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Impact of influenza vaccination on respiratory illness rates in children attending private boarding schools in England, 2013–2014: a cohort study

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SUMMARY

Several private boarding schools in England have established universal influenza vaccination programmes for their pupils. We evaluated the impact of these programmes on the burden of respiratory illnesses in boarders. Between November 2013 and May 2014, age-specific respiratory disease incidence rates in boarders were compared between schools offering and not offering influenza vaccine to healthy boarders. We adjusted for age, sex, school size and week using negative binomial regression. Forty-three schools comprising 14 776 boarders participated. Almost all boarders (99%) were aged 11–17 years. Nineteen (44%) schools vaccinated healthy boarders against influenza, with a mean uptake of 48·5% (range 14·2–88·5%). Over the study period, 1468 respiratory illnesses were reported in boarders (5·66/1000 boarder-weeks); of these, 33 were influenza-like illnesses (ILIs, 0·26/1000 boarder-weeks) in vaccinating schools and 95 were ILIs (0·74/1000 boarder-weeks) in non-vaccinating schools. The impact of vaccinating healthy boarders was a 54% reduction in ILI in all boarders [rate ratio (RR) 0·46, 95% confidence interval (CI) 0·28–0·76]. Disease rates were also reduced for upper respiratory tract infections (RR 0·72, 95% CI 0·61–0·85) and chest infections (RR 0·18, 95% CI 0·09–0·36). These findings demonstrate a significant impact of influenza vaccination on ILI and other clinical endpoints in secondary-school boarders. Additional research is needed to investigate the impact of influenza vaccination in non-boarding secondary-school settings.

Key words: Epidemiology, infectious disease control, influenza vaccines, surveillance, vaccine-preventable diseases.

INTRODUCTION

Influenza impacts on school-aged children and their families and results in a considerable burden of disease across the population each year [1]. School children can shed the virus for long periods [2] and have contact patterns increasing influenza attack rates [3, 4]. They are recognized to be the main drivers of the spread of influenza infection [5, 6].

Recent studies on the impact of universal influenza vaccination for school children have shown that as well as preventing cases of influenza in children (direct

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effects) [7–10], by interrupting transmission the burden of influenza can also be reduced in both unvaccinated students and other age groups (indirect effects) [11–14]. Mathematical modelling studies have shown that extending a selective influenza vaccination programme to all healthy children aged 2–16 years was likely to be the optimal long-term prevention strategy [15–17].

Based on this evidence, a universal influenza vaccine programme is being implemented across the UK for all children aged 2–16 years, with a roll-out over several seasons. In 2013–2014 in England, live attenuated influenza vaccine (LAIV) was offered to all children aged 2 and 3 years (healthy children and children in a clinical risk group, except where specifically contraindicated [18]). In addition, children of primary-school age (5–11 years) in several pilot areas were offered the vaccine, although no secondary-school-age pilots were undertaken in 2013–2014. There is a paucity of data on the impact of a programme to vaccinate all secondary-school students against influenza, with the few published studies [8, 12] comparing entire communities instead of specific schools. In addition, these studies were conducted outside Europe and did not consistently observe indirect effects in secondary-school-aged children.

The Medical Officers of Schools Association (MOSA), an association founded in 1884, involves a network of more than 200 predominantly boarding schools around the UK. Public Health England (PHE) and MOSA have developed a long-standing surveillance programme to monitor illness in children attending these schools. The scheme was started in 1979 after an outbreak of influenza A(H1N1) in the winter of 1977–1978. Up to 40 schools participate in the MOSA-PHE infectious disease surveillance scheme each season, involving more than 10 000 boarders mostly in secondary schools. Some of these schools are already vaccinating boarders with influenza vaccine using a range of policies.

The objective of this study was to evaluate the impact of influenza vaccination in MOSA schools on the burden of respiratory illness and specifically influenza-like illness (ILI) in school-aged boarders.

METHODOLOGY

Study population and general characteristics

In November 2013, all schools affiliated with MOSA were invited to participate for the academic year 2013–2014. Schools were excluded if they were not admitting boarders and if they were located outside England. For schools admitting boarders and day pupils, only boarders were followed as accurate ascertainment of respiratory illness by health staff was only possible for this group.

Data collection methods

A cross-sectional online survey tool was created and completed by the head nurse or the general practitioner (GP) of each participating school at the beginning of the season (ClassApps, USA). The survey included questions about the number of boarders and day pupils with a breakdown by school year (for calculation of year-specific sickness rates). School population figures were validated using data available on the Department for Education's website [19] and then checked back with the school. Information on schools' influenza vaccine policy, including groups targeted and type of vaccine used was collected directly from each participating school.

Over 6 months (25 November 2013 to 25 May 2014), the head nurse of the medical centre in each participating school in collaboration with the responsible GP was invited to complete a weekly online questionnaire about the number of new episodes of respiratory illness in boarders. The criteria for reporting a case were: (i) a new episode of respiratory illness in a boarder *and* (ii) the boarder was admitted to the school's medical centre/sanatorium and/or treated in bed elsewhere on nurse's or doctor's advice. Boarders going back directly to lessons after visiting the medical centre were not reported. A boarder with two different illness episodes requiring admission could be reported twice. Three types of respiratory illnesses were reported: (i) upper respiratory tract infection (URTI; cold, pharyngitis, sinusitis or otitis media), (ii) influenza-like illness (ILI; sudden onset of measured fever (>38 °C), with cough or sore throat, in the absence of other diagnoses [20]), and (iii) chest infection (bronchitis, pneumonia or pleurisy). The three categories were mutually exclusive and the school staff had to determine how to classify an acute respiratory illness. Only the names of admissible illnesses were given for URTI and chest infection, while a pre-defined case definition was given for ILI, our main endpoint. Questions to determine the school year of each ill boarder were also included. Two reminders were sent by email to schools that had not completed their weekly return.

When a school reported an ILI outbreak ($\geqslant 2$ cases of ILI occurring in the same school within 7 days), swabbing kits were distributed by PHE to collect combined nose and throat swabs in order to obtain laboratory confirmation of the diagnosis. Up to five samples could be collected in an ILI outbreak from affected boarders (sampling $\leqslant 7$ days after symptom onset).

Influenza vaccine uptake

After the seasonal influenza vaccination campaign was completed in December 2013, a short survey was sent to each school in February 2014 to estimate the school-level cumulative uptake of influenza vaccine in boarders in 2013–2014, with a breakdown by school year. A 'vaccinating school' was defined as a school offering influenza vaccine to all healthy boarders and to boarders with an underlying clinical risk factor (high-risk boarders). Schools only offering influenza vaccine to high-risk boarders or not offering it to any boarder were referred as 'non-vaccinating schools'.

Statistical analysis

We calculated respiratory illness (ILI, URTI, chest infections, all three respiratory illnesses combined) incidence rates in boarders over the period 25 November 2013 to 25 May 2014 and presented them by week, school year and influenza vaccination policy. The denominator used was the total number of follow-up weeks for boarders under observation (boarder-weeks). Periods when the school was closed or had not sent its weekly return were excluded from follow-up time. We also compared the weekly ILI incidence rate in boarders with the weekly proportion of laboratory-confirmed influenza-positive swabs in a national respiratory virus surveillance system with samples from both secondary and primary care (Respiratory DataMart System [21]).

We compared vaccinating and non-vaccinating schools by calculating incidence rate ratios (RR) and 95% confidence intervals (CI), adjusting for age and sex of boarders, school size and week. The total impact of offering influenza vaccine to healthy boarders (effect on vaccinated and non-vaccinated secondary-school boarders) was calculated according to the following equation:

$$\text{impact} = 1 - \frac{\text{RR}(\text{vaccinating schools})}{\text{RR}(\text{non-vaccinating schools})} \times 100\%.$$

We also calculated the number of boarders needed to vaccinate (NNV) to prevent one admission with respiratory illness:

$$\text{NNV} = \frac{\text{influenza vaccine uptake (vaccinating schools)}}{\text{cumulative incidence rate (non-vaccinating schools)} - \text{cumulative incidence rate (vaccinating schools)}}.$$

As a secondary analysis, we assessed if vaccinating schools with higher influenza vaccine uptake had a lower incidence of respiratory illness in boarders relative to schools with lower vaccine uptake. The categories used for vaccine uptake were <30%, 30–49% and $\geqslant 50\%$. Negative binomial regression was used in all models to take account of clustering of cases between schools. The significance level was set at 5% and tests were two-sided. All analyses were performed using Stata v. 13 software (StataCorp LP, USA).

Ethics statement

The MOSA scheme is managed by the PHE Centre for Infectious Disease Surveillance and Control as part of national surveillance of influenza including the influenza vaccine programme and falls under existing approvals.

RESULTS

Participation and characteristics of MOSA schools

A total of 43/222 MOSA schools (19%), representing 14 776/49 395 boarders (30%), agreed to participate in the study for the academic year 2013–2014 (Fig. 1). All schools participated until the end of the project. There was a good geographical spread of vaccinating and non-vaccinating schools across England (Fig. 2).

Nineteen schools (44%) offered influenza vaccine to healthy as well as high-risk boarders. Most of these schools also offered influenza vaccine to healthy day pupils and teaching staff (Fig. 1). The remaining 24 schools offered influenza vaccine only to high-risk boarders except for two schools that were not offering influenza vaccine to any pupil.

Three schools (7%) offered the LAIV to healthy and high-risk boarders and four additional schools (9%) offered LAIV to only high-risk boarders. The remainder of schools offered inactivated influenza vaccine.

Forty schools admitted boarders and day pupils and three schools only admitted boarders. Most of

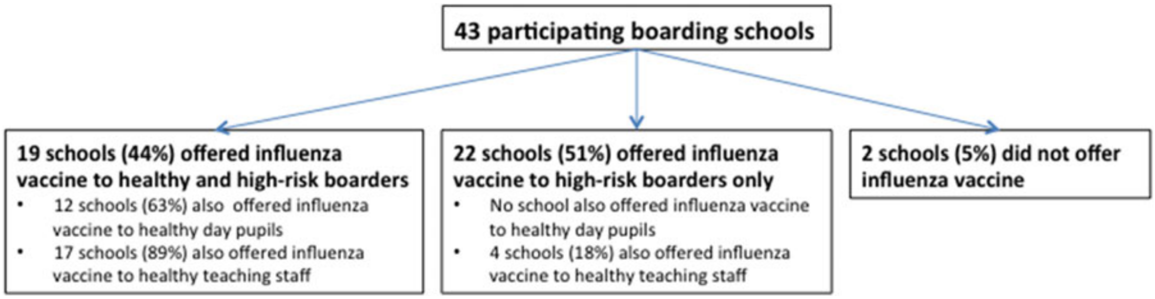

Fig. 1. Influenza vaccination policies in participating boarding schools, 2013–2014.

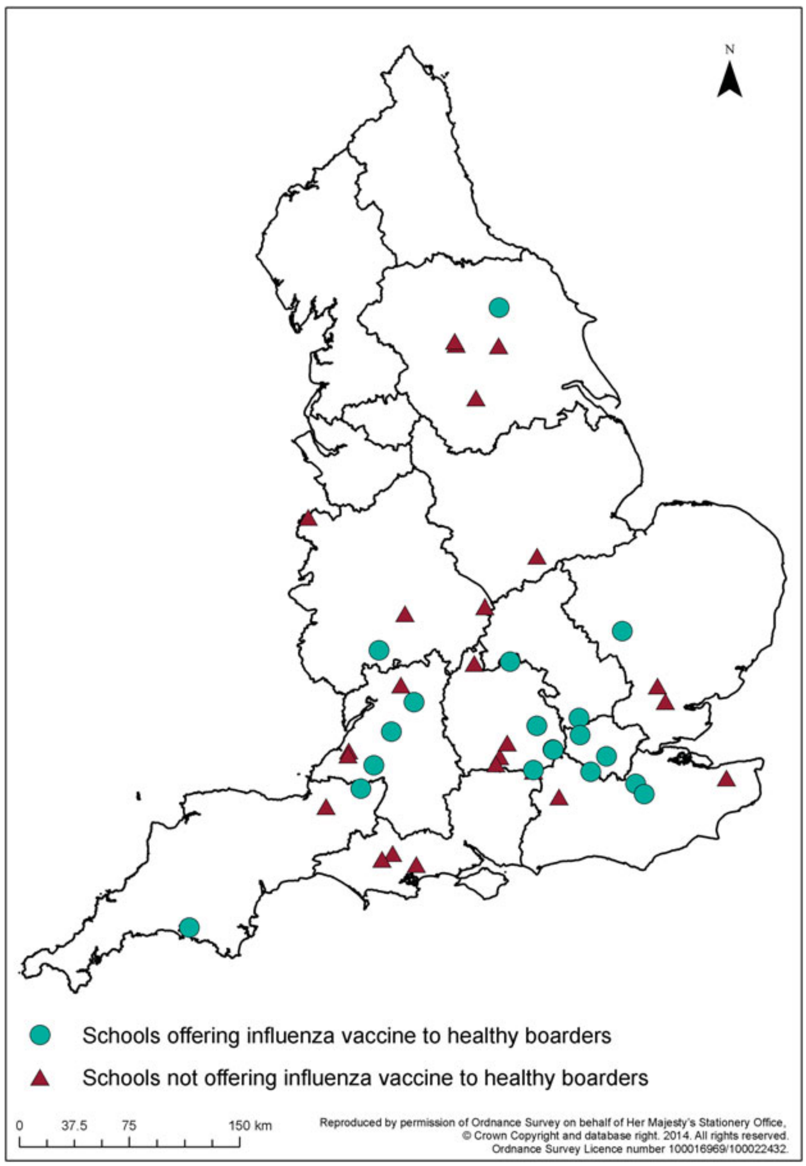

Fig. 2. Geographical spread of participating boarding schools across England ($n = 43$), by flu vaccination policy, 2013–2014.

the schools were mixed (34/43, 79%), with five schools admitting boys only and four schools admitting girls only. There were nearly 1·5 times more boys than girls in participating schools, particularly in schools vaccinating healthy boarders where the ratio was more than 2:1 (Table 1). However, there were no

Table 1. *Characteristics of participating schools and students according to the school's influenza vaccination policy, 2013–2014*

	Schools offering influenza vaccine to healthy boarders ($n = 19$) (44%)	Schools not offering influenza vaccine to healthy boarders ($n = 24$) (56%)	Total	P value
Total population (mean per school)	13 493 (710)	16 051 (669)	29 544 (687)	0·743
No. of students by type (mean per school)				
Boarders	7427 (391)	7349 (306)	14 776 (344)	
Day pupils	6066 (319)	8702 (363)	14 768 (343)	0·696
No. of students by sex (mean per school)				
Boys	9733 (512)	7733 (322)	17 466 (406)	
Girls	4260 (224)	8007 (334)	12 267 (285)	0·070
No. of boarders by school year (mean per school)				
Years 1–6	48 (3)	111 (5)	159 (4)	0·236
Year 7	122 (6)	182 (8)	304 (7)	0·240
Year 8	144 (8)	234 (10)	378 (9)	0·328
Year 9	1239 (65)	1138 (47)	2377 (55)	0·669
Year 10	1320 (70)	1211 (51)	2531 (59)	0·582
Year 11	1310 (69)	1274 (53)	2584 (60)	0·816
Year 12	1657 (87)	1627 (68)	3284 (76)	0·533
Year 13	1587 (84)	1572 (66)	3159 (74)	0·456
No. of day pupils by school year (mean per school)				
Years 1–6	1616 (85)	2464 (107)	4080 (95)	0·471
Year 7	435 (23)	775 (34)	1210 (28)	0·226
Year 8	442 (23)	771 (34)	1213 (28)	0·231
Year 9	708 (37)	913 (40)	1621 (38)	0·566
Year 10	748 (39)	1031 (45)	1779 (41)	0·642
Year 11	737 (39)	999 (43)	1736 (40)	0·501
Year 12	712 (37)	929 (40)	1641 (38)	0·714
Year 13	668 (35)	820 (36)	1488 (35)	0·874

The Kruskal–Wallis equality of populations rank test was used for statistical comparisons between vaccinating and non-vaccinating schools. For total population, the mean number of students per school was compared. For type and sex of students, the proportion of boarders and boys in each school, respectively, was compared. For school year, the proportion of boarders and day pupils for each school year was compared in each school.

statistically significant differences in the number of boarders and their age and sex between vaccinating and non-vaccinating schools (all P values $\geqslant 0{\cdot}05$). There was a mean of 344 boarders per school (range 25–1300). Most boarders were of secondary-school age [school years 7–13 (aged 11–17 years), 98·9%], with only 159 primary-school boarders [school years 1–6 (aged 5–10 years), 1·1%].

Influenza vaccine uptake

The mean influenza vaccine uptake for all boarders in participating schools was 27·0%. The influenza vaccine uptake in the 24 schools not offering influenza vaccine to healthy boarders (mean, 5·4% in all boarders; range 0·8–11·9%) was systematically lower than the influenza vaccine uptake in the 19 schools offering influenza vaccine to healthy boarders (mean 48·5% in all boarders, range 14·2–88·5%). Twelve schools vaccinating healthy boarders for influenza reported vaccine uptake by school year; there was a gradual decrease in uptake with older age of boarders (60·0% for years 1–6 to 41·2% for year 13, P value for trend <0·001).

Only 14 schools reported influenza vaccine uptake for day pupils, including eight schools vaccinating healthy day pupils. The mean influenza vaccine uptake for these eight schools was 20·2% (range 2·9–28·6%). Nineteen schools reported influenza vaccine uptake for teaching staff, including 16 schools vaccinating healthy teaching staff. The mean vaccine uptake for these 16 schools was 20·7% (range 4·0–59·0%).

Table 2. *Weekly incidence rate of respiratory illnesses reported by participating schools, by diagnosis and school year, 2013–2014*

School year	No. of boarders	URTI (*n*)	Incidence rate, URTI (/1000 boarder-weeks)	ILI (*n*)	Incidence rate, ILI (/1000 boarder-weeks)	Chest infections (*n*)	Incidence rate, chest infections (/1000 boarder-weeks)	All respiratory illnesses (*n*)	Incidence rate, all respiratory illnesses (/1000 boarder-weeks)
Years 1–6	159	29	9·98	1	0·34	1	0·34	31	10·67
Year 7	304	40	7·65	5	0·96	1	0·19	46	8·80
Year 8	378	57	8·71	4	0·61	0	0·00	61	9·32
Year 9	2377	256	6·15	28	0·67	16	0·38	300	7·21
Year 10	2531	265	5·97	31	0·70	8	0·18	304	6·85
Year 11	2584	218	4·80	22	0·48	18	0·40	258	5·68
Year 12	3284	258	4·48	21	0·36	17	0·30	296	5·14
Year 13	3159	146	2·63	17	0·31	9	0·16	172	3·10
Total	**14 776**	**1269**	**4·90**	**129**	**0·50**	**70**	**0·27**	**1468**	**5·66**

URTI, Upper respiratory tract infection; ILI, influenza-like illness.
There were 65 URTIs, one ILI and one chest infection reported without information on age group; these cases were excluded from this table and from other analyses.

Rate of respiratory illnesses

During the surveillance period, the participation for the weekly questionnaire was high (94% of all weekly surveys completed). Most of the illnesses reported were URTIs (1269 cases, 4·90/1000 boarder-weeks), as shown in Table 2. There were less ILI reports (129 cases, 0·50/1000 boarder-weeks) and chest infections (70 cases, 0·27/1000 boarder-weeks) reported. The rate of respiratory illnesses was lower in older boarders (years 1–6, 10·67/1000 boarder-weeks; year 13, 3·10/1000 boarder-weeks; *P* value for trend <0·001). However, the majority of illnesses (97·9%) were reported from secondary-school boarders (years 7–13).

The 2013–2014 season was relatively mild, with low levels of influenza activity reported through national influenza surveillance [22]. Influenza A(H1N1)pdm09 was the dominant circulating virus. According to the Respiratory DataMart System, overall influenza positivity in the general population peaked at the end of February 2014 (Fig. 3*a*, thick green line). In participating schools, the rate of ILI was high before Christmas (Fig. 3*a*, ■—■). There was then a peak in ILI during the week ending 2 February 2014, when the rate of all respiratory illnesses reported also peaked (Fig. 3*b*). The highest ILI rates in MOSA schools occurred about 1 month earlier than the peak of influenza positivity within the Respiratory DataMart System.

There were 18 ILI outbreaks reported in MOSA schools during the 2013–2014 season (between 2 and 12 cases per outbreak); four (22%) occurred in the 19 schools offering influenza vaccine to healthy boarders and 14 (78%) in the 24 schools not offering influenza vaccine to healthy boarders. There were a significantly lower number of outbreak-related ILI cases in vaccinating *vs.* non-vaccinating schools (8 *vs.* 68 cases, respectively; $P < 0{\cdot}001$). Swabbing was successfully undertaken for only three of the 18 outbreaks (17%): two were negative by polymerase chain reaction testing for influenza (one vaccinating and one non-vaccinating school) and one outbreak was positive for influenza A(H1N1)pmd09 virus (5/6 confirmed cases in a non-vaccinating school). Overall, 5/11 (45%) samples collected during ILI outbreaks in participating schools were positive for influenza, all in non-vaccinating schools.

Rate of respiratory illness and vaccination policy

The weekly rate of respiratory illness, including influenza, was generally lower in schools offering

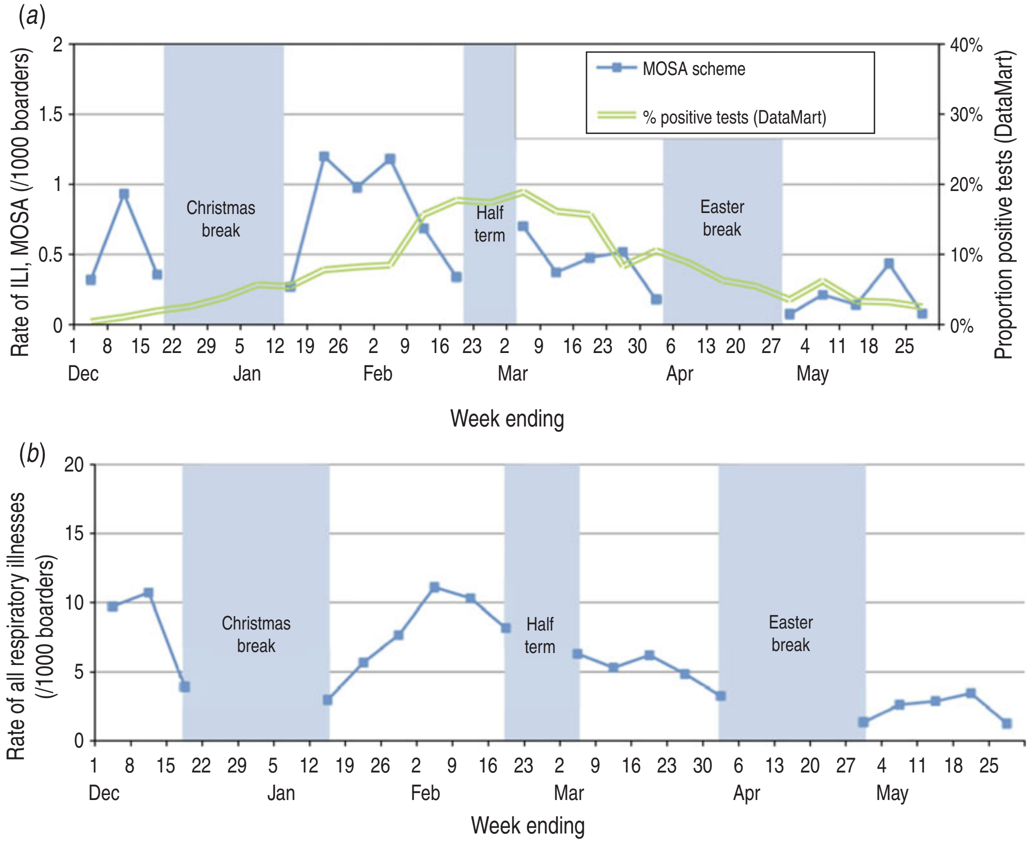

Fig. 3. Weekly rate of respiratory illness reported in boarders, Medical Officers of Schools Association (MOSA) participating schools, 2013–2014. (*a*) Weekly rate of influenza-like illness (ILI) reported in all boarders (■—■) and weekly proportion of laboratory-confirmed influenza-positive samples taken from both primary and secondary healthcare settings (thick green line), as reported by the Respiratory DataMart System. (*b*) Weekly rate of all respiratory illnesses reported in all boarders. The rates of illness for the weeks before and after each school break slightly underestimate the real value as some schools were not open for the whole 7-day period.

influenza vaccine to healthy boarders (Fig. 4*a*, *b*). As there were few primary-school boarders, only 31 illnesses were reported for school years 1–6 (2%). These younger boarders were excluded from vaccine impact analyses in order to focus on secondary-school boarders.

For the whole study period, 33 ILIs with admission to the health centre were reported in vaccinating schools in secondary-school-aged boarders (0·26/1000 boarder-weeks, 95% CI 0·18–0·36/1000) compared to 95 ILIs in non-vaccinating schools (0·74/1000 boarder-weeks, 95% CI 0·60–0·91/1000), as shown in Table 3. The rate of ILI in boarders in vaccinating schools was 65% lower than the rate of ILI in non-vaccinating schools (RR 0·35, 95% CI 0·23–0·52). After taking into account the differences in characteristics between the two groups (age of boarders, sex, school size, week), the difference was smaller but the rate was still significantly reduced by 54% (adjusted RR 0·46, 95% CI 0·28–0·76). The rate was also reduced by 28% for URTIs (adjusted RR 0·72, 95% CI 0·61–0·85) and by 82% for chest infections (adjusted RR 0·18, 95% CI 0·09–0·36). Using the formula to calculate the number needed to vaccinate, one admission for ILI in the health centre was prevented after 50 influenza vaccine doses were administered to boarders. As the incidence rate of URTI was higher, only eight boarders needed to be vaccinated to prevent one URTI admission in the health centre.

A higher vaccine uptake was associated with a greater impact on the of URTI. Compared with non-vaccinating schools, the RRs for vaccinating schools with an influenza vaccine uptake of <30%, 30%–49% and ⩾50% were 0·97 (95% CI 0·76–1·24), 0·67 (95% CI 0·54–0·83) and 0·33 (95% CI 0·24–0·47), respectively. For ILI, there was no evidence of a dose-response relationship but CIs were wide. Compared with non-vaccinating schools, the RRs

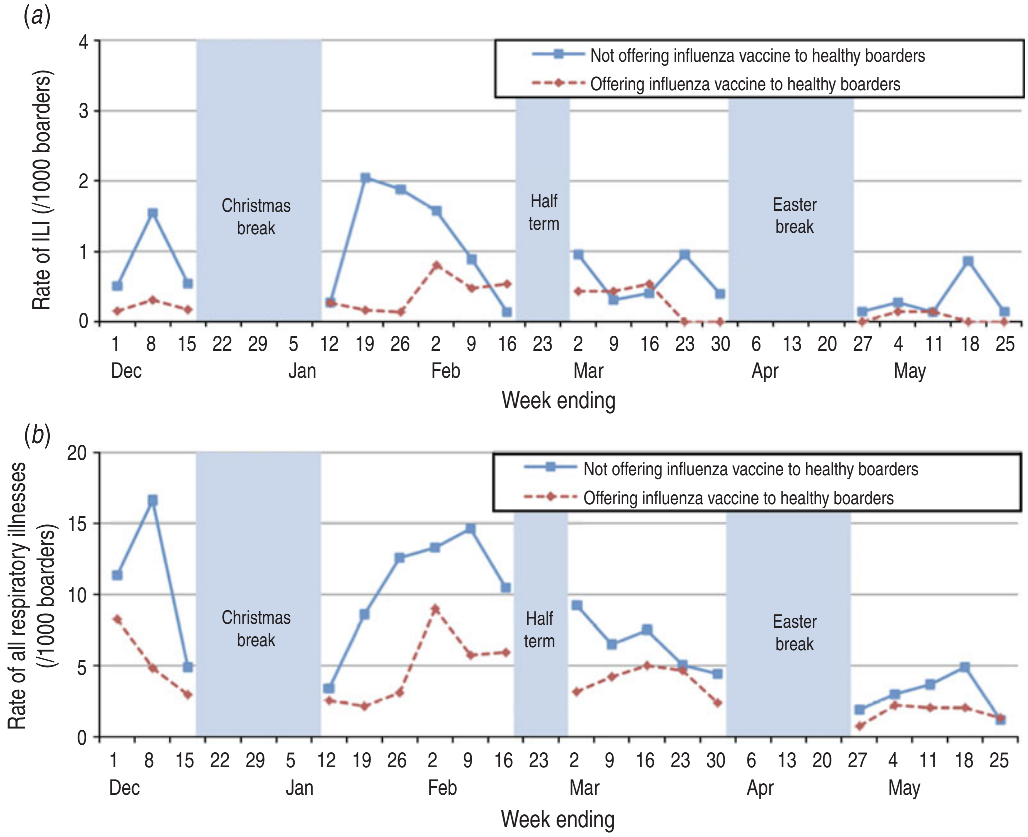

Fig. 4. Weekly rate of respiratory illness reported in boarders, Medical Officers of Schools Association (MOSA) participating schools, by influenza vaccine policy, 2013–2014. (*a*) Weekly rate of influenza-like illness (ILI) reported in participating schools. (*b*) Weekly rate of all respiratory illnesses reported in participating schools. The rates of illness for the weeks before and after each school break slightly underestimate the real value as some schools were not open for the whole 7-day period.

Table 3. *Incidence rate ratio of respiratory illness in all boarders in study schools offering influenza vaccine to healthy boarders compared to schools that were not, by diagnosis, 2013–2014*

	Schools vaccinating healthy boarders (7379 secondary-school boarders)		Schools not vaccinating healthy boarders (7238 secondary-school boarders)			
Illness	No. of cases	Incidence rate (/1000 boarder-weeks)	No. of cases	Incidence rate (/1000 boarder-weeks)	Crude incidence rate ratio (95% CI)	Adjusted incidence rate ratio (95% CI)
URTI	429	3·35	811	6·33	0·53 (0·47–0·60)	0·72 (0·61–0·85)
ILI	33	0·26	95	0·74	0·35 (0·23–0·52)	0·46 (0·28–0·76)
Chest infection	17	0·13	52	0·41	0·33 (0·18–0·57)	0·18 (0·09–0·36)
All respiratory illnesses	**479**	**3·74**	**958**	**7·48**	**0·50 (0·45–0·56)**	**0·65 (0·56–0·76)**

CI, confidence interval; URTI, upper respiratory tract infection; ILI, influenza-like illness.
The analysis excludes primary-school boarders (1·1% of boarders). Adjusted results take into account age and sex of the boarders, school size and week.

for vaccinating schools with an influenza vaccine uptake of <30%, 30–49% and $\geqslant$50% were 0·14 (95% CI 0·04–0·47), 0·64 (95% CI 0·35–0·1·16) and 0·52 (95% CI 0·21–1·27), respectively.

DISCUSSION

The MOSA scheme has been a longstanding programme contributing to the national influenza surveillance in England. In 2013–2014, this scheme comprising 43 schools and 15 000 boarders investigated respiratory illness rates between schools with programmes to vaccinate all healthy boarders and schools without such programmes. Vaccinating schools achieved an average uptake of 49% in all boarding pupils. A 54% reduction of ILI in all boarders was observed at these schools compared to non-vaccinating schools, after adjusting for characteristics such as age, sex, school size and time of the year. This represents about two boarder admissions for ILI in the health centre prevented per 100 vaccinated boarders. A significant reduction of URTI (28%) and chest infection (82%) disease rates was also noted. These findings are the first in England and elsewhere in Europe to assess the impact of childhood influenza vaccination on respiratory illness in secondary-school settings in all pupils (both vaccinated and non-vaccinated).

The reduction of 54% in ILI rates for schools vaccinating boarders was similar or even higher than in community studies that investigated the impact of a school-based influenza vaccine programme on acute respiratory illnesses. For example, Grijalva *et al.* [8] found a 30–45% reduction of medically attended acute respiratory illnesses in children aged 5–17 years in Tennessee, USA when comparing a county with a school-based influenza vaccination campaign and other surrounding counties. Another study showed a reduction lower than 20% [9]. The decrease in ILI rates found in the current study (54%) was also higher than the mean influenza vaccine uptake in schools immunizing healthy boarders (49%). Some of this observed reduction is likely to be due to the indirect effects of the vaccination programme (herd immunity) since vaccinated and protected boarders are less likely to transmit the infection to others in the school. This has been observed in other studies targeting school children [5, 13, 23]. Schools vaccinating healthy boarders were more likely to vaccinate day pupils and staff, which may also contribute to indirect effects. Another contributing factor may be the low intensity of the 2013–2014 influenza season [24]. Basta *et al.* [16] suggested that the indirect effects of influenza vaccination may be higher during mild seasons, as it may be easier to reduce transmission near or below the epidemic threshold. Vaccination may also have a higher impact in closed settings like boarding schools, where students mix preferentially with the same age groups. Several studies in boarding schools have found an appreciable impact of influenza vaccination, with direct vaccine effectiveness ranging from 36% to 63% [25–27]. However, the indirect effects of influenza vaccination on unprotected boarders were not considered in these studies.

In addition to ILI, the rate of URTI was 26% lower in schools vaccinating healthy boarders compared to those that were not. A high proportion of influenza infections are known to be asymptomatic or present with mild clinical illness [28]. During an influenza season, 15–20% of the population can be infected by seasonal influenza, a proportion about 20-fold higher than the cumulative ILI rates in the current study (8·7/1000 boarders). We hypothesize that many mild influenza infections were reported as URTIs, which would explain the lower URTI rate in schools vaccinating healthy children. Furthermore, the difference was higher for ILI (54%), which is a more specific case definition compared to URTI [29]. Nonetheless, this demonstrates that, in the context of a low-intensity influenza season and relatively high vaccine uptake in schools resulting in a degree of herd immunity, approximately 12 URTI cases with admission to the health centre were prevented for every 100 boarders vaccinated.

The increase in influenza rates in participating schools occurred earlier than the increase in the proportion of tests positive for influenza in the general population. This supports evidence that compared to other parts of the population, activity generally appears earlier in school-aged children, particularly in settings such as boarding schools, and that this could contribute to their role in transmission [3]. Additionally, boarders often travel back to school from international locations and can import early cases of influenza, suggesting surveillance of ILI in boarders could detect the first signs of influenza activity. By contrast, less specific indicators such as school absenteeism have not consistently been able to detect influenza activity earlier than traditional influenza surveillance tools [30–33].

There are several limitations to this study. First, there was no routine nasopharyngeal swabbing to confirm each ILI case. Swabbing was only offered during ILI outbreaks (defined as ⩾2 cases of ILI occurring in the same school within 7 days) and was successfully undertaken for only 3/18 (17%) of them, either because the outbreaks occurred in schools that did not participate in the swabbing scheme or because the swabs would have been collected more than 7 days after symptom onset in the affected schools. Several ILIs were reported by non-vaccinating schools before the increase of influenza activity in the general population. It is probable that many of these ILIs were influenza cases occurring early in these non-vaccinated schools, which were more vulnerable to influenza outbreaks. However, respiratory syncytial virus was circulating in December 2013 and some ILIs may have been due to this virus. This highlights the importance of obtaining timely laboratory confirmation of outbreaks of ILI in future seasons. Second, the participating schools under study were neither randomized nor blinded to receive vaccine. Some school characteristics (e.g. frequency of hand washing or degree of exclusion in case of respiratory illness) were not systematically collected and could act as potential confounders. Health staff from non-vaccinating schools may also have been more likely to report an infection as an ILI as most boarders were known to be unvaccinated. Nonetheless, it is unlikely that this bias accounts for the difference between vaccinating and non-vaccinating schools as a standardized clinical definition was used for ILI and as a protective effect was seen for the other clinical respiratory endpoints. Moreover, the high reporting rate for the weekly returns in both vaccinating (91%) and non-vaccinating (95%) schools shows the high involvement in both groups. Schools never omitted to complete a weekly return because they were too busy with outbreaks of respiratory illnesses in boarders. Therefore, there is unlikely to be a significant reporting bias. Third, we did not find a significant dose-response relationship when studying the association between ILI rates and vaccine uptake, possibly because of power issues related to the low number of ILI cases reported. However, the fact that schools with higher vaccine uptake had lower URTI rates is reassuring. Finally, the results are for a single influenza season where low activity was observed. The effectiveness of influenza vaccines can vary according to various factors such as the setting and viral circulation patterns [34]. It will be important to assess if a similar impact is observed during upcoming influenza seasons.

The MOSA surveillance scheme remains important for the surveillance of respiratory illnesses in England. It can help to detect transmission of influenza early in the season, particularly when linked to virological sampling. In addition, the scheme is helpful to complement the evaluation of the new childhood influenza vaccine programme which only targeted primary-school students in 2013–2014 [35]. This year's results, demonstrating a 54% reduction of ILI in schools vaccinating healthy boarders, add to the evidence base supporting the roll-out of the universal influenza vaccination programme to secondary schools in future years. With the continued roll-out of the new childhood influenza vaccination programme in England, additional research is needed to measure the impact of secondary-school influenza vaccination on influenza swab positivity and in non-boarding secondary-school settings.

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DECLARATION OF INTEREST

None.

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