included for HIV. HCV was also higher in homeless males (21%, 95% CI 13% - 28%) than homeless females (18%, 95% CI 12% - 24%) in the pooled estimates but similar prevalence reported in both sexes for the UK study; 27% in males and 28% in females.[24] Another review showed varying prevalence of HIV among males and females, with most of the studies reporting higher prevalence in men.[37] In a meta-analysis of global data, reviewers assessed gender differences in the prevalence of HIV, HCV and HBV among People Who Inject Drugs.[56] The authors reported that there are country-level differences in the gender-based variation in the prevalence of the three infectious diseases. For Western Europe, the pooled prevalence of HIV was slightly higher in women (RR 1.15, 95% CI 0.70 – 1.89), HCV was slightly lower in women (RR 0.88, 95% CI 0.63-1.24) and HBV was comparable (RR 1.00, 95% CI 0.25-3.95). Anti-HEV IgG-positive rates was slightly higher in male (13.39%, 95% CI 11.34-15.59; I 2 = 99%) compared to female (12.25% 95% CI 10.05-14.63).[57] A multivariable meta-regression analysis showed that the prevalence of chlamydia is higher in women than in men (a difference of 1.1%, 95% CI 0.1%-2.1%).[33] However, for both meta-analyses, reviewers reported significant heterogeneity between studies which may be due to differences in study designs and populations.[33, 56] so the pooled effect estimates should be interpreted with caution. Several other reviews have reported the association of male or female gender with higher risk of various infectious diseases such as Toxocariasis, *Helicobacter pylori*, gastrointestinal infections, meningococcal disease among others.[20, 75, 81, 87, 100] We identified a meta-analysis of mortality and morbidity in specific inclusion health groups

(homeless individuals, prisoners, sex workers and individuals with substance abuse disorders) in high income countries.[20] The standardised mortality ratio for infectious diseases was higher in females (5·58, 95% CI 1·46–9·70) than males (2·83, 95% CI 1·61–4·05),[20] although there was significant heterogeneity between studies.

Three reviews explored the association between vaccination and sex.[64, 77, 91] In a meta-analysis of factors associated with European parents' vaccination decision for their children, female children were less likely to be vaccinated (OR 0.57, 95% CI 0.56–0.58).[91] However, the authors highlighted that the effect was not significant in a random effects model. Similar observation was also reported in a review of health care use among very young children from immigrant families.[77] The authors highlighted a UK study which examined son preferences among South Asian Muslim and non-Muslim children and found that boys were more likely to be vaccinated compared to girls for MMR (100% South Asian non-Muslim boys vs 93% in south Asian non-Muslim girls) and polio (94% South Asian Muslim boys vs 89% South Asian Muslim girls).[77] However, the differences were not statistically significant. In a review of social determinants of seasonal influenza vaccine uptake in elderly people, the authors highlighted that while the proportion of vaccinated men are often higher than women, the differences are not statistically significant in multivariate regression analysis.[64]

Some reviews examined the prevalence of HIV and STIs among transgender populations. In a recent review, the prevalence of HIV and STIs was reported to be generally higher in transgender women compared to transgender men.[95] In a previous meta-analysis, transgender women sex-workers had higher prevalence of HIV (pooled crude prevalence 27.3%) compared with male sex workers (15.1%) and non-transgender women sex workers (4.5%).[72] The authors hypothesized that the higher prevalence of HIV among males and transgender women may be due to higher rates of unprotected sex among male sex workers although this was not explored due to limitations with the data.[72] More so, there was significant heterogeneity between studies which hinders the generalisability of the estimates and the reviewers did not compare the prevalence in transgender women to transgender males.

Two reviews examined the association of AMR with sex of participants.[18, 42] In a meta-analysis of studies from Europe, male patients were more likely to have MDR TB (OR 1.38, 95% CI 1.16 – 1.65).[42] The only UK study included in the analysis also showed higher risk among males (OR 1.57, 95% CI 1.22 to 2.04). In another review factors associated with antimicrobial-resistant gonorrhoea,

heterosexual men were almost twice as likely to have gonorrhoea with reduced susceptibility to ceftriaxone compared to women.[18]

Marriage and civil partnership

Four reviews described the influence of being married or in civil partnerships on vaccination.[51, 64, 69, 91] In a review which examined uptake of various vaccines (including seasonal influenza, pneumococcal, herpes zoster ad pandemic influenza vaccine) among older adults (≥60 years) from Europe, six out of seven studies reported lower uptake among unmarried individuals (about 30% in the pooled estimate).[52] However, there was considerable heterogeneity between studies. One of the UK studies included in the review reported no significant association between seasonal vaccine uptake and marital status (OR 1.30, 95% CI 0.80 – 2.10) while the other reported lower uptake among unmarried people (OR 0.54, 95% CI 0.44 – 0.67). Another meta-analysis of the factors associated with seasonal vaccine uptake among older adults reported higher uptake among those who are married (OR 1.23, 95% CI 1.17–1.28).[69] In another review of determinants of influenza vaccine uptake in adults (≥65 years), three of the included studies reported higher uptake among married people, two reported no association while one reported higher uptake among those who were never married compared to the married, widowed or divorced.[64] Another review showed that parents who are not married were less likely to vaccinate their children against measles, mumps, and rubella (OR 0.80, CI 0.66 – 0.96).[91]

We did not identify any reviews that examined the association of marital status with infectious disease prevalence or AMR.

Pregnancy and maternity

Two reviews reported prevalence of infectious diseases (HBV and HCV) in pregnant women compared to the general population.[48, 49] In one of the reviews, prevalence of HBV surface antigen among pregnant women was compared to that of the general population in seven countries and higher prevalence was found among pregnant women in six of those countries.[49] However, the review found no general population estimates for the UK, so it is not clear whether the prevalence is also higher among pregnant women in the UK. On the other hand, the prevalence of

anti-HCV antibody was found to be lower among pregnant women in the UK compared to the general population.[49] Another review also reported that the pooled prevalence of HCV seroprevalence among pregnant women was lower (2.0%, 95% CI 1.3% - 3.1%) compared to that of the general population (2.3%, 95% CI 1.6% - 3.5%), although the confidence interval overlaps, indicating no significant difference in the prevalence among pregnant women compared to the general population.[48]

We did not identify any reviews that examined the association of pregnancy with vaccination uptake or risk of AMR.

Religion or belief

A recent meta-analysis of two studies showed that religious events attendance was significantly associated with a decreased risk of invasive meningococcal disease with an OR of 0.47 (95% CI, 0.28–0.79, p 0.0004) and low heterogeneity (p 0.62, $I^2 = 0.0\%$).[87] Five other reviews examined association between religion and vaccination. In one meta-analysis, there was no strong evidence between initiation of HPV vaccination and religion as well as frequency of attendance at a place of worship.[44] This was also reported in another meta-analysis which assessed factors associated with various vaccination among older adults living alone.[51] In a review which aimed to describe under vaccinated groups in Europe and beliefs, attitudes and reasons for non-vaccination, the reviewers identified five groups which included two religious groups: the Jewish Orthodox in the United Kingdom and Belgium and the Orthodox Protestants in the Netherlands.[13] The authors reported that two major measles outbreaks in England and Belgium between year 2007 and 2008 happened within the Orthodox Jewish communities as many of the children were incompletely vaccinated. However, they did not identify any article reporting recent data on vaccination coverage among the group. Children's MMR vaccination coverage among Orthodox Jewish children in north east London between year 1991 to 1992 was reported as 79% (95% CI 75 – 85), similar to that of the general population.[13] In one review of pneumococcal and meningococcal vaccination determinants, non-religious people were reported to show higher vaccination acceptance compared to religious people, however, this was based on findings in one study.[60] Another review of factors associated with suboptimal compliance to vaccinations in children in developed countries reported one study which found that absence of religion was associated with suboptimal compliance.[39]

Sexual orientation

Eight included reviews examined the association of sexual orientation with infectious disease topics.[18, 28, 38, 49, 52, 70, 72, 88] Of those reviews relating to the association between HIV and sexual orientation, three included UK studies. The prevalence ratio reported for the UK study included was high (39.6, 95% CI 31.1 to 50.5) when compared to the general population.[70] In another review, MSM are found to be at particular risk of acquiring HIV post-migration.[38] However, in a network meta-analysis, heterosexual contact showed the highest risk for advanced HIV disease compared to MSM as well as injection drug use among people living with HIV.[28] A meta-analysis of 25 studies showed higher prevalence of HIV among transgender women sex workers compared to biologically female sex workers (relative risk 4.02, 95% CI: 1.60 -10.11).[72] However, the authors reported high heterogeneity between studies.

Some of the reviews examined disparities of HIV in MSM but did not compare risk among MSM with other populations.[61, 76] However, in a series published by the authors of one of those reviews, they reported that Black MSM are more than 100 times more likely be HIV infected compared to the general UK population (OR 111·4, 95% CI 85·4–145·2) using a meta-analytic approach to combine 10 effect sizes.[101] This association was also high in the USA (OR 72·1, 95% CI 64·9–80·1) and Canada (95% 72·6, 34·2–154·0). The worldwide estimate showed 15 times higher prevalence of HIV among Black MSM compared to the general population.

Reviews also showed that HBV, HCV and HDV are higher in MSM.[49, 52, 88] For example, a meta-analysis of global evidence on the prevalence and incidence of HCV infection among MSM showed that the prevalence of HCV is generally higher among MSM compared to the general population.[52] For UK studies, pooled prevalence ratio of HCV in MSM compared with general population was 7.61 (95% CI 6.88-8.39), in HIV negative MSM compared to the general population was 1.40 (95% CI 0.89-2.11) and in HIV-positive MSM vs general population was 10.38 (95% CI 9.05-11.84).[52]

In one of the reviews, AMR- NG (for cefixime) was reported to be more common among MSM compared with men who have sex with only women in England and Wales (OR 5.47, 95% CI 3.99–7.48).[18]

We did not identify any reviews which assessed the association of sexual orientation with vaccination.

Disability

None of the reviews we identified reported disability related inequalities in the infectious diseases topics that were the focus of this overview. However, one of the reviews suggested that disability was associated with higher incidence of listeriosis.[67]

Evidence Relating to Socioeconomic Inequalities

Forty-one reviews (49%) reported association for socioeconomic status. This included factors such as level of education/income (29, 34%),[19, 21, 22, 25, 30, 33, 34, 36, 43-46, 51, 53, 55, 59-61, 64, 67, 69, 75, 78, 79, 87, 90-92, 96] employment/occupation (16;19%),[19, 22, 25, 30, 33, 34, 53, 54, 57, 59-61, 64, 67, 91, 92] social class/area level socioeconomic status (10; 11%),[22, 39, 43, 51, 59, 60, 64, 69, 83, 92] deprivation (8; 9%),[19, 33, 44, 59, 64, 67, 68, 97] and residence/living situation (15; 17%).[21, 30, 32, 41, 43, 64, 65, 67, 69, 75, 78, 81, 87, 91, 92] Evidence relating to socioeconomic status is generally consistent showing that those with lower level of income, lower educational attainment, unemployment, higher area level deprivation, lower socioeconomic status, or poor living situations are at higher risk of infectious diseases, AMR and often had lower vaccine uptake. The findings are described in detail below.

Level of education/income and employment/occupation

Many reviews highlighted that low income, poverty and unemployment were associated with various infectious diseases including, HIV, STIs, TB, HBV, HCV among others.[19, 30, 53, 54, 57, 61, 67, 75, 78, 79, 87, 90] In a meta-analysis including studies from UK, USA and Croatia, the pooled prevalence shows that those with lower occupational class or unemployment were more likely to have chlamydia (OR 1.49, 95% CI 1.07 – 2.08).[33] There was no significant heterogeneity between the studies. However, it is worth noting that the two UK studies included in the meta-analysis reported ambiguous association between lower occupational class and chlamydia (OR 0.79, 95% CI 0.27 – 2.32 in women and 0.98, 95% CI 0.32 – 2.98 in men).[33] The wide confidence intervals suggest possible lack of statistical power in the studies which may have been mitigated in the meta-analysis. Another review suggested that among those living with HIV, low income was also associated with poorer quality of life.[46]

Authors have also reported that during economic crises those who had experienced reductions in income and involuntary unemployment were at higher risk of contracting TB.[90] Those with low level of income, education and who are unemployed were also found to be at higher risk of TB death.[53]

Many reviews examined the association between level of income, education or occupation and vaccination uptake or incomplete vaccination.[22, 25, 34, 43-45, 51, 55, 59, 60, 64, 69, 91, 92, 96] For example, a recent meta-analysis showed that a low household income was associated with 10% (95% CI 5%to 15%) decrease in seasonal vaccine uptake among older adults.[69] In a meta-analysis of factors associated with MMR vaccination uptake in European parents, lower income (OR 0.64, 95% CI 0.51–0.80) and lower education (OR 0.64, 95% CI 0.48–0.84) were associated with lower MMR vaccination uptake but the association with employment type (including self-employed, unemployed, full-time or part time) was not statistically significant (OR 0.75, 95% CI 0.43 – 1.33).[91] In another meta-analysis seasonal influenza vaccine uptake among older adults was associated with higher education (OR 1.05, 95% CI 1 – 1.11) and higher income (OR 1.26, 95% CI 1.08 – 1.47).[51] The reviewers also found, in stratified analysis, that education was not significantly associated with seasonal influenza vaccine uptake in countries where vaccines were provided free-of-charge but vaccine uptake was still associated with higher income among this group.[51]

We identified two reviews that explored the association between AMR and level of income or education.[21, 36] In one meta-analysis, therapy failure and MDR among people with TB was significantly associated with low income (unadjusted OR 2.00, 95% CI: 1.69-2.33; adjusted OR 1.77) and low education (unadjusted OR 2.11 95% CI 1.55-2.86; adjusted OR 1.69) even after adjusting for potential confounders.[36] However, there was significant heterogeneity between studies. In the other review, four out of six studies which reported association between AMR and low income reported positive association.[21] Likewise, five out of nine studies which explored association with education level also reported that lower education is associated with higher risk of AMR.[21]

Area level deprivation / Social status/ Living situation

Many reviews examining association with area level socioeconomic status,[22, 39, 43, 51, 59, 60, 64, 69, 83, 92] deprivation[19, 33, 44, 59, 64, 67, 68, 97] or living situation[21, 30, 32, 41, 43, 64, 65, 69, 75, 78, 81, 87, 91, 92] were included. A meta-analysis of five effect estimates from the UK showed significant association between neighbourhood deprivation and chlamydia infection (combined OR 1.76, 95 % CI: 1.14–1.49).[33] In a

review of TB in South Asian communities in the UK, authors reported that some studies showed significant associations between TB incidence, deprivation, and population density for non-South Asian children, however, there was no significant association observed in the South Asian group.[68] The authors commented that the lack of association observed in the South Asian group may be due to lack of significant variation in deprivation within the group. In another meta-analysis, TB was associated with residing in an urban area (OR 1.52, 95%CI 1.35–1.72).[65] A meta-analysis including datasets from various parts of the world, showed that toxocariasis was associated with being resident in rural areas (OR 1.76, 95% CI 1.35 – 2.31).[81] The prevalence of TB was higher among those living in overcrowded or poor housing conditions.[32] A review also showed evidence that AIDS mortality is significantly associated with lower socioeconomic status.[83] Another review examined the factors associated with the development of recurrent wheezing/asthma after respiratory syncytial virus lower respiratory tract infection (RSV LRTI) in early life.[41] The authors reported that among the children exposed to RSV LRTI in early life, those living in a home environment with moisture damage were more likely to develop asthma (OR 2.9; 95% CI, 1.3–6.3).[41] Poor living conditions were also associated with Group A Streptococcal infection, gastrointestinal infections and meningococcal disease.[19, 30, 67, 75, 78, 87]

Reviewers have noted that association between socioeconomic status with gastrointestinal infection is inconsistent which may be due to variations in pathogens, population studied or poor quality of many of the included studies.[19, 67] For example, in a meta-analysis of the association between socioeconomic status and gastrointestinal infection in developed countries authors reported children from lower socioeconomic status were at higher risk (RR 1.51, 95% CI 1.26 – 1.83) but not adults (RR 0.79, 95% CI 0.58 – 1.06).[19] The authors also reported a higher risk with low socioeconomic status for pathogens that are transmitted from person-to-person (RR 1.65, 95% CI 1.05 – 2.59) but lower risk for environmental pathogens (RR 0.46, 95% CI 0.23-0.91) using foodborne pathogens as the reference group.[19] In another review of the impact of socioeconomic status on foodborne illness in high income countries, the reviewers identified 16 studies which covered four pathogens.[67] Authors reported that high socioeconomic status was associated with illness in the majority of studies that examined E. coli, *Campylobacter*, salmonellosis, and infection but illness was associated with low socioeconomic status in one study of listeriosis.

Area level deprivation, area level socioeconomic status, and living situations have also shown association with vaccination uptake.[22, 39, 43, 44, 51, 59, 60, 64, 69, 91, 92, 97] For example, one of the reviews examined vaccination uptake based on deprivation status and found that those in the most deprived

areas were less likely to be vaccinated compared to those from affluent areas among clinically-at risk groups (such as, those with asthma, age ≥ 65 years, pregnant women among others).[97] This association was reported in the six UK studies included in that subgroup. In one review of factors associated with HPV vaccine uptake, the majority (11 out of 14) of the identified articles reporting association with socioeconomic status or area-level indicators found that those from lower socioeconomic groups had lower HPV vaccine uptake in Europe.[43] However, two UK studies included only showed this association among girls aged 14-16 years and 17-18 years. Lower SES was associated with lower MMR vaccination uptake in a meta-analysis including two UK studies (OR 0.64, 95% CI 0.51–0.80).[91] A similar association was observed in the two UK studies included. In another meta-analysis, high social class was associated with higher seasonal influenza vaccine uptake among older people (OR 1.20, 95% CI 1.06-1.36).[69] The same review also showed that older people living alone were less likely to have seasonal influenza vaccination compared to those who are not living alone (OR 0.70, 95% CI 0.51-0.96).[69] Living in a rural area was associated with incomplete or delayed childhood vaccination.[92] Living in a rural area was also associated with a non-significant decrease in seasonal vaccination uptake in Europe (OR 0.94, 95% CI 0.79–1.11).[69] People from the most deprived areas often had lower vaccine uptake.[43, 44, 51, 59, 64]

Only one of the reviews explored association between AMR and area level deprivation.[21] The reviewers identified four studies which examined the association between social deprivation and AMR (all four studies related to different microorganisms) and only one of the four reported a positive association. The study which reported a positive association was a cohort study conducted among UK residents undergoing coronary artery bypass. Patients from the most deprived neighbourhoods (according to postcode) had a seven-fold higher post-operative MRSA infection rate compared to those from the least deprived areas. However, another UK cohort study included in the same review reported a negative association between socioeconomic status (measured by Jarman score) and resistance to metronidazole (relating to resistant *Helicobacter pylori*) among those undergoing endoscopy. Various factors may have contributed to the inconsistency in findings, such as, differences in the measure of deprivation and microorganisms examined. The reviewers also examined other indicators of deprivation and found that two studies examining the association between AMR and poor water and sanitation both reported positive associations while five out of eight studies examining the association with poor housing and living condition reported a positive association. The evidence suggests that those living in deprived areas or in poor living conditions are at higher risk of AMR.

4. Conclusion

This overview of reviews provides a broad synopsis of three dimensions of inequalities (inclusion health groups, protected characteristics, and socio-economic inequalities) across several infectious disease topics. It syntheses the existing literature by dimension of inequality rather than to focus on each infectious disease individually. We found evidence across several infectious diseases showing that people of specific inclusion health groups and lower socio-economic status are often at higher risk of infectious diseases, AMR, and lower vaccination rates. With regards to the dimension of protected characteristics, ethnicity and sexual orientation appears to be the most consistently reported factors contributing to inequalities. We also identified several evidence gaps which we have highlighted in the evidence matrix (Appendix 2).

Of all the three dimensions of inequalities assessed in this overview of reviews, the evidence relating to people in the inclusion health groups are the most consistent although the volume of evidence identified for each group varied. Most of the reviews identified under this dimension concerned migrants. Several reviews showed higher prevalence of infectious diseases, AMR and lower vaccine uptake among migrants compared to non-migrants. More so, vulnerable migrants (such as refugees, asylum-seekers, and trafficked persons) are at higher risk when compared to general migrants. It is worth noting that the rate varied depending on the country of origin.[27, 63] Pre-migration risk may contribute to higher prevalence among migrants. For example, a review showed higher incidence of TB in post-migration populations, especially among those with higher risk in pre-migration screening compared to the host countries.[27], Evidence also showed that migrants are at higher risk of contracting infectious diseases even post-migration.[54] Although there were only a few reviews identified for other inclusion health groups, the evidence suggests that homelessness is associated with risk of infectious diseases and AMR. Gypsy Roma/ Traveller community are often under vaccinated and are also at greater risk of infectious diseases. People who engage in sex work are more likely to be infected with sexually transmitted diseases.

With regards to protected characteristics, there is a plethora of evidence from reviews showing higher prevalence of infectious diseases and lower levels of vaccination among minority ethnic groups. We also identified several reviews suggesting higher prevalence of infectious diseases and AMR among MSM. These suggest that ethnicity and sexual orientation are important factors to target.

Many reviews examined the association with age, however, the association varied depending on the specific infectious disease or type of vaccination. More so, for most of the reviews, the comparator age groups are often not clearly reported in reviews. For example, some authors reported that the prevalence of STIs peak between age 20 – 35.[18, 33, 35] TB transmission was also found to be associated with younger age.[65, 85] On the other hand, HCV and HEV are more prevalent in older age.[48, 57] Authors also reported that MMR vaccine uptake decreased with child's age[91] and HBV vaccination was associated with younger age.[96] There is evidence of higher prevalence of AMR-NG among those 25 years or older compared to younger adults,[18] while another review showed evidence of MDR TB among those younger than 65 years compared to older people.[42] Therefore, we are not able to identify specific age groups with generally higher risk across various infectious disease topics. Other factors besides equity issues may contribute significantly to associations with age. For example, people in the sexually active age groups are more likely to contract STIs whereas people of older ages, where immunity is weaker, are more likely to get infectious diseases associated with low immunity. Also, vaccinations are often offered at specific ages so it is expected that uptake would be higher among those groups that are targeted. However, it is important to highlight that we found evidence suggesting that childhood vaccination compliance is lower for children of younger mothers/parents.[39, 60, 92]

The association of sex with infectious diseases was also widely reported in reviews but varied depending on the specific infectious disease or type of vaccination. For example, in a meta-analysis of studies from Western Europe, HIV prevalence was slightly higher in women, while HCV was slightly lower in women, but HBV was comparable.[56] Also, there is evidence of higher prevalence of TB and HEV among men compared to women.[24, 57] In another review chlamydia was reported to be higher in women than men.[33] A meta-analysis of studies from Europe suggested that male children are be more likely to be vaccinated.[91] Among elderly people, influenza vaccination uptakes were higher in men, although the differences are not statistically significant in multivariate regression analysis.[64] Review evidence also suggests that when compared to women, men are more likely to have MDR TB[42] and gonorrhoea with reduced susceptibility to ceftriaxone.[18] Based on the findings of this work, sex may be important for some infectious diseases but the gender at higher risk may vary across diseases.

Reviews which assessed association of religion with infectious diseases are focused on vaccination and the findings were inconsistent. Some authors reported that vaccination coverage among

Orthodox Jewish people are similar to the general population, others suggested religious people show lower vaccination acceptance compared with non-religious people while others reported suboptimal compliance was associated with absence of religion. Reviews identified for the association with marital status also focused on vaccination and they reported higher vaccination uptake among those who are married. When compared with the general population, pregnant women had higher risk of HBV in another review while in another review a slightly lower prevalence of HCV was observed among pregnant women though the difference was not statistically significant. One review reported that transgender women sex workers were more likely to have HIV compared to non-transgender women sex workers.[72] None of the identified reviews examined the relationship between disability and the infectious disease topics of interest. As shown, it is not possible to draw a conclusion regarding the association of religion, marital status, disability and pregnancy with infectious diseases based on the findings of this overview of reviews as the evidence is scant and often inconsistent. More evidence is therefore needed to be able to establish the presence and direction of any associations with infectious diseases.

For socioeconomic factors, we identified several reviews providing compelling evidence of higher risk of infectious diseases, AMR and lower vaccination uptake among those with lower level of income, lower educational attainment, unemployment, higher area level deprivation, lower socioeconomic status, and poor living situations. Although the majority of the evidence in this dimension concerns vaccination, it is clear that those of lower socioeconomic status are often at higher risk overall and should be targeted for intervention.

This rapid overview of reviews covered three dimensions of inequalities across several infectious diseases, with particular focus on those highlighted by PHE, and has provided a broad overview of inequalities in infectious diseases. Using a systematic approach, we conducted a comprehensive literature search of four electronic databases with no language limits, and we contacted experts from our networks to identify any articles that may have been missed. The protocol used to guide the conduct of this review was designed a priori. Data extraction was checked by a second reviewer to improve accuracy and quality assessments were performed by two reviewers independently. Due to the timeframe required for the work, we could not complete all the initial titles and abstract screening in duplicate, however, the full texts of potentially relevant reviews were independently screened by two reviewers. Despite our best efforts, we acknowledge that some relevant reviews may have been missed, which is a potential limitation of this project. Also, the lack of synthesised evidence observed in some areas does not necessarily mean a lack of evidence. There may be primary studies

in those areas which have not been synthesised in reviews and meta-analyses. In addition, some underserved populations (such as people who inject drugs and prisoners) are not covered in this overview of review as these are beyond the scope of the work. Notwithstanding, we believe this review provides a broad overview of available evidence relating to inequalities in infectious diseases in developed countries, relevant to the UK, and highlights areas where evidence may be lacking or minimal.

The quality of the included reviews varied significantly as the review included various types of literature review which report all explicit objectives, clear search strategies and eligibility criteria. Therefore, many of the reviews are not necessarily systematic reviews for which AMSTAR2 is designed. Heterogeneity between studies was a limitation reported in many of the included reviews and so pooled estimates should be interpreted with caution. Some reviews reported non-significant findings as well as significant findings, allowing us to bring these into our synthesis- but some reviews did not report non-significance findings obscuring possible trends that may have been apparent during synthesis. It is also worth noting that some of the reviews did not identify UK studies, however, they all included developed countries and therefore provides evidence relevant to UK settings.

Overall, this overview of review evidence highlights specific populations that are consistently at higher risk of infectious diseases, AMR and less likely to be vaccinated. Targeting such high-risk populations will be useful in combatting infectious diseases and reducing health inequalities. The evidence gaps highlighted in this overview of reviews may be considered by policy makers when designing services and policies, and when commissioning future evidence syntheses or primary studies.

References

1. WHO WHO. Human rights and health 2017 [Available from: https://www.who.int/news-room/fact-sheets/detail/human-rights-and-health.
2. Marmot M. Inequalities in health. New England Journal of Medicine. 2001;345(2):134-5.
3. Marmot M, Wilkinson R. Social determinants of health. Oxford2005.
4. Graham H. Social determinants and their unequal distribution: clarifying policy understandings. Milbank Q. 2004;82(1):101-24.
5. House of Parliament. UK Trends in Infectious Disease. In: technology. Poosa, editor. 545 ed2017.
6. Hughes GJ, Gorton R. Inequalities in the incidence of infectious disease in the North East of England: a population-based study. (1469-4409 (Electronic)).
7. PHE PHE. Health protection report, Weekly report.; 2016. Contract No.: 22.
8. Baker EH. Socioeconomic Status, Definition. The Wiley Blackwell Encyclopedia of Health, Illness, Behavior, and Society. 2014:2210-4.
9. PHE PHE. Public Health Matters [Internet]2019. [16th April, 2021]. Available from: https://publichealthmatters.blog.gov.uk/2019/03/22/tackling-tuberculosis-in-under-served-populations/.
10. The Hepatitis C Trust LDAPF. Reducing health inequalities in London by addressing hepatitis C. 2013.
11. Low N, Sterne Ja Fau - Barlow D, Barlow D. Inequalities in rates of gonorrhoea and chlamydia between black ethnic groups in south east London: cross sectional study. (1368-4973 (Print)).
12. CDC CfDCaP. *Vaccines and Preventable Diseases* 2016 [Available from: https://www.cdc.gov/vaccines/vpd/index.html.
13. Fournet N, Mollema L, Ruijs WL, Harmsen IA, Keck F, Dur, et al. Under-vaccinated groups in Europe and their beliefs, attitudes and reasons for non-vaccination; two systematic reviews. BMC Public Health. 2018;18(1):196.
14. Rotheram S, Cooper J, Barr B, Whitehead M. How are inequalities generated in the management and consequences of gastrointestinal infections in the UK? An ethnographic study. Social Science & Medicine. 2021;282:114131.
15. Semenza JC, Giesecke J. Intervening to reduce inequalities in infections in Europe. Am J Public Health. 2008;98(5):787-92.
16. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ. 2017;358:j4008.
17. Stevens A. Putting high-risk under-served populations at the centre of joint efforts to eliminate
Hepatitis B and C, Tuberculosis and HIV and halt the rise in sexually
transmitted infections PHE
Infectious Diseases Strategy 2020-20252020.
18. Abraha M, Egli-Gany D, Low N. Epidemiological, behavioural, and clinical factors associated with antimicrobial-resistant gonorrhoea: a review. F1000Research. 2018;7:400.
19. Adams NL, Rose TC, Hawker J, Violato M, O'Brien SJ, Barr B, et al. Relationship between socioeconomic status and gastrointestinal infections in developed countries: A systematic review and meta-analysis. PLoS ONE [Electronic Resource]. 2018;13(1):e0191633.
20. Aldridge RW, Story A, Hwang SW, Nordentoft M, Luchenski SA, Hartwell G, et al. Morbidity and mortality in homeless individuals, prisoners, sex workers, and individuals with

substance use disorders in high-income countries: a systematic review and meta-analysis. Lancet. 2018;391(10117):241-50.
21. Alividza V, Mariano V, Ahmad R, Charani E, Rawson TM, Holmes AH, et al. Investigating the impact of poverty on colonization and infection with drug-resistant organisms in humans: a systematic review. Infectious Diseases of Poverty. 2018;7(1):76.
22. Arat A, Burstrom B, Ostberg V, Hjern A. Social inequities in vaccination coverage among infants and pre-school children in Europe and Australia - a systematic review. BMC Public Health. 2019;19(1):290.
23. Behera MR, Intarak R. HIV risk among labor migrants: An in-depth study of the literature. Indian Journal of Public Health Research and Development. 2020;9(12):107-15.
24. Beijer U, Wolf A, Fazel S. Prevalence of tuberculosis, hepatitis C virus, and HIV in homeless people: a systematic review and meta-analysis. The Lancet Infectious Diseases. 2012;12(11):859-70.
25. Bocquier A, Ward J, Raude J, Peretti-Watel P, Verger P. Socioeconomic differences in childhood vaccination in developed countries: a systematic review of quantitative studies. Expert Review of Vaccines. 2017;16(11):1107-18.
26. Bonten M, Johnson JR, van den Biggelaar AHJ, Georgalis L, Geurtsen J, de Palacios PI, et al. Epidemiology of Escherichia coli Bacteremia: A Systematic Literature Review. 2021(1537-6591 (Electronic)).
27. Chan IHY, Kaushik N, Dobler CC. Post-migration follow-up of migrants identified to be at increased risk of developing tuberculosis at pre-migration screening: a systematic review and meta-analysis. The Lancet Infectious Diseases. 2017;17(7):770-9.
28. Chen Q, Zeng D, She Y, Lyu Y, Gong X, Feinstein MJ, et al. Different transmission routes and the risk of advanced HIV disease: A systematic review and network meta-analysis of observational studies. EClinicalMedicine. 2019;16:121-8.
29. Chernet A, Utzinger J, Sydow V, Probst-Hensch N, Paris DH, Labhardt ND, et al. Prevalence rates of six selected infectious diseases among African migrants and refugees: a systematic review and meta-analysis. European Journal of Clinical Microbiology & Infectious Diseases. 2018;37(4):605-19.
30. Coffey PM, Ralph AP, Krause VL. The role of social determinants of health in the risk and prevention of group A streptococcal infection, acute rheumatic fever and rheumatic heart disease: A systematic review. Plos Neglected Tropical Diseases. 2018;12(6):22.
31. Colledge S, Leung J, Grebely J, Degenhardt L, Peacock A, Hickman M, et al. Socio-demographic and ecological factors associated with anti-HCV prevalence in people who inject drugs: A systematic review. Drug & Alcohol Dependence. 2020;209:107899.
32. Cormier M, Schwartzman K, N'Diaye DS, Boone CE, Dos Santos AM, Gaspar J, et al. Proximate determinants of tuberculosis in Indigenous peoples worldwide: a systematic review. The Lancet Global Health. 2019;7(1):e68-e80.
33. Crichton J, Hickman M, Campbell R, Batista-Ferrer H, Macleod J. Socioeconomic factors and other sources of variation in the prevalence of genital chlamydia infections: A systematic review and meta-analysis. BMC Public Health. 2015;15:729.
34. De Vito E, Parente P, de Waure C, Poscia A, Ricciardi W. A review of evidence on equitable delivery, access and utilization of immunization services for migrants and refugees in the WHO European Region. WHO Regional Office for Europe WHO Health Evidence Network Synthesis Reports. 2017.
35. Denning DW, Kneale M, Sobel JD, Rautemaa-Richardson R. Global burden of recurrent vulvovaginal candidiasis: a systematic review. The Lancet Infectious Diseases. 2018;18(11):e339-e47.
36. Di Gennaro F, Pizzol D, Cebola B, Stubbs B, Monno L, Saracino A, et al. Social determinants of therapy failure and multi drug resistance among people with tuberculosis: A review. 2017(1873-281X (Electronic)).

37. Eilami O, Nazari A, Dousti M, Sayehmiri F, Ghasemi M. Investigation of HIV/AIDS prevalence and associated risk factors among female sex workers from 2010 to 2017: a meta-analysis study. HIV/AIDS Research and Palliative Care. 2019;11:105-17.
38. Fakoya I, Alvarez-del Arco D, Woode-Owusu M, Monge S, Rivero-Montesdeoca Y, Delpech V, et al. A systematic review of post-migration acquisition of HIV among migrants from countries with generalised HIV epidemics living in Europe: mplications for effectively managing HIV prevention programmes and policy. BMC Public Health. 2015;15:561.
39. Falagas ME, Zarkadoulia E. Factors associated with suboptimal compliance to vaccinations in children in developed countries: a systematic review. 2008(1473-4877 (Electronic)).
40. Falla AM, Ahmad AA, Duffell E, Noori T, Veldhuijzen IK. Estimating the scale of chronic hepatitis C virus infection in the EU/EEA: a focus on migrants from anti-HCV endemic countries. 2018(1471-2334 (Electronic)).
41. Fauroux B, Simoes EAF, Checchia PA, Paes B, Figueras-Aloy J, Manzoni P, et al. The Burden and Long-term Respiratory Morbidity Associated with Respiratory Syncytial Virus Infection in Early Childhood. Infectious Diseases and Therapy. 2017;6(2):173-97.
42. Faustini A, Hall AJ, Perucci CA. Risk factors for multidrug resistant tuberculosis in Europe: a systematic review. Thorax. 2006;61(2):158-63.
43. Fern, ez de Casadevante V, Gil Cuesta J, Cantarero-Arevalo L. Determinants in the Uptake of the Human Papillomavirus Vaccine: A Systematic Review Based on European Studies. Frontiers in Oncology. 2015;5:141.
44. Fisher H, Trotter CL, Audrey S, MacDonald-Wallis K, Hickman M. Inequalities in the uptake of human papillomavirus vaccination: a systematic review and meta-analysis. International Journal of Epidemiology. 2013;42(3):896-908.
45. Forshaw J, Gerver SM, Gill M, Cooper E, Manikam L, Ward H. The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis. BMC Infectious Diseases. 2017;17(1):801.
46. Ghiasv, H, Higgs P, Noroozi M, Ghaedamini Harouni G, Hemmat M, et al. Social and demographical determinants of quality of life in people who live with HIV/AIDS infection: evidence from a meta-analysis. Biodemography & Social Biology. 2019;65(1):57-72.
47. Gorjana R, Chapman J, Flight I, Wilson C. Factors associated with parents' attitudes to the HPV vaccination of their adolescent sons : A systematic review. Preventive Medicine. 2017;95(1):26-37.
48. Greenaway C, Thu Ma A, Kloda LA, Klein M, Cnossen S, Schwarzer G, et al. The Seroprevalence of Hepatitis C Antibodies in Immigrants and Refugees from Intermediate and High Endemic Countries: A Systematic Review and Meta-Analysis. PLoS ONE [Electronic Resource]. 2015;10(11):e0141715.
49. Hahne SJM, Veldhuijzen IK, Wiessing L, Lim TA, Salminen M, van de Laar M. Infection with hepatitis B and C virus in Europe: a systematic review of prevalence and cost-effectiveness of screening. Bmc Infectious Diseases. 2013;13:16.
50. Hermann JS, Featherstone RM, Russell ML, MacDonald SE. Immunization Coverage of Children in Care of the Child Welfare System in High-Income Countries: A Systematic Review. American Journal of Preventive Medicine. 2019;56(2):e55-e63.
51. Jain A, van Hoek AJ, Boccia D, Thomas SL. Lower vaccine uptake amongst older individuals living alone: A systematic review and meta-analysis of social determinants of vaccine uptake. Vaccine. 2017;35(18):2315-28.
52. Jin FY, Dore GJ, Matthews G, Luhmann N, Macdonald V, Bajis S, et al. Prevalence and incidence of hepatitis C virus infection in men who have sex with men: a systematic review and meta-analysis. Lancet Gastroenterology & Hepatology. 2020;6(1):39-56.

53. Kawatsu L Fau - Ishikawa N, Ishikawa N. [Socio-economic factors that influence tuberculosis death among the youth and middle-aged population: a systematic review]. 2014(0022-9776 (Print)).
54. Kentikelenis A, Karanikolos M, Williams G, Mladovsky P, King L, Pharris A, et al. How do economic crises affect migrants' risk of infectious disease? A systematic-narrative review. European Journal of Public Health. 2015;25(6):937-44.
55. Larson HJ, Jarrett C, Eckersberger E, Smith DMD, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: A systematic review of published literature, 2007-2012. Vaccine. 2014;32(19):2150-9.
56. Leung J, Peacock A, Colledge S, Grebely J, Cunningham EB, Hickman M, et al. A Global Meta-analysis of the Prevalence of HIV, Hepatitis C Virus, and Hepatitis B Virus Among People Who Inject Drugs-Do Gender-Based Differences Vary by Country-Level Indicators? Journal of Infectious Diseases. 2019;220(1):78-90.
57. Li P, Liu J, Li Y, Su J, Ma Z, Bramer WM, et al. The global epidemiology of hepatitis E virus infection: A systematic review and meta-analysis. Liver International. 2020;40(7):1516-28.
58. Lindsay L, Wolter J, De Coster I, Van Damme P, Verstraeten T. A decade of norovirus disease risk among older adults in upper-middle and high income countries: a systematic review. BMC Infectious Diseases. 2015;15:425.
59. Lucyk K, Simmonds KA, Lorenzetti DL, Drews SJ, Svenson LW, Russell ML. The association between influenza vaccination and socioeconomic status in high income countries varies by the measure used: a systematic review. BMC Medical Research Methodology. 2019;19(1):153.
60. Malerba V, Costantino C, Napoli G, Marchese V, Casuccio A, Tabacchi G, et al. Antimeningococcal and antipneumococcal vaccination determinants: a European systematic literature review. 2015(1120-9763 (Print)).
61. Millett GA, Peterson Jl Fau - Flores SA, Flores Sa Fau - Hart TA, Hart Ta Fau - Jeffries WLt, Jeffries Wl 4th Fau - Wilson PA, Wilson Pa Fau - Rourke SB, et al. Comparisons of disparities and risks of HIV infection in black and other men who have sex with men in Canada, UK, and USA: a meta-analysis. 2012(1474-547X (Electronic)).
62. Mipatrini D, Stefanelli P, Severoni S, Rezza G. Vaccinations in migrants and refugees: a challenge for European health systems. A systematic review of current scientific evidence. Pathogens and Global Health. 2017;111(2):59-68.
63. Morais S, Costa AR, Ferro A, Lunet N, Peleteiro B. Contemporary migration patterns in the prevalence of Helicobacter pylori infection: A systematic review. Helicobacter. 2017;22(3).
64. Nagata JM, Hern, ez-Ramos I, Kurup AS, Albrecht D, Vivas-Torrealba C, et al. Social determinants of health and seasonal influenza vaccination in adults >=65 years: a systematic review of qualitative and quantitative data. BMC Public Health. 2013;13:388.
65. Nava-Aguilera E, Andersson N, Harris E, Mitchell S, Hamel C, Shea B, et al. Risk factors associated with recent transmission of tuberculosis: systematic review and meta-analysis. International Journal of Tuberculosis and Lung Disease. 2009;13(1):17-26.
66. Nellums LB, Thompson H, Holmes A, Castro-Sanchez E, Otter JA, Norredam M, et al. Antimicrobial resistance among migrants in Europe: a systematic review and meta-analysis. The Lancet Infectious Diseases. 2018;18(7):796-811.
67. Newman KL, Leon JS, Rebolledo PA, Scallan E. The impact of socioeconomic status on foodborne illness in high-income countries: a systematic review. Epidemiology & Infection. 2015;143(12):2473-85.
68. Offer C, Lee A, Humphreys C. Tuberculosis in South Asian communities in the UK: a systematic review of the literature. Journal of Public Health. 2015;38(2):250-7.
69. Okoli GN, Lam OLT, Racovitan F, Reddy VK, Righolt CH, Neilson C, et al. Seasonal influenza vaccination in older people: A systematic review and meta-analysis of the determining factors. Plos One. 2020;15(6):26.

70. Oldenburg CE, Perez-Brumer AG, Reisner SL, Mattie J, Barnighausen T, Mayer KH, et al. Global burden of HIV among men who engage in transactional sex: a systematic review and meta-analysis. PLoS ONE [Electronic Resource]. 2014;9(7):e103549.
71. Oldenburg CE, Perez-Brumer AG, Reisner SL, Mimiaga MJ. Transactional Sex and the HIV Epidemic Among Men Who have Sex with Men (MSM): Results From a Systematic Review and Meta-analysis. AIDS & Behavior. 2015;19(12):2177-83.
72. Operario D, Soma T, Underhill K. Sex work and HIV status among transgender women: systematic review and meta-analysis. Journal of Acquired Immune Deficiency Syndromes: JAIDS. 2008;48(1):97-103.
73. Platt L, Grenfell P, Fletcher A, Sorhaindo A, Jolley E, Rhodes T, et al. Systematic review examining differences in HIV, sexually transmitted infections and health-related harms between migrant and non-migrant female sex workers. Sexually Transmitted Infections. 2013;89(4):311-9.
74. Platt L, Jolley E, Rhodes T, Hope V, Latypov A, Reynolds L, et al. Factors mediating HIV risk among female sex workers in Europe: a systematic review and ecological analysis. BMJ Open. 2013;3(7).
75. Possenti A, Manzano-Román R, Sánchez-Ovejero C, Boufana B, La Torre G, Siles-Lucas M, et al. Potential Risk Factors Associated with Human Cystic Echinococcosis: Systematic Review and Meta-analysis. 2016(1935-2735 (Electronic)).
76. Prost A, Elford J, Imrie J, Petticrew M, Hart GJ. Social, behavioural, and intervention research among people of Sub-Saharan African origin living with HIV in the UK and Europe: literature review and recommendations for intervention. AIDS & Behavior. 2008;12(2):170-94.
77. Pulver A, Ramraj C, Ray JG, O'Campo P, Urquia ML. A scoping review of female disadvantage in health care use among very young children of immigrant families. Social Science & Medicine. 2016;152:50-60.
78. Richterman A, Sainvilien DR, Eberly L, Ivers LC. Individual and Household Risk Factors for Symptomatic Cholera Infection: A Systematic Review and Meta-analysis. 2018(1537-6613 (Electronic)).
79. Rodrigo C, Rajapakse S. HIV, poverty and women. International Health. 2010;2(1):9-16.
80. Rossi C, Shrier I, Marshall L, Cnossen S, Schwartzman K, Klein MB, et al. Seroprevalence of chronic hepatitis B virus infection and prior immunity in immigrants and refugees: a systematic review and meta-analysis. PLoS ONE [Electronic Resource]. 2012;7(9):e44611.
81. Rostami A, Riahi SM, Holl, CV, Taghipour A, Khalili-Fomeshi M, et al. Seroprevalence estimates for toxocariasis in people worldwide: A systematic review and meta-analysis. PLoS Neglected Tropical Diseases [electronic resource]. 2019;13(12):e0007809.
82. Rostami A, Riahi SM, Contopoulos-Ioannidis DG, Gamble HR, Fakhri Y, Shiadeh MN, et al. Acute Toxoplasma infection in pregnant women worldwide: A systematic review and meta-analysis. Plos Neglected Tropical Diseases. 2019;13(10):20.
83. Salgado-Barreira A, Estany-Gestal A, Figueiras A. [Effect of socioeconomic status on mortality in urban areas: a systematic critical review]. Cadernos de Saude Publica. 2014;30(8):1609-21.
84. gren A, Schepisi MS, Sotgiu G, Huitric E, Migliori GB, Manissero D, et al. Tuberculosis transmission between foreign- and native-born populations in the EU/EEA: a systematic review. European Respiratory Journal. 2014;43(4):1159-71.
85. Schepisi MS, Motta I, Dore S, Costa C, Sotgiu G, Girardi E. Tuberculosis transmission among children and adolescents in schools and other congregate settings: a systematic review. New Microbiologica. 2019;41(4):282-90.
86. Schierhout G, McGregor S, Gessain A, Einsiedel L, Martinello M, Kaldor J. Association between HTLV-1 infection and adverse health outcomes: a systematic review and meta-analysis of epidemiological studies. Lancet Infectious Diseases. 2020;20(1):133-43.

87. Spyromitrou-Xioufi P, Tsirigotaki M, Ladomenou F. Risk factors for meningococcal disease in children and adolescents: a systematic review and META-analysis. European Journal of Pediatrics. 2020;179(7):1017-27.
88. Stockdale AJ, Kreuels B, Henrion MYR, Giorgi E, Kyomuhangi I, de Martel C, et al. The global prevalence of hepatitis D virus infection: Systematic review and meta-analysis. Journal of Hepatology. 2020;73(3):523-32.
89. Strifler L, Morris SK, Dang V, Tu HT, Minhas R, Jamieson FB, et al. The health burden of invasive meningococcal disease: A systematic review. Paediatrics and Child Health (Canada). 2016;19:e92.
90. Suhrcke M, Stuckler D, Suk JE, Desai M, Senek M, McKee M, et al. The impact of economic crises on communicable disease transmission and control: a systematic review of the evidence. PLoS ONE [Electronic Resource]. 2011;6(6):e20724.
91. Tabacchi G, Costantino C, Napoli G, Marchese V, Cracchiolo M, Casuccio A, et al. Determinants of European parents' decision on the vaccination of their children against measles, mumps and rubella: A systematic review and meta-analysis. Human vaccines & Immunotherapeutics. 2016;12(7):1909-23.
92. Tauil Mde C, Sato AP, Waldman EA. Factors associated with incomplete or delayed vaccination across countries: A systematic review. 2016(1873-2518 (Electronic)).
93. Tavares AM, Fronteira I, Couto I, Machado D, Viveiros M, Abecasis AB, et al. HIV and tuberculosis co-infection among migrants in Europe: A systematic review on the prevalence, incidence and mortality. PLoS ONE [Electronic Resource]. 2017;12(9):e0185526.
94. Tollefson D, Bloss E, Fanning A, Redd JT, Barker K, McCray E. Burden of tuberculosis in indigenous peoples globally: A systematic review. International Journal of Tuberculosis and Lung Disease. 2013;17(9):1139-50.
95. Van Gerwen O, Muzny C, Austin E, Musgrove K, Jani A. Prevalence of STIs and HIV in transgender women and men: A systematic review. Sexually Transmitted Infections. 2020;95:A335.
96. Vet R, de Wit JB, Das E. Factors associated with hepatitis B vaccination among men who have sex with men: a systematic review of published research. International Journal of STD & AIDS. 2017;28(6):534-42.
97. Vukovic V, Lillini R, Lupi S, Fortunato F, Cicconi M, Matteo G, et al. Identifying people at risk for influenza with low vaccine uptake based on deprivation status: a systematic review. European Journal of Public Health. 2020;30(1):132-41.
98. Wayal S, Aicken CRH, Griffiths C, Blomquist PB, Hughes G, Mercer CH. Understanding the burden of bacterial sexually transmitted infections and Trichomonas vaginalis among black Caribbeans in the United Kingdom: Findings from a systematic review. Plos One. 2018;13(12):19.
99. Yu YJ, Bruna S, McCarty C. HIV Risk among trafficked women: a systematic review of the global literature. Aids Care-Psychological and Socio-Medical Aspects of Aids/Hiv. 2020:11.
100. Zamani M, Ebrahimtabar F, Zamani V, Miller WH, Alizadeh-Navaei R, Shokri-Shirvani J, et al. Systematic review with meta-analysis: the worldwide prevalence of Helicobacter pylori infection. Alimentary Pharmacology and Therapeutics. 2018;47(7):868-76.
101. Millett GA, Jeffries Wl 4th Fau - Peterson JL, Peterson Jl Fau - Malebranche DJ, Malebranche Dj Fau - Lane T, Lane T Fau - Flores SA, Flores Sa Fau - Fenton KA, et al. Common roots: a contextual review of HIV epidemics in black men who have sex with men across the African diaspora. (1474-547X (Electronic)).