Assessing the Relationship Between Seasonal and H1N1 Influenza Vaccination Status in Michigan Children, 2009–2010

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ABSTRACT

Objectives. To examine the relationship between the outcome of vaccination for H1N1 influenza and receipt of seasonal influenza vaccine in Michigan children during the 2009–2010 season, we examined the influenza vaccination status of all Michigan residents aged six months to 18 years who were enrolled in the Michigan Care Improvement Registry.

Methods. We calculated descriptive statistics for dichotomous and categorical variables, including numbers of children vaccinated with either influenza A (H1N1) monovalent vaccine and/or seasonal influenza vaccine, gender, race/ethnicity, provider type, moved-or-gone-elsewhere (MOGE) status, and vaccine type. We used logistic regression, adjusting for potential confounders and effect modifiers (age and MOGE status), to calculate odds ratios associated with H1N1 vaccine status (vaccinated vs. unvaccinated).

Results. Michigan children who were vaccinated for seasonal influenza from August 1, 2009, to February 27, 2010, were 6.26 (95% confidence interval 6.18, 6.34) times as likely as children who were unvaccinated for seasonal influenza to be vaccinated with H1N1 2009 monovalent vaccine. Private health-care providers administered 91% of the seasonal influenza vaccine and 59% of the H1N1 vaccine.

Conclusions. Increasing seasonal influenza vaccination campaign efforts could also benefit pandemic influenza vaccination efforts. Special educational outreach to parents regarding the importance of influenza vaccination for all children, regardless of age, may be needed. Stocking and offering traditional seasonal vaccine with pandemic-specific vaccine may aid in increasing immunization uptake. Efforts should be made to ensure that private providers are supplied with adequate pandemic vaccine as part of preparedness planning.

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On June 11, 2009, the World Health Organization announced the first global influenza pandemic in 41 years.[1] Following the announcement, the U.S. Food and Drug Administration approved an influenza A (H1N1) 2009 monovalent vaccine on September 15, 2009, for protection against the novel H1N1 virus. Eventually, five H1N1 monovalent vaccine formulations—one live attenuated and four inactivated—were manufactured and approved, all of which contained the A/California/7/2009 (H1N1) v-like strain.[2,3]

The Advisory Committee on Immunization Practices (ACIP) releases annual recommendations for seasonal influenza vaccine composition.[4] Typically, the seasonal trivalent influenza vaccine is updated every year with the most current circulating influenza strains and contains two subtype A influenza strains and one influenza B strain. Per ACIP recommendations, the 2009–2010 seasonal influenza strains included in the trivalent vaccines were A/Brisbane/59/2007 (H1N1)-like, A/Brisbane/10/2007 (H3N2)-like, and B/Brisbane/60/2008-like antigens. However, the 2009–2010 flu season was unique in that two separate influenza vaccines were recommended: the standard trivalent seasonal influenza vaccine and the H1N1 2009 monovalent vaccine. Although the target groups for these two vaccines were not identical, children six months to 18 years of age were prioritized for immunization with both vaccines to provide protection against all strains of influenza.[5]

The unusual recommendation for receipt of two different influenza vaccines in the same season naturally gave rise to questions regarding their relationship relative to any possible interaction and any ensuing impact on intent to receive or actual receipt of one or both vaccines. A recent study by Maurer et al. investigated the intention of adults aged 18 years and older to be vaccinated with the new H1N1 vaccine in the context of seasonal influenza vaccine receipt the previous season.[6] The study findings suggest an association between intent to receive the H1N1 vaccine during the 2009–2010 season and receipt of the seasonal influenza vaccine during the 2008–2009 season.

Another study conducted by the Centers for Disease Control and Prevention (CDC) on intent of adults to receive both H1N1 2009 monovalent and seasonal influenza vaccines found a majority of parents planned to have their children vaccinated with both vaccines.[7] Additionally, combined data from the Behavioral Risk Factor Surveillance System and the 2009 National H1N1 Flu Survey showed a strong positive correlation between self-reported receipt of seasonal and H1N1 influenza vaccination in adults and children.[8] Two other studies showed that 34.7% of health-care personnel and 34.1% of pregnant women received both the seasonal and H1N1 influenza vaccines during the 2009–2010 flu season.[9,10]

While these published studies better characterize the intention of adults and children to be vaccinated and address self-reported vaccination status in adult health-care personnel or adult pregnant women, there are no studies to date that utilize actual 2009–2010 vaccination coverage data on children to confirm these findings.

For this study, we used immunization records from the Michigan Care Improvement Registry (MCIR), Michigan's immunization information system (IIS), to determine if being vaccinated for seasonal influenza was associated with an increased likelihood of receiving the H1N1 vaccine during the 2009–2010 flu season in Michigan children aged six months to 18 years.

METHODS

We assessed the 2009–2010 influenza vaccination status of all Michigan residents aged six months to 18 years who were enrolled in the MCIR. Age was calculated as of the end of the study period, February 27, 2010, and the eligibility criteria based on age were determined at this point in time. Children in the study may have received only the H1N1 2009 monovalent vaccine, only the seasonal influenza vaccine, neither vaccine, or both vaccines during the 2009–2010 flu season. To better define the predictive relationship of seasonal influenza vaccination for H1N1 vaccination, only children who received both vaccines on the same day or received the seasonal vaccine before the H1N1 vaccine were included in the study population (i.e., children who received the H1N1 vaccine first were removed). For this study, we defined the 2009–2010 flu season as beginning August 1, 2009, and ending February 27, 2010.

Data on vaccination status were derived from the MCIR, a Web-based application that has been operational since 1998, although it contains immunization records from before that year. Health-care providers, health departments, school health centers, pharmacies, and other vaccine providers can electronically input immunizations given to people of any age into the MCIR. Providers are required to report school exclusionary vaccinations to the MCIR if the individual was born after December 31, 1993, and is younger than 20 years of age. Providers may electively report vaccinations given to individuals if they were born before January 1, 1994. The MCIR is automatically populated with the electronic birth certificates of all children born in Michigan after December 31, 1993. Other forms of MCIR data collection include direct data entry via the MCIR Web interface, data transfer from billing systems

and electronic medical records, and paper scan forms. Schools also may enter immunization data into the MCIR, but only provider-verified immunizations were used in this analysis.

Providers entering data into the MCIR are asked to supply the date of vaccination; the vaccination type (e.g., live vs. inactivated influenza vaccine); and any updates to the child's information, such as change of address, among other options. ZIP code and county of residence are recorded when adding a child's record to the MCIR or are automatically populated if derived from an electronic birth record, and are updated as needed and linked to the child's individual MCIR identification. A provider may flag an individual as moved or gone elsewhere (MOGE) to indicate that a patient has moved out of the area or switched to another provider. This variable functions to notify providers of an invalid address and to eliminate individuals so marked from reminder or recall queries. Provider type was categorized as either public or private; no provider type is recorded for unadministered vaccines. Public is defined by vaccines administered at a local health department (LHD) or LHD satellite clinic, and private includes all other facilities. Mother's race/ethnicity is automatically derived from electronic birth certificates for children born after December 31, 1993, and is broken down into the following categories: white, black, American Indian, Asian or Pacific Islander, Hawaiian, other nonwhite, or unknown.

Influenza vaccination type was recorded in the MCIR, and for the H1N1 monovalent vaccine, choices included (*1*) novel influenza-H1N1-09—live virus for nasal administration (live attenuated influenza vaccine [LAIV] or FluMist®); (*2*) novel influenza-H1N1-09—inactivated, preservative-free injectable; (*3*) novel influenza-H1N1-09—inactivated injectable (monovalent inactivated vaccine); and (*4*) novel influenza-H1N1-09—all formulations (although no records entered in the MCIR included this last code). The choices for the seasonal influenza vaccine included (*1*) influenza virus vaccine—live, attenuated, for intranasal use (LAIV or FluMist); (*2*) influenza virus vaccine—split virus including purified surface antigen (trivalent inactivated influenza vaccine); and (*3*) influenza virus vaccine—not otherwise specified.

For our analysis, the principle predictor of interest was vaccination status for seasonal influenza, and the primary outcome assessed was H1N1 vaccination status. We treated vaccination for seasonal influenza as a dichotomous variable and categorized children as either "vaccinated" or "unvaccinated" for seasonal influenza any time from August 1, 2009, to February 27, 2010. If a child had no record in the MCIR of receiving a seasonal influenza vaccination during that time period, we categorized them as unvaccinated for seasonal influenza. If a child received two or more doses of seasonal influenza vaccine, only the first dose was included in the analysis. As the outcome of interest, the H1N1 vaccination status variable was dichotomized as either vaccinated or unvaccinated for H1N1 any time from October 5, 2009, to February 27, 2010. We chose the October date because it marks the initial availability of the H1N1 2009 monovalent vaccine to the public. If there was no record in the MCIR of a child receiving the H1N1 vaccine, we categorized the child as unvaccinated for H1N1. If a child received two or more doses of H1N1 vaccine, only the first dose was included in the analysis.

Mean age and standard deviations were calculated as a continuous variable, and distribution by percentage was calculated for four categories, based on the age of the study participants. We calculated descriptive statistics, including frequencies and proportions, for dichotomous and categorical variables, including numbers vaccinated with H1N1 monovalent vaccine and/or seasonal influenza vaccine, gender, race/ethnicity, provider type, MOGE status, and vaccine type. A logistic regression model was developed to determine if H1N1 2009 monovalent vaccination status differed by seasonal influenza vaccination status. Odds ratios (ORs), 95% confidence intervals (CIs), and *p*-values were reported.

To assess for possible confounding, age, gender, and MOGE status were separately modeled with H1N1 vaccination status as the main outcome and with receipt of seasonal influenza vaccine using logistic regression. By separately assessing the percent change in the OR between the crude and adjusted models, as well as testing significance within the model, we determined age and MOGE status were confounders. Age was assessed as an effect modifier because it may affect H1N1 vaccination status in those who are vaccinated for seasonal influenza but not in those who are unvaccinated for seasonal influenza. It is also important to note that children in the MCIR system are not always flagged for removal if they relocate out of the state, which could result in an overestimation of the older age groups in the analysis. Age was determined to be an effect modifier if the OR for seasonal influenza vaccination status showed a >10% change when separately compared with the saturated model and the model adjusted for age as an effect modifier of seasonal influenza vaccination status. Final multivariable models were created, adjusting for MOGE status as a confounder and age as both a confounder and effect modifier. ORs and 95% CIs were reported for all covariates, as well as an overall

model *p*-value. We used SAS® version 9.1 to estimate all statistics and models.[11]

This study was approved by the Michigan Department of Community Health Institutional Review Board (IRB) (#770-PHAEPI) and exempted for use of secondary data analysis by the University of Michigan IRB (HUM00036643).

RESULTS

A total of 3,004,536 children aged six months to 18 years were eligible for inclusion in our study. Of that total, 8.0% (n=240,261) received both the H1N1 2009 monovalent and seasonal influenza vaccines, 8.0% (n=240,980) received only the seasonal influenza vaccine, 8.9% (n=267,689) received only the H1N1 vaccine, and 75.1% (n=2,255,606) received neither vaccine. Among the children who received both vaccines, 34.2% received them on the same day.

The study population was 49% female, and the mean age of all subjects was 9.91 ± 5.24 years (Table 1). Children aged six months to 4 years had a greater proportion of vaccination overall (41.4%), but especially for receipt of both seasonal and H1N1 influenza vaccinations (17.2%). Receipt of seasonal influenza vaccination only, H1N1 vaccination only, or both seasonal and H1N1 influenza vaccinations decreased with age; children 15–18 years of age had the lowest vaccine

Table 1. Characteristics of Michigan children aged six months to 18 years, by type of influenza vaccine administered, August 2009–February 2010 (*n*=3,004,536)

	Vaccine type			
Characteristic	*Seasonal influenza only* N *(percent)*	*H1N1 influenza only* N *(percent)*	*Seasonal and H1N1 influenza*[a] N *(percent)*	*Total population* N
Gender				
Female	118,518 (8.1)	131,415 (9.0)	117,314 (8.0)	1,465,698
Male	122,364 (8.0)	136,155 (8.9)	122,877 (8.0)	1,533,929
Unknown	98 (2.0)	119 (2.4)	70 (1.4)	4,909
Age, continuous (mean ±SD)	7.4 ±5.2	9.3 ±5.0	6.6 ±5.0	9.9 ±5.2
Age				
Six months–4 years	89,500 (15.0)	54,783 (9.2)	102,723 (17.2)	597,019
5–9 years	67,798 (8.7)	82,987 (10.6)	68,352 (8.8)	781,368
10–14 years	52,914 (6.0)	78,399 (8.9)	45,988 (5.2)	883,193
15–18 years	30,768 (4.1)	51,520 (6.9)	23,198 (3.1)	742,956
Mother's race/ethnicity				
White	65,930 (15.3)	40,608 (9.4)	80,473 (18.7)	430,444
Black	16,035 (15.4)	4,899 (4.7)	10,487 (10.1)	104,127
American Indian	440 (14.9)	325 (11.0)	605 (20.5)	2,950
Hawaiian	9 (18.0)	4 (8.0)	5 (10.0)	50
Asian or Pacific Islander	3,003 (14.2)	2,087 (9.8)	5,180 (24.4)	21,218
Other nonwhite	1,039 (13.9)	756 (10.1)	1,193 (16.0)	7,471
Unknown	154,524 (6.3)	219,010 (9.0)	142,318 (5.8)	2,434,074
Vaccine type				
LAIV (FluMist®)	40,282 (17.9)	93,043 (41.5)	91,164 (40.6)[b]	NA
Injectable shot	197,580 (29.8)	132,713 (20.0)	332,082 (50.1)[b]	NA
Seasonal (not otherwise specified)	3,118 (50.9)	NA	3,004 (49.1)[b]	NA
H1N1 injectable (preservative-free)	NA	41,933 (43.6)	54,272 (56.4)[b]	NA
Moved or gone elsewhere				
Yes	8,762 (2.5)	7,049 (2.0)	5,452 (1.6)	350,487
No	232,218 (8.8)	260,640 (9.8)	234,809 (8.9)	2,654,049

[a]34.2% of H1N1 influenza vaccinations were given simultaneously with seasonal influenza vaccine.

[b]Counts are not mutually exclusive. As all children received both a seasonal and an H1N1 influenza vaccination, the cumulative sum of all vaccine types are double. A total of 240,261 children received both a seasonal and an H1N1 influenza vaccination.

SD = standard deviation

LAIV = live attenuated inactivated vaccine

NA = not applicable

uptake. For children aged 5–9 years, 10–14 years, and 15–18 years, the highest percentage received H1N1 influenza vaccination only (10.6%, 8.9%, and 6.9%, respectively). No substantial gender differences were observed between those receiving seasonal only, H1N1 only, or both seasonal and H1N1 influenza vaccinations. We found the highest proportion of vaccinations for both seasonal and H1N1 influenza among Asian or Pacific Islander (24.4%), American Indian (20.5%), and white (18.7%) children; the lowest proportions vaccinated for H1N1 only (4.7%) and both seasonal and H1N1 influenza (10.1%) were found among black children.

Administration of seasonal influenza vaccine peaked in the study group during the week ending October 10, 2009 (n=56,266 vaccinations that week). Uptake of the H1N1 vaccine peaked during the week ending November 7, 2009 (n=80,041 vaccinations that week). Uptake velocity differed between the two: there was a gradual increase and decrease in administration of seasonal influenza vaccine, while H1N1 vaccine uptake increased and dropped off more precipitously. Administration of both vaccines had substantially decreased by the week ending December 26, 2009, with minimal levels of uptake by the study's cutoff date, February 27, 2010 (Figure).

Of those who received the seasonal influenza vaccine, 82% received the trivalent inactivated influenza vaccine, 17% received the LAIV, and 1% were recorded as receiving a not-otherwise-specified dose. Of those who received the H1N1 vaccine, 50% received the monovalent inactivated vaccine, 35% received the LAIV, and 16% received the preservative-free injectable. Private providers administered 91% of the seasonal influenza vaccine and 59% of the H1N1 vaccine, with the remainder administered by health departments. Mother's race/ethnicity was recorded for only 19.0% of the children (in part because providers are unable to input this information via the MCIR interface) and, therefore, it was not assessed as a possible confounder.

Logistic regression results of the univariate analysis revealed that a child aged six months to 18 years living in Michigan was 8.40 times as likely to receive an H1N1 vaccine if the child also received a seasonal influenza vaccine (95% CI 8.34, 8.46; $p<0.001$) (Table 2). Age, gender, and MOGE status were tested for confounding by a >10% change in the OR between the crude model and each separate model. Age was found to be a confounder, with an 11.8% change in OR. Conversely, gender was not found to be a confounder, given a 0.1% change in OR. MOGE status showed a 7.8% change in OR and, thus, was retained in the multivariate model for reasons described herein. Age was assessed as an effect modifier between the association of seasonal influenza vaccination and H1N1 vaccination. Using the same >10% change criterion between the saturated model and the model adjusting for age as an effect modifier, age was included in the final model as an effect modifier, with a 10.5% change in OR (Table 2).

A final multivariable regression model was developed to explore the associations between H1N1 vaccination as the main outcome, seasonal influenza vaccination status as the primary exposure, age and MOGE status as the measured confounders, and age as an effect modifier. In this final model, we determined that children

Figure. Influenza vaccinations administered to Michigan children aged six months to 18 years, by week, August 2009–February 2010

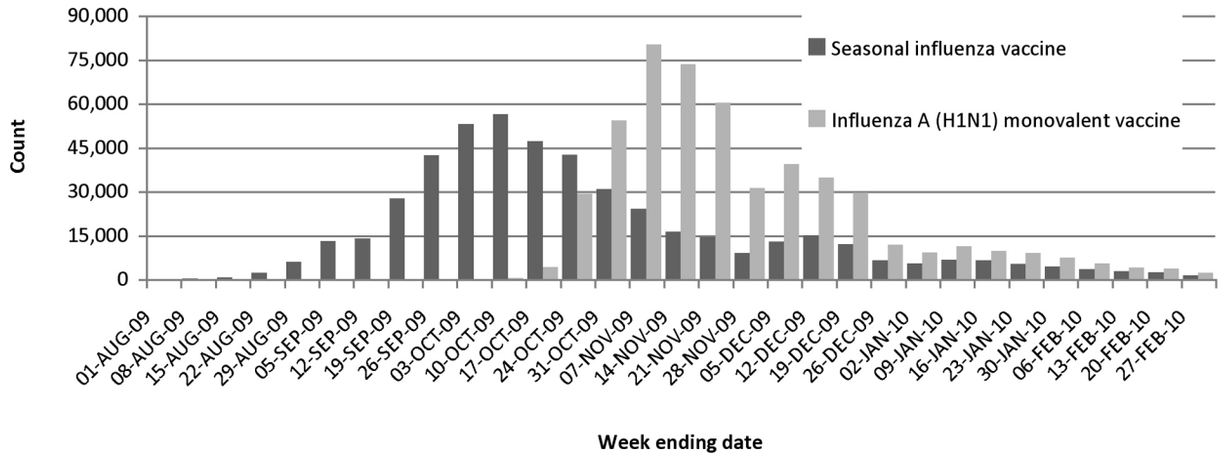

Table 2. Impact of seasonal influenza vaccination status on the likelihood of receiving the influenza A (H1N1) monovalent vaccine among Michigan children aged six months to 18 years, August 2009–February 2010

Variable	*Unadjusted OR (95% CI)*	*Adjusted OR[a] (95% CI)*
Seasonal influenza vaccination	8.40 (8.34, 8.46)	6.26 (6.18, 6.34)
Age (continuous)	NA	0.96 (0.959, 0.961)
MOGE	NA	0.24 (0.24, 0.25)
Age × seasonal influenza vaccination (interaction term)	NA	1.01 (1.01, 1.02)

[a]Adjusted model includes seasonal influenza vaccination, age, MOGE status, and interaction term between increasing age and receipt of seasonal influenza vaccination.

OR = odds ratio

CI = confidence interval

NA = not applicable

MOGE = moved or gone elsewhere

vaccinated for seasonal influenza from August 1, 2009, to February 27, 2010, were 6.26 times as likely as those not vaccinated to be vaccinated with the H1N1 2009 monovalent vaccine between October 5, 2009, and February 27, 2010 (Table 2). ZIP code and county of residence were not included in the final multivariable regression analysis due to each variable having too many categories, which would negatively impact the accuracy of the final OR.

DISCUSSION

This study found that children residing in Michigan during the 2009–2010 flu season were more than six times as likely to receive the H1N1 2009 monovalent vaccine if they also received the seasonal influenza vaccine (vs. children not vaccinated for seasonal flu). Although the children who received both the seasonal and H1N1 influenza vaccines comprised comparable proportions of males and females, they otherwise tended to be younger (aged six months to 4 years) and were more likely to be Asian or Pacific Islander or white than black.

It may be that parents perceived the health risk for seasonal and H1N1 influenza to be greater for babies and young children than those in older age groups and, thus, were more likely to have the former immunized with both vaccines. Older children, especially teenagers, are also more likely to exercise greater decision-making authority and countermand parental wishes regarding personal health-care issues, which could help account for the relatively low proportion who were immunized with either seasonal or H1N1 influenza vaccine, or both, in this age group. Additionally, teenagers may face other access barriers to vaccination, such as competing time demands from school and work, which could adversely impact immunization levels. The substantial age differences associated with the likelihood for influenza vaccination may call for more intense educational efforts directed at parents and focused on the importance of influenza vaccination for all children, regardless of age.

Overall, black children were less likely than white or Asian or Pacific Islander children to be immunized with seasonal, H1N1, or both influenza vaccines, which is consistent with other studies identifying racial/ethnic disparities in influenza vaccine coverage across populations.[12–15] This disparity in coverage may point to access barriers and the need to conduct more intense marketing and educational campaigns on the importance of influenza vaccination specifically directed at African American communities.

This finding could be useful for future pandemic vaccination efforts directed at increasing the uptake of pandemic influenza vaccine. Such efforts suggest that public health infrastructure, which promotes and supports annual seasonal influenza vaccination, could be an important component of pandemic influenza preparedness programs. Although children who received the seasonal influenza vaccine were more likely to receive the H1N1 vaccine, the distribution of use of the two did not completely coincide. Therefore, it might be possible to further increase use of a pandemic influenza vaccine through co-administration with seasonal influenza vaccine, offering it at the same times and locations as the seasonal vaccine. And, because children were more likely to receive the seasonal influenza vaccination from a private provider, stocking these providers with the pandemic vaccine may be a more effective option for increasing uptake, as opposed to arranging mass vaccination clinics through public agencies. Additional studies should be undertaken to

fully elucidate the impact of vaccine distribution on immunization coverage levels in children.

The results from this study support those of a previous study[6] demonstrating a strong positive influence on receipt of the H1N1 vaccine in people immunized with the seasonal influenza vaccine. However, they do not support the findings of a similar CDC study that revealed the majority of parents intended to have their children vaccinated against both H1N1 and seasonal influenza. Only about 8% of all children in the MCIR aged 6 months to 18 years received both influenza vaccines, while a comparable proportion received only the seasonal (8.0%) or the H1N1 (8.9%) vaccine. It may be that the CDC study was not generalizable to Michigan, or perhaps parents in Michigan did not follow through on their intent to have their children receive both vaccines. The latter may be a more plausible explanation, given that the 2009 novel H1N1 influenza virus was not as catastrophic as first expected (which may have diminished initial resolve to receive it), and the H1N1 vaccine was not widely available until after pandemic influenza activity had peaked.

Our study highlights the benefits of using data derived from an IIS to better understand variables associated with vaccine uptake and other immunization-associated issues in a timely fashion. The data used for our analysis reflected vaccination activity in the most recent flu season and yielded rapid results that can inform future vaccination campaigns. The fact that the immunization data are entered by vaccine providers eliminates the need to rely on individual recall, as in survey studies, and provides a standardized format for related demographic and other variables. Further, using the MCIR for this analysis generated a large sample size that likely captured most children residing in Michigan from August 1, 2009, to February 27, 2010.

Limitations

Our study had a number of limitations. To dichotomize both the exposure and the outcome, assumptions about vaccination status were made. If no vaccination was recorded for a child in the MCIR (H1N1 and/or seasonal influenza), we categorized the child as unvaccinated for either or both vaccines, which may have resulted in an overestimation of unvaccinated children. Seasonal influenza vaccine use may be underreported in the MCIR because, under Michigan law, seasonal influenza vaccination is not a requirement for school entry and is not required to be entered into the MCIR.[16] Also, commercial community vaccinators, such as pharmacies and urgent care centers, administer seasonal influenza vaccine, but not all these providers reliably input administered vaccine into the MCIR. Conversely, in an effort to facilitate tracking and adverse-event monitoring, all H1N1 2009 monovalent vaccine administered in Michigan was required to be recorded in the MCIR during the 2009–2010 flu season.[17] However, H1N1 vaccine coverage estimates using our MCIR data (16.9%) fall outside the confidence limits of the Behavior Risk Factor Surveillance System/National H1N1 Flu Survey data (23.8%–38.6%), suggesting that many administered doses may go unreported.[9] Collectively, these issues may result in an underrepresentation of the exposure in this analysis and, therefore, an underestimation of effect.

This analysis only included vaccinations administered and entered into the MCIR through February 27, 2010. Nationally, influenza activity peaked in the week ending October 24, 2009, and subsequently declined.[18] Creating a cutoff point considerably after peak influenza activity was reasonable and should not have been a source of major bias in the measure of association. The MOGE status was included in the final multivariate model, despite falling short of the >10% change in OR criteria. This was done to adjust for individuals who have moved out of Michigan but have not been removed from the MCIR. However, it is important to note that if a child moves out of state, there is no flag to denote this, resulting in an increased denominator, particularly among older individuals. And, if these children relocated within Michigan but their new address is unavailable, they do not receive influenza reminder and recall notifications from their provider or LHO.

A final limitation of this analysis was the inability to adjust for other unmeasured variables, such as local health jurisdiction, race/ethnicity, and parent/provider attitudes. While some race/ethnicity data are recorded for children in the MCIR, it was too incomplete to be included in the final multivariate analysis. Race/ethnicity may play an important role in whether an individual received H1N1 vaccine, seasonal influenza vaccine, or both; however, in a recent survey on intent to receive H1N1 and seasonal influenza vaccine during the 2009–2010 season, race/ethnicity was not associated with an individual's intent to receive vaccine.[7] Implementation of the H1N1 influenza vaccination campaign and coverage rates differed widely by local health jurisdiction, including when and if they chose to use the ACIP-recommended subset of target groups for use during limited vaccine availability. This subset included all children aged six months to 4 years and children and adolescents aged 5–18 years who had a high-risk condition. Categorization of local health jurisdictions by vaccination strategy was beyond the scope of this study but is an area recommended for

future investigation. The mechanism by which receipt of seasonal influenza vaccine increased the likelihood of receipt of H1N1 vaccine requires further study. Parental knowledge and provider recommendation at the time of seasonal influenza vaccination may have played a role.

CONCLUSIONS

These data suggest that the likelihood of children being immunized with pandemic influenza vaccine is significantly increased if they have also received the seasonal influenza vaccine, although this relationship becomes weaker as children age. These findings could inform future influenza pandemic vaccination program planning. Additional educational outreach to inform parents of the need to vaccinate all children for influenza, regardless of age, may be warranted, as are efforts to increase influenza vaccination marketing campaigns and improve influenza vaccination access in African American communities. It may also be beneficial for planners to offer seasonal influenza and pandemic influenza vaccines concurrently, if possible, given the vagaries of vaccine production and supply. Private providers are an increasingly important source of seasonal influenza vaccine administration. As such, planners should help to ensure the private sector has adequate stock of pandemic influenza vaccine to offer along with the traditional seasonal influenza vaccine. Further studies using data from IISs should be utilized to help develop strategies to improve pandemic and seasonal influenza vaccine uptake.

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