Public Health England

Protecting and improving the nation's health

Seasonal influenza vaccine uptake in children of primary school age

Winter season 2018 to 2019

Final data for 1 September 2018 to 31 January 2019

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Executive summary

This report describes key uptake statistics and ecological predictors for uptake of the live attenuated influenza vaccine (LAIV), targeted at children of primary school age in the 2018 to 2019 season in England.

School data providers returned school-level vaccine uptake data for a total of 148 Local Authorities in England, covering all 14 Local NHS England Teams for vaccines administered from 1 September 2018 to 31 January 2019.

Based on school-level data returned by 148 Local Authorities in England, the national cumulative vaccine uptake from 1 September 2018 to 31 January 2019 was:

- 60.2% (2,345,950/3,893,908) in children in school year reception to year 5 across England
- 62.7% (209,838/334,659) in children in school year reception to year 6 across pilot areas in England
- all-age uptake increased for populations in the most deprived decile (from 44.4% in the 2015 to 2016 season to 47% in the 2018 to 2019 season)
- populations having the highest black and ethnic minority composition also saw an increase in uptake over the same period (from 60.4% to 66% respectively).
- populations with the highest Muslim faith composition also saw an increase in uptake over the same period (from 42.4% in the 2015 to 2016 season to 46.9% in the 2018 to 2019 season) – similarly for areas with the highest Jewish faith populations (from 51.9% to 58.7% over the same period).

An analysis of population-level predictors of uptake in primary school children indicates:

- LAIV uptake remained significantly and independently associated with deprivation, ethnicity and religious faith variables after risk adjustment.
- after adjusting for a range of risk factors, the largest effects were seen for deprivation and ethnicity – uptake in areas in the most-deprived decile was significantly lower than areas in the least deprived decile (18 percentage points difference) and uptake in populations with the highest (>34%) BME composition was also significantly lower (8.4 percentage points difference) than areas with the lowest (<5%).BME composition
- areas with the highest percentage Muslim faith population (≥6%) had a significantly lower uptake (5.5 percentage points difference) than areas with 0% Muslim population, after risk-adjustment
- London PHE region had a significantly lower uptake (9 percentage points difference) compared to the baseline North PHE region after risk adjustment
- Pilot areas had significantly higher uptake (2.6 percentage points difference) than non-pilot areas, after risk adjustment.

Background

Seasonal influenza is a common viral infection mainly affecting the upper respiratory tract. Although influenza can affect all age groups, children under 5 years and the elderly (over 65 years) are disproportionately susceptible to complications from influenza infection. Other groups that are also disproportionately vulnerable to complications from influenza are individuals in defined clinical risk groups (which includes asthma, heart disease and weakened immunity), those that are morbidly obese (BMI ≥40) and pregnant women.

Influenza is easily spread in school settings due to children being in close proximity with each other. Universal school vaccination provides not only direct protection by preventing infection in school age children but provides indirect benefits by preventing wider transmission in families and communities.

The United Kingdom, has had a long-standing vaccination programme targeting the elderly (aged 65 years and over) and those in younger age groups in clinical risk groups. Vaccination of young children was added to this programme in the 2013 to 2014 season, following recommendations form the Joint Committee on Vaccination and Immunisation (JCVI) in 2012[1]. Children have been included into the vaccination programme through a phased rollout, with additional age group cohorts added each year, with the aim to eventually cover all children aged 2 to 16 years in England.

In the 2013 to 2014 season, the newly licensed live attenuated influenza vaccine (LAIV) was first offered to children aged 2 to 3 years across England – made available through GP practices (primary care). Alongside this, Public Health England (PHE) commissioned a pilot LAIV vaccination programme to provide vaccines to children of primary school age from reception class to year 6 (4 rising to 11 years) in 11 Local Authorities in England. Schools in these pilot areas offered the LAIV to healthy and at-risk children in whom the vaccine was not contraindicated. At the end of this season, the overall cumulative uptake in the pilot scheme was 52.5%, ranging from 35.8% to 71.5% between pilot areas[2].

Since the 2013 to 2014 season, the national programme has been expanding annually to include additional school year cohorts, alongside continuation of the pilot scheme.

During the 2018 to 2019 season, the LAIV programme was extended to cover children in school years reception to year 5 (aged 4 rising to 10 years) through the school delivery model as before. Children aged 2 to 3 years continued to be offered the vaccine through GP practices. Cumulative school-level vaccine uptake data were manually submitted through ImmForm for all children of school-age on a monthly basis. Vaccine uptake was recorded locally at school level and then reported to ImmForm by

local authority (LA). At the end of the influenza season, final cumulative vaccination data including data on refusals and contraindications was collected at school-level across England and submitted to PHE. This school-level data was used to evaluate predictors of vaccine uptake of LAIV.

Methods

End of season data for the 2018 to 2019 school-age influenza programme were collected at the school-level and submitted to PHE between February and June of 2019. This dataset comprised mandatory data items on LAIV vaccine uptake used for routine reporting and additional data on refusals and contraindications, all collected through a standardised data collection tool developed by PHE and disseminated to designated school data providers. Most of the data providers used this tool. These tools allowed for the entry of either child- or school-level data, which is then aggregated into school totals per LA. For confidentiality reasons, PHE only collected school-level data. The end of season data items requested for this study are outlined in Annex B. The PHE dataset was enhanced by linkage to census-based population indicators collated by the Office for National Statistics made accessible from web-based census data services.

Uptake

End of season uptake for the school-age influenza programme was calculated based on the number of children in the target population eligible for LAIV who were reported to have received one dose of influenza vaccine between 1 September 2018 to 31 January 2019. If children received multiple doses, only the first dose was counted.

The target population was defined as the number of primary school-age children (aged 4 to 9, rising to 10 years) born between 1 September 2007 and 31 August 2014, as defined by the child's age on 1 September 2018. This season all children in reception (aged 4 rising to 5 years), year 1 (aged 5 rising to 6 years), year 2 (aged 6 rising to 7 years), year 3 (aged 7 rising to 8 years), year 4 (aged 8 rising to 9 years) and year 5 (aged 9 rising to 10 years) were offered the vaccine. All primary school-aged children aged 4 rising to 11 years (born between 1 September 2007 and 31 August 2014) resident in pilot areas were also offered the vaccine.

Predictors of uptake

Firstly, the latest postcode for each school was extracted from web-based data available from the Gov.uk website[3]. This postcode was then used to find the Lower Super Output Area Level (LSOA) code and the 2015 deprivation deciles for each school using GeoConvert: UK Data Service Census Support tool[4]. The deprivation data is based on the 2015 Index of Multiple Deprivation. The LSOA level data is based on 2011 census geographical boundaries.

Data on religion, ethnicity, age, sex and rural/urban setting by LSOA were downloaded from Nomis (a web service commissioned by ONS)[5]. The data was merged with the

existing dataset by matching to LSOA. Age and sex were used to allow aggregation of the ethnicity and religious faith data. Religion and ethnicity predictors were included in a regression model to evaluate their association with influenza vaccine uptake for those aged 0 to 15 years old.

Each LSOA is associated with a postcode and comprised a resident population range of 1,000 to 3,000[6]. The Index of Multiple Deprivation (IMD) is an overall score assigned to each LSOA summarising its relative level of deprivation based on 7 domains.

1. Income.
2. Employment.
3. Health.
4. Education.
5. Crime.
6. Service access.
7. Living environment.

The 2015 updated IMD scores were available by decile (from the GeoConvert data services site).

Information on ethnic constitution of each LSOA is available according to the following categories: White/Mixed/Asian/Black/Other[7]. The proportion of black or minority ethnic residents (BME, defined as non-white British) in each LSOA was divided into quartiles.

Information on the religious constitution of each LSOA is available for Christian /Buddhist/Hindu/Jewish/Muslim/Sikh/Other/None[8]. as reported in the original 2011 census. Populations that reported as belonging to the Jewish and Muslim faiths were also of interest due to concerns over the use of porcine gelatine in the vaccine. As 95% of schools were in an area where Jewish communities accounted for less than 1% of the local population, LSOAs identifying as were grouped according to whether the percentage of the local population of Jewish faith fell into one of 2 demographic groups: 0% or >0. Similarly, LSOAs were grouped according to whether the percentage of the Muslim population fell into one of 3 demographic groups: 0%, 1-5% or 6%+.

Classification of the LSOA as rural (Town and fringe/Village or hamlet/Isolated dwelling) or urban (Major conurbation/Minor conurbation/City and town) was available from the ONS 2011 census[5]

Vaccine uptake was calculated by each of these population characteristics. A linear regression analysis was undertaken to identify population factors associated with influenza vaccine uptake. Uptake in primary schools was linearly regressed against the same population-level variables (area, deprivation, ethnicity, religious constitution and rurality) to determine if changes in uptake could be explained. All the variables were

included in a multiple linear regression model to provide adjusted estimates. The methodology was previously published in a study examining predictors of LAIV uptake and since then repeated for subsequent annual reports on this topic[9].

Consent, refusal, refused but previously vaccinated and non-responders

For each eligible child, a parental consent form for the influenza vaccination was sent out to parents through the child's school. The return of these forms was recorded by the school/local authorities and information on the number of consents, refusals and no form returned was submitted to PHE within the data collection tool at the end of the season. Not all areas provided this information and when it was provided, it was not always done so consistently.

Consent

Calculated from the number of consent forms returned by all children in a year group, divided by the final denominator for that year group. Consent is defined as direct parental consent to vaccinate. In some cases, consent includes children who are contraindicated for vaccination with LAIV.

Refusal

Calculated from the number of forms returned by all children in a year group, divided by the final denominator for that year group. Refusal is defined as direct refusal to vaccinate. In some cases, this includes children who are contraindicated for he vaccination with LAIV.

Refused but previously vaccinated

Calculated from the number of forms returned which stated a refusal based on the fact that the child had been previously vaccinated within the 2018 to 2019 flu season, divided by the final denominator for that year group.

No consent form returned

Calculated from the number of forms not returned in each year group, divided by the final denominator for that year group. When no consent form was returned for a child, that child would not be vaccinated through the school programme. These non-responder counts were either provided by the school level data submission or calculated from the final denominator by subtracting the sum of consent and refusal counts. No returns may also include children contraindicated for vaccination with LAIV.

Contraindications

Data was collected for contraindications based on the risk-groups outlined in the Green Book[10]. The number of children contraindicated for vaccination were recorded and aggregated by risk group. Contraindications were split into 2 groups.

1. Prior contraindications: pre-existing contraindications such as anaphylactic reaction (other than olvabumin); immunosuppression or severe asthma (full list in the Green book).
2. On-day contraindications such as severe asthma, active wheezing or acute illness.

Not all schools or LAs reported data for contraindications, and those who did not always do so consistently. Where contraindications were reported, the affected children were offered either an injectable quadrivalent inactivated influenza vaccine on site, or were referred to their primary care physician for vaccination.

Other reasons for non-vaccination

Data was also collected for those who refused vaccination due to the porcine content of the vaccine, those children who were absent on the day and for the children who refused to be vaccinated on the day. As with the contraindication data, not all schools or LAs reported this information and those who did often filled out this section inconsistently.

Data Limitations

The analysis in this report (based on school-level data from manual returns of the data collection tool), differed marginally from the final cumulative data published in the annual report for the same 2018 to 2019 season[11]. Data for the latter was based on Immform data returns uploaded by local authorities and subsequently validated via automated and manual processes. However in this study the cumulative uptake for all children in reception to year 5 decreased by <1 of a percentage point (0.6%) compared to the corresponding figure in the annual report.

For children (reception to year 6) in pilot areas LAIV uptake increased by only one tenth of a percentage point (0.1%) compared to the corresponding figure in the recent annual report. These minor differences are likely to be due to the fact that the school-level dataset can uncover errors not picked up by LAs when submitting the final cumulative figures at the time of the influenza reporting season. For example, the duplication of some schools' uptake data or the need to exclude data due to missing URNs or the fact that the denominator of the school was smaller than the reported number of children vaccinated. However, these errors affected a small number of schools.

Other data exclusions were related to aspects of enhanced dataset such as non-match of school postcodes or schools with missing information on one or more of the enhanced variables required for the descriptive and regression analysis. Finally other exclusions were LAs that did not use a school delivery model (n=1) and LAs that did not return a completed data collection tool (n=3). Details on the excluded schools can be found in (Annex D).

Regarding all school-level data

In this study, data was collected for Bassetlaw, so for the purpose of these analyses it formed an LA separate from Nottinghamshire, resulting in 2 separate LAs. Furthermore, LAs Leicestershire and Rutland were merged due to small numbers, as was City of London with Hackney and Cornwall with the Isles of Scilly; this resulted in 3 LAs contributing to the total of 151 LAs in the study. The Isles of Scilly, however, is the only LA to still use the GP delivery model, and its data was therefore excluded from this school-level analysis. The data from Cornwall was still included.

Predictors of LAIV uptake

For the linear regression analysis of children in school years reception to year 5, a total of 84,466/103,564 records comprising school level data by age cohort were successfully matched to their postcodes. Hence 19,098 of these records were unable to

be matched to the LSOA classification and could not be included in the regressions for uptake predictors; they were, however, still included in the descriptive analyses.

The year group cohorts that could not be matched to their postcodes, in the dataset for the regression analysis included cohorts that had listed their school URN as 111111, 777777, 888888 or 999999, which correspond to home educated, unknown school URN and schools that have been excluded or refused to offer the school-based delivery programme.

Results

Uptake: school years reception to 5, 2018 to 2019, England

In the 2018 to 2019 season, a total of 98% (148/151) of LAs included in this study returned school-level data using the standardised data collection tool. This returned data covered 2,345,950 children reported to have received at least one dose of influenza vaccine, out of a total of 3,893,908 eligible children. This results in a cumulative uptake of 60.2% for the period of 1 September 2018 to 31 January 2019, with uptake ranging from 48.4% in London to 68.5% in Hampshire, Isles of Wight and Thames Valley (Table 1). Uptake by year group was also calculated (not shown): 63.7%, 63.3%, 61.2%, 59.9%, 57.7% and 55.8% in years reception to 5, respectively.

The 3 LAs who did not submit school-level data for analyses also used the school-delivery model, but as no school-level data was provided by them, they were excluded from this report. From data previously submitted by these 3 LAs, it can be estimated that uptake in these 3 regions was 58.1% (65,251/112,371) between 1 September 2018 to 31 January 2019.

Table 1. Estimated proportion of children in school years reception to year 5 in England who were vaccinated between 1 September 2018 to 31 January 2019.with at least one dose of influenza vaccine in schools, by NHS England Local Team

NHS England Local Team[a,b]	No. of children eligible for vaccination	No. of children vaccinated with at least 1 dose of influenza vaccine	Vaccine uptake (%)
London	**595,473**	**288,440**	**48.4**
London	595,473	288,440	48.4
Midlands and East	**1,195,642**	**735,538**	**61.5**
Central Midlands	298,047	177,970	59.7
East	307,363	190,534	62
North Midlands	257,156	169,474	65.9
West Midlands	333,076	197,560	59.3
North	**1,070,059**	**670,004**	**62.6**
Cheshire and Merseyside	172,465	112,790	65.4
Cumbria and North East	213,859	129,384	60.5
Greater Manchester	224,730	138,590	61.7
Lancashire	109,784	67,607	61.6
Yorkshire and Humber	349,221	221,633	63.5

South East	**656,904**	**418,893**	**63.8**
Hampshire, Isle of Wight and Thames Valley	288,417	197,454	68.5
Kent, Surrey and Sussex	368,487	221,439	60.1
South West	**375,830**	**233,075**	**62**
North	177,221	113,489	64
South	198,609	119,586	60.2
Total	**3,893,908**	**2,345,950**	**60.2**

[a]Denominators represent the number of children in school years reception to 5 who were eligible for vaccination. Denominators are based on school-roll figures obtained directly from schools. If these figures were unavailable then Department of Education January 2018 school census figures were used.
[b]The 3 LAs who did not provide school-level data were excluded, as was the Isle of Scilly, as here they used the GP delivery model.

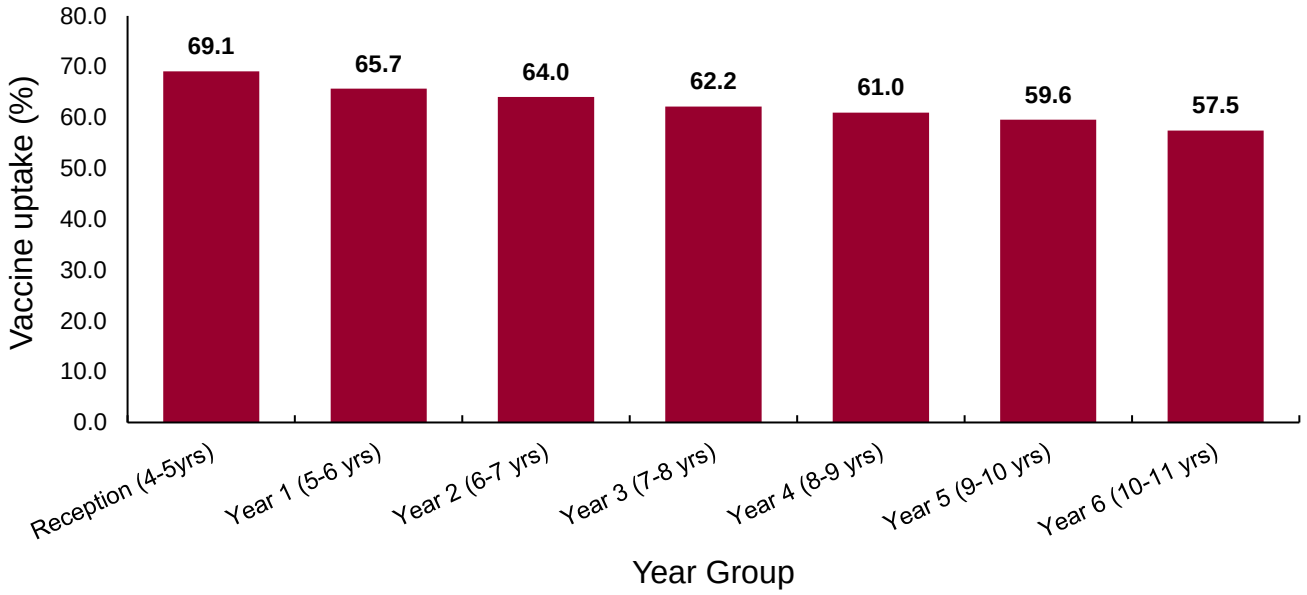
Uptake: school years reception to 6 in pilot areas in England

In pilot areas, an estimated 209,838 children of school years reception to year 6 were vaccinated with the influenza vaccine, out of a total of 334,659 (Table 7). This resulted in an overall uptake of 62.7%, ranging from 68.5% in Leicestershire and Rutland to 45% in Leicester, for between 1 September 2018 to 31 January 2019. With regards to year group, vaccine uptake in pilot areas was highest for reception (ages 4 rising to 5) at 69.1% and the lowest for year 6 (ages 10 rising to 11) at 57.5%. A trend of decreasing uptake for increasing year group is observed (Figure 6).

Table 7. Cumulative vaccine uptake in pilot areas in England, for primary school children in years reception to year 6 vaccinated between 1 September 2018 and 31 January 2019

Pilot area	No. of children eligible for vaccination	No. of children vaccinated with at least 1 dose of influenza vaccine	Vaccine uptake (%)
Bury	17,380	11,539	66.4
Essex	123,810	82,984	67
Gateshead	16,050	9,741	60.7
Havering	19,632	11,352	57.8
Leicester	32,885	14,809	45
Leicestershire and Rutland	57,707	39,501	68.5
South Tyneside	11,910	7,064	59.3
Southend on Sea	16,028	10,221	63.8
Sunderland	22,053	12,497	56.7
Thurrock	17,204	10,130	58.9
Total	**334,659**	**209,838**	**62.7**

Figure 6. Estimated cumulative proportion of primary school children in school years reception to year 6 in pilot areas across England vaccinated with the influenza vaccine (LAIV) in England, between 1 September 2018 to 31 January 2019



Uptake by PHE region, 2018 to 2019, England

The PHE region level analysis showed that there was little variation between North, South and Midlands and East regions, each having a median uptake of two-thirds of the population. However in London the median uptake was <50% (Table 2 and Figure 1).

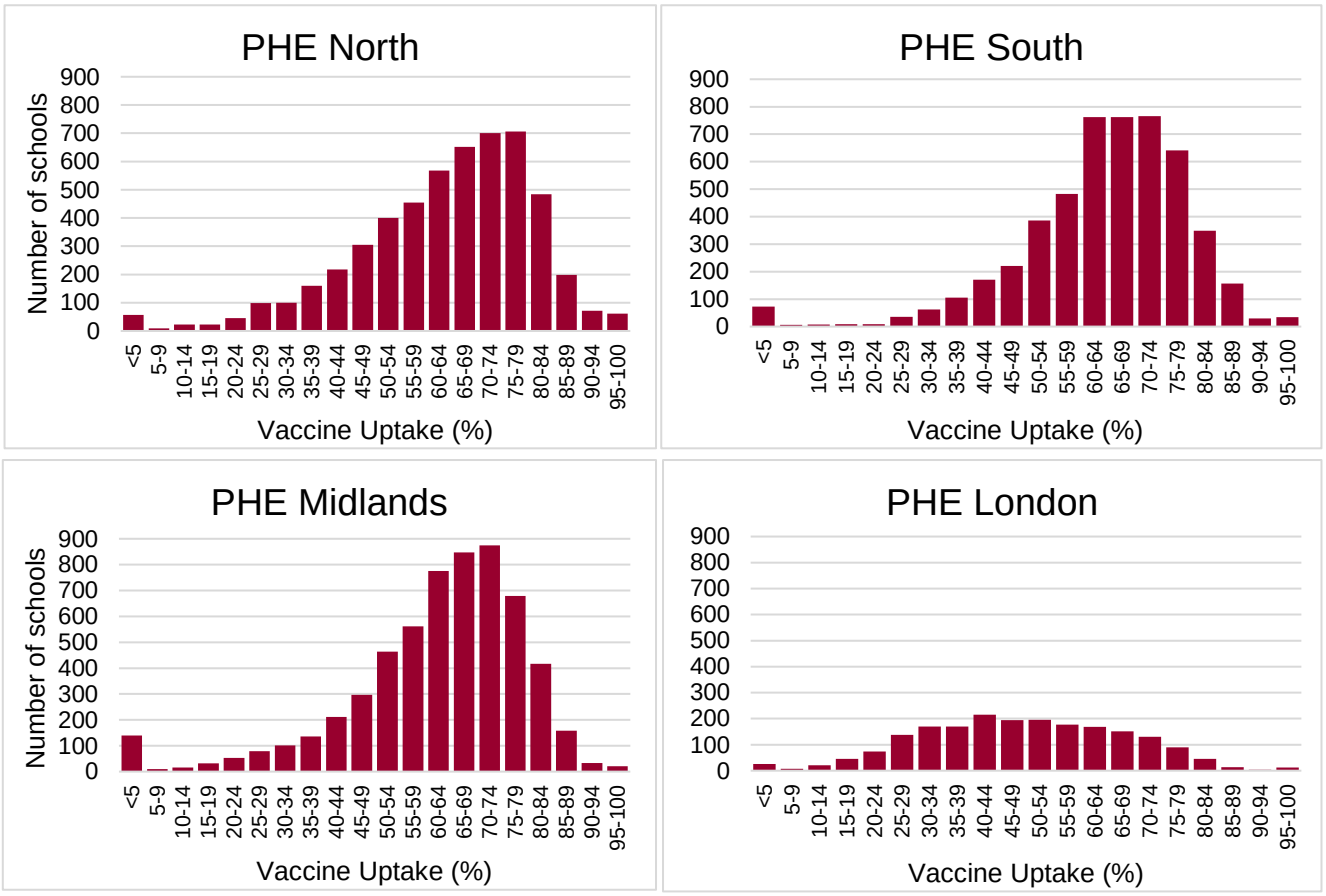
Figure 1 shows the distribution of uptake at school level. The distributions for the non-London regions are left skewed with peaks in the 70-79% uptake range whereas London has relatively flatter and broader distribution, with uptake peaking in the 40-44% range. Extremities at both ends of the uptake spectrum (≥90% and ≤10%) reflect schools with true high or low uptake respectively.

Table 2. Median vaccine uptake by PHE region, 2018 to 2019 season, England

PHE Region	Number of schools	Median Uptake[a]	IQR[a]
North	5,331	66.7	53.8 to 76.2
South	5,063	66.4	57.1 to 74.5
Midlands and East	5,911	65.5	54.3 to 73.9
London	2,053	48.6	36.1 to 63

[a]URNs listed as 111111, 777777, 888888, and 999999, which correspond to home educated, unknown school URN and schools who refused to offer the school-based delivery programme were excluded.

Figure 1. Cumulative uptake of the school-delivery influenza vaccine by PHE region from 1 September 2018 to 31 January 2019, England



Analysis of inequalities in LAIV uptake, England

Analyses were conducted to compare vaccine uptake for different demographic groups between the 2015 to 2016 season to the 2018 to 2019 season.

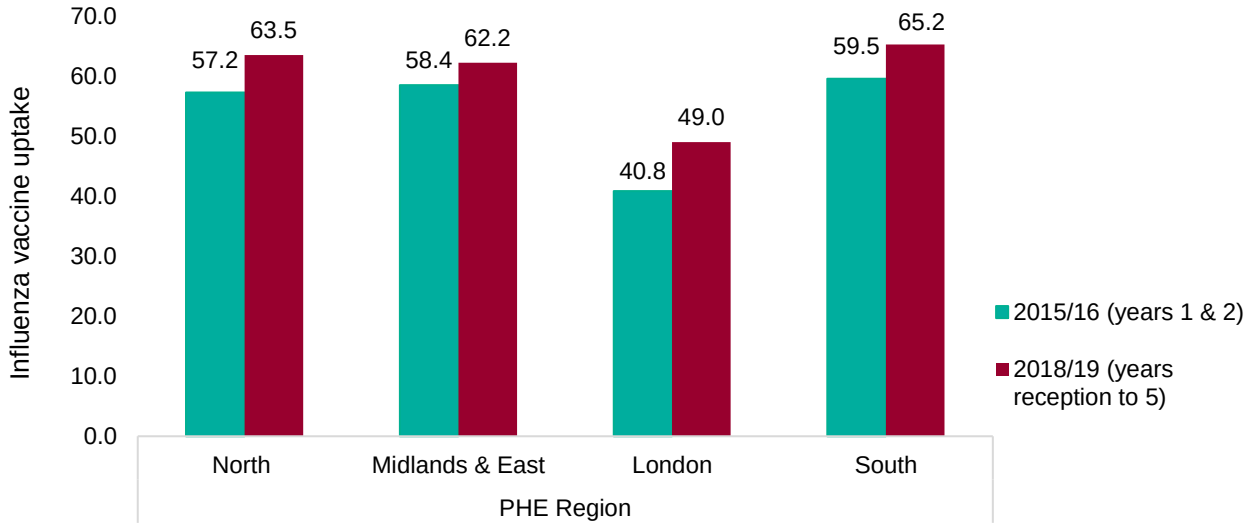
These analyses were conducted for the main vaccination programme, excluding the additional cohorts vaccinated within the pilot programme in each year of analysis. Due to this, it is important to note that the following cohorts were vaccinated under the main programme over the previous years:

- 2015 to 2016 vaccinated year 1 and 2
- 2016 to 2017 vaccinated years 1, 2 and 3
- 2017 to 2018 vaccinated years reception, 1, 2, 3 and 4
- 2018 to 2019 vaccinated years reception, 1, 2, 3, 4, and 5

A comparison of uptake across PHE regions in 2015 to 2016 and separately 2018 to 2019 is shown in figure 2. It should be noted that caution is needed when making direct inter-year comparisons due to differences in the underlying target population in these seasons with the 2015 to 2016 season composed of school year cohorts 1 and 2 which expanded

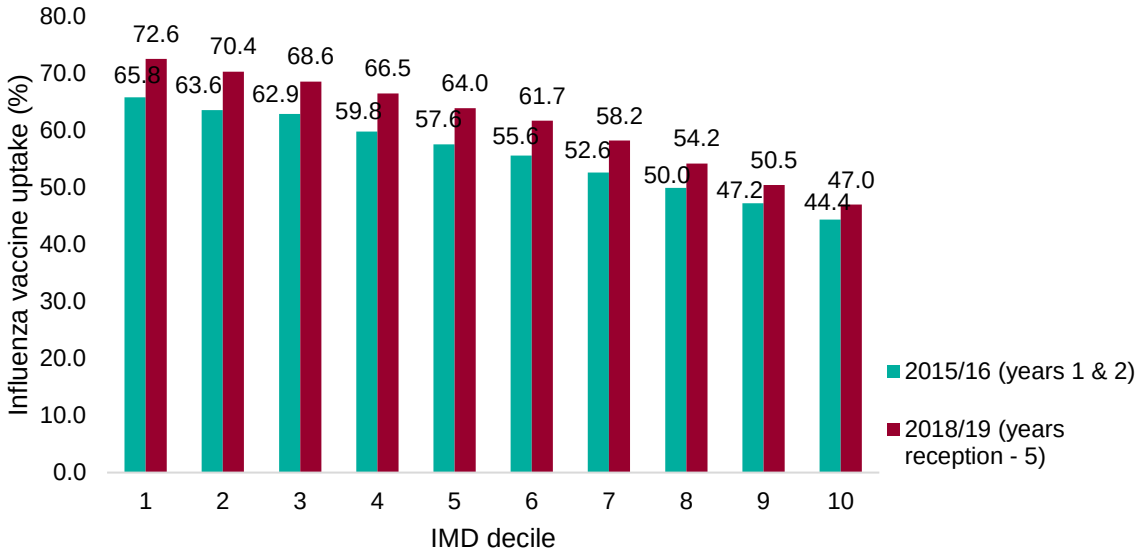
in subsequent years due to the incremental roll out of the LAIV programme so that by the 2018 to 2019 season the target population was composed of reception to year 5 cohorts. Generally however, London did consistently show the lowest uptake compared to the other PHE regions in both seasons. The South region consistently showed the highest uptake compared to the other three PHE regions in both seasons.

Figure 2. Influenza vaccine uptake across PHE regions in England between 2015 to 2016 and 2018 to 2019, alongside the increase in uptake of each PHE region between 2015 to 2016 and 2018 to 2019 in England



Uptake in IMD groups 1 (least deprived decile) to 10 (most deprived decile) is shown for 2015 to 2016 and the 2018 to 2019 flu seasons (Figure 3). Both seasons showed a general deprivation gradient in LAIV uptake, meaning decreasing LAIV vaccine uptake as deprivation increased. The gap between LSOAs in the least and most deprived decile was large (72.6% and 47% respectively). Although an increase in uptake is observed for the most deprived group (from 44.4% in the 2013 to 2014 season to 47% in the 2018 to 2019 season), the underlying target population did differ over time due to the incremental expansion of the programme.

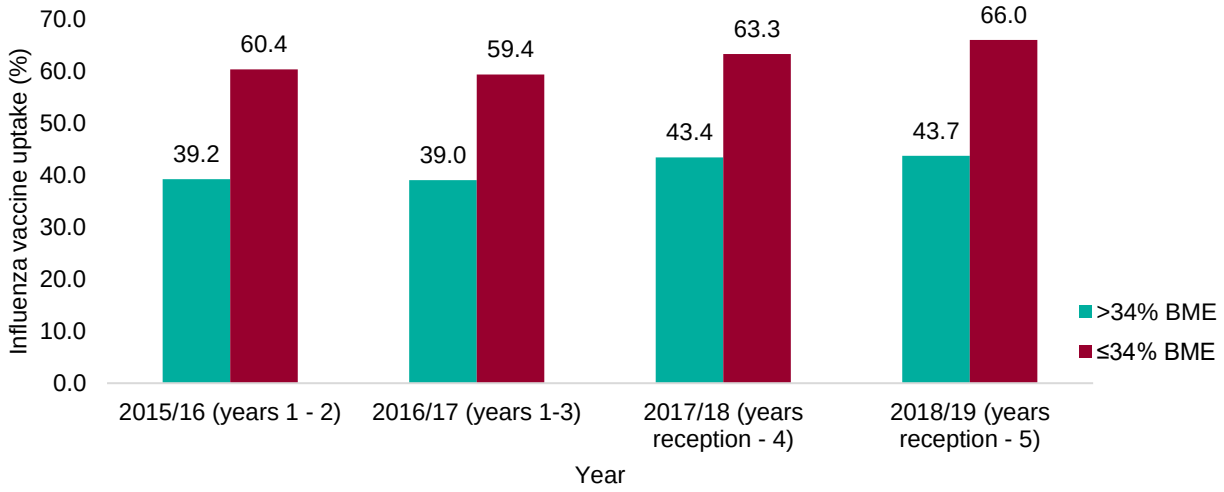
Figure 3. Change in LAIV vaccine uptake from the 2015 to 2016 to the 2018 to 2019 flu seasons across IMD deciles 1 (least deprived) to 10 (most deprived), England



Analysis was conducted to compare influenza vaccine uptake between populations with >34% and ≤34% BME composition between 2015 to 2016 and 2018 to 2019 seasons (Figure 4). It is important to note that the BME data is based on data collected in the 2011 census, for which the response rate was estimated at 94%. Furthermore, the BME group is not a homogenous group and the percentage may mask differences in uptake found between the different ethnicities included in the BME definition. It is likely to also be confounded by deprivation.

The results of the BME analysis show that uptake was consistently lower among populations with >34% BME than in populations with ≤34% BME composition despite the differences in underlying target population (Figure 4). Although an increase in uptake for the ≥34% BME group is observed over time (from 60.4% in the 2013 to 2014 season to 66% in the 2018 to 2019 season) the underlying target population did differ over time due to the incremental expansion of the programme with added cohorts in each year.

Figure 4. Comparison of LAIV uptake between populations with ≤34% and >34% black and minority ethnic composition between 2015 and 2016 and 2018 to 2019 in England. (The BME analysis based on a 94% response rate on BME in the 2011 census)



Uptake across Lower Layer Super Output Areas (LSOA) was compared between areas that have no Jewish faith populations and those with a Jewish population of over 0%. Similarly, uptake was compared between areas that had no Muslim faith population and areas with 1-5% and 6+% Muslim population (Figure 5).

These analyses showed that since 2015 to 2016, a general pattern emerges where uptake has consistently been lower in populations with >0% Jewish and Muslim faith population (Figure 5). In the 2018 to 2019 season LSOAs with 0% Jewish population had an uptake of 62.1% compared to 58.7% in LSOAs where the Jewish faith population was >0%. However this difference was not as large as the one between LSOAs with 0% and >6% Muslim populations (67.4% and 46.9% respectively). The latter result may be confounded by deprivation which is explored and discussed later in this report.

In terms tracking progress in uptake in these faith groups over time, an increase is observed for the highest exposure group in both faiths. Uptake for LSOAs with >6% Muslim faith population increased from 42.4% in the 2015 to16 season to 46.9% in the 2018 to 2019 season. Similarly uptake in the highest Jewish population (>0%) increased from 51.9% to 58.7% over the same time period respectively. However, caution is required in interpreting the trends in uptake due to differences in the school cohort composition as a result of the incremental roll out of the programme over the years, as indicated earlier.

Figure 5. Uptake across Jewish and non-Jewish alongside Muslim and non-Muslim faith LSOAs in the 2015 to 2016 and in the 2018 to 2019 seasons, England

Analyses were also conducted to compare the uptake between rural and urban areas and pilot and non-pilot areas across England in the 2015 to 2016 flu season through to the 2018 to 2019 flu season (Table 3). The results show that (regardless of the differences in the underyling target population in each season), a general pattern emerges where the overall uptake has been consistently higher in rural areas than in urban areas in each of the seasons.

With regards to pilot and non-pilot areas, pilot areas tended to show a pattern of consistently higher vaccine uptake than non-pilot areas over the 4 winter seasons (Table 3).

Table 3. Recorded influenza vaccine uptake for the 1 September 2018 to 31 January 2019 for England, split by geographical location to be classified as either rural or urban. Comparison of influenza vaccine uptake is also compared between pilot and non-pilot areas for this time

Area	Uptake (%)			
	2015 to 2016	2016 to 2017	2017 to 2018	2018 to 2019
Rural	63.7	63.2	66.3	63.7
Urban	54.1	53.4	57	55.1
Pilot	60	60	63.1	63.7
Non-Pilot	55.3	54.7	58.1	61.2

Contraindications and other reasons for non-vaccination: School years reception to year 5, 2018 to 2019 season, England

Information on reasons for not vaccinating were collected which covered known contraindications, refusals/absences, refusals due to the vaccine's porcine content and all other reasons (Table 4.)

With regards to known contraindications, 9,806/18,358 (53.4%) school reported data on refusals due to contraindications, this excludes schools with URNs 111111, 888888 and 999999 which covers home schooled children, children educated outside of school and schools with unknown URNs, respectively. Regarding all other reasons for non-vaccination, a total of 7,860/18,358 (42.8%) schools reported data (again, excluding URNs 111111, 888888 and 999999).

A total of 103,947 primary school children eligible for LAIV in the 2018 to 2019 season (from reception to year 5 inclusive) did not receive the vaccine due to a range of reported reasons (Table 4). Overall, the most common reason for non-vaccination was the child refusing on the day, or being absent on the day (n=58,144) which accounted for 55.9% of total reported reasons for non-vaccination. The second most common reason for a child not being vaccinated was represented by the 'other/unknown reason' and made up 30.5% of all reasons for non-vaccination (n=31,718). No further information was available for reasons falling into this category.

Known contraindications reported prior to or on vaccine delivery day accounted for 6% of total reasons for non-vaccination. Among the known contraindications reported prior to vaccination delivery day, the most common was immunosuppression of a family member (n=1,004) and immunosuppression of the child themselves (n=750), each accounting for 1% and 0.7% of all reasons for non-vaccination, respectively. For contraindications recorded on the vaccine delivery day, the most common was the child being unwell (n=2,446) which accounted for 2.4% of all reported reasons for non-vaccination.

Finally, 7.6% (n=7,856) of those reporting reasons for non-vaccination listed the reason as due to the porcine content of the vaccine.

Table 4. Reasons for non-vaccination, including known contraindications, collected by immunisation staff during vaccination visits to schools in England between 1 September 2018 and 31 January 2019

Contraindication / Reason for non-vaccination		Number of children affected	% of total reasons for contraindication / non-vaccination
Known contraindications			
Prior		**3,597**	**3.5**
	Confirmed egg allergy	723	0.7
	Immunosuppression (family)	1,004	1
	Previous allergy to flu vaccine	545	0.5
	Severe asthma	379	0.4
	Immunosuppression (personal)	750	0.7
	Another vaccine given/due	66	0.1
	Cardiac disease/ Salicylate therapy	130	0.1
On day		**2,632**	**2.5**
	Child unwell	2,446	2.4
	Asthma/wheezing	186	0.2
Child refused/absent		**58,144**	**55.9**
Known reasons for refusal: vaccine contains porcine gelatine		**7,856**	**7.6**
Other and unknown		**31,718**	**30.5**
Total		**103,947**	**100**

Predictors of uptake: school years reception to year 5, 2018 to 2019, England

The results of the unadjusted univariate and risk adjusted multivariate regression analyses are shown in table 5. Figure 6 shows a graphical representation of the risk adjusted estimates.

Using available data for this analysis (n=3,017,113), the risk adjusted model showed that deprivation, ethnicity and populations belonging to certain religious faiths, rurality, region and pilot status all remained independently associated with uptake. The largest effects were seen for those in the most deprived groups and for those in populations with ≥34% black or minority ethnic (BME) when compared to their respective baseline groups. Vaccine uptake was estimated to be 18 percentage points lower in schools falling in the most deprived decile (IMD 10) compared to the baseline group (least deprived decile). Schools falling in LSOAs with the highest ethnicity population (≥34%) had vaccine uptake that was estimated to be 8.4 percentage points lower compared to the baseline group (<5% ethnicity population).

Although the difference in vaccine uptake between highest and lowest exposure groups ‘attenuated’ or shrunk after risk adjustment, vaccine uptake effects remained statistically significant. Attenuation of vaccine uptake was most marked for ethnicity and Muslim population variables. In the unadjusted model LAIV vaccine uptake in schools located in LSOAs with the highest ethnicity composition was 22.5 percentage points lower than the baseline group but after risk adjustment, contracted to being 8.4 percentage points lower than the baseline group, although this difference was still high.

Similarly schools located in LSOAs with the highest population with Muslim faith (>6%) had LAIV uptake was estimated to be 19.2% percentage lower compared to the baseline (non-Muslim population 0%) before risk adjustment. After adjustment, uptake contracted to being 5.5 percentage points lower than the baseline group (population with non-Muslim faith). LSOAs with the highest population with Jewish faith also experienced attenuated effects (shrinking of difference with the non-Jewish faith baseline group) after risk adjustment. Although the risk adjusted uptake was marginally lower than the baseline this was statistically significant at the 5% level.

IMD (in deciles) showed uptake decreased progressively as deprivation increased compared to the baseline (table 5 and figure 6) and statistically significant at each decile. However the difference between the most and least deprived deciles remained very high even after risk adjustment (18% percentage points lower in most deprived compared to the least deprived decile). The difference between the least and most exposed groups for the ethnicity and IMD variables in particular remained high after adjustment.

Pilot areas were shown to have a significantly higher uptake than non-pilot areas in the adjusted and unadjusted models.

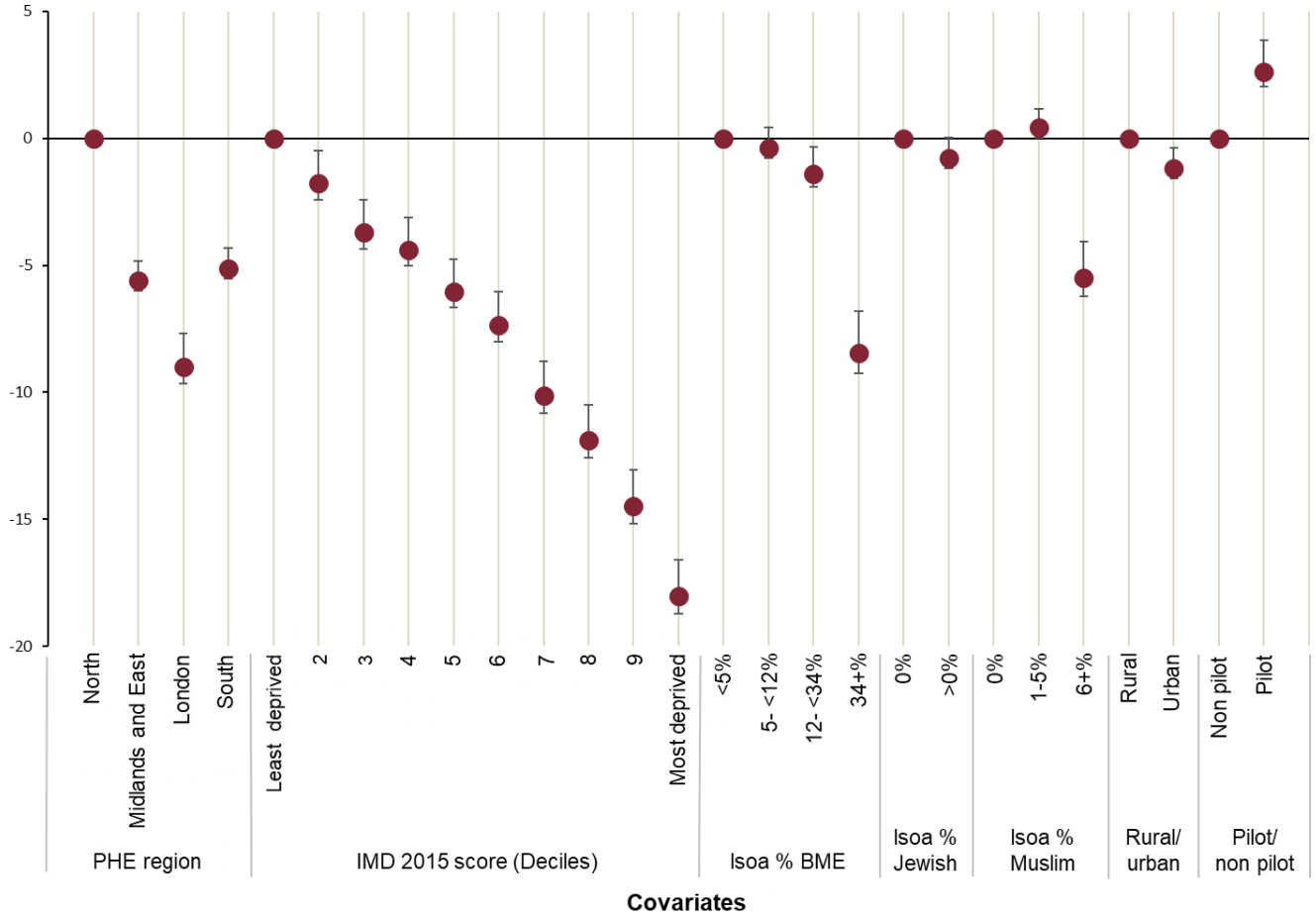
London uptake was 18% percentage points lower than the baseline group (North) in the unadjusted model and although contracting after risk adjustment, the difference remained high (9 percentage points lower than the baseline). The other 3 regions had lower uptake than the North prior to risk adjustment but after risk adjustment the magnitude increased.

Table 5. The adjust and unadjusted impact of various predictors on influenza vaccine uptake for children of primary school years reception to year 5, uptake data between 1 September 2018 and 31 January 2019, England

Covariate		Total Number of children	Crude uptake (%)	Unadjusted		Adjusted[a]	
				Estimated % uptake change (95% CI)	p-value	Estimated % uptake change (95% CI)	p-value
PHE Region of School	North	0	0.0	Baseline	-	Baseline	-
	Midlands and East	0	0.0	-4.18 (-4.57 to -3.79)	<0.001	-5.60 (-5.98 to -5.21)	<0.001
	London	0	0.0	-18.05 (-18.60 to -17.50)	<0.001	-8.99 (-9.63 to -8.34)	<0.001
	South	0	0.0	-1.08 (-1.49 to -0.67)	<0.001	-5.14 (-5.55 to -4.74)	<0.001
IMD 2010 Score of school (decile)	1 (Least deprived)	0	0.0	Baseline	-	Baseline	-
	2	0	0.0	-1.61 (-2.29 to -0.93)	<0.001	-1.78 (-2.43 to -1.13)	<0.001
	3	0	0.0	-3.46 (-4.13 to -2.78)	<0.001	-3.71 (-4.36 to -3.06)	<0.001
	4	0	0.0	-4.33 (-4.99 to -3.67)	<0.001	-4.38 (-5.02 to -3.74)	<0.001
	5	0	0.0	-6.37 (-7.03 to -5.71)	<0.001	-6.03 (-6.67 to -5.39)	<0.001
	6	0	0.0	-8.56 (-9.23 to -7.89)	<0.001	-7.35 (-8.01 to -6.70)	<0.001
	7	0	0.0	-12.29 (-12.98 to -11.59)	<0.001	-10.14 (-10.81 to -9.46)	<0.001
	8	0	0.0	-15.64 (16.35 to -14.94)	<0.001	-11.88 (-12.58 to -11.19)	<0.001
	9	0	0.0	-19.36 (-20.07 to -18.65)	<0.001	-14.47 (-15.18 to -13.76)	<0.001
	10 (Most deprived)	0	0.0	-21.59 (-22.30 to -20.89)	<0.001	-18.00 (-18.71 to -17.29)	<0.001
School lsoa % black or minority ethnicity	<5%	0	0.0	Baseline	-	Baseline	-
	5 to <12%	0	0.0	-0.89 (-1.27 to -0.51)	<0.001	-0.38 (-0.79 to 0.032)	0.071
	12 to <34%	0	0.0	-5.97 (-6.38 to -5.56)	<0.001	-1.40 (-1.93 to -0.88)	<0.001
	34+ %	0	0.0	-22.48 (-22.93 to -22.03)	<0.001	-8.44 (-9.27 to -7.62)	<0.001
School lsoa % Jewish	0%	0	0.0	Baseline	-	Baseline	-
	>0%	0	0.0	-3.42 (-3.83 to -3.01)	<0.001	-0.79 (-1.19 to -0.39)	<0.001
School lsoa % Muslim	0%	0	0.0	Baseline	-	Baseline	-
	1 to 5%	0	0.0	-1.50 (-1.84 to -1.16)	<0.001	0.41 (0.03 to 0.78)	0.032
	6+%	0	0.0	-19.17 (-19.60 to -18.74)	<0.001	-5.49 (-6.21 to -4.77)	<0.001
Rural/Urban school	Rural	0	0.0	Baseline	-	Baseline	-
	Urban	0	0.0	-7.72 (-8.06 to -7.37)	<0.001	-1.20 (-1.61 to -0.80)	<0.001
Pilot/ Non-Pilot	Non-pilot	0	0.0	Baseline	-	Baseline	-
	Pilot	0	0.0	2.97 (2.35 to 3.59)	<0.001	2.63 (2.02 to 3.23)	<0.001

[a]Predictor variables used were, PHE region, IMD score, lsoa % black or minority ethnicity, lsoa% Jewish, lsoa% Muslim, Rural/Urban school, and pilot non-pilot status

Figure 6. Adjusted linear regression showing the change in percentage uptake of population-level predictors when compared to baseline values for children in school years reception to year 5 in England, 1 September 2018 to 31 January 2019. Corresponding 95% confidence intervals are also shown



Discussion

During the 2018 to 2019 influenza season, the school-age vaccination programme was extended to include children in year 5, with those in years reception to year 4 being already included in the programme across England. For the 2018 to 2019 season, an overall influenza vaccine uptake of 60% was achieved for England for years reception to year 5. In pilot areas, on overall uptake of 62.7% was achieved in England for children aged reception to year 6.

However, as alluded to earlier, there are caveats with some interpretation of the results. The aggregation of all black and ethnic minorities into one group has drawbacks. Although this allows for rapid and easy interpretation, this is not a homogenous group. The BME definition encompasses those from all ethnic minorities in England as based on the % BME for each location from the 2011 Census. The overall LAIV uptake based on a broad BME category may mask the hardest-to-reach subgroups. Furthermore ethnicity is likely to also be confounded by deprivation hence the rationale for targeting deprivation to improve uptake in future campaigns.

Another caveat, as mentioned is associated with evaluating the trends in the all-age uptake over time. The cohort composition changed in successive seasons due to the phased roll-out of the LAIV programme. For this reason, looking at general patterns of uptake in certain groups over time are perhaps more useful than drawing firm conclusions from inter-year comparisons.

Another potential weakness in the data is the lack of information regarding entire schools that refused LAIV vaccination. Very few local authorities provided information on the number of schools that refused on that basis, so it is likely that some schools that had refused to take part in the vaccination programme were excluded from the denominator or numerator calculations for uptake. Further work is needed in the future to ensure that refusing schools are included in the data collection as they may represent pockets of potentially susceptible populations.

With regards to the contraindication analyses, the results give a useful impression of which contraindications were most common in those schools who provided information. In non-pilot regions, only 53.4% of schools provided information on contraindications and for those who did not provide this information, it was not clear if the absence of response represented no contraindications reported by the children or their guardians, or if this information was not recorded by the vaccination teams. Due to this, care should be taken when extrapolating the results of this section of the analyses.

In both pilot and non-pilot areas, vaccine uptake decreases as year group increased. Reception showed the highest uptake whilst children in school years 5 and 6 showed

the lowest uptake in non-pilot and pilot areas respectively. However vaccine uptake increased in all corresponding cohorts since the 2017 to 2018 season[12].

This report included a new analysis examining evidence of inequalities in uptake. In the 2018 to 2019 season, a large gap in uptake was observed between LSOAs in the most and least deprived deciles (47% and 72.6% respectively). Similarly a large gap in LAIV uptake was observed between LSOAs with lowest and highest black and ethnic minority population (66% and 43.7% respectively). Populations with the highest Muslim faith composition also saw lower uptake compared to the non-Muslim population (67.4% and 46.9% respectively). Similarly populations with the highest Jewish faith composition had lower LAIV uptake compared to non-Jewish population (58.7% and 62.1% respectively).

Although a gap in uptake occurred between the least and most exposed subgroups within the latest season, over time however the uptake increased for the most exposed groups. From the 2015 to 2016 to the 2018 to 2019 seasons, the all-age uptake increased for populations in the most deprived decile (from 44.4% to 47% respectively). Populations with highest black and ethnic minority composition also saw an increase in uptake (from 60.4% to 66% respectively) and for populations with the highest Muslim (from 42.4% to 46.9%) or Jewish faith composition (from 51.9% to 58.7% respectively). However whilst the increasing trend is encouraging the caveat with this interpretation is that the underlying eligible cohorts differed in the respective seasons due to the expanding programme over time.

The ecological analyses looking at population level predictors of uptake indicate that after risk-adjustment all predictors included in the model were strongly and significantly associated with LAIV uptake including ethnicity, level of deprivation and populations with highest proportion of certain religious faiths. The largest and most striking effects were seen for IMD. After risk adjustment uptake in the most deprived decile was 18 percentage points lower than the least deprived decile. The adjusted model also showed that schools falling in LSOAs with the highest ethnicity population (≥34%) had vaccine uptake that was 8.4 percentage points lower compared to the baseline group (<5% ethnicity population).

Attenuation of effects post risk adjustment were observed in general. However, for IMD and ethnicity in particular, the difference in uptake between the baseline and the highest exposure group in these variables remained high despite risk adjustment. The Muslim faith variable also saw a contraction in the difference between the highest exposure and the baseline groups – LSOAs with populations >6% Muslim composition had an uptake that was significantly lower (5.5 percentage points difference) than LSOAs with 0% Muslim faith (the baseline group). But this difference was still large and appears to have increased slightly compared to 2017 to 2018 season (where uptake was 3.81 percentage points lower in LSOAs with ≥6% Muslim population compared to the non-

Muslim population in the modelled analysis). However, the caveat is that the underlying target population differed between the 2 seasons due to the additional year 5 in the 2018 to 2019 season which recorded the lowest uptake of all school year groups.

Pilot areas experienced a significantly higher uptake (2.6 percentage points higher) compared to non-pilot areas and rural areas had significantly higher uptake than urban areas post risk adjustment.

Regarding PHE region, the lowest uptake has consistently been observed for London, and the highest for the South. Despite adjusting for important confounders namely deprivation and ethnicity, London still had an uptake estimated to be almost 9 percentage points lower than the reference group (North region). The difference in uptake after risk adjustment was still remarkably high. Further study is needed to explain this finding for London such as operational factors that impede vaccine completion in schools.

Overall, the evidence from this analysis suggests that efforts could be directed to reduce inequalities in vaccine uptake. The striking and consistent difference in uptake between the lowest and highest deprivation deciles is an important area for future prevention strategies. This will help to improve vaccine uptake in the groups with the greatest need.

The school-age influenza vaccination programme has continued to increase each year, in terms of coverage and uptake. From September 2019, all eligible children of school-age reception to year 6 will be vaccinated in schools in England. This will result in children aged 4 rising to 11 receiving the LAIV vaccine primarily through the school-based programme.

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- PHE and NHS staff responsible for planning and delivering the school-based vaccination programme for primary school children and providing the end of season data return to run this report
- ImmForm staff that provided and supported the online survey

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Annexes

Annex A. Year group cohorts

Academic group	Age range on 1 September 2018	Birth Date	
		Born from date	Born to date
Reception	Aged 4 to 5 years	1 September 2013	31 August 2014
1	Aged 5 to 6 years	1 September 2012	31 August 2013
2	Aged 6 to 7 years	1 September 2011	31 August 2012
3	Aged 7 to 8 years	1 September 2010	31 August 2011
4	Aged 8 to 9 years	1 September 2009	31 August 2010
5	Aged 9 to 10 years	1 September 2008	31 August 2009
6	Aged 10 to 11 years	1 September 2007	31 August 2008

Annex B. End of season data collection variables

Category	Data Type	Description
School URN	Count (integer)	Department of Education's register of educational establishments in England and Wales school specific URN code (Edubase)
School name	Categorical (School Name)	LA Registered School Name
Year group	Categorical (0 to 6)	Year group cohorts as defined in Annexe A.
Denominator (provisional pre-filled LEA figures)	Count (integer)	The PROVISIONAL denominator is based on the January 2018 Department of Education school census figures and is therefore only a PROVISIONAL estimate of the total no. of children eligible for influenza vaccination in the LA geography. This denominator should be updated with the Actual denominator.
Denominator (actual if different)	Count (integer)	The ACTUAL denominator will replace the PROVISIONAL denominator and should reflect the total no. of children eligible for influenza vaccination in the LA geography based on school roll figures as reported directly by schools (including home school students in the LA.)
Difference if amended	Count (integer)	Difference between the actual and provisional denominators
Parental consent total	Count (integer)	Consent forms/parental attendance on the day
Parental refusal	Count (integer)	Consent forms returned indicating refusal for consent
No. Form Returned total	Count (integer)	The number of non-responders through no form returned/non-attendance
No. Vaccinated with one dose of LAIV since 1 September 2018	Count (integer)	Total doses of nasal LAIV vaccine given to children on the day(s) of the vaccine campaign

%	Calculated field =No. vaccinated with one dose LAIV since 1 September 2018/Denominator (actual if different)	Percentage uptake
No. vaccinated with one dose of TIV since 1 September 2018	Count (integer)	Total doses of TIV vaccines given to children on the day(s) of the vaccine campaign
%	Calculated field =No. vaccinated with one dose TIV since 1 September 2018/Denominator (actual if different)	Percentage uptake
No. that have received flu vaccine since 1 September 2018	Count (integer)	Total doses of all vaccines given to children on the day(s) of the vaccine campaign
%	Calculated field =No. that have received flu vaccine since 1 September 2018/ Denominator (actual if different)	Percentage uptake
Consented but not given	Count (integer)	Total number of children that consent but did not receive the vaccine
Total GP referrals	Count (integer)	Total number of children who were referred to the GP for vaccination
No. Yellow Cards Issued	Count (integer)	Total number of children who were issued a yellow card

Contraindications	Data Type	Description
Total No. of contraindications	Count (integer)	Total number of children with contraindications
Previous allergy to flu vaccine	Count (integer)	Total number of children who have an allergy to flu vaccine
Egg Allergy	Count (integer)	Total number of children who have an egg allergy
Severe asthma	Count (integer)	Total number of children who have severe asthma
Another live vaccine given/due	Count (integer)	Total number of children who have/had another live vaccine due/given
Immunosuppression (personal)	Count (integer)	Total number of children with an immunosuppression
Immunosuppression (family)	Count (integer)	Total number of children who have a family member with an immunosuppression
Cardiac disease/salicylate therapy	Count (integer)	Total number of children with a cardiac disease/ salicylate therapy
On day: child unwell	Count (integer)	Total number of children who were unwell on the day of the vaccination campaign
On day: child absent	Count (integer)	Total number of children who were absent on the day of the vaccination campaign
On day: child refused	Count (integer)	Total number of children who refused the vaccine on the day of the vaccination campaign
On day: allergies	Count (integer)	Total number of children who had allergies on the date of the vaccination campaign
Other	Count (integer)	Other contraindications not previously stated
Comments	Text	Comments

Annexe C: Table of Local Authorities not included in the study due to missing data or having a GP delivery model

NHS England Team	Local Authority
Non-responders	
NHS England London	Croydon
	Lewisham
NHS England North (Yorkshire and Humber)	Leeds
GP Uptake	
NHS England South West (South West South)	Kernow (Cornwall and Isles of Scilly)*
*School-level data were submitted for Cornwall LA	

Annexe D: Number of schools that did not submit any data or had submitted data where the numerator was greater than the denominator

NHE England Local Team	Local Authority	Total number of schools where number vaccinated was greater than denominator
London	Havering	1
Midlands and East (Central Midlands)	Leicester	1
	Leicestershire and Rutland	2
	Lincolnshire	38
Midlands and East (North Midlands)	Staffordshire	2
Midlands and East (West Midlands)	Birmingham	3
	Coventry	2
	Solihull	2
	Worcestershire	10
North (Cheshire and Merseyside)	Cheshire East	3
North (Cumbria and North East)	Northumberland	1
North (Greater Manchester)	Bolton	1
	Oldham	1
	Salford	4
	Stockport	2
	Tameside	1
	Wigan	4
North (Yorkshire and Humber)	Sheffield	1
South East (Hampshire, Isle of Wight and Thames Valley)	Isle of Wight	1
	Oxfordshire	1
South West (North)	Gloucestershire	3