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Original Research

# Did school characteristics affect the uptake of meningococcal quadrivalent vaccine in Greater Manchester, United Kingdom?

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ABSTRACT

*Objectives:* The objective of this study was to assess if school characteristics were associated with the uptake of the meningococcal ACWY (MenACWY) vaccine in Greater Manchester in 2017/18.

*Study design:* This is an ecological cross-sectional study.

*Methods:* We analysed data on all 129 schools in seven local authorities in Greater Manchester from the Department for Education and from local child health information systems to determine whether school characteristics, including school type and Ofsted effectiveness score, were associated with vaccine uptake. Schools with no eligible pupils were excluded. We undertook single-variable and multivariable analysis and considered key interactions.

*Results:* The overall uptake rate was 80.7%, with a median uptake per school of 80.6% (interquartile range, 69.0%–87.4%). Lower vaccination rates were associated with lower overall effectiveness scores (odds ratio [OR]: 3.54, 95% confidence interval [CI]: 3.00–4.19) and lower numbers of pupils eligible for vaccination (OR: 1.39, 95% CI: 1.28–1.51). Schools with a lower percentage of pupils for whom English is a second language and high deprivation were associated with lower uptake (OR: 1.58, 95% CI: 1.41–1.78). In addition, community schools (the schools with the most local authority oversight) had lower vaccination rates than other categories of schools.

*Conclusions:* In this study, uptake rates of the MenACWY vaccine were associated with all five school characteristics considered. Effectiveness scores for schools had the largest association with vaccine uptake, with poorer schools having lower uptake. These characteristics should be used by vaccination providers to prioritise their interventions to increase immunisation rates.



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## Introduction

Invasive meningococcal disease is a serious bacterial infection caused by *Neisseria meningitidis* (the meningococcus) which caused 237 deaths between 1st January 2011 and 30th June 2015 in England. Around 10% of the population in England has asymptomatic nasopharyngeal carriage of meningococcus.[1] Carriage rate varies with age and is highest in adolescence. In some individuals, meningococcus causes invasive disease such as meningitis or septicaemia. Septicaemia is associated with a case fatality of 10–12%[2] or long-term disability such as limb loss or neurological impairment in 11–19% of survivors.[3]

*N. meningitidis* bacteria are divided into 12 serogroups, of which B, W, Y and C are the most common in England. In England, the number of cases of invasive serogroup W infection has been increasing over the past 10 years, attributed to the emergence of an endemic virulent strain (serogroup W135);[4] between 2008/09 and 2014/15 cases increased from 19 to 176 per year.[5] There were 193 cases in 2017/8.[6]

In response, the Department of Health (DH) introduced an immunisation programme in 2015 using a quadrivalent meningococcal ACWY (MenACWY) vaccine, replacing the meningococcal C conjugate vaccine previously offered to the same age group.[7] This targeted young people in school years nine and ten (aged 13–15 years) because higher carriage is seen in adolescents and young adults and this age group drives transmission across the population. The vaccine protects individuals from invasive disease and reduces carriage, thus also protecting the unvaccinated population and promoting herd immunity. The target for the vaccination programme is 70%.[8] Average vaccine uptake for young people by the end of year 10 was 82.5% nationally,[9] but this masks variation across England. In addition to this routine programme, there is a catch-up programme provided in general practice for older teenagers and university students. Public Health England (PHE) estimates that the vaccination has reduced the expected numbers of cases of MenW by 69% in school leavers who are vaccinated.[1]

The MenACWY immunisation programme in England is commissioned and monitored by joint PHE and National Health Service (NHS) England teams. The programme is delivered in schools by healthcare providers.

Information on school characteristics associated with vaccine uptake may be helpful to prioritise school-based interventions to improve uptake rates. The few studies that have examined the relationship between school characteristics and vaccine uptake have focused on the human papillomavirus (HPV) vaccine.[10,11] A study in two areas of Greater Manchester found that uptake of the HPV vaccine in schools was lower in schools with a higher proportion of pupils entitled to free school meals.[10] The aim of this study was to identify the characteristics of secondary schools that were associated with higher MenACWY vaccine uptake in schools in Greater Manchester in 2016/17.

## Methods

### *Study design*

This is an ecological cross-sectional study using routine data.

### *Setting*

Greater Manchester is a city region in North West England with a population of 2.8 million, representing approximately 4.2% of the population of England.[12] It is a predominantly urban area served by ten local authorities. About a quarter of the population live in areas that are amongst the most deprived 10% in the country.[13]

In England, publicly funded compulsory education for 11- to 16-year-olds is provided by secondary schools and these schools vary in the level of oversight required by local authorities (LAs), ranging from those where staff are employed by LAs and the admissions policy is determined by the LA to schools that are funded directly by central government with no local oversight.

Uptake data were requested from all ten boroughs in Greater Manchester. Compared with the national average, a higher proportion of pupils in Greater Manchester are eligible for free school meals. Children are eligible for free school meals if their families are on a low income.[14] This is used as a proxy for deprivation. In addition to measuring deprivation, we looked at Ofsted (the English school inspection body) overall effectiveness scores. Ofsted overall effectiveness score is an overall measure of a school's performance including leadership, quality of teaching, learning and assessment and safeguarding.[15]

In Greater Manchester, MenACWY school-based vaccinations are delivered by health organisations providing core school nursing services or by specialist independent services. Vaccination sessions are provided in school during school hours. In addition to national publicity, local interventions to improve uptake are carried out at the school level, such as providing information to parents via the school, the provision of drop-in advice sessions or providing additional catch-up vaccination sessions.

### *Population*

All 129 secondary schools with eligible children in year 10 in the school year September 2016–August 2017 in the local authorities of Bolton, Bury, Manchester, Oldham, Rochdale, Trafford and Wigan in Greater Manchester.

### *Data variables, sources of data and data collection*

The following school characteristic variables were downloaded from the Department of Education (DfE) website: Ofsted overall effectiveness score; type of school, percentage of pupils who speak English as a second language (EASL) and percentage of pupils with free school meals eligibility (FSME) in the past six years (Table 1).

**Table 1 – School characteristics used to assess association with meningococcal quadrivalent vaccine uptake in year 10, Greater Manchester, 2017–18.**

| Variable | Description |
|---|---|
| Ofsted overall effectiveness score | The overall effectiveness score reported by Ofsted at the schools last inspection. |
| Type of school | School types were collated into three groups:<br>Academy and free schools – funded by the government but independent from the local authority<br>Foundation and voluntary schools – funded via the local authority, but the governing body employs the staff and sets admissions policy<br>Community schools – where the local authority employs the staff, owns the buildings and sets admissions policy |
| Number of eligible pupils | The number of pupils eligible for the MenACWY vaccine within the school |
| Percentage of total school population eligible for free school meals | The percentage of the total school population that have been eligible for free school meals in the last 6 years. This is used as a proxy for deprivation. |
| Percentage of total school population with English as a second language | The percentage of the total school population where English is not a first language, often indicating that English is not the first language with parents. |

MenACWY = meningococcal ACWY.

In England, the Child Health Information Services (CHIS) are responsible for providing a register of children to ensure the provision of immunisations and other services to eligible children. They are commissioned and monitored by NHS England. They also submit data to support the monitoring of immunisation programmes.[16]

Routine submissions from the CHIS to the PHE screening and immunisation team in Greater Manchester were used to obtain information from 137 schools on the number of pupils eligible for vaccination and the number vaccinated by the end of year 10. Eight schools with no eligible pupils for MenACWY were excluded, leaving 129 schools.

Percentage of pupils with EASL and percentage of pupils with FSME were dichotomised into low and high groups. The number of eligible pupils was dichotomised into smaller and larger schools.

Data were downloaded into Microsoft Excel.

### *Analysis and statistics*

We linked the data sets from the CHIS and the DfE school performance tables for secondary schools using school name and postcode to create a single data set. Analysis was carried out using JASP, version 0.9, and Open Epi, version 3.01. Vaccine uptake was calculated by type of school, size of school, Ofsted rating, proportion of pupils with EASL and proportion of pupils with FSME in the last six years (as dichotomous variables). For each variable, relative risks were calculated, and Chi-squared tests used to assess statistical significance of possible associations with uptake of the MenACWY vaccine.

Multivariable logistic regression models were fitted to the data to estimate adjusted odds ratios and possible associations between school characteristics and uptake. Variables identified in single-variable analysis as associated with the outcome ($P < 0.2$) were used to build an initial model that was then simplified by a backwards stepwise approach based on Akaike information criterion (AIC), examining at each step for possible confounders. After fitting of a main effects model, an *a priori* hypothesis of interaction between pupils with FSME (as a marker of deprivation) and percentage of pupils with EASL was tested.

## Results

Seven of the ten boroughs (70%) in Greater Manchester were able to provide data for a total of 129 secondary schools. Data were not received from three boroughs because of technical issues and timescale of the study. We analysed data from 129 schools (19,898 eligible pupils, median 168 eligible pupils per school). A total of 16,065 (80.7%) pupils received the MenACWY vaccination. The median uptake per school was 80.6% (interquartile range: 69.0%–87.4%).

Key school characteristics are shown in Table 2. Three quarters of the schools (75.2%) were judged to be good or outstanding by Ofsted, and nearly half (48.3%) were academies or 'free' schools.

Single-variable analysis found that significant associations with vaccine uptake existed for each of the variables studied (Table 3).

In multivariable analysis, after adjustment for other factors, a low Ofsted overall effectiveness score had the strongest

**Table 2 – Characteristics of secondary schools in the study, in Greater Manchester, 2017–18.**

| School characteristic | N | % |
|---|---|---|
| Number of schools | 129 | 100 |
| Type of school | | |
| Academy or free school | 61 | 48.3 |
| Community school | 35 | 27.1 |
| Foundation or voluntary | 33 | 25.6 |
| Ofsted rating – overall effectiveness | | |
| Outstanding – 1 | 33 | 25.6 |
| Good – 2 | 64 | 49.6 |
| Requires improvement – 3 | 23 | 17.8 |
| Inadequate – 4 | 9 | 7.0 |
| | Median | IQR |
| Number of eligible pupils per school | 168 | 106–213 |
| Percentage of pupils with English as a second language | 10.1 | 4.3–29.1 |
| Percentage of children eligible for free school meals | 20.3 | 11.1–29.1 |

IQR = interquartile range.

**Table 3 – Association between school characteristics and meningococcal quadrivalent vaccine uptake in year 10, Greater Manchester, 2017/18.**

| Predictor | Eligible | Vaccinated | Uptake | Relative risk | (95% CI) | P-value |
|---|---|---|---|---|---|---|
| Type of school | | | | | | <0.001 |
| Community school | 4188 | 3121 | 74.5% | 1.0 | | |
| Foundation or voluntary school | 6223 | 5087 | 81.7% | 2.88 | (2.79–2.97) | |
| Academy or free school | 9487 | 7857 | 82.8% | 2.91 | (2.82–3.00) | |
| Overall effectiveness (Ofsted) | | | | | | <0.001 |
| 4 – Inadequate | 1299 | 812 | 62.5% | 1.0 | | |
| 3 – Requires improvement | 3748 | 2864 | 76.4% | 1.22 | (1.17–1.28) | |
| 2 – Good | 10,229 | 8366 | 81.8% | 1.31 | (1.25–1.37) | |
| 1 – Outstanding | 4622 | 4023 | 87.0% | 1.39 | (1.33–1.45) | |
| Number of eligible pupils | | | | | | |
| Smaller (below median) | 5707 | 4368 | 76.5% | 1.0 | | |
| Larger (median and above) | 14,191 | 11,697 | 82.4% | 1.30 | (1.27–1.32) | <0.001 |
| Percentage of pupils with English as a second language | | | | | | |
| High (median and above) | 10,412 | 8464 | 81.3% | 1.0 | | |
| Low (below median) | 9486 | 7601 | 80.1% | 0.99 | (0.97–1.00) | <0.001 |
| Percentage of children eligible for free school meals | | | | | | |
| High (median and above) | 7827 | 5595 | 76.6% | 1.0 | | |
| Low (below median) | 12,071 | 10,070 | 83.4% | 1.09 | (1.07–1.11) | <0.001 |

CI = confidence interval.

association with low vaccine uptake (Table 4). Schools with higher percentage of pupils with FSME had lower uptake of this vaccine, as did community schools. In the single-variable analysis, schools with higher proportions of pupils with EASL had higher uptake, but after multivariate analysis, this effect is reversed and it becomes associated with lower vaccine uptake.

For schools with a less number of pupils with EASL, lower deprivation (denoted by low FSME) was associated with higher uptake (OR: 1.58, 95% CI: 1.41–1.78). For schools with a high number of pupils with EASL, the relationship between deprivation and uptake remained but was attenuated (OR: 1.14, 95% CI: 1.05–1.25).

## Discussion

### *Vaccination uptake*

This is the first study looking at how uptake of MenACWY vaccine in schools in the UK is associated with school characteristics. Because MenACWY is a recent addition to the routine vaccination programme in the UK, there have been very few studies on factors associated with the uptake of this vaccine. The studies that have taken place have considered the catch-up programme in general practice rather than the school-based programme.[17] Overall, vaccination uptake in

**Table 4 – Associations (adjusted odds ratios) between school characteristics and meningococcal quadrivalent vaccine uptake in year 10, in Greater Manchester, in 2017/18.**

| Predictor | Odds ratio | (95% CI) | P-value |
|---|---|---|---|
| Type of school | | | |
| Community school | | | |
| Foundation or voluntary school | 1.53 | (1.39–1.69) | <0.001 |
| Academy or free school | 1.45 | (1.32–1.59) | <0.001 |
| Overall effectiveness (Ofsted) | | | |
| 4 – Inadequate | | | |
| 3 – Requires improvement | 2.14 | (1.85–2.49) | <0.001 |
| 2 – Good | 2.89 | (2.51–3.34) | <0.001 |
| 1 – Outstanding | 3.54 | (3.00–4.19) | <0.001 |
| Number of eligible pupils | | | |
| Smaller (below median) | | | |
| Larger (median and above) | 1.39 | (1.28–1.51) | <0.001 |
| Percentage of pupils with English as a second language | | | |
| High (median and above) | | | |
| Low (below median) | 1.49 | (1.28–1.73) | <0.001 |
| Percentage of children eligible for free school meals | | | |
| High (median and above) | | | |
| Low (below median) | 1.58 | (1.41–1.78) | <0.001 |
| Interaction – Low percentage of free school meals, low percentage of English is not a first language | 0.49 | (0.40–0.59) | <0.001 |

CI = confidence interval.

schools is high, averaging 80.7%, and is much higher than the MenACWY catch-up programme delivered in primary care, with uptake of only around 31% in North West England.[17] This is reassuring given that school-based vaccination is the predominant method of MenACWY vaccination and supports previous literature demonstrating that uptake of school-based vaccinations is higher than primary care vaccinations.

### School organisational factors

This study identified that schools with better overall effectiveness scores from Ofsted have higher uptake. This may be due to more effective schools being better able to support vaccination activities within the school. They may also be able to build better relationships with parents and other organisations. A systematic review of the organisation and delivery of school-based vaccination programmes in high-income countries found that institutional relationships between educational settings and healthcare providers were important for effective school-based programmes.[18] This association between school quality and vaccine uptake is an important finding, but it is worth noting that Ofsted scores may be correlated with other factors, such as deprivation, which could be confounding this association.[19]

Academies, 'free' schools, foundation and voluntary schools had higher uptake than community schools. The higher rates of vaccine uptake in schools with more independence from the local authority than community schools may be linked to these schools having to be more organised to maintain their independence. It may be related to other confounding factors not included in this analysis because these groups also vary in other factors such as that there are a higher proportion of religious schools that are voluntary-controlled or voluntary-aided schools and community schools may include more schools for children with specific special educational needs. In addition, we did not include information on how much promotion work each school carried out. These factors may influence vaccine uptake.

### Pupil- and parent-related factors

Uptake of the vaccine was also higher in schools with a lower proportion of pupils with FSME. This is in keeping with previous research because FSME is used as a marker for deprivation and previous research studies have found an association between deprivation and lower uptake of MenACWY vaccine in primary care.[17] The finding is concerning because deprivation has previously been linked to higher incidence of invasive meningococcal disease due to factors such as overcrowded living conditions and higher nasopharyngeal carriage of meningococcus due to higher smoking rates.[20–23] It may therefore require additional attention when implementing a vaccine programme.

In this study, schools with a higher proportion of EASL pupils were associated with lower vaccine uptake, once adjusted for the other variables. When analysed as a single-variable, the association appears to be in the opposite direction, but the multivariable model suggests that this was due to confounding by other variables included in the model. Having EASL pupils within a school may reduce vaccine uptake within a school because these pupils are likely to have parents who have English as an additional language. This could make communication with parents about the benefits of the vaccination programme and the consent procedures more complex. It is also possible that, along with families from poorer backgrounds, health beliefs about vaccination may have influenced uptake, with a systematic review of qualitative research demonstrating that factors relating to ethnicity effect how parents from black and Asian minority groups view vaccinations.[24] Therefore, it is possible that vaccine knowledge and education needs might be different amongst families where English is not the first language. This would be worth further exploration because education of children and their families could be targeted in the future.

Not having English as a first language and ethnic group are related, with very few white British pupils being identified as not having English as a first language, less than 1% at age 11 years.[25] A study of the uptake of the MenACWY vaccine in the 2015/16 catch-up campaign in general practice in the North West found that practices with a higher proportion of patients from an ethnic minority had increased vaccine uptake.[17] This does not correlate with our study, but this may be due to the differences between pupils who do not have English as a first language and pupils from ethnic minority backgrounds, as well as differences in the geographical areas examined, for example, in the general practice study, ethnic minorities did not include non-British whites. In particular, this may be a product of the ethnic minority backgrounds of pupils in Greater Manchester, with a large population of black and other white ethnic minorities, who have previously been shown to have low uptake of vaccinations, in comparison to large Asian communities elsewhere in the North West, who are consistently shown to have high uptake of vaccinations.[26–28] Furthermore, certain areas of Greater Manchester, notably the city of Salford, were excluded from this project, which have large Asian populations, and this may have skewed the study's findings.

Uptake is also higher in schools with higher numbers of pupils eligible for vaccination, and it is less clear why this might be. This is an interesting finding, and a previous study evaluating uptake of the catch-up MenACWY programme in primary care also found that uptake of the vaccine increases with the number of patients eligible for vaccination.[17] It may be that, in both schools and primary care, the organisation of vaccination sessions may be easier or may be prioritised where they involve more individuals.

All the educational factors included in this project (Ofsted rating, school type, FSME and EASL) are likely to interact heavily and, in combination, to influence vaccination uptake. Although there is no single clear explanation as to why certain schools have higher uptake than others, this is likely to be the result of a multifactorial pathway, with all of the factors explored previously playing a part.

### Strengths and limitations

The strengths of this study are that we obtained data from all the 129 publicly funded schools in seven local authority areas with nearly 20,000 eligible pupils. Data were collected electronically which reduces transcription errors, and there were no missing data. The study was conducted and

reported according to the Strengthening the Reporting of OBservational studies in Epidemiology (STROBE) guideline for cross-sectional studies.[29]

There are some key limitations to this study. We only considered five potential independent variables, and there may be other potential confounding factors that may not have been considered. These could include demographic factors such as ethnicity, disability and religion or organisational factors such as admissions policy or funding mechanisms. A further potential confounding factor is that, as mentioned in the Section Introduction, there are activities that schools can take to increase uptake, such as parent information sessions and health promotion literature, and it is not known what activities individual schools may have undertaken and how these may have influenced the results.

In addition, it was not possible to determine the reasons why pupils did not receive the vaccine: Reasons might include absence on the day of vaccination, failure to obtain consent or refusal of the vaccine by the child. Other limitations include using binary variables rather than continuous variables, which may have missed more complex associations. Using an ecological study design means that this study could be subject to the ecological fallacy. Further cross-sectional studies could be carried out on individual data to test these hypotheses.

This study's findings could be used to support MenACWY vaccine programme providers. The school characteristics associated with lower vaccine uptake can be used to provide indications of which schools should be prioritised to receive additional support to improve vaccine uptake. Most importantly, more research should be carried out to understand why schools with certain characteristics tend to have lower uptake. Also, because the vaccination programme is new, improvements may occur over time and these associations may change.

### Conclusions

This study conducted in Greater Manchester showed that uptake of the MenACWY vaccine in schools in Greater Manchester overall is high. However, uptake is lower in schools with lower Ofsted overall effectiveness ratings, fewer eligible pupils, a higher proportion of pupils for whom English is not a first language community schools and a higher proportion of pupils eligible for free school meals. Providers and commissioners of school-based vaccinations should consider how to further research these associations to investigate possible causes.

## Author statements

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### Ethical approval

No ethical approval was required because these data were either collected for public health surveillance under the Health Protection Legislation (England) Guidance 2010 (http://www.legislation.gov.uk/uksi/2010/659/contents/made) or for secondary analysis of data in the public domain.

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### Competing interests

None declared.

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