Public Health England

Protecting and improving the nation's health

National Immunisation Programme: health equity audit

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Contents

Acronyms used in this report

BAME	Black and minority ethnic
BCG	Bacillus Calmette-Guérin (tuberculosis vaccine)
CHIS	Child Health Information Systems
COVER	Cover of vaccination evaluated rapidly programme
DHSC	Department of Health and Social Care
DTaP	Diphtheria, Tetanus and Pertussis
GP	General Practice or General Practitioner
HEA	Health Equity Audit
Hib	Haemophilus influenzae type B
HPV	Human Papilloma Virus
IPV	Inactivated Polio Vaccine
JCVI	Joint Committee on Vaccination and Immunisation
LA	Local Authority
LAC	Looked After Children
MenACWY	Meningitis A, C, W, Y
MenB	Meningitis B
MMR	Measles Mumps and Rubella
MSM	Men who have sex with men
NEET	Not in employment, education, or training
NHS	National Health Service
PHE	Public Health England
PHOG	Public Health Outcomes Group
PPV	Pneumococcal Polysaccharide Vaccine
SEM	Social ecological model
SES	Socio-economic status
SIT	Screening and Immunisation Team
TIP	Tailoring Immunization Programmes

Main points

Background

Health inequalities are systematic differences in health status or in the distribution of health resources between different population groups that are unfair or avoidable. NHS England and PHE have a remit in law to reduce health inequalities, and to promote equality of opportunity.

Equality in immunisation is an important way to address health inequalities. Ensuring that coverage is not only high overall, but also within underserved communities is also essential for disease control and elimination strategies.

Audit findings

The Immunisation Programme has achieved high coverage overall in the population. However, we have demonstrated that avoidable inequalities in vaccination still exist within some population groups.

Inequalities in immunisation for a given population group can be complex to describe and may vary between areas

Community, institutional, and policy factors, as well as the health beliefs and knowledge of individuals and within families may lead to inequalities in vaccination.

There are limitations in terms of available data and evidence to describe and monitor the situation, and to explain why inequalities may have occurred.

Recommendations

We have made recommendations to develop a national vaccinations inequality strategy, and provide a template local action plan to enable best practice; share new practice and evaluation findings between stakeholders to develop the evidence base; develop locally relevant data and intelligence resources to support needs assessment; use existing data sources to develop a routine report to monitor inequalities in routine vaccination coverage for key indicators, at national and regional level; continue national level leadership and support to address inequalities

Executive summary

Background

Health inequalities are systematic differences in health status or in the distribution of health resources between different population groups that are unfair or avoidable. Health inequalities in England exist across a range of dimensions or characteristics, including some of the nine protected characteristics of the Equality Act 2010, socioeconomic position and geography. Both NHS England and PHE have a remit in law to reduce health inequalities, and to promote equality of opportunity.

Immunisation is one of the most cost-effective public health interventions. Childhood immunisation in particular helps to prevent disease and promote child health from infancy, creating opportunities for children to thrive and get the best start in life. Equality in immunisation is an important way to address health inequalities. Ensuring that coverage is not only high overall, but also within underserved communities is also essential for disease control and elimination strategies.

The core service specification for the National Immunisation Programme drawn up between NHS England and PHE recommends a Health Equity Impact Assessment (or audit) for commissioning and review of immunisation programmes

Objectives

The objectives of this audit were to:

- describe how the national immunisation programme identifies and addresses inequalities
- describe the areas and extent of inequalities in vaccine coverage
- identify evidence gaps for areas where inequalities have not yet been adequately estimated
- identify how inequalities in vaccination uptake may arise, to inform a framework for action

We used a combination of vaccination coverage data from routine sources, as well as a review of peer-reviewed literature relevant to the England programme to audit all routine immunisations (excluding influenza) offered as at 1 September 2017.

Audit findings

We demonstrated that the National Immunisation Programme works to identify and address inequalities. There are dedicated systems for data collection, and there is specific research into inequalities. The programme has achieved high coverage overall in the population. However, we have demonstrated that avoidable inequalities in vaccination still exist within some population groups.

Inequalities for a given group can vary in extent in different immunisation programmes. Additionally, inequalities for a given group may be larger or smaller in different parts of the country, or when individuals belong to more than one group at a time that may experience inequalities.

We have also demonstrated that community, institutional, and policy factors, as well as the health beliefs and knowledge of individuals and within families may lead to inequalities in vaccination. Finally, we have identified limitations in terms of available data and evidence to describe and monitor the situation, and to explain why inequalities may have occurred.

Recommendations (in brief)

1. Develop a national vaccinations inequality strategy, and provide a template local action plan to enable best practice.
2. Share new practice and evaluation findings between stakeholders to develop the evidence base.
3. Develop locally relevant data and intelligence resources to support needs assessment, for example by collaborating with other organisations to link data to better characterise inequalities.
4. Use existing data sources to develop a routine report to monitor inequalities in routine vaccination coverage for key indicators, at national and regional level.
5. Continue national level leadership and support to address inequalities.

1. Introduction

Immunisation is one of the most successful public health interventions, allowing the prevention and mitigation of disease in millions of people every year. Immunisation reduces morbidity and mortality, and is highly cost-effective, even cost-saving. By preventing the transmission of communicable disease, immunisation not only benefits the vaccinated individual but also those who are unvaccinated by means of the herd effect. Immunisation has enabled the global eradication of smallpox, and the elimination of once-common childhood diseases like measles and rubella from some regions of the world.

The National Immunisation Programme

Programme content and structure

The National Immunisation Programme provides protection from 19 diseases to the population across the life course. Most vaccines in the programme are offered to everyone in a particular age group, while others, such as the tuberculosis vaccine Bacillus Calmette-Guérin (BCG), are targeted to high risk groups. As of Spring 2019, there were 14 universal and 5 selective vaccines; the most recent immunisation schedule can be found here https://www.gov.uk/government/publications/the-complete-routine-immunisation-schedule

Vaccination programme policy

The Joint Committee on Vaccination and Immunisation (JCVI) is the independent statutory Departmental Expert Committee that advises the Secretary of State for Health on the provision of vaccination and immunisation services.

The JCVI considers the epidemiology of the disease, vaccine efficacy, safety, impact and cost-effectiveness, and makes recommendations regarding immunisation strategy to the Department of Health and Social Care (DHSC). These recommendations include whether vaccines should be adopted nationally, which population groups should receive vaccination, and what dosage schedules are appropriate. The JCVI also identifies areas for further research, and considers new evidence as it arises.

Programme delivery

Immunisation services are commissioned by National Health Service (NHS) England, and provided mostly by general practices, local immunisation teams and pharmacists. Public Health England (PHE) Screening and Immunisation Teams (SITs) within NHS England support local implementation. PHE also provides national guidance and standards, based on JCVI recommendations, along with surveillance and analysis of coverage. Local Authority Directors of Public Health have a scrutiny function over the local delivery of the immunisation programme.

The immunisation programme is mainly delivered through primary care. Some programmes receive support from specialist services, for example maternity services supporting the delivery of prenatal immunisations. The adolescent immunisation programmes are school-based.

Vaccine coverage data and programme evaluation

Vaccine coverage data are used for the national evaluation of vaccine programme delivery and the assessment of overall population protection [1]. Child Health Information Systems (CHIS) local population registers are used as data sources to estimate coverage for routine and selective childhood vaccinations as part of the as part of the Cover of vaccination evaluated rapidly (COVER) programme [2]. For most newer vaccine programmes and for those targeting people older than 5 years PHE extracts vaccination and population data directly from general practice systems using ImmForm, an online platform[1]. COVER and ImmForm are specifically designed to capture data on vaccine coverage at national, regional and local levels. Results are routinely analysed, with quarterly and annual reporting. ImmForm coverage data can be aggregated by certain population characteristics, for instance ethnicity, gender or co-morbidity, but information is dependent on data quality in the general practice record.

Vaccine coverage data are also used, in conjunction with disease incidence data, to estimate vaccines' effectiveness and impact, and in making policy decisions [3], for example the herpes zoster (shingles) vaccine programme was evaluated in 2017 [4].

Health equality in England

Health inequalities

Health inequalities[1] in England exist across a range of dimensions or characteristics, including some of the nine protected characteristics of the Equality Act 2010, socioeconomic position and geography [5].

Some types of health inequality – sometimes referred to as health inequities – are differences in health or distribution of health resources that are unfair or avoidable [6]. At the same time, some 'health inequalities' – for example, the selective vaccination programmes described above – are not necessarily considered to be inequitable programmes, even though they are not offered to the entire population equally; that is because the differences in eligibility can be justified. With limited resources, it is not justifiable to vaccinate the entire population against each vaccine-preventable disease, and so the balance of risk and benefit is carefully considered when deciding which groups should receive vaccine.

Equality legislation

There is a requirement under the Public Sector Equality Duty section of the Equality Act 2010 for all public authorities to promote equality of opportunity; to prevent discrimination, harassment and victimisation, and to foster good relations between the different protected characteristics groups. Additionally, under the Health and Social Care Act 2012, both NHS England and PHE have a remit to reduce health inequalities. PHE's Health Equity Board provides senior leadership governance for PHE's fulfilment of the equality duty and our legal duties on health inequalities from the Health and Social Care Act 2012, and approve equality objectives to ensure the promotion of equality and fairness in all PHE business [7].

Equality duties and immunisation

Specifically for immunisations, NHS England has a legal duty to offer immunisation to 'hard to reach groups, for example gypsy traveller children or looked after children, who may require special and specific arrangements;' and people 'moving into the country from abroad who have incomplete or unknown vaccination status.' The core service specification for the National Immunisation Programme drawn up between NHS

1. Frequently, outside of Britain the term 'health inequality' simply refers to systematic differences in health/healthcare provision. When inequalities are judged to be unfair or avoidable, they may be referred to as health inequities. In Britain, health inequities are instead referred to as health inequalities(Whitehead et al. 2005) with the same connotations of unfairness and injustice, and we will use this terminology in this report.

England and PHE has reduction in health inequalities as a key objective in delivery of the programme [8]. Exclusion of people with protected characteristics should be subject to careful scrutiny and justification. Providers should be able to show that services have no barriers to access for groups defined by the Equality Act 2010, and must optimise access for underserved populations. Local contracts are required to address reduction in variation across communities and population groups. SITs, local authorities and providers must identify and address inqualities at local level.

The importance of equitable immunisation

Immunisation is one of the most cost-effective public health interventions. High immunisation rates are key to preventing the spread of infectious disease, complications and possible early death among individuals. Childhood immunisation in particular helps to prevent disease and promote child health from infancy, creating opportunities for children to thrive and get the best start in life. Giving every child the best start in life is recognised as a key intervention to narrow health inequalities [9], and reducing inequalities in immunisation coverage should allow everyone to have the same opportunities to lead a healthy life, in all age groups.

Groups with a higher risk of disease, or more severe disease, benefit even more from vaccination; ensuring high coverage in these groups can narrow inequality in disease outcomes. Examples of varied disease burden include greater pertussis morbidity and mortality in female than male infants less than 2 months of age [10], more pertussis deaths in infants of Black and Minority Ethnic (BAME) groups [10], and Hib being significantly higher in Asian than White groups in North East Thames before the introduction of the Hib vaccine [11]. The prenatal pertussis programme and the dramatically successful Hib vaccination programme [11] should contribute to reducing these inequalities in disease burden.

Herd immunity, the indirect protection of non-immune individuals from infection due to interruption of disease transmission by immune (vaccinated) members of their surrounding population, extends the benefits of the national immunisation programme to unvaccinated individuals. Therefore, herd protection intrinsically reduces disease inequalities arising from for example, unequal healthcare access or when individuals cannot receive vaccination for medical reasons. However, the extent of this protective effect will depend on population mixing patterns, and requires a threshold level of coverage, which varies according to the infection. For example, 93-95% coverage of a measles containing vaccine is required to stop the transmission of measles which could lead to an outbreak [12]. If unvaccinated individuals are clustered in specific groups this will lower coverage and decrease herd immunity, making outbreaks more likely in these groups, and threatening transmission to the wider non-immune population.Therefore ensuring that coverage is not only high overall, but also within underserved communities is essential for disease control and elimination strategies [13]. In addition,

some vaccines such as tetanus or shingles offer direct protection only, therefore indviduals only benefit from these vaccines if they are themselves vaccinated.

Purpose and scope of the audit

The core service specification for the National Immunisation Programme drawn up between NHS England and PHE recommends a Health Equity Impact Assessment (or audit) for commissioning and review of immunisation programmes.

The objectives of this audit were to:

- describe how the national immunisation programme identifies and addresses inequalities
- describe the areas and extent of inequalities in vaccine coverage;
- identify evidence gaps for areas where inequalities have not yet been adequately estimated
- identify how inequalities in vaccination uptake may arise, to inform a framework for action

Scope of the audit

The audit covered all routine immunisations as at 1 September 2017. Selective immunisations and vaccines for individuals with underlying medical conditions were excluded. We do note however that targeted or selective immunisation programmes can be used to narrow a health inequality. For example, compared to heterosexual men, men who have sex with men (MSM) have higher rates of human papillomavirus (HPV) infection and HPV-related disease. Evidence suggested MSM receive little indirect benefit from a vaccination programme that only targets girls, therefore opportunistic HPV vaccination for MSM was piloted in sexual health clinics (SHC) in England between 2016 and 2018 [14].

The influenza immunisation programme is managed separately from the rest of the national immunisation programme, and therefore was not included in this audit.

The audit considered the following measures of under-vaccination within a population: overall vaccine coverage, delayed vaccination, and completion of vaccine schedules. A range of population characteristics thought to be associated with inequality were considered.

For the purposes of this report, the following dimensions or characteristics across which health inequalities may exist were taken accouont of:

- age
- gender
- geography including rural/urban split

- socio-economic status (SES) including deprivation, employment, income and occupational status, educational attainment
- ethnic origin
- religion
- disability and health status including learning and physical disabilities, mental and chronic physical illnesses
- underserved groups including travellers, migrants, prisoners, looked after children (LAC), homeless
- parental factors including lone parents, family size, parental age, parental illness
- sexual orientation
- gender re-assignment

Methods

Please see the appendix for a description of the data sources and methods used to prepare this report.

2. Inequalities in vaccination coverage

How the National Programme identifies and addresses inequalities

The UK National Immunisation Programme is a global leader in surveillance of vaccine coverage, identification of inequalities, and initiatives to target and minimise inequalities in coverage and disease incidence. This section briefly describes how inequalities are identified, and some of the structures and initiatives in place to tackle them.

Identifying and monitoring inequalities in vaccination coverage

Routine coverage monitoring data collated by COVER and ImmForm are periodically analysed, and the analyses include recommendations on how to reduce the inequalities that are identified. However, PHE does not routinely publish an inequalities in immunisations coverage monitoring report, which could be used to more conveniently quantify and monitor trends in inequalities in coverage for a range of immunisation programmes. Inequalities are also specifically investigated through research and service evaluations designed to answer specific questions regarding inequalities in vaccine uptake. These are undertaken at the national and local level by a number of agencies. PHE, Health Protection Research Units (PHE-academia collaborative teams), SITs and Local Authorities are all engaged to determine the extent of inequalities nationally and locally. For example, the Tailoring Immunization Programmes (TIP) approach has been used to undertake epidemiological analysis in the Charedi Jewish community of North London [15], and inequalities in timeliness of receiving vaccines has been investigated [16].

Addressing inequalities in vaccination coverage

System leadership

Reduction in health inequalities is a key objective in delivery of the vaccination programme. For this reason a tripartite technical group, comprising representation from PHE, NHS England, and DHSC was formed to focus on this issue. The group also has vaccination provider, local authority, and academic representation.

The group brings relevant stakeholders together to:

- coordinate and support existing inequalities work streams
- identify the key priority areas for action in terms of programmes, geographical areas and or specific protected characteristics and communicate this to commissioners and providers
- identify gaps in the understanding of inequalities which would benefit from further research

The aim of the group is to:

- provide national level guidance and evidence for commissioners and providers discharging their duties
- inform commissioning decisions by the appropriate governance bodies such as Public Health Oversight Group (PHOG) who are responsible for assurance for the national immunisation programme
- inform relevant policy decisions by the Department of Health

Supporting underserved groups and disadvantaged communities

PHE works in partnership with NHS England local teams and Directors of Public Health to ensure that local population needs are understood and addressed by local immunisation services. Screening and Immunisation Teams are responsible for identifying areas of inequalities and work closely with providers, Local Authorities and primary care to address inequalities in uptake and coverage across communities through strategies to increase access, information and choice for disadvantaged communities.

For example, there is specific work being undertaken with Orthodox Jewish groups [15] and Eastern European communities [17] to determine and address the specific barriers to accessing vaccination within these communities with low coverage and higher outbreak risk.

Inequalities in vaccine coverage

The following section will set out the evidence showing where inequalities in coverage exist for various population characteristics. The possible reasons for these inequalities, and an action framework to address them will be discussed in the next section.

Age

Evidence from the UK school-based programmes (Influenza, HPV and MenACWY vaccines) is clear that there is a correlation between the age that children and young people are offered the vaccine and vaccine coverage: the earlier a vaccine is offered, the greater the completion and coverage [18]. A study of 13 to 19 year old women

attending Sexual Health Services across England found that offer, acceptance and completion levels for HPV were lower in 17 to 19 year olds [19]. This was also seen in MenACWY vaccine uptake among first-year undergraduates at a Liverpool university [20], with younger individuals more likely to receive the vaccine.

Vaccine coverage data quality is less complete in older individuals, particularly those born before 2000. This potentially masks inequalities as it is difficult to ascertain whether low coverage in these older individuals represents data issues or under-immunisation. This is particularly true for adults born abroad, who are less likely to be vaccinated compared with British born individuals of the same age, and for whom vaccine coverage is not well captured [21].

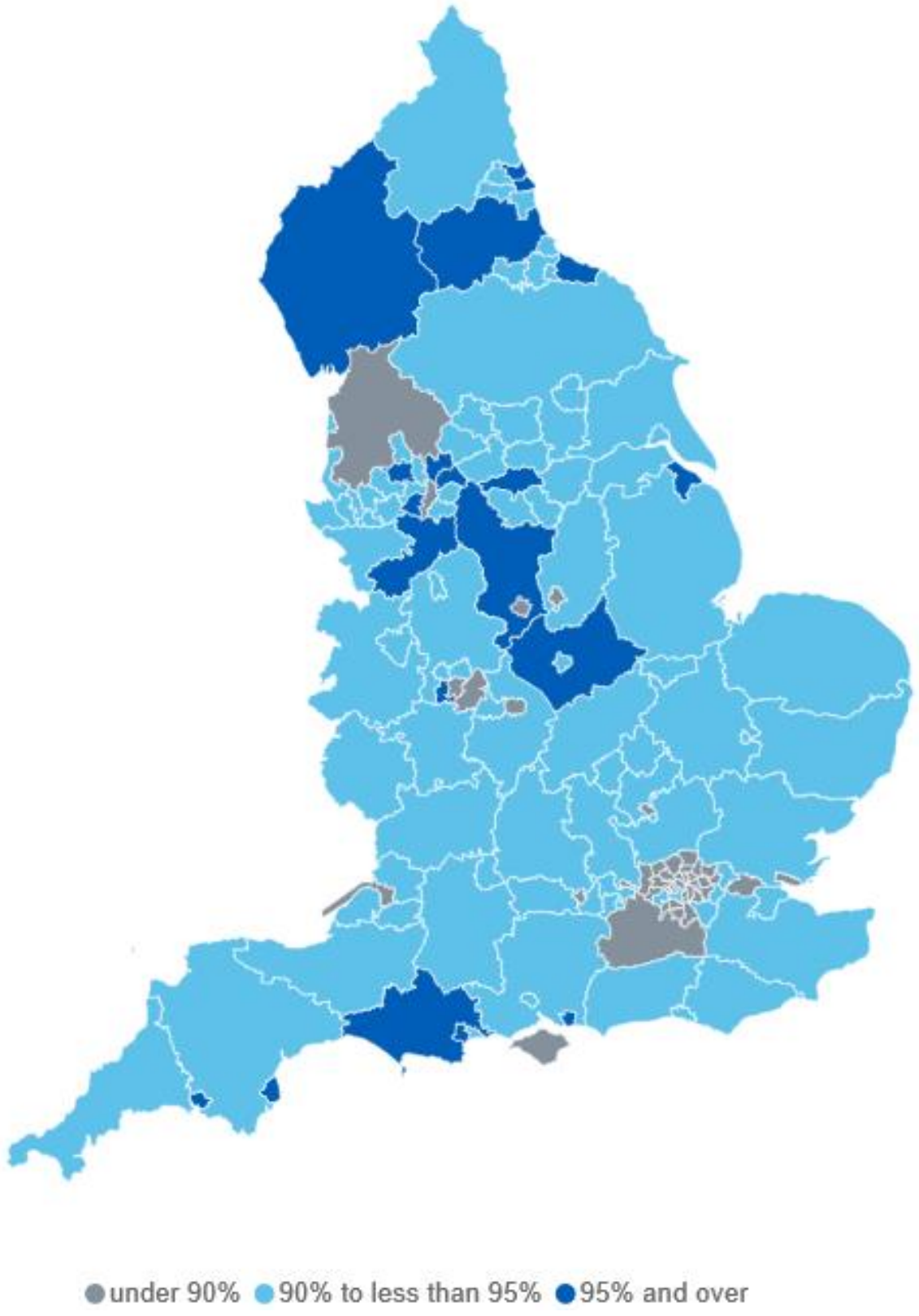
Gender

Routine monitoring of vaccine coverage of the childhood programme reveals that there are only small gender differences in uptake. For example, MenB coverage at 52 weeks (2 doses) is 93.5% in females and 92.5% in males. In the adult programmes, shingles vaccine uptake has a small gender difference. It is 45.8% for females and 44.8% for males in the routine cohort for the year to August 2017.

Geography

Local Authority level variation in coverage for each of the routine early years and school-based immunisations is detailed in the appendix Tables A2 and A3. Overall, vaccine coverage measured at age 2 years in England is high, being at or near to 95% for the uptake of primary vaccinations. However, coverage varies significantly between geographical areas. At the regional level, London and the South East tend to have the lowest coverage for most childhood vaccines and HPV, and the North East the highest. For all vaccines, only a minority of local authorities achieve coverage of less than 90%. Performance varies with vaccine type, and worsens for booster doses. These figures highlight geographical inequalities in terms of vaccine timeliness as well as uptake. Geographical inequality also exists for the adult programmes, as shown in Table A4 in the appendix. Map 1 below illustrates the typical regional differences seen in the childhood programmes, using the MMR programme as an example.

Map 1. MMR 1 coverage at age 2 years by local authority, England 2017 to 2018



Source: NHS Digital Childhood Vaccination Statistics dashboard

Rural – Urban effect

Vaccine coverage by Local Authority varies according to the whether the area is predominantly urban, urban with significant rurality, or predominantly rural. This is shown in Table 1 below. Compared to predominantly urban areas, vaccine coverage in urban with significant rural, and predominantly rural areas is consistently higher.

Table 1. Percentage vaccine coverage by local authority rural/urban status, England 2016 to 2017

Programme	Predominant Urban	Urban with Significant Rural	Predominant Rural
DTap/IPV/Hib at 12 months	92.9	95.6	94.5
DTaP/IPV/Hib at 5 years	95.3	97.0	96.9
MMR 1 dose at 24 months	90.6	94.1	94.1
MMR 2 doses at 5 years	86.5	90.9	90.8
HPV 1 dose by Year 9	88.4	91.3	89.5

Socioeconomic status

Socioeconomic status can be assessed using a variety of indicators including at the area level (typically done using the Index of Multiple Deprivation (IMD) 2015 in England)[2], and individual level indicators such as by the occupation, or by the educational attainment of parents.

We used published routine coverage data[3] (2016 to 2017 and 2017 to 2018 financial year) to compare population coverage for each of the primary childhood immunisations (where data was available), HPV, and PPV and shingles adult immunisation programmes stratified by decile of IMD[4].
These data showed that, for the age groups by which vaccination is recommended in the national schedule, 2017 to 2018 coverage in the least deprived population decile was 1-2% higher than in the national average.

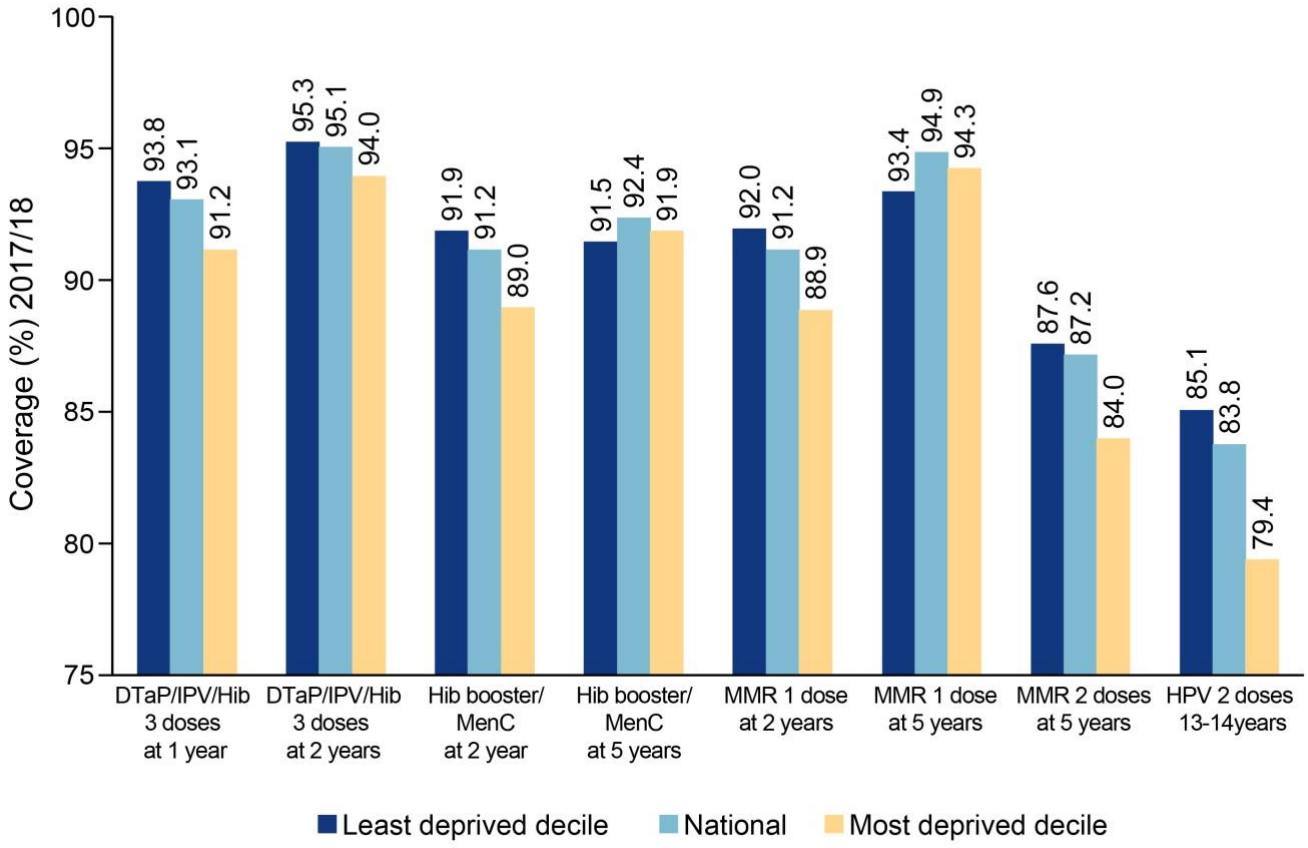
[2] The Index of Multiple Deprivation (IMD) combines information from seven domains to produce an overall relative measure of deprivation for a particular area. The domains are combined using the following weights: Income Deprivation (22.5%); Employment Deprivation (22.5%); Education, Skills and Training Deprivation (13.5%); Health Deprivation and Disability (13.5%); Crime (9.3%); Barriers to Housing and Services (9.3%); Living Environment Deprivation (9.3%)
[3] Available from https://fingertips.phe.org.uk/profile/health-protection/data#page/0/gid/1938132804/pat/6/par/E12000008/ati/102/are/E10000025/iid/92324/age/99/sex/4
[4] From fingertips data source: deprivation deciles were defined using the Index of Multiple Deprivation 2015 local authority scores. They were created by ranking upper tier local authorities in England from most to least deprived and dividing these into ten categories with approximately equal numbers of local authorities in each

There were greater gaps (up to 5.7%) in coverage when compared to the most deprived decile (see chart 1 below). The greatest absolute inequality in coverage was seen for vaccinations after infancy: HPV 2 doses at 13 to 14 years (5.7%), and MMR 2 doses by 5 years (3.6%). Data for shingles and PPV (excluded from chart 1 due to their much lower coverage) showed the same gradient (PPV coverage in 65 years and older national average 69.5%, most deprived 68.4%, least deprived 70.9%, absolute inequality 2.5%; shingles coverage at age 70 years national average 44.4%, most deprived 41.0%, least deprived 46.4%, absolute inequality 5.4%).

When we reviewed childhood immunisation coverage at ages above that when immunisation is recommended by the national schedule (i.e. 5-in-1 at 2 years of age, MMR 1 at 5 years of age, Hib booster/MenC at 5 years), which assess how well children who missed vaccination catch up, the gradient in coverage was now absent (MMR 1, Hib booster/MenC), or smaller (5-in-1).

In summary, there were delays in achieving equitable coverage for the primary immunisations analysed, particularly immunisations initiated after infancy, and for the 5-in-1 vaccine coverage remained inequitable despite the opportunity to catch up. However, coverage overall was high, and in the context of wider inequalities differences between most and least deprived deciles were relatively small. These results are based on national averages and may not represent the situation at a more local level, where inequalities may be more or less pronounced.

Chart 1. Immunisation coverage nationally, and in the least- and most- deprived population decile for routine childhood and HPV immunisation programmes with data available, England 2017 to 2018



Source: PHE Fingertips Health Protection Profiles

Immunisation coverage declined by up to 0.4% for 7/9 programme coverage indicators between 2016 to 2017 and 2017 to 2018 except for HPV at age 13 to 14 years, and the 5-in-1 at age 2 years (see table 2). In the least deprived decile coverage decreased for 3/9 indicators and increased in 5/9, whereas in the most deprived decile coverage decreased for 8/9 indicators and falls were greater than the national average. Thus, though falls in coverage were seen nationally across most programmes, they were larger in the most deprived compared to the average, whilst coverage was more likely to have *increased* in the least deprived (except for HPV), widening inequalities compared to 2016 to 2017. Further analysis is required to place these findings in the context of longer term trends in coverage for more and less deprived populations.

Table 2. Changes in national immunisation programme coverage, and for the least and most-deprived population decile, England 2016 to 2017-2017 to 2018

Immunisation and age group	Change in coverage (%) from 2016 to 2017 and 2017 to 2018		
	National	Least deprived decile	Most deprived decile
DTaP/IPV/Hib 3 doses at 1 year	-0.3	0	-0.4
DTaP/IPV/Hib 3 doses at 2 years	0	0.8	-0.5
Hib booster/MenC at 2 year	-0.3	0.3	-1
Hib booster/MenC at 5 years	-0.2	-0.2	-0.8
MMR 1 dose at 2 years	-0.4	0.3	-1.5
MMR 1 dose at 5 years	-0.1	0.7	-1
MMR 2 doses at 5 years	-0.4	0.3	-1.8
HPV 2 doses 13 to 14 years	0.7	-1.3	2.9
PPV at age 65+	-0.3	-0.1	-0.5

*A change in eligibility criteria for shingles vaccine in 2017 to 2018 precludes comparison with 2016 to 2017

Literature review evidence showed that, in general, lower socioeconomic status was associated with lower coverage, as well as later attainment of vaccination, and completion of primary and booster courses (see table 3 below). However, the relationship was not straightforward and could vary by SES indicator, coverage indicator, ethnicity, vaccine programme, age of delivery, and over time. Interpretation was also complicated due to varying geographic locations, level of analysis (individual versus area-level), and more or less complete adjustment for other potential explanatory factors. Evidence from the literature review was not located for all vaccination programmes.

Table 3. Relationship between indicators of socioeconomic status and vaccination coverage indicators, by immunisation programme on literature review

Vaccine Programme	SES indicator	Relationship between vaccination coverage indicators and lower SES (ref)
Rotavirus	Area-level deprivation	Lower coverage [22]
Shingles	Area-level deprivation	Lower coverage [23, 24]
DTaP/IPV	Area-level deprivation	Lower coverage [25]; ethnicity dependent lower coverage[α] [26]
Primary vaccines (2,3,4 months)	Area-level deprivation	Lower coverage (i.e. partially immunised) [27]
	Parental education	Higher coverage (unimmunised) [27]
MMR	Area-level deprivation	Neutral or lower coverage; MMR 1 delayed in Scotland [25], [28], [29]
	Unemployment	Lower coverage* [30]
	Parental occupation	Higher coverage [31]
	Parental education	Higher coverage [30], [31], [27]
HPV	Area-level deprivation	Neutral or lower coverage in school; lower after school; lower for completion of full course [32], [33], [34], [35], [36]
	Unemployment	Lower coverage** [19]
	Parental occupation	Higher coverage [37]
	Parental education	Higher coverage [37]

*[α] in this London study, increasing deprivation was only associated with lower vaccination uptake in children of white-British ethnicity; *maternal unemployment; **for women not in employment, education, or training (NEET)*

Ethnic origin

For the routine childhood vaccinations there was no simple relationship between ethnicity and coverage (see table 4 below). The relationship could vary by immunisation programme, and by area. However, coverage did appear to be more consistently lower than White-British children in certain ethnic groups, for example Black Caribbean, Somali, White Irish and White Polish populations. Some ethnic groups, notably South Asian ethnicities, tended to enjoy similar or higher vaccination coverage than White children. For MMR these relationships were less consistent, in that coverage in children of White ethnicity could be lower or the same as other non-White groups, thought to perhaps reflect differences with respect to awareness of the MMR controversy [38]. For HPV, lower indicators of coverage were consistently seen for non-White ethnic groups. Where both factors were adjusted for, deprivation was typically less of an influential determinant of vaccination than ethnic group.

Table 4. Relationship between ethnicity and vaccination coverage, by immunisation programme on literature review

Immunisation Programme	Ethnic group	Relationship between ethnicity and coverage indicator(s) compared to White-British reference group [citation(s)]
5-in-1	Smaller ethnic groups[α]	Lower coverage [26]*
	Somali and Bangladeshi	Lower 3-dose completeness at 6 months[16]*
	Polish, Somali and Caribbean	Less likely to have pre-school booster [16]*
Primary vaccines (2,3,4 months)	Black Caribbean	Lower coverage (unimmunised) [27]**
	Pakistani, Black African	Higher coverage (fully immunised) [27]**
Rotavirus	White-Irish, Black Caribbean and 'other' ethnicities	Lower coverage and completion [22]**
MMR 1	Asian and Afro-Caribbean	Higher coverage [38]*
	Afro-Caribbean and Somali, White	Lower coverage (Asian reference) [39]*
	Non-white	No relationship [28]**
(Rubella immunity in pregnancy)	Non-white (especially South Asian, Oriental place of birth)	Lower prevalence of immunity [40]*
HPV	Non-white	Lower coverage [37]**
	Black or 'other' ethnicity	Lower completion or catch-up [41]*
	Ethnic minority	Lower coverage [32]**
	Asian, Black and Other ethnic minority	Lower initiation [33]**
	Asian/British Asian, Black/British Black, Chinese	Lower initiation [35]**
Shingles	Mixed: White and Black African, Black – Other	Lower coverage [23]**
	Non-white ethnicities	Lower coverage [24]**

*Study setting in London; [α] Example ethnic groups with generally lower coverage included Somali, White-Polish, Nigerian, Caribbean, White-Irish, and other/mixed/unspecified ethnic populations; **England or UK-wide, or non-London study or sample;

Religion

A small amount of evidence exists for inequalities in vaccination coverage by religious affiliation, mainly in Orthodox Jewish communities. An analysis of 5-in-1 and MMR vaccination coverage in the London Borough of Hackney showed a much lower coverage in a children's centre area serving the majority of the borough's Charedi Orthodox Jews [15]. Inequality for other religious groups is less clear. For example HPV vaccination of girls in London schools was not associated with religious affiliation after adjusting for ethnicity, and a study in South East England further education colleges showed girls with no religious affiliation were less likely to have received the catch-up HPV vaccine than those of Christian faith [41]. A national-level study suggested that, compared with schools of no religious character, Muslim and Jewish schools achieved lower coverage for HPV but not for MenACWY [18].

Disability and health status

Learning disability

Children with learning disability were less likely to be fully immunised than their peers in the general population. A study of children at special schools for severe learning or physical disabilities in Bath found that 59% were fully immunised for their age, compared to 83% of controls. This was significant for pertussis, measles and rubella [42]. An analysis of immunisation uptake in children with learning disabilities from the Millennium Cohort Study showed that they were significantly less likely to have received any or all of the recommended vaccines at age 9 months, or to have completed pertussis and Hib vaccination by age 3. However, they were more likely to have received BCG by age 3 and age 5 [43].

Physical disability

No data could be found relating to vaccine coverage in UK children or adults with physical disability. A study of children in Saskatchewan, Canada with physical disabilities showed a 63% vaccination coverage compared to 80% to 93% in the general child population [44].

Chronic physical illness

There were very few studies located regarding the impact of chronic physical illness on vaccine uptake. Chronic illness in children within the family was associated with lower immunisation uptake for measles and pertussis [45], but this was not specific to only the child with the chronic illness, and included the siblings. For adults, using nursing home residence as a proxy indicator of illness, PPV coverage among Scottish nursing home residents in 2001 was a mean of 11%, falling to <5% in the vast majority of individual

homes [46]. In one UK study, older adults living in care homes had a 46% lower shingles vaccination uptake than non-residents during 2013 to 2015 [24].

Other under-vaccinated groups

Inadequate vaccine coverage in under-vaccinated groups is often demonstrated by outbreaks among these communities. There have been measles outbreaks in Europe between 2005 and 2008 in Roma & Sinti, Traveller, and Steiner communities [47]. A UK-wide measles outbreak occurred among Steiner communities in 1999 [48], while outbreaks of measles in traveller communities are well documented [49-51].

Travellers

It is difficult to determine vaccination coverage levels in traveller populations, as many may face barriers to engagement with health services [52]. Estimated uptake rates for MMR and polio vaccines among Gypsy Travellers in 2010 suggested far lower rates than in the England population; possibly below 50% in some areas [53]. Recent work at traveller sites in the West Midlands to determine MMR coverage in children up to 15 years of age showed total coverage of 71.1%, with coverage in 1-3.5 year olds of 60.6% and coverage in 3.5-15 year olds of 73.9% (Ash Banerjee, PHE, private communication).

Migrants

Migrant communities also exhibit more outbreaks of vaccine-preventable disease, suggesting inadequate coverage. In a recent measles outbreak in West Yorkshire, there were more cases in areas with a higher density of new migrants (A.Gilbert and H.McAuslane, PHE, private communication).

Lower levels of vaccine coverage are also seen, which may be due to missed vaccinations in the country of origin or missed opportunities for uptake after arrival. For example, between 2003-2016 there were 15 cases of congenital rubella syndrome in the UK, of which the mother of the case was born abroad in 14 (where place of birth of the mother was known). Some of these mothers were recent entrants to the UK, whilst others had been resident in the country for some years, but after the age of routine MMR vaccination [54]. Migrant mothers, especially those from Sub-Saharan Africa and South Asia, were more likely to be rubella seronegative than women born in the UK, on testing on newborn blood spots [55]. These findings underline the need to check vaccination status of new arrivals prior to pregnancy. There are also alternative examples of lower coverage amongst migrants for other routine immunisations: higher HPV vaccination coverage was observed in local authorities with smaller migrant populations [37], international students were less likely to get MenACWY vaccine in a study at the University of Liverpool [20].

Prisoners

There are several published studies on vaccine coverage of Hepatitis A and Hepatitis B amongst UK prisoners [56] , but we have found no published data on coverage of routine vaccinations in prison populations.

Looked after children

There is limited evidence around vaccine coverage among looked after children (LAC), but what is available suggests these children are less likely to be vaccinated. LAC in health districts across the UK had lower levels of Men C coverage (67%) than children at home (85%) [57]. LAC in East Surrey in 2001 were significantly less likely to have received primary immunisations (3 doses of DTaP/IPV) and MenC than non-LAC in the same area. MMR1 and preschool booster (DT/IPV) coverage was lower too, but not significantly different [58]. Coverage may be lower and/or delayed in older LAC [59, 60], LAC who are unaccompanied minors travelling to the UK alone [61], and LAC with parenting issues rather than receiving respite care for chronic disability [59].

Parental factors

Lone parents

Though relatively few in number, studies have consistently shown that children of lone parents were less likely to receive or complete childhood primary vaccinations [27, 62-64].

Parents with large families

Having a large family reduces the likelihood of vaccination against MMR or the primary course for younger children, independent of lone parent status where this was also adjusted for [27, 30, 62, 63]. This effect is enhanced for each extra older child in the family [27, 45, 63].

Parental age

The Millenium Cohort Study also provided evidence of vaccination inequality for young and old mothers. Having a mother aged under 20 at birth, was significantly associated with being unimmunised against MMR [30], while having a mother aged at least 40 years old was associated with being unimmunised with the primary course (2,3,4 months), although their children were less likely to be partially immunised [27].

Summary of results

The UK National Immunisation Programme works to identify and address inequalities. There are dedicated systems for data collection, and specific research into inequalities. The programme has achieved high coverage overall in the population. However, we have demonstrated that avoidable inequalities in vaccination still exist within some population groups. Evidence of inequality in coverage has been shown for the following characteristics:

- age
- geography
- socioeconomic status (deprivation, employment, income/occupation, education);
- ethnicity
- religion
- disability and health status (learning disability, physical disability, chronic physical illness)
- underserved and hard to reach (travellers, migrants, prisoners, LAC)
- parental factors (lone parents, large families, parental age)

These inequalities exist not just for overall coverage, but also for timing of vaccines and completion of vaccine schedules. The inequalities vary by vaccine programme, geographic locality and geographic unit of analysis. As such, there was evidence that the situation is complex: the extent of a particular inequality in vaccination e.g. by ethnicity, may vary when that domain intersects with one or more other domain (that is, there may be ‘intersectional’ effects). Further research is needed to determine how inequalities in vaccine coverage may translate into inequality in adverse health outcomes.

Limitations

The following are limitations of this report but also reflect the limitations in the data and/or wider related literature, and include the following:

- selection bias – we may not have detected all the studies of interest for the included groups. Alternatively, there may be groups and characteristics we have not considered within our report scope but who also experience lower vaccination coverage
- information bias – many studies reported missing data or used proxy measures of participant characteristics, for example area-level deprivation being used in place of other SES indicators
- indirect evidence – for many of the characteristics of interest, there were very few studies, and some were small and dated. A lot of the data was locale specific, particularly for London, so the findings may not always be generalisable to other parts of England, or to the present day situation. Similarly, MMR and HPV were the focus for many of the studies and may not generalise to other vaccinations

- weak study designs – included studies were often of an ecological or other observational design, and these are subject to biases. We have not assessed the risk of bias from the various study designs, or biases that might have arisen from the way they were conducted

Evidence gaps

A key limitation is the lack of data (or just extrapolated data) on vaccine coverage in the following groups:

- adults with learning disability
- children or adults with physical disability, mental illness or chronic physical illness
- homeless
- children of parents with health conditions including disability
- sexual orientation
- transgender

3. Explaining and tackling inequalities in vaccination

An action framework to address inequalities in vaccination

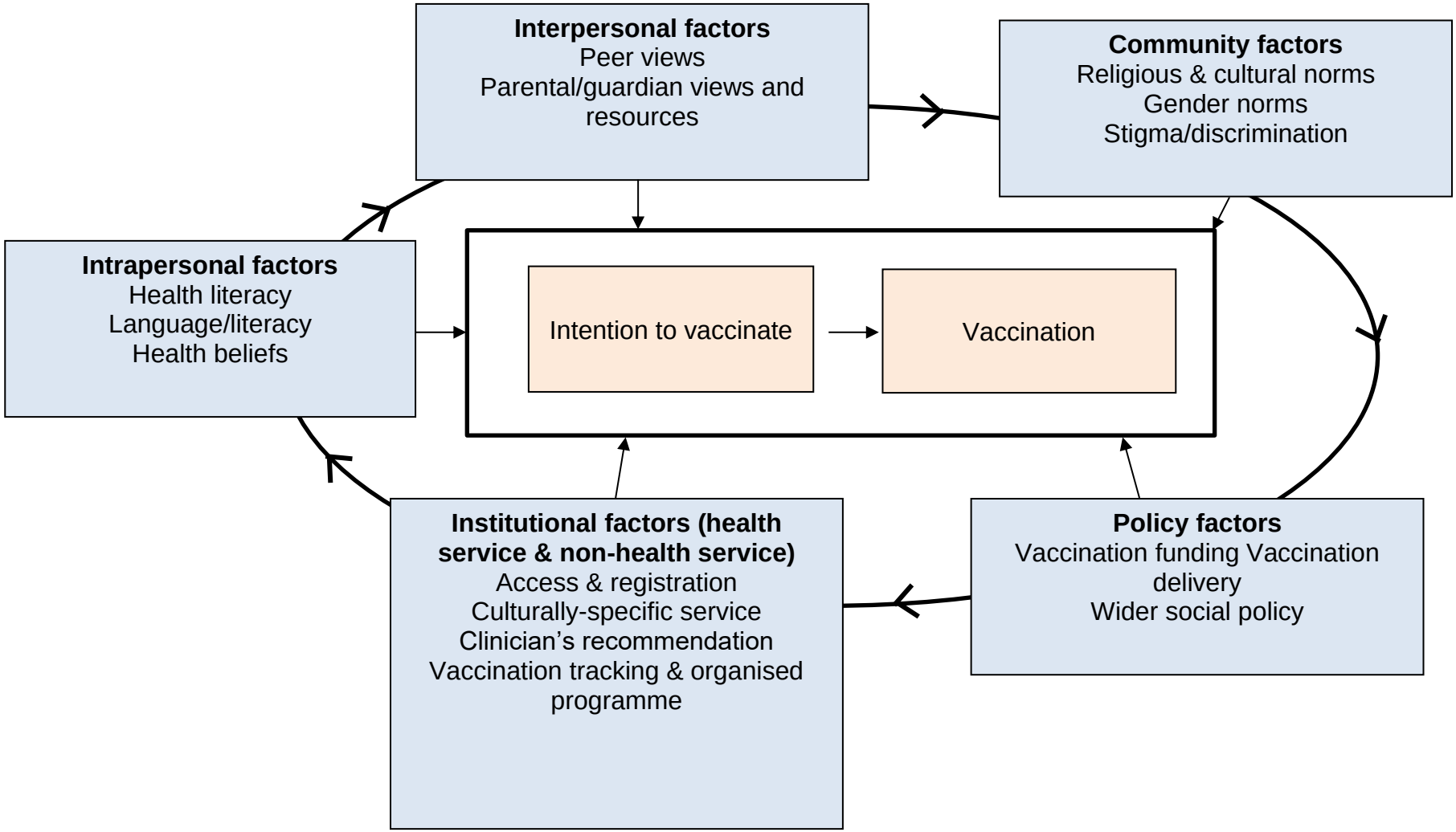
Developing a framework or model to determine the potentially prevailing reasons for inequalities is recommended to develop appropriately targeted interventions to address them [5]. Social ecological models (SEM) combine elements from behavioural, epidemiological, and social science disciplines [65]. By doing so, SEMs acknowledge that individual behaviour is determined by intrapersonal factors, but they also recognise it is shaped by determinants at other levels such as by interpersonal relationships, by institutions, community factors, and social/health service policy [65, 66]. Barriers may therefore be identified that are shared across communities and populations rather than just by individuals, and their removal can bring about more efficient, equitable and sustainable behaviour change [65].

Though we were aware of literature reviews which considered factors influencing overall population vaccine uptake [67-69], these factors may not be the same issues which result in inequalities [5, 70]. As we are unaware of a literature review specifically of the factors which may influence inequalities in immunisation in high income settings, we undertook our own rapid review. A full description of the methods used to develop our model (as well as more detailed results) are described in the appendix, however we specifically considered which factors were responsible for inequalities in indicators of vaccination coverage or intention to vaccinate in high-income populations, or factors that were responsible for lower coverage indicators or intention to vaccinate in any of the specific groups (in a high-income setting) included in this report. Additionally, we only included studies that examined vaccinations included in the routine immunisation programme, as per the scope of this report.

The action framework

The main themes within the social ecological model action framework are summarised in the text and figure 1 below. Table A6 in the appendix provides more details on the potential factors explaining variation in intention to vaccinate or vaccination coverage within each level of the model.

Figure 1. Social-ecological model action framework of factors influencing inequality in vaccination uptake, or low vaccination uptake in specific populations in high income settings



Intrapersonal factors

Lower health literacy, manifest as a lack of knowledge about the importance of vaccination, the vaccination schedule, and how to access vaccination was evident for several populations including recent migrants/refugees [71] and Roma [72]. In certain minority ethnic groups there was concern that vaccinations may not be effective or safe in their specific population [73]. Such uncertainty could be exacerbated by language and literacy barriers in all these populations [71-73]. This may explain why hesitancy to vaccinate due to concerns about need, effectiveness and safety were also evident in similar population groups [71-73]. For some specific groups such as Anthroposothists and Orthodox Protestants, hesitancy to vaccinate was also associated with beliefs about vaccination rather than lack of knowledge or familiarity with the healthcare system or vaccination [72]. Bocquier noted that high SES parents/guardians were generally more confident about the safety of childhood vaccination [74]. However, a lower MMR uptake, and also a greater hesitancy to vaccinate or adopt new vaccines was seen in higher SES [74]. The authors theorised that for specific vaccinations, higher SES parents may have greater distrust of science and industry.

Interpersonal factors

Relatively fewer interpersonal factors were offered as potential explanatory factors for under-vaccination. Recent migrants or refugees were reported to be influenced by the views and actions of family and friends when considering whether to vaccinate their own children [71]. In some BAME communities, parental attitudes towards sexual practices influenced by their religion which promotes sexual abstinence before marriage were cited as reasons for parents being more likely to reject HPV vaccination for their daughters, as the parents perceived it would be unnecessary if they only had one sexual partner in a married relationship [73, 75]. Some migrant or refugee parents were also concerned vaccination would promote greater promiscuity [71]. For children in foster care, interviews with foster carers revealed that ‘hectic’ home lives led to missed appointments for vaccinations [76].

Institutional factors

Despite a potentially greater need for information on the importance and process of vaccination, black and minority ethnic groups, and recent migrants/refugees were potentially less likely to receive a recommendation to vaccinate from a healthcare professional [71, 73, 77]. This may have been in part due to healthcare professionals perceiving parents as being less open to the benefit of vaccination [75], or being potentially unable to afford vaccination (in countries with charges) [77]. For Roma and Irish Traveller populations [72], and for recent migrants/refugees [71], access to care issues were important. This could be due to very mobile lifestyles in the case of Roma or Traveller communities, but primary care registration that was perceived as complex or restrictive, or services that were inflexible or not culturally specific were also barriers, including for other groups [72].

Children in care faced particular institutional barriers, notably frequent moves between homes or institutions, a lack of continuity of social care workers, a lack of tracking of vaccination status, and competing demands on foster carers leading to a failure to offer vaccination, or missed or forgotten appointments [76].

BAME elderly in care homes in the USA were less likely than white counterparts to have pneumococcal vaccination, particularly in for-profit rather than state-run homes [78]. Their vaccination status was less likely to be tracked, and they were less likely to reside in homes benefitting from an organised vaccination programme [78].

Community factors

Religious and cultural community norms were found to be likely to contributing to vaccine hesitancy or under-vaccination in recent migrant/refugee, BAME and in some other specific population groups. A relatively disempowered social position for women, and a reticence to present for preventive healthcare in men led to gender roles influencing vaccination decision-making in refugee and migrant communities [71]. Norms inhibiting discussion of sexual health limited HPV vaccination discussion in some migrants and refugees [71]. Similarly, some BAME communities may perceive HPV to be unnecessary where sex was seen to be unlikely to occur outside of marriage due to religious reasons [73, 75]. An approach that ill health may be simply one's fate, particularly affiliated with religious norms, sometimes contributed to vaccine hesitancy in some BAME [73] and Orthodox Jewish populations [72]. There was also some uncertainty in UK Somali parents as to whether vaccination was permitted for religious reasons [73]. Roma and Irish Travellers lower vaccination rates were attributed in part to marginalisation, stigma or discrimination by the host community limiting access to vaccination services. High spatial mobility of some of these communities may also lead to difficulty reaching them to offer vaccination [72].

Policy factors

Policy regarding vaccine-delivery and funding is likely to impact on inequalities. School-delivery compared to community-delivery models for HPV vaccination was thought likely to narrow SES-disparities in uptake [67]. On comparison of international delivery-models within primary care, countries with dedicated well-baby clinics showed higher overall rates of vaccination, and there were less social inequities. Lowest vaccination coverage rates and larger inequities associated with parental SES were observed mostly in countries without hierarchical[5] primary care systems that also lacked well-baby clinics [79]. Lack of fully funded programmes that are cost-free at the point of use

[5] Primary care services with a hierarchical model work under government control and are governed by de-centralized authorities.

have been cited as barriers to vaccination access for lower SES families [74, 75], and recent migrants and refugees [71]. In addition to health policy, wider social policies may indirectly impact on vaccination uptake. For example, access to formal education may impact on health literacy [72].

Between-level interaction

Vaccination was influenced by factors at all levels of the model. In addition, factors influencing vaccination are themselves likely to be influenced by factors within other levels of the model. For example, knowledge regarding the importance of vaccination will be influenced by whether a clinician recommends vaccination, and such a recommendation will be more likely to occur about in healthcare systems with fully-funded community delivery models. In common with many behavioural models and models of vaccine hesitancy, it is important to recognise that individuals may intend to vaccinate their children/themselves, but this may not be acted upon because of other external factors either modifying their intentions or limiting opportunity to complete vaccination.

Limitations

Using a social ecological model allowed us to consider a comprehensive range of factors potentially influencing inequalities. Our findings are consistent with reviews of the effect of interventions to increase vaccine uptake: multi-component interventions which facilitate action and address barriers to uptake are effective [80-82], potentially more so than interventions attempting to influence people's thoughts and feelings about vaccination, or the social norms about vaccination [81].

However, we did not find information on any barriers for some populations e.g. children with a disability, nor necessarily for all vaccinations offered within the routine programme. Despite this limitation, due to the often cross-cutting nature of barriers faced by different populations, the model still provides a framework for addressing inequalities in all groups, but evidence gaps should be addressed. For the studies we did include, their validity is likely to vary, and we did not undertake grading of study quality to assess how this may influence our findings. Additionally, due to limitations of the included study methods, or the volume and nature of the primary research, we have been unable to indicate which factors, if any, may be the more important determinants of vaccination. Finally, though we limited our search to high-income settings, some of the studies were predominantly from settings with differing healthcare policies from the UK, which may limit generalisability. These limitations should be considered by policymakers, and addressed by more comprehensive research, which was beyond the scope of this report.

4. Conclusions and recommendations

Conclusions

We have demonstrated that the UK National Immunisation Programme works to identify and address inequalities. There are dedicated systems for data collection, and specific research into inequalities. In general, coverage of routine vaccinations is high. However, we have demonstrated that avoidable inequalities in vaccination still exist within some population groups. Inequalities for a given group can vary in extent in different immunisation programmes. Additionally, inequalities for a given group may be larger or smaller in different parts of the country, or when individuals belong to more than one group at a time that may experience inequalities. These inequalities threaten health goals for individuals and communities, most urgently in the form of infectious disease outbreaks. We have also demonstrated that community, institutional, and policy factors, as well as the health beliefs and knowledge of individuals and families may lead to inequalities in vaccination. Finally, we have identified limitations in terms of available data and evidence to describe and monitor the situation, and to explain why inequalities may have occurred.

Recommendations

The public health response should recognise the importance of developing and using local intelligence and data to set priorities for action. Evidence-based, tailored interventions acting on barriers at multiple levels should be enacted; these interventions should be evaluated and the findings shared between stakeholders.

Recommendation 1: develop a national vaccinations inequality strategy, and provide a template local action plan to enable best practice

Public Health England's national immunisation team with assistance from stakeholders in PHE screening and immunisation teams, the NHS, academics, local government, and third sector organisations, should develop a national vaccinations inequality strategy. This should include a local action plan template resource that can be used by stakeholders in a needs assessment to understand inequalities in their area, then prioritise, plan and evaluate evidence-based interventions to tackle inequalities in vaccination

Recommendation 2: share new practice and evaluation findings between stakeholders to develop the evidence base

Public Health England's national immunisation team should develop resources to enable sharing of best practice and findings of evaluations between local immunisations stakeholders

Recommendation 3: develop locally relevant data and intelligence resources to support needs assessment

Public Health England's national immunisation team with assistance from stakeholders in PHE screening and immunisation teams, the NHS, academics, local government, and third sector organisations, should develop a database of datasets that can be used to better characterise inequalities in vaccination, for example by data linkage, particularly in groups where there is currently an evidence gap

Stakeholders addressing inequalities at a local level should consider gathering local intelligence and bespoke data when setting priorities and planning interventions, for example using the World Health Organisation's *Tailoring Immunization Programmes (TIP)* [83] approach. Wider community, institutional, and policy barriers and facilitators to vaccination should be considered as well as the health beliefs and knowledge of individuals, as outlined in the social-ecological model in section 5 of this HEA

Recommendation 4: monitor inequalities in coverage for key indicators

Public Health England's national immunisation team, in discussion with stakeholders, should consider using existing data sources to develop a routine report to monitor trends in routine vaccination coverage inequalities at national and regional level, for key indicators such as by area level deprivation, and by geography

Recommendation 5: continue national level leadership and support to address inequalities

The inequalities technical sub-group of the tri-partite (PHE, NHS, DHSC) Immunisation Programme Implementation Group should continue to provide national level leadership and support to efforts to reduce inequalities in vaccination, for example through advocacy to policy-makers, disseminating information, and helping to shape the research agenda

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References

1. Edelstein M, et al (2017). Extracting general practice data for timely vaccine coverage estimates: The England experience. *Vaccine*, 2017. **35**(38): 5110-5114.
2. Public Health England (2019). Cover of vaccination evaluated rapidly programme. https://www.gov.uk/government/collections/vaccine-uptake.
3. Amirthalingam, G., J. White, and M. Ramsay (2012). Measuring childhood vaccine coverage in England: the role of Child Health Information Systems. *Euro Surveill.* **17**(16): 20149.
4. Amirthalingam G, et al (2018) Evaluation of the effect of the herpes zoster vaccination programme 3 years after its introduction in England: a population-based study. *Lancet Public Health* **3**(2): e82-e90.
5. Whitehead, M (2005). Glossary. A typology of actions to tackle social inequalities in health. *Journal of Epidemiology and Community Health* **61**: 473-478.
6. Public Health England (2017). Health Profile for England 2017. Chapter 5: inequalities in health: https://www.gov.uk/government/publications/health-profile-for-england/chapter-5-inequality-in-health#introduction.
7. Public Health England (2017). Equality objectives for 2017-2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/593090/PHE_Equality_objectives_2017_to_2020.pdf.
8. NHS public health functions agreement 2017 to 2018 (2017). Core service specification National immunisation programme.
9. Marmot M, Goldblatt P, Allen J et al (2010). *Fair Society, Healthy Lives. The Marmot Review*.
10. Byrne L et al (2018). Hospitalisation of preterm infants with pertussis in the context of a maternal vaccination programme in England. *Arch Dis Child*: 224-229.
11. Urwin G, Yuan MF, Feldman R (1994). Prospective study of bacterial meningitis in North East Thames region, 1991-3, during introduction of *Haemophilus influenzae* vaccine. *BMJ*: 1412-4.
12. Funk S (2017). Critical immunity thresholds for measles elimination (WHO).
13. Zimmerman LA, Muscat M, Singh S et al (2019). Progress Toward Measles Elimination - European Region, 2009–2018. *MMWR Morb Mortal Wkly Rep* **68**: 396-401.
14. Edelstein M et al (2019). Implementation and evaluation of the human papillomavirus (HPV) vaccination pilot for men who have sex with men (MSM), England, April 2016 to March 2017. *Euro Surveill.* **24**(8): 1800055.
15. Letley L et al (2018). Tailoring immunisation programmes: Using behavioural insights to identify barriers and enablers to childhood immunisations in a Jewish community in London, UK. *Vaccine* **36**(31): 4687-4692.
16. Tiley K et al (2018). Inequalities in childhood vaccination timing and completion in London. *Vaccine*.

17. Bell S, Edelstein M, Zatonski M, Ramsay M, Mounier-Jack S (2019). I don't think anybody explained to me how it works': a qualitative study exploring vaccination and primary health service access and uptake amongst Polish and Romanian communities in England. BMJ Open (Accepted for publication).

18. Edelstein M et al (2018). A conmparison of vaccination coverage for different year groups and delivery models within school-based vaccination programmes in England in 2015/16. In *European Public Health Conference*, Ljubljana.

19. Sacks RJ, C.A., Wilkinson DM, Robinson AJ (2014). Uptake of the HPV vaccination programme in England: a cross-sectional survey of young women attending sexual health services*. Sex Transm Infect*: 315-21.

20. Blagden S, Seddon D, Hungerford D, Stanistreet D (2017). Uptake of a new meningitis vaccination programme amongst first-year undergraduate students in the United Kingdom: a cross-sectional study*.* PLOS One.

21. Edelstein M et al (2017). Who is at risk of measles in England? An age-specific estimation of measles susceptibility in individuals born 1985-2014. In *ESCAIDE Conference*. 2017. Stockholm.

22. Byrne L. et al (2018). Predictors of coverage of the national maternal pertussis and infant rotavirus vaccination programmes in England. *Epidemiol Infect*.. **146**(2): 197-206.

23. Ward C, White J, Amirthalingam G, Tiley K, Edelstein M (2017). Sociodemographic predictors of variation in coverage of the national shingles vaccination programme in England 2014/15*. Vaccine*: 2372-8.

24. Jain A, et al (2018). Zoster vaccination inequalities: A population based cohort study using linked data from the UK Clinical Practice Research Datalink*.* PLOS ONE **13**(11): e0207183.

25. Sandford H, Tata LJ, Browne I, Pritchard C (2015). Is there an association between the coverage of immunisation boosters by the age of 5 and deprivation? An ecological study. *Vaccine* **33**(9): 1218-1222.

26. Wagner KS et al (2014). Childhood vaccination coverage by ethnicity within London between 2006/2007 and 2010/2011*. Arch Dis Child* **99**(4): 348-53.

27. Samad L et al (2006). *Differences* in risk factors for partial and no immunisation in the first year of life: prospective cohort study*. BMJ* **332**(7553): 1312-3.

28. Lamden KH, Islay G (2008). General practice factors and MMR vaccine uptake: structure, process and demography*. Journal of Public Health*: 251-7.

29. Friederichs, V., J.C. Cameron, and C. Robertson (2006). Impact of adverse publicity on MMR vaccine uptake: a population based analysis of vaccine uptake records for one million children, born 1987-2004*. Arch Dis Child*. **91**(6): 465-8.

30. Pearce A et al (2008). Factors associated with uptake of measles, mumps, and rubella vaccine (MMR) and use of single antigen vaccines in a contemporary UK cohort: prospective cohort study. *BMJ*. **336**(7647): 754-7.

31. Wright JA and Polack C (2006). Understanding variation in measles-mumps-rubella immunization coverage - a population-based study*. Eur J Public Health* **16**(2): 137-42.

32. Roberts SA et al (2011). Human papillomavirus vaccination and social inequality: results from a prospective cohort study. *Epidemiol Infect*. **139**(3): 400-5.

33. Spencer JC, Calo WA, and Brewer NT (2019). Disparities and reverse disparities in HPV vaccination: A systematic review and meta-analysis. *Prev Med*. **123**: 197-203.

34. Hughes A et al (2014). Coverage of the English national human papillomavirus (HPV) immunisation programme among 12 to 17 year-old females by area-level deprivation score, England, 2008 to 2011. *Euro Surveill*. **19**(2).

35. Fisher H et al (2014). Examining inequalities in the uptake of the school-based HPV vaccination programme in England: a retrospective cohort study. *J Public Health* **36**(1): 36-45.

36. Sinka K et al (2014). Achieving high and equitable coverage of adolescent HPV vaccine in Scotland. *J Epidemiol Community Health* **68**(1): 57-63.

37. Jean S 3rd, Elshafei M and Buttenheim A (2018). Social determinants of community-level human papillomavirus vaccination coverage in aschool-based vaccination programme. *Sex Transm Infect*. **94**(4): 248-253.

38. Mixer RE, Jamrozik K and D. Newsom (2007). Ethnicity as a correlate of the uptake of the first dose of mumps, measles and rubella vaccine. *J Epidemiol Community Health* **61**(9): 797-801.

39. Cockman P et al (2011). Improving MMR vaccination rates: herd immunity is a realistic goal. BMJ **343**: d5703.

40. Tookey PA, Cortina-Borja M and Peckham CS (2002). Rubella susceptibility among pregnant women in North London, 1996-1999. *J Public Health Med*. **24**(3): 211-6.

41. Bowyer HL et al (2014). Association between human papillomavirus vaccine status and other cervical cancer risk factors. *Vaccine*. **32**(34): 4310-6.

42. Tuffrey C and Finlay F (2001). Immunisation status amongst children attending special schools. *Ambulatory Child Health*. **7**(3-4): 213-217.

43. Public Health England (2015). The determinants of health inequities experienced by children with learning disabilities.

44. Tervo RC and Taylor B (1982). Vaccinations and the physically handicapped child. *Canadian Medical Association journal*. **127**(6): 475-477.

45. Department of Paediatric Epidemiology, IoCH (1989). The Peckham Report. National Immunisation Study: Factors Influencing Immunisation Uptake in Childhood. Action Research for the Crippled Child.

46. Kyaw MH et al (2002). Influenza and pneumococcal vaccination in Scottish nursing homes: coverage, policies and reasons for receipt and non-receipt of vaccine. *Vaccine*. **20**(19-20): 2516-22.

47. Muscat M (2011). Who gets measles in Europe? *J Infect Dis*. **204** Suppl 1: S353-65.

48. Hanratty B et al (2000). UK measles outbreak in non-immune anthroposophic communities: the implications for the elimination of measles from Europe. *Epidemiol Infect*. **125**(2): 377-83.

49. Cohuet S et al (2009). A measles outbreak in the Irish traveller ethnic group after attending a funeral in England, March-June 2007. *Epidemiol Infect*. **137**(12): 1759-65.

50. Health Protection Agency (2007). Measles outbreak in the Traveller community.

51. Health Protection Agency (2010). Confirmed measles cases in England and Wales in 2010: update to end-June.

52. McFadden A et al (2018). Gypsy, Roma and Traveller access to and engagement with health services: a systematic review. *Eur J Public Health* **28**(1): 74-81.

53. Dar O et al (2013). Mapping the Gypsy Traveller community in England: what we know about their health service provision and childhood immunization uptake. *J Public Health* . **35**(3): 404-12.

54. Bukasa A et al (2018). Rubella infection in pregnancy and congenital rubella in United Kingdom, 2003 to 2016. *Euro Surveill*. **23**(19): 17-00381.

55. Hardelid P et al (2009). Rubella seroprevalence in pregnant women in North Thames: estimates based on newborn screening samples. *Journal of Medical Screening* **16**(1): 1-6.

56. Madeddu G et al (2019).Vaccinations in prison settings: A systematic review to assess the situation in EU/EEA countries and in other high income countries. *Vaccine* **37**(35): 4906-4919.

57. Hill CM, Mather M and J. Goddard (2003). Cross sectional survey of meningococcal C immunisation in children looked after by local authorities and those living at home. *BMJ* (Clinical research ed.): **326**(7385): 364-365.

58. Rodrigues VC (2004). Health of children looked after by the local authorities. *Public Health* **118**(5): 370-6.

59. Walton S and Bedford H (2017). Immunization of looked-after children and young people: a review of the literature. *Child Care Health Dev*. **43**(4): 463-480.

60. Coventry and Rugby CCG (2015). Looked after children: annual report, 2015/16.

61. Garry S and John-Legere S (2015). Evaluating MMR coverage of looked after children (lac): are we comparing apples with oranges if we consider this population as one group? *Archives of Disease in Childhood*. **100** (suppl. 3): A176.

62. Li J and Taylor B (1993). Factors affecting uptake of measles, mumps, and rubella immunisation. *BMJ* (Clinical research ed.) **307**(6897): 168-171.

63. Pearson M et al (1993). Primary immunisations in Liverpool. I: Who withholds consent? *Archives of disease in childhood* **69**(1): 110-114.

64. Sharland M et al (1997). Lone parent families are an independent risk factor for lower rates of childhood immunisation in London. Communicable Disease Report. CDR review. **7**(11): R169-72.

65. White F, Stallones L, Last JM (2013). Global Public Health. Ecological Foundations. Oxford University Press.

66. McLeroy KR, Steckler A, Glanz K (1988). An ecological perspective on health promotion programs. *Health Educ Q.* **15**(4): 351-377.

67. Gallagher KE et al (2016). Factors influencing completion of multi-dose vaccine schedules in adolescents: a systematic review. *BMC Public Health* **16**: 172.

68. Smith LE, Amlot R, Weinman J, Yiend J, Rubin J (2017). A systematic review of factors affecting vaccine uptake in young children. *Vaccine* **35**: 6059-6069.

69. Favin M, Steinglass R, Fields R, Banerjee K, Sawhey M (2012). Why children are not vaccination: a review of the grey literature. *International Health* **4**: 229-238.

70. Reading R et al (1994). Do interventions that improve immunisation uptake also reduce social inequalities in uptake? *BMJ*. **308**(6937): 1142.

71. Wilson L et al (2018). Barriers to immunization among newcomers: a systematic review. *Vaccine* **36**(8): 1055-1062.

72. Fournet N et al (2018) Under-vaccinated groups in Europe and their beliefs, attitudes and reasons for non-vaccination; two systematic reviews. *BMC Public Health* **18**(1): 196.

73. Forster AS et al (2017). Ethnicity-specific factors influencing childhood immunisation decisions among Black and Asian Minority Ethnic groups in the UK: a systematic review of qualitative research. *J Epidemiol Community Health* **71**(6): 544-549.

74. Bocquier A et al (2017). Socioeconomic differences in childhood vaccination in developed countries: a systematic review of quantitative studies. *Expert Rev Vaccines* **16**(11): 1107-1118.

75. Ferrer BH, Trotter C, Hickman M, Audrey S (2014). Barriers and facilitators to HPV vaccination of young women in high-income countries: a qualitative systematic review and evidence synthesis. *BMC Public Health* **14**.

76. Hermann JS et al (2019). Immunization coverage of children in care of the child welfare system in high-income countries: a systematic review. *Am J Prev Med*. **56**(2): e55-e63.

77. Gilkey MB and McRee AL (2016). *Provider communication about HPV vaccination: a systematic review. Hum Vaccin Immunother.* **12**(6): 1454-68.

78. Travers JL et al (2018). *Racial/ethnic disparities in influenza and pneumococcal vaccinations among nursing home residents: a systematic review. Gerontologist* **58**(4): e205-e217.

79. Arat A et al (2019). Social inequities in vaccination coverage among infants and pre-school children in Europe and Australia - a systematic review. *BMC Public Health* **19**(1): 290.

80. Crocker-Buque T, Edelstein M and Mounier-Jack S (2016). Interventions to reduce inequalities in vaccine uptake in children and adolescents aged <19 years: a systematic review. *J Epidemiol Community Health* 1-11.

81. Brewer NT et al (2017). Increasing vaccination: putting psychological science into action. *Psychological Science in the Public Interest* **18**(3): 149-207.

82. NICE (2017). Immunisations: reducing differences in uptake in under 19s.

83. World Health Organization (2013). The Guide to Tailoring Immunization Programmes. 2013: http://www.euro.who.int/__data/assets/pdf_file/0003/187347/The-Guide-to-Tailoring-Immunization-Programmes-TIP.pdf.

Appendix

Methods for part 2.0: Inequalities in vaccination coverage

Vaccination coverage data

Data were obtained on vaccination coverage for each of the routine national immunisation programmes in England and Wales as at 1 September 2017. Influenza vaccination was excluded, as were selective vaccinations, and vaccines for individuals with underlying medical conditions. The most recent data were obtained where possible.

Coverage data were sought for all the included vaccinations for a range of characteristics which are protected, or are associated with inequality, as listed below:

- age
- gender
- geography including rural/urban split
- socio-economic status (SES) including deprivation, employment, income and occupational status, educational attainment
- ethnic origin
- religion
- disability and health status including learning and physical disabilities, mental and chronic physical illnesses
- underserved groups including travellers, migrants, prisoners, looked after children (LAC), homeless
- parental factors including lone parents, family size, parental age, parental illness
- sexual orientation
- gender re-assignment

Routine data sources

The two main data sources for vaccination coverage in England and Wales, are the Cover of vaccination evaluated rapidly (COVER) programme, and ImmForm, a website for vaccine uptake data collections and vaccine ordering.

Both COVER and ImmForm contain data on national, regional and local coverage. ImmForm also has data on ethnicity and gender for some programmes.

Data was taken from the first two systems as shown below for analysis of geographic variation in coverage by Local Authority, and rural-urban status.

Table A1. Vaccine programme data extraction source, England 01 September 2016 to 31 August 2017

Vaccine	COVER	ImmForm
DTaP/IPV/Hib (5-in-1)	√	
PCV	√	
Rotavirus	√	√
Men B		√
Hib/Men C	√	
MMR	√	
DTaP/IPV	√	
HPV (school programme)		√
Td/IPV		√
MenACWY		√
PPV		√
Shingles		√

Rural/urban classification was based on Office of National Statistics Rural-Urban Classification of Local Authority Districts 2011. Where there were several districts within an upper tier local authority, the total rural population was calculated as a percentage of the total population for all the districts within the upper tier local authority. This was used to classify the upper tier LA population as Predominantly Urban (≤25% rural), Urban with Significant Rural (26%-49% rural), or Predominantly Rural (≥50% rural).

For coverage by deprivation decile, 2016 to 2017-2017 to 2018 financial year routine coverage data were extracted from a published source (PHE Fingertips Health Protection Profiles): https://fingertips.phe.org.uk/profile/health-protection/data#page/0/gid/1938132804/pat/6/par/E12000008/ati/102/are/E10000025/iid/92324/age/99/sex/4

Literature review for part 2.0: Inequalities in vaccination coverage

A comprehensive literature search was carried out for inequalities in vaccination coverage, from 1988 to 2018, using the NICE Evidence Search, Medline, Embase and CINAHL databases. A total of 486 references were returned, of which 144 remained after removal of duplicates and screening for relevance. The reference list of each paper was reviewed for additional relevant sources.

The papers were reviewed, and exclusions made as follows: not including coverage information regarding at least one of the factors of interest; overseas studies where UK information was available; non-routine delivery; studies prior to 2007 where more recent information was available.

Supplementary data sources

Screening and immunisation leads for the nine PHE centres were contacted to request any local data on inequalities in vaccine coverage. Responses were received from three leads.

Sources were also suggested by national experts in the field of immunisation.

Local authority level immunisation coverage for early years and school-based immunisations

Table A2: Early Years (age 0-5) immunisations coverage at Local Authority level*, England 2016 to 2017

Vaccine type	Programme	Local Authority Coverage no.(%)		
		95% and over	90% to <95%	Under 90%
Primary	DTaP/IPV/Hib by 12 months	68 (46)	59 (40)	22 (15)
	DTaP/IPV/Hib by 5 years	110 (74)	34 (23)	5 (3)
Booster	DTaP-IPV booster by 5 years	5 (3)	53 (36)	91 (61)
Primary	PCV 1 dose by 24 months	66 (44)	64 (43)	19 (13)
Booster	PCV 2 doses by 24 months	34 (23)	73 (49)	42 (28)
Primary	Rotavirus by 12 months	9 (6)	80 (55)	57 (39)
Primary	MenB 2 doses by 26 weeks	11 (11)	41 (39)	52 (50)
	MenB 2 doses by 52 weeks	45 (43)	36 (35)	23 (22)
	MenB 2 doses by 78 weeks	47 (45)	37 (36)	20 (19)
Primary	MMR 1 dose by 24 months	37 (25)	70 (47)	42 (28)
Booster	MMR 2 doses by 5 years	7 (5)	60 (40)	82 (55)
Primary	Hib/MenC by 24 months	33 (22)	74 (50)	42 (28)
	Hib/MenC by 5 years	51 (34)	66 (44)	32 (21)

* 149 LAs except for Men B – 104 LAs; Rotavirus – 146 LAs. Three small LAs (City of London, Isles of Scilly and Rutland) are counted within larger neighbouring LAs giving a total of 149.

Table A3: School-based immunisations by Local Authority*, England 2016 to 2017

Programme	Local Authority Coverage no.(%)		
	90% and over	80% to <90%	Under 80%
HPV 1 dose by Year 9	73 (48)	65 (43)	13 (9)
HPV 2 doses by Year 9	33 (22)	72 (48)	46 (30)
MenACWY by Year 9	34 (28)	53 (43)	36 (29)
Td/IPV school leaver booster by Year 9	30 (25)	49 (41)	40 (34)

* HPV - 151 LAs; MenACWY – 123 LAs; Td/IPV school-leaver booster - 119 LAs.

Table A4. Comparison of top 10 best and worst performing Local Authorities for Early Years and Adult vaccines

Local Authority	DTaP/IPV/HIb 5 yrs %	Local Authority	PPV %	Local Authority	Shingles %
South Tyneside	99.4	Knowsley	80.7	Windsor & Maidenhead	92.3
Redcar & Cleveland	99.3	Trafford	76.2	Oxfordshire	73.0
Barnsley	99.1	St Helens	76.0	St Helens	63.8
Tameside	99.0	Bracknell Forest	75.9	Slough	59.0
Derbyshire	98.9	Cambridgeshire	75.7	Southampton	58.0
Warwickshire	98.8	Bolton	75.5	Enfield	57.9
Leicestershire	98.8	South Tyneside	75.4	Barking & Dagenham	55.7
County Durham	98.7	Cheshire West & Chester	75.2	Surrey	55.3
Northumberland	98.7	Derby	75.1	Medway	54.5
Dorset	98.7	Darlington	74.8	Kirklees	54.4
Merton	91.7	Thurrock	61.4	Westminster	31.4
Sutton	91.7	Haringey	61.1	Hammersmith & Fulham	30.9
Croydon	91.3	Waltham Forest	60.6	Southend on Sea	28.8
Hackney	91.2	Hounslow	60.6	Wolverhampton	28.4
Waltham Forest	91.1	Islington	60.1	Wigan	26.5
Barking & Dagenham	87.8	Southend on Sea	58.2	Sutton	23.8
Surrey	86.8	Southwark	56.7	Kensington & Chelsea	23.6
Hammersmith & Fulham	86.6	Westminster	56.0	Hartlepool	23.2
Kensington & Chelsea	79.2	Hammersmith & Fulham	54.9	Salford	21.3
Westminster	76.1	Kensington & Chelsea	49.4	Tameside	17.5

Method to develop the social ecological model in part 3.0

We used rapid overview review methods to locate relevant studies which either:

- considered which factors were responsible for *inequalities* in vaccination (coverage, timeliness or completeness) or intention to vaccinate in high-income populations, or
- considered which factors were responsible for lower intention to vaccinate, low vaccine coverage, timeliness, or completeness in any of the specific groups (in a high-income setting) included in this report.

As recommended [5], we did not include studies which considered factors responsible for lower vaccination in the general population in high-income settings, as these factors may not align with the determinants of inequality [5], and thus potentially undermine the effectiveness of subsequent interventions to tackle inequality specifically [70]. Additionally, we only included studies that examined vaccinations included in the routine immunisation programme, as per the scope of this report.

Search strategy to populate the social ecological model

Study inclusion criteria

Dimension	Criteria
Study type	Quantitative observational (cross-sectional, case-control, cohort) or qualitative studies
Population	a) Children or adults in high income settings* OR b) Children or adults in high income settings* AND in specific population groups hypothesised to be at risk of lower vaccination coverage, timeliness or completeness
Exposure	Any characteristics of individuals, communities, or programmatic or contextual factors investigated for an association with the outcomes

Outcome(s)	Inequalities in intention to vaccinate, vaccination uptake, coverage, timeliness or completion (routine England vaccine programme only) in population (a) OR Intention to vaccinate, vaccination uptake, coverage, timeliness or completion (routine England vaccine programme only) in population (b) OR Factors thought to determine intention to vaccinate, vaccination uptake, timeliness or completion on qualitative studies in population (b)

* Any study reporting findings that can be attributed specifically to an Organisation for Economic Cooperation and Development (OECD) country

Search terms and database

We searched Pubmed on 08 April 2019 using the following keyword strategy:
(vaccine OR vaccination) OR "vaccination" [MeSH Terms] OR immunisation OR "immunization" [MeSH Terms]

AND
(uptake OR completeness OR hesitancy OR coverage) OR "vaccination coverage" [MeSH Terms]

AND
("systematic review" [Publication Type]) OR "systematic review".

Results for the social ecological model action framework

Search results

We retrieved 385 studies from our search and 2 further studies from hand-searching included study references. All study screening was performed by a single author (DR). After screening titles and abstracts we retained 23 studies for full text screening. Of these, we retained 10 for inclusion. The studies in the table below were rejected on screening the full text.

Study	Reason for rejection
Spencer 2019	Does not investigate factors potentially associated with inequality
Jain 2017	Does not investigate factors potentially associated with inequality
Mipatrini 2017	Does not investigate factors potentially associated with inequality
Harris 2016	Does not investigate factors potentially associated with inequality
Tabacchi 2016	Does not investigate factors potentially associated with inequality
Tauil 2016	Does not investigate factors potentially associated with inequality
Wilson 2015	Does not investigate factors potentially associated with inequality
De Casadevante 2015	Does not investigate factors potentially associated with inequality
Cook 2013	Does not report findings specific to vaccination
Fisher 2013	Does not investigate factors potentially associated with inequality
Katz 2010	Does not investigate factors potentially associated with inequality
McFadden 2018	Does not report findings specific to vaccination
Kentikelenis 2015	Does not report findings specific to vaccination

Description of included studies

Table A5. Characteristics of included systematic reviews informing the social ecological model

Author, year	Country setting	Included study designs	Population	Vaccinations
Arat, 2019	EEA, EFTA, Australia	Quantitative	Children, stratified by SES indicators	MMR, DTP
Hermann, 2019	High-income (World Bank definition)	Quantitative and qualitative	Children in care of the child welfare system	Childhood
Wilson, 2018	'High-income'	Qualitative	Recent migrants or refugees	Childhood, adolescent or adult vaccines
Fournet, 2018	Europe	Qualitative	'Under-vaccinated group': Orthodox Jews, Roma, Orthodox Protestant, Anthroposothists, Irish Travellers	Childhood, adolescent or adult vaccines
Bocquier, 2017	High-income ('very high' on UN HDI)	Quantitative	Children, stratified by SES indicators	Publicly-funded childhood vaccines (excluding HPV)

Travers, 2018	**USA**	**Quantitative**	**Nursing home residents**	**Pneumococcal and influenza (data on latter not extracted for this report)**
Forster, 2017	UK	Qualitative	Black and minority ethnic groups	Childhood and adolescent vaccinations
Gallagher, 2016	Any (only high-income specific data extracted for this report)	Quantitative and qualitative	Adolescents, stratified by SES indicators	Adolescent multi-dose vaccines (data on HPV only relevant in this study for this review)
Gilkey, 2016	USA	Quantitative and qualitative	Adolescents (or their guardians) from black and minority ethnic groups	HPV vaccine
Ferrer, 2014	High-income (World Bank definition)	Qualitative	Adolescents (with a focus on black and minority ethnic groups)	HPV vaccine

EEA – European Economic Area; EFTA – European Free Trade Association; UN – United Nations; HDI – Human Development Index; SES – Socio-economic status; MMR - Measles, Mumps and Rubella; DTP – Diphtheria, Tetanus, Pertussis; HPV – Human Papilloma Virus

Factors identified by included systematic reviews as potentially explaining vaccination inequalities

Table A6. Potential factors identified by systematic reviews potentially explaining unequal vaccination coverage, timeliness or completion for specific populations in high income settings

Level of model	Factor	Direction of effect on inequalities (- less equal; + more equal)	Count of studies and populations referred to (study reference(s) in brackets)
Intrapersonal	Lack of knowledge regarding vaccine-preventable diseases/vaccination	-	2 Migrant [71], BAME [73]
	Lack of knowledge of vaccination schedule	-	2 Migrant [71], Specific UV [72]
	Lack of knowledge to navigate healthcare system	-	2 Migrant [71], Specific UV [72]
	Language barrier	-	3 Migrant [71], Specific UV [72], BAME [73]
	Literacy barrier	-	2 Specific UV [72], BAME [73]
	Hesitancy regarding effectiveness	-	2 Migrant [71], BAME [73]
	Hesitancy regarding need, severity of infection, or vulnerability to infection	-	3 Migrant [71], Specific UV [72], BAME [73]
	Hesitancy regarding side effects or safety	-/+	4 Migrant [71], Specific UV [72], SES [74], BAME [73]
	Lack of trust in authorities/health service	-/+	3 BAME [75], Specific UV [72], SES [74]
	Belief in traditional/complementary remedies	-	1 Specific UV [72]
	Lower confidence to ask for providers' advice on vaccination	-	1 BAME [77]
Interpersonal	Peer view of value of vaccination	+/-	1 Migrant [71]
	Parental attitudes towards sexual practices	-	3 BAME [73, 75] Migrant [71]
	Hectic home life with competing household needs	-	1 Children in welfare [76]

Institutional	Clinician failing to recommend vaccine	-	3 BAME [75, 77], Migrant [71]
	Cultural specific service not offered	-	2 Migrant [71], Specific UV [72]
	Complex registration process	-	1 Migrant [71]
	Inflexible clinic appointments	-	1 Specific UV [72]
	Difficulty or restriction in registration	-	1 Specific UV [72]
	Complex process to provide vaccination incurring time/travel cost to patient	-	1 SES indicators [74]
	Uncollaborative communication style with parents	-	1 BAME [77]
	For-profit care home setting	-	1 BAME [78]
	Failure to have vaccination status tracked	-	2 BAME [78], Children in welfare [76]
	Lack of organised vaccination programme in institutions	-	2 BAME [78], Children in welfare [76]
	Discontinuity of social care/social worker or repeated care placement moves	-	1 Children in welfare [76]
	Specialised nursing service to improve inter-agency partnership	+	1 Children in welfare [76]
Community	Cultural norms inhibiting discussion of vaccination e.g. sexual health & HPV	-	1 Migrant [71]
	Religious/cultural norms promoting fatalistic approach to illness	-	2 Specific UV [72], BAME [73]
	Perceived stigma, marginalisation, and/or discrimination due to social group	-	1 Specific UV [72]
	Highly mobile lifestyle	-	1 Specific UV [72]
	Religious/cultural norm leading to uncertainty whether vaccination permitted	-	1 BAME [73]
		-	2 BAME [73, 75]
	Cultural religious norms that sex does not occur before marriage hence HPV risk perceived as low	-	1 Migrant [71]
	Women's health less valued	-	1 Migrant [71]
	Men less likely to attend for preventive treatment		
Policy	Vaccination not provided cost-free at point of care	-	3 Migrant [71], SES indicators [74, 75]
	School-delivered vs. community delivered vaccination	+	1 SES indicators [67]
	Dedicated well-baby clinics within primary care models	+	1 SES indicators [79]

BAME – Black and Minority Ethnic Groups; Specific UV – specific under-vaccinated groups: Orthodox Jews, Roma, Orthodox Protestant, Anthroposothists, Irish Travellers; SES indicators – Socio-economic Status indicators: parental income, parental education, area-level deprivation, parental occupation.