Influence of commissioned provider type and deprivation score on uptake of the childhood flu immunisation.

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Abstract

BACKGROUND: Since 2015/16 the UK seasonal influenza immunisation programme has included children aged 5 and 6 years. In the South West of England school-based providers, GPs or community pharmacies were commissioned to deliver the vaccine depending on the locality. We aimed to assess variation in vaccine uptake in relation to the type of commissioned provider, and levels of socioeconomic deprivation.

METHODS: Data from the South West of England (2015-16 season) were analysed using multilevel logistic regression to assess variation in vaccine uptake by type of commissioned provider, allowing for clustering of children within delivery sites.

RESULTS: Overall uptake in 5 and 6 year olds was 34.3% (37555/109404). Vaccine uptake was highest when commissioned through school-based programmes 50.2% (9983/19867) and lowest when commissioned through pharmacies, 23.1% (4269/18479). Delivery through schools resulted in less variation by site and equal uptake across age groups, in contrast to GP and pharmacy delivery for which uptake was lower among 6 year olds. Vaccine uptake decreased with increasing levels of deprivation across all types of commissioned provider.

CONCLUSION: School-based programmes achieve the highest and most consistent rates of childhood influenza vaccination. Interventions are still needed to promote more equitable uptake of the childhood influenza vaccine.

Introduction

The highest rates of influenza infection are in the very young due to their lack of previous exposure to the virus and absence of immunity. Young children also excrete more virus for longer periods leading to high rates of onwards transmission.[1] Annually, between 10-40% of children become infected with influenza with symptoms varying from mild symptoms to severe illness[2,3] (around one in every 100 children under 5 years, is hospitalised).[4]

Until recently the UK influenza vaccination programme, commissioned by NHS England and Public Health England (PHE), targeted only vulnerable individuals at risk of serious illness or death from influenza: those with long term conditions or in long term care, immunocompromised, over 65 years of age or pregnant, and carers. Epidemiological models suggest that vaccinating healthy children reduces transmission, contributing to the protection of vulnerable people and reducing the overall burden of community influenza;[5] accordingly the influenza vaccination schedule was modified in 2013/14 to include live attenuated influenza vaccine (LAIV) for all children aged 2-4 years. In addition, a 2 year pilot vaccination programme was implemented in selected geographical areas in either primary (years 1 and 2: ages 5 and 6 years) or secondary (years 7 and 8: ages 11 and 12 years) schools.[6]

LAIV has been shown to work well in children and has had a good safety profile over many years;[7,8] several other countries have recently recommended or implemented national programmes of vaccination of healthy children.[9] In the United States (US) influenza vaccination has been recommended for all children aged 6 months and above since the 2008-09 influenza season.[10] The UK school-based LAIV vaccination pilot demonstrated a reduction in influenza-related illness, primary care consultations, hospital admissions and deaths across the whole community;[11] subsequently the national programme was extended in 2015/16 to include children in years 1 and 2 with a phased roll out extending the eligible cohort year on year.[12] The national commissioning strategy preferred a school-based vaccination programme , as the evidence from the pilots showed a higher uptake and acceptability of this as opposed to other commissioned provider types (e.g community pharmacies or GPs). Nonetheless any provider qualified through the national procurement framework was permitted to deliver the vaccine programme, subject to commissioning decisions within each Local Authority area. In the early years of the childhood influenza vaccination programme, commissioners were restricted by what was locally available which led to a range of non school-based providers being commissioned.

People living in socio-economically deprived areas have been shown to have a significantly higher risk of death due to influenza compared to those living in areas with low levels of deprivation.[13] Equitable delivery is a key aim of the national vaccination programme and ongoing assessment is essential to the success of the programme. During the period of the original 2 year pilot programme, vaccine uptake was shown to vary between local areas, with deprivation and ethnicity being identified as predictors of low uptake.[11]

The South West was one of the few regions in England in which the 2015/ 16 childhood influenza vaccine was delivered through a range of commissioned provider types: school- based vaccination teams, General Practices (GPs) or community pharmacies depending on the locality. We examined vaccine uptake among eligible primary school children (aged 5 and 6 years) across localities in the South West of England for the 2015/16 influenza season, to look for evidence of variation and inequalities in uptake by commissioned provider type (school-based, GP or pharmacy).

Methods

We obtained influenza vaccine uptake data from the two Screening and Immunisation Teams (SITs) covering the Public Health England South West Centre for the 2015/16 influenza season. Uptake was calculated as the proportion of children in the eligible population who were reported to have received the influenza vaccine during the campaign period (1 September 2015 to 31 January 2016). The eligible population was all children in school year 1 (aged 5 rising to 6 yrs) and year 2 (aged 6 rising to 7 yrs) born between 1 September 2008 and 31 August 2010, as defined by their age on September 1st 2015. [14] The SIT provided data on the number of eligible children registered at each school (for areas with school- based vaccination programmes) or GP practice (for areas with GP or pharmacy vaccination programmes). Additional data were collected from schools in North Somerset and Somerset on the proportion of consent forms not returned.

GP practices

GPs were commissioned to offer vaccinations in Bath and North East Somerset, Gloucestershire, Swindon, Wiltshire, Devon (including Plymouth but excluding Torbay, which commissioned school delivery), Cornwall and Isles of Scilly for children aged 5 and 6 years old. Data on vaccination of registered patients were obtained by GP practice for the entire campaign period (1 September 2015 to 31 January 2016) with the exception of three practices in Cornwall which supplied data to the end of December 2015 only.

Schools

School nursing vaccination teams were commissioned to deliver vaccination in schools in North Somerset, Somerset and Torbay to children in school years 1 (children aged 5 rising to 6 years old) and 2 (children aged 6 rising to 7 years old). Two schools chose not to offer vaccination on site and pupils were directed instead to community sessions run by the vaccination provider. Vaccination data were obtained for the entire campaign period, aggregated by school for North Somerset and Somerset and by GP in Torbay.

Pharmacies

Vaccinations in Bristol and South Gloucestershire were commissioned through a large pharmaceutical chain, who, like other providers, had achieved accreditation on the national framework for procurement of childhood influenza vaccination to deliver the service within their own pharmacies for children aged 5 and 6 years. Data on vaccinated GP registered patients were aggregated by GP practice, up until the end of January 2016.

Statistical analysis

Statistical analyses were done using Stata v14 (StataCorp LP, 2015, College Station,TX). When calculating vaccine uptake we included total number of doses of vaccine delivered, not just those delivered by commissioned services (i.e. an intention to treat analysis by commissioned delivery method). For example, vaccinations delivered by GPs in areas where school immunisation teams were commissioned to deliver vaccinations were included in the calculations for vaccine uptake in that area. To assess relationships between vaccine uptake and deprivation, vaccination administration sites were assigned to Indices of Multiple Deprivation (IMD) 2015 deprivation quintiles based upon the postcode address of the site because location information was unavailable for individual children and for all specific site catchment areas. In analyses, all children in school year 1 were assumed to be aged 5 and all children in school year 2 aged 6 years. We used multilevel logistic regression to investigate differences in vaccine uptake by commissioned provider type (with GPs considered the base case), age of the individuals and deprivation of the site allowing for nesting of children within delivery sites. Univariable analyses were conducted with a single random effect for site, to assess significance of covariates (age, IMD quintile and vaccine delivery method) for inclusion in the multivariable model. Covariates were assessed in turn and retained in the multivariable model only if $p \leq 0.05$ in the presence of all other covariates, after which previously discarded covariates were reconsidered for entry. Additional random effects and interactions between covariates were explored in the same way. We tested for interactions between commissioned provider type and both age and IMD quintile, to assess whether there was any variation in uptake by commissioned provider type for different age groups and if there was any evidence of socio-demographic inequalities in vaccination uptake in relation to the type of provider.

Results

Data were available for 771 sites, comprising 393 GP, 302 school and 76 pharmacies which included 54,992 children aged 5 years old and 54,412 children aged 6 years old. Across all sites vaccine uptake in 5 and 6 year olds was 34.3% (37555/109404), and was slightly higher in 5 year olds (35.6%, 19596/54992) compared to 6 year olds (33.0%, 17959/54412). Vaccine uptake across GP commissioned services was 32.8% (23303/ 71058). Data were missing for the final month of the campaign from 3 GP practices, representing an estimated 0.15% of overall GP data. Across school-based delivery commissioned services vaccine uptake was 50.2% (9983/ 19867); a small proportion of these children were vaccinated through their GP (2.3%, 199/ 8680, of children in North Somerset and Somerset; data were unavailable for Torbay). Vaccination data were not available from all sites of pharmacy commissioned services: we found missing values for vaccination of 6-year-olds at two of 76 pharmacy sites (176 children). In these areas 23.1% (4269/ 18479) of eligible children received vaccinations, although 46.2% (1974/ 4269) of these vaccinations were actually delivered via GPs.

In univariable analyses age, commissioned provider type (GPs, schools and pharmacies) and deprivation quintile were associated with vaccine uptake (Table 1) and these factors remained independently associated in a multivariable model. The final model also included random effects at site level for age and commissioned provider type, and an interaction between age and commissioned provider type (Table 2).

Table 1. *Univariable analysis of factors associated with vaccine uptake, allowing for clustering of children within delivery sites*

Variable	N	Nvacc	(%)	OR	(95% CIs)	p
Age						
5 year olds	54992	19596	(35.6)	1.00 (ref)		
6 year olds	54412	17959	(33.0)	0.88	(0.86 to 0.90)	<0.0001
Provider type						
GP practice	71058	23303	(32.8)	1.00 (ref)		
School	19867	9983	(50.2)	2.23	(2.04 to 2.45)	
Pharmacy	18479	4269	(23.1)	0.58	(0.51 to 0.67)	<0.0001
IMD quintile						
1 (least deprived)	17871	7271	40.7	1.00 (ref)		
2	22701	8687	38.3	0.88	(0.75 to 1.02)	
3	25453	9036	35.5	0.76	(0.65 to 0.89)	
4	26169	7688	29.4	0.51	(0.43 to 0.60)	
5 (most deprived)	17210	4873	28.3	0.48	(0.40 to 0.58)	<0.0001

N, number in cohort; Nvacc, number vaccinated; OR, odds ratio; 95% CIs, 95% confidence interval
P value refers to inclusion of the categorical variable as a set rather than inclusion of a single category/ quintile.

Table 2. *Multivariable analysis of factors associated with vaccine uptake, allowing for clustering of children within delivery sites*

Variable	aOR	(95% CIs)	p
Fixed effects			
Age			
5 year olds	1.00 (ref)		
6 year olds	0.845	0.807 to 0.885	<0.001
Provider type			
GP practice	1.00 (ref)		
School	1.941	1.774 to 2.123	<0.001
Pharmacy	0.606	0.520 to 0.705	<0.001
Interaction between Age and Provider type			
6 years#School	1.187	1.091 to 1.291	<0.001
6 years#Pharmacy	1.011	0.904 to 1.130	0.852
IMD quintile			
1 (least deprived)	1.00 (ref)		
2	0.889	0.792 to 0.998	0.047
3	0.782	0.698 to 0.876	<0.001
4	0.594	0.525 to 0.672	<0.001
5 (most deprived)	0.551	0.481 to 0.632	<0.001
Constant	0.684	0.616 to 0.759	<0.001
Random effects at site level	Estimate	(95% CIs)	
Age	0.045	0.034 to 0.058	
6 years, 5 years			
Delivery model			
GP	0.313	0.261 to 0.375	
School	0.089	0.061 to 0.128	
Pharmacy	0.266	0.179 to 0.396	

aOR, adjusted odds ratio; 95% CIs, 95% confidence interval
Random effects show variance of effect between sites (on log-odds scale)

Compared to GP delivery, the odds of vaccine uptake were considerably higher (approximately doubled) when provided in schools, and much lower when provided in community pharmacies. Across all types of provider, the odds of vaccine uptake progressively reduced with increasing deprivation and approximately halved in the most deprived quintile compared to the least deprived.

Under GP and pharmacy delivery, the odds of vaccine uptake were slightly lower for 6-year-olds compared to 5-year-olds, but this difference was not seen with school delivery. Site-to-site variation in uptake (after adjusting for age and IMD quintile) was greatest for GP and pharmacy delivery, and considerably less for school delivery, as shown by the random effects for commissioned provider type. Predicted vaccine uptake by type of provider and deprivation quintile is shown in Figure 1.

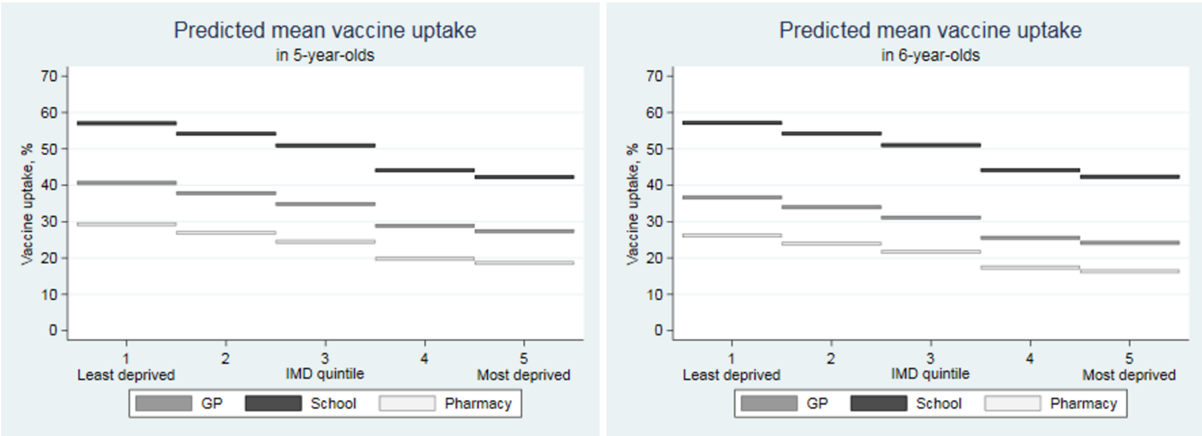

Figure 1 Predicted mean vaccine uptake by commissioned provider (GP/ school-based/ pharmacy) and Index of Multiple Deprivation (IMD) quintile for 5 and 6 year olds (multivariable model)

Information on children with consent forms not returned, the number of vaccination refusals and number of children referred to their GP for vaccination was available for schools in Somerset and North Somerset (286 sites, with data on 16784 children of whom 8481 were vaccinated). In univariable analyses, the proportion of consent forms not being returned was not associated with age ($p= 0.2994$) but was higher for those in more deprived areas (Table 3). The proportion of vaccinations actively refused was not associated with age ($p= 0.6262$) or IMD 2015 quintile ($p= 0.9174$). Similarly, the proportion of children referred to primary care for vaccination was not associated with age ($p= 0.5972$) or IMD 2015 quintile ($p= 0.4705$).

Table 3. *Odds ratio of consent form not being returned by Indices of Deprivation 2015 quintile in North Somerset and Somerset schools, univariable analysis allowing for clustering of children within delivery sites*

IMD quintile	OR	(95% CIs)	P
1 (least deprived)	1.00 (ref)		
2	1.15	(0.97 to 1.36)	
3	1.26	(1.07 to 1.49)	
4	1.92	(1.54 to 2.37)	
5 (most deprived)	2.19	(1.72 to 2.80)	< 0.0001

OR, odds ratio; 95% CIs, 95% confidence interval
P value refers to inclusion of IMD quintile as a set rather than inclusion of a single quintile.

Discussion

Main findings of this study

The highest overall vaccination rates were achieved through school-based programmes; rates were lower in areas which offered vaccination via GPs and lower still in areas offering pharmacy-based vaccination. There was variation in vaccination uptake between sites for all commissioned providers but, after controlling for age and IMD quintile, this was very much less for school-based provision than for other methods. School-based provision also achieved equal vaccination uptake for both age groups, in contrast with pharmacy and GP provision which resulted in slightly lower vaccination uptake among 6 year olds compared with 5 year olds.

What is already known on this topic

Relatively high uptake of vaccines through schools has been reported in relation to adolescent vaccination programmes such as those for Human Papillomavirus (HPV) and Meningitis A,C,W and Y (MenACWY).[15–17] There are few published studies comparing different settings for vaccine provision in younger children, however surveillance data from the 2014-15 influenza season indicate that overall vaccine uptake for primary school children (aged 4 to 11 years) in England was higher in school-based pilots as compared with provision through GPs and community pharmacies .[18]

Low uptake of vaccines through pharmacies was also reflected in an influenza surveillance report from the 2015-16 year, since the South West was one of the few areas in England where vaccination was offered through pharmacies instead of schools and vaccine uptake in this region was lower than the national average for 5 and 6 year olds.[19] A review of evaluations of community pharmacy delivery initiatives has shown no evidence that they increase overall uptake of the influenza vaccine (in adults and children) compared to standard delivery through GPs, though they were deemed acceptable and convenient venues for vaccination.[20]

Associations between socio-economic deprivation and low vaccine uptake are widely reported, although evaluations of adolescent vaccination programmes such as HPV or adolescent boosters have found that school-based delivery programmes mitigate this to some extent.[17,21,22] This could reflect differences in consent mechanisms in primary and secondary schools, or in levels of perceived risk of disease and effectiveness of vaccine for teenage vaccines as compared to the influenza vaccine.[23,24] It is recognised that factors contributing to low vaccine uptake among children from a lower socio-economic background are numerous and complex; hence locally developed, multicomponent interventions may be required to ensure equity in vaccine delivery.[15,25]

What this study adds

To our knowledge this is the first study examining uptake of LAIV among children which examines the interacting effects of deprivation score and age with commissioned type of vaccine provider (school-based, GP or pharmacy). As of 2018 almost all areas in England are commissioning school-based providers to deliver the vaccine, due to evidence that this increases uptake. Our findings strengthen the rationale for this approach and provide evidence that it promotes equitable uptake by reducing variation by site and between age groups.

In addition, whilst there remains a socio-economic gradient in uptake of the childhood influenza vaccine regardless of the commissioned provider type, we have shown that on average vaccine uptake was higher in schools- based programme in the most deprived areas than in GP programmes in the most affluent areas (see **Figure 1**). For areas commissioning a school-based programme, higher levels of deprivation were associated with lower returns for consent forms but did not affect the proportion of vaccines that were actively refused. The association between deprivation and low rates of consent form returns in schools is likely to have been attenuated by differences in provider practices. In one school within a deprived area, the standard approach of sending consent forms electronically to the school to print and distribute to parents resulted in such poor returns that the service providers attended in person to distribute forms to parents at the school gates . Rates of consent and uptake of the vaccine in this site were subsequently very high. This example highlights the need for vaccine delivery initiatives that reflect the local context, for instance addressing the multiple and complex drivers behind non-return of consent forms in more deprived areas, in order to reduce inequalities in uptake of the childhood influenza vaccine.

Limitations of this study

There are limitations to this study, which is observational and may be subject to ecological bias and confounding by factors that were not adjusted for in the multivariable analysis such as child ethnicity, religion, and family size.[11,26] Since deprivation scores were assigned using postcodes of vaccination sites we may have inaccurately judged levels of deprivation for some children, however our approach is arguably more useful in terms of informing interventions to tackle social inequalities at the site level (within schools, GP practices or pharmacies) Our results may not be entirely generalisable, particularly given the fact that only one pharmacy chain was involved in the delivery of vaccines during the study period which might not reflect the performance of other pharmacy providers.

The degree of clustering at site level may have varied depending on the type of provider; on average schools cater for fewer children (median 51 children) than GP practices (median 169) or pharmacies (median 246) and there is likely to be more interaction within groups of children and parents associated with schools than with other sites. To counter this, we used appropriate multilevel modelling methods to take account of the clustered nature of the data (by school or GP) and avoid bias in estimates and unduly narrow standard errors. By including random effects for site, we demonstrated less variation in vaccination uptake between school sites as compared to GPs and pharmacies: this is the reverse of what we would see if clustering were more pronounced in school commissioned areas and gives us confidence in our conclusion that school-based delivery is more consistent across different sites as compared to GP or pharmacy delivery.

Acknowledgements:

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

HC, RK, EB-P, RR and MH acknowledge support from the NIHR Health Protection Research Unit in Evaluation of Interventions at the University of Bristol.

References

[1] Munoz FM. The impact of influenza in children. Semin Pediatr Infect Dis 2002;13:72–8.
[2] Antonova EN, Rycroft CE, Ambrose CS, Heikkinen T, Principi N. Burden of paediatric influenza in Western Europe: a systematic review. BMC Public Health 2012;12:968. doi:10.1186/1471-2458-12-968.
[3] Effler P V. Every Year Is an Influenza Pandemic for Children: Can We Stop Them? Pediatrics 2012;130:554–6. doi:10.1542/peds.2012-1171.
[4] Poehling KA, Edwards KM, Weinberg GA, Szilagyi P, Staat MA, Iwane MK, et al. The Underrecognized Burden of Influenza in Young Children. N Engl J Med 2006;355:31–40. doi:10.1056/NEJMoa054869.
[5] Fleming DM, Taylor RJ, Haguinet F, Schuck-Paim C, Logie J, Webb DJ, et al. Influenza-attributable burden in United Kingdom primary care. Epidemiol Infect 2016;144:537–47. doi:10.1017/S0950268815001119.
[6] Department of Health, Public Health England, NHS England. The national flu immunisation programme 2016/17: supporting letter 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/529954/Annual_flu_letter_2016_2017.pdf (accessed October 26, 2017).
[7] de Lusignan S, Correa A, Ellis J, Pebody R. Influenza vaccination: in the UK and across Europe. Br J Gen Pract 2016;66:452–3. doi:10.3399/bjgp16X686677.
[8] Salisbury D, Ramsay M, Noakes K, editors. Immunisation against infectious disease: the green book chapter 19., London: 2006.
[9] Mereckiene J, Cotter S, Nicoll A, Lopalco P, Noori T, Weber J, et al. Seasonal influenza immunisation in Europe. Overview of recommendations and vaccination coverage for three seasons: pre-pandemic (2008/09), pandemic (2009/10) and post-pandemic (2010/11). Euro

Surveill 2014;19:20780.
[10] Fiore AE, Shay DK, Broder K, Iskander JK, Uyeki TM, Mootrey G, et al. Prevention and control of influenza: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2008. MMWR Recomm Reports Morb Mortal Wkly Report Recomm Reports 2008;57:1–60.
[11] Green HK, Andrews N, Letley L, Sunderland A, White J, Pebody R. Phased introduction of a universal childhood influenza vaccination programme in England: population-level factors predicting variation in national uptake during the first year, 2013/14. Vaccine 2015;33:2620–8. doi:10.1016/j.vaccine.2015.03.049.
[12] MacDonald P. Extension of influenza immunization program to children in England - Future plans. Hum Vaccin Immunother 2016;12:2707–8. doi:10.1080/21645515.2016.1218099.
[13] Zhao H, Harris RJ, Ellis J, Pebody RG. Ethnicity, deprivation and mortality due to 2009 pandemic influenza A(H1N1) in England during the 2009/2010 pandemic and the first post-pandemic season. Epidemiol Infect 2015;143:3375–83. doi:10.1017/S0950268815000576.
[14] Public Health England. National Childhood Influenza Vaccination Programme 2015 to 2016 Seasonal influenza vaccine uptake for children of primary school age. 2016.
[15] Fisher H, Trotter CL, Audrey S, MacDonald-Wallis K, Hickman M. Inequalities in the uptake of Human Papillomavirus Vaccination: a systematic review and meta-analysis. Int J Epidemiol 2013;42:896–908. doi:10.1093/ije/dyt049.
[16] Public Health England. Vaccine coverage estimates for the school-based meningococcal ACWY (MenACWY) adolescent vaccination programme in England, to 31 August 2018. 2019.
[17] Mandal S, Campbell H, Ribeiro S, Gray S, Carr T, White J, et al. Risk of invasive meningococcal disease in university students in England and optimal strategies for protection using MenACWY vaccine. Vaccine 2017;35:5814–8. doi:10.1016/j.vaccine.2017.09.024.
[18] Public Health England. Surveillance of influenza and other respiratory viruses in the United Kingdom: winter 2014 to 2015. 2015.
[19] Public Health England. Surveillance of influenza and other respiratory viruses in the United Kingdom: winter 2015 to 2016. 2016.
[20] Perman S, Kwiatkowska RM, Gjini A. Do community pharmacists add value to routine immunization programmes? A review of the evidence from the UK. J Public Health (Bangkok) 2018. doi:10.1093/pubmed/fdy021.
[21] Kumar VM, Whynes DK. Explaining variation in the uptake of HPV vaccination in England. BMC Public Health 2011;11:172. doi:10.1186/1471-2458-11-172.
[22] Tessier E, Warburton F, Tsang C, Rafeeq S, Boddington N, Sinnathamby M, et al. Population-level factors predicting variation in influenza vaccine uptake among adults and young children in England, 2015/16 and 2016/17. Vaccine 2018;36:3231–8. doi:10.1016/j.vaccine.2018.04.074.
[23] Blagden S, Seddon D, Hungerford D, Stanistreet D. Uptake of a new meningitis vaccination programme amongst first-year undergraduate students in the United Kingdom: A cross-sectional study. PLoS One 2017;12:e0181817. doi:10.1371/journal.pone.0181817.
[24] Department of Health. Factors associated with uptake of vaccination against pandemic influenza Scientific Evidence Base Review. 2011.
[25] Crocker-Buque T, Edelstein M, Mounier-Jack S. Interventions to reduce inequalities in vaccine uptake in children and adolescents aged. J Epidemiol Community Health 2017;71:87–97. doi:10.1136/jech-2016-207572.
[26] Hardelid P, Rait G, Gilbert R, Petersen I. Factors associated with influenza vaccine uptake during a universal vaccination programme of preschool children in England and Wales: a cohort study. J Epidemiol Community Health 2016;70:1082–7. doi:10.1136/jech-2015-207014.