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Natalie A. Viator Date

The Effect of Birth Month on Influenza Immunization among Infants Ages 6-23 Months: Evaluation Using the New York State Immunization Information System

By

Natalie A. Viator

Master of Public Health

Department of Epidemiology

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Saad B. Omer, MBBS, MPH, PhD
Committee Chair

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Robert A. Bednarczyk, PhD
Committee Member

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B.S., The University of Texas at Austin, 2011

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology

2016

Abstract

The Effect of Birth Month on Influenza Immunization among Infants Ages 6-23 Months: Evaluation Using the New York State Immunization Information System

By Natalie A. Viator

BACKGROUND AND OBJECTIVES: Since 2004, the Advisory Committee on Immunization Practices has recommended annual influenza vaccination for children ages 6-23 months. Influenza vaccine demand peaks by November and declines in subsequent months. This seasonality may prevent all children from receiving their first dose of influenza vaccine upon becoming eligible. The objective of this study was to assess the relationship between infant birth month and receipt of influenza vaccine by age 23 months.

METHODS: All children with demographic or immunization data in the New York State Immunization Information System born between 2009-2013 who survived through January 2016 were included in the study. Risk ratios were estimated using log-binomial regression. Risk ratios for receipt of influenza vaccine by age 23 months were adjusted for race/ethnicity.

RESULTS: The unadjusted risk of receipt of a first influenza vaccine dose was significantly higher for all non-September births compared to September births (all $p < 0.001$). The risk of receipt of a first dose rose from October through April before falling in May and continuing to decline through August. The trend of the relationship between birth month and receipt of a first dose of influenza vaccine was consistent across all race/ethnicity groups.

CONCLUSIONS: Children born in March-April are eligible for influenza vaccine for more person-months during the peak immunization months compared to those born in August-October. Additional late-season immunization is required to offer more vaccination opportunities to children born in fall months.

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Thank you to Dr. Dina Hoefer and the New York State Immunization Information System staff for making these data available.

Thank you to my mom and dad. They are the reason I have loved science since the beginning. They encouraged me to pursue my graduate degree and take the road less traveled. It was worth it.

Finally, thank you to my significant other Cash. His endless support and patience during my time at RSPH made all the difference.

This thesis is dedicated to my beloved late grandparents, Janet and Tom.

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CHAPTER I: BACKGROUND

The Influenza Virus and Influenza Disease

Influenza virus is highly infectious via respiratory transmission.[1] The nuclear material determines the virus's antigen type – A, B, or C. Influenza A may cause moderate to several illness among all age groups. Influenza B generally confers for more mild disease than Influenza A and primarily infects children. Influenza C is uncommonly reported as a cause of illness in humans due to subclinical disease.[1] The virus penetrates the respiratory epithelial cells and proceeds to destroy the host cell as it replicates.[1] The virus is shed in respiratory secretions for approximately 5-10 days.[1] The incubations period is usually 2 days and the signs and symptoms of illness vary widely.

On average, more than 200,000 influenza-associated hospitalizations occur each year. The risk for complications and hospitalizations due to influenza are higher among those over the age of 65, young children, and person with certain medical conditions.[1]

U.S. Burden of Influenza in Young Children

Common influenza disease signs and symptoms among infants and young children include otis media, seizures, croup, conjunctivitis, nausea and vomiting, diarrhea, and abdominal pain.[2] This population may also have non-specific febrile illness, making it difficult to distinguish from other respiratory viral pathogens.[2] Hospitalization rates for children under age 23 months are comparable to those among persons aged 65 years and older.[1] At this time, there is no approved vaccine for infants < 6 months of age.

Challenges in Availability and Administration of Seasonal Influenza Vaccine

Previous studies have cited logistical barriers as reasons for limited vaccination coverage among children. Late delivery of both commercial and Vaccines for Children (VFC) stock impact vaccination early in the season when well-child visits are occurring. This may necessitate parents or guardians make separate visits specifically for receipt of influenza vaccine, which may further discourage uptake.[3] In one study, healthcare providers cite difficulty of giving a second dose to children if the first was administered late in the season as a barrier. This study concluded that sampled primary care physicians reported a willingness to vaccinate until February/March in spite of data that suggest this occurs infrequently.[4,5] These providers supporting late-season vaccination cited decreased patient demand in the late-season months and inadequate vaccine supply during winter months as barriers.[5] They found it difficult to administer the recommended second dose if the first was given late in the season. Parents may be less likely to return their children for the second dose late in the season once the perceived threat is low. If providers are uncertain of their late-season vaccine supply, they may defer any vaccination until the next season.[5]

More doses of influenza vaccine are administered than any other vaccine annually. The need for annual immunization is burdensome to healthcare professionals who administer vaccine.[6]

Traditional seasonal demand for influenza vaccine is in the fall months, starting in September. Demand diminishes after November.[6] However, between 1976-2006, 45% of influenza season activity occurred in February. In some seasons, activity peaked into April or May.[6] This discrepancy reinforces the need for sustained vigilance in immunization for the duration of the vaccination season, as long as vaccine is available. Given the timing of peak influenza activity, late-season vaccination is clinically beneficial in the majority of years.

The seasonal vaccine distributional typically starts in September and vaccine is distributed in stages throughout the immunization season as supplies are available.[6] Delays in distribution at the local level early in the immunization season disrupt projected administration among health care providers.[6]

With the number of vaccine manufacturers, annual national supplies in the United States are stable. Healthcare personnel must work to increase patient demand for vaccine as long as it is available and decrease missed opportunities.[4] Expanding the immunization season beyond January will provide protection for a larger percentage of the at-risk population.[6]

Clinicians must forecast the number of doses to order from manufacturers or distributors based on previous year's data and projected patient visits. They may be encouraged to under-estimate the number of required doses to protect against unused stock and financial losses.

The Need to Prime the Infant Immune System, the Two-Dose Influenza Vaccine Recommendation, and Trends in Compliance

Seasonal influenza vaccination for healthy children aged 6-23 months was first explicitly recommended by the Advisory Committee on Immunization Practice (ACIP) in 2004.[7] For the 2004-2005 season, recommendations further specified that two doses be given at least four weeks apart among previously unvaccinated children under 9 years of age to provide sufficient antibody responses.[7]

Health care providers are encouraged to offer influenza vaccine by October and for as long as the viruses are circulating. The ACIP urges healthcare providers to avoid missed clinical opportunities by offering influenza vaccine during routine visits once vaccine becomes available.[8] Children who require 2 doses of vaccine should receive the first dose as soon as vaccine becomes available. Providers are encouraged to administer the second dose before December if possible.[7]

Previous data from the 2009-2010 influenza season showed minimal increase in the coverage of $\geq$1 influenza vaccine doses among children aged 6-23 months compared to the 2008-2009 season.[9] Among this age group, the CDC estimated full vaccination coverage was approximately 35% for the 2009-2010 season.[9] Another study using National Immunization Survey data found that full influenza immunization coverage was approximately 44.7% for the

2011-2012 season.[10] Annual influenza vaccination coverage among children aged 6-23 months continues to lag behind the Healthy People 2020 goal of 70%.[11]

Immunization Information Systems

The CDC defines immunization information systems (IIS) as “confidential, population-based, computerized databases that record all immunization doses administered by participating providers to persons residing within a given geopolitical area.”[12] The electronic exchange of patient data between health information systems, including electronic health records (EHRs), and IIS support clinicians’ ability to administer appropriate vaccinations at the point of care. On January 1, 2008, New York’s Immunization Registry Law took effect. This law required that health care providers report all doses of immunization administered to individuals under the age of 19 years in additional to any known immunization history to the New York State Immunization Information System (NYSIIS).[13] The state laws that mandate reporting of all vaccine doses to NYSIIS make it the most complete source for its population. As of 2013, NYSIIS’s inclusion of births occurring within its geopolitical region was estimated to be nearly 100% according to the CDC’s IIS Annual Report.[14] Various commercial off-the-shelf and open source IIS products exist in today’s health information technology landscape. The IIS program community, the CDC’s IIS Support Branch, the American Immunization Registry Association, the Public Health Informatics Institute, and IIS vendors are among the key stakeholders who work to improve immunization clinical decision support (CDS) according to ACIP immunization recommendations. CDS is the “automated process that determines the recommended immunization needed for a patient and delivers these recommendations to the healthcare provider.”[15] While CDS continues to improve, barriers exist in all health information system implementations. Additionally, challenges in provider use at the point of clinical care may decrease the impact these systems have on improving health outcomes.

CHAPTER II: MANUSCRIPT

Introduction

Children under the age of 2 years have the highest risk for severe complications and hospitalizations due to influenza among pediatric populations.[16] Since 2004, the Advisory Committee on Immunization Practices (ACIP) has recommended annual influenza vaccination for young children aged 6-23 months who do not have contraindications. Children receiving influenza vaccine for the first time should receive 2 doses in the same season, separated by at least 4 weeks. Eligible children are advised to receive vaccine as soon as it becomes available.[7,17–27] Despite these recommendations, between 2 and 35 children in this age group have died annually of influenza-assocatied causes since the 2004-2005 season.[28]

Since the 2011-2012 influenza season, the Centers for Disease Control and Prevention (CDC) have reported the total doses of vaccine distributed during the peak immunization season. This period ranges from the last week of August through the first week of March.[29–33] While consumer demand for influenza vaccination peaks in October and November and decreases dramatically in subsequent months vaccine may still be distributed as late as March or April, typically considered “late-season” immunization months.[34] This seasonality of immunization administration may prevent all children from receiving their first dose of influenza vaccine upon becoming eligible. For example, infants born in September reach age 6 months and become eligible for influenza vaccine in March (Appendix A). As a result of this seasonality, both providers and parents may forget about the need for late-season immunization. Additionally, providers may struggle to convince parents to accept late-season vaccine for their children.[5,34] In most influenza seasons, late-season immunization offers a clinical benefit as influenza activity can last as late as May.[35,36]

Despite these issues with timing of influenza vaccine delivery, there are no published studies on the effect of birth month on receipt of influenza immunization among young children aged 6-23 months. Our study used immunization data for the childhood population from the New York State Immunization Information System (NYSIIS) to assess the association between birth month and receipt of any dose of influenza vaccine through age 23 months. Additional associations examined included birth month and first receipt of vaccine relative to eligibility and receipt of a second dose of vaccine in the same immunization season as the first dose. We also examined the association between birth month and missed clinical opportunities for vaccination as indicated by receipt of diphtheria, tetanus, and acellular pertussis (DTaP) vaccine.

Methods

We conducted a retrospective cohort study using NYSIIS data provided by the New York State Department of Health (NYSDOH) Bureau of Immunization. The NYSIIS jurisdiction includes all of New York State, outside of New York City. The primary exposure was birth month. The primary outcome was the receipt of at least one dose of influenza vaccine through age 23 months. Additional outcomes of interest included: receipt of the first influenza vaccine dose in the first immunization season of eligibility, receipt of a second influenza vaccine dose in the same immunization season as the first dose, and missed clinical opportunities for vaccination based on the receipt of at least one dose of DTaP vaccine.

The NYSIIS data were used to assemble a retrospective cohort of young children born between January 1, 2009 and December 31, 2013. Children with either any immunization history or demographic data in NYSIIS by January 2016 were included. The NYSIIS dataset contained deidentified demographic data for each child in the cohort including: New York State birth status (i.e., New York State vs elsewhere), birth month and year, and death status. Date of relocation to New York State was not available. No birthdates more specific than birth month were provided. Therefore, patient age was calculated assuming the day of birth was the 15th of the month.

Children identified in NYSIIS as having died at any point prior to January 2016 were excluded from the cohort as this information was not accompanied by a date of death, precluding assessment of time in the cohort. Gender, race, and ethnicity data were also provided where available.

We used CVX codes developed and maintained by the CDC's National Center of Immunization and Respiratory Diseases to identify all seasonal influenza and DTaP vaccine doses administered to our cohort.[37] Data accompanying all vaccine doses included: vaccine type, administration month and year, historical administration indicator, and administering organization type. Funding program type, trade name, and manufacturer name data were included where available. No data on vaccination date more specific than month were provided. Therefore, all dates of vaccine administration were assumed to occur on the 15th of the month. Doses of influenza vaccine were excluded if the child was under age 6 months at the date of administration or if the vaccine trade name did not match the CVX code.

A child's first eligible immunization season was determined to be the season during which the child reached age 6 months. Each putative influenza immunization season began in July and continued through the following June, based on an annual seasonal influenza vaccine expiration date of June 30.

Influenza immunization status was assessed between the ages of 6-23 months and children were classified as being fully vaccinated, partially vaccinated, or unvaccinated during the first immunization season. Fully vaccinated was defined as receiving a first vaccine dose through age 23 months and a second dose in the same season. Partially vaccinated was defined as receiving a first dose of vaccine through age 23 months, without a second dose in the same season. Unvaccinated was defined as receiving no doses of influenza vaccine through age 23 months.

Among children who received their first dose of vaccine in the 2nd or 3rd eligible immunization season, we calculated the median and interquartile range of age in months at first dose. We examined the association between birth month and each of the outcomes using log-binominal regression to estimate risk ratios. Children born between October-December became eligible for influenza vaccine between April-June, the months prior to seasonal vaccine expiration. In the absence of late-season immunization, these children had fewer opportunities to be immunized in their first eligible immunization season compared to children born in other months. To give these children opportunities for immunization comparable to those in earlier birth months, we performed a sensitivity analysis among October-December births to evaluate the impact of defining an immunization season beginning in April and continuing through the following March.

Analyses of receipt of a first influenza vaccine dose through age 23 months were adjusted for potential confounders and effect modification. Potential covariates considered included gender, race/ethnicity, and New York State birth status. Additional covariates that could not be considered due to inadequate data included parity and multiple birth order.

All missed clinical opportunities were separated into two categories – missed clinical opportunities and severe missed clinical opportunities. Missed clinical opportunities included when a child received at least one dose of DTaP vaccine between the months of October-March, was eligible for influenza vaccine, and received the first dose of influenza vaccine after the dose of DTaP vaccine. Severe missed clinical opportunities included when a child received at least one dose of DTaP vaccine between the months of October-March, was eligible for influenza vaccine, and did not receive any dose of influenza vaccine. Only doses of DTaP administered between October-March qualified as indicators for missed clinical opportunities. Due to this definition, October-December births did not qualify to have missed opportunities during their first eligible immunization season.

All statistical analyses were conducted using SAS version 9.4 (Cary, NC). All results used a two-tailed significance level of α=0.05. The study was reviewed and approved by the Emory University Institutional Review Board.

Results

We identified 750,117 children in NYSIIS born between January 1, 2009 and December 31, 2015. Of these, 2,263 children were excluded due to death prior to January 1, 2016. The final study population consisted of 747,854 participants. There were 914,598 doses of influenza vaccine administered to this population. Of those, 2,608 doses were excluded because the child was under age 6 months at the time of administration. Two doses were excluded as the vaccine trade name did not match the CVX vaccine product. The final number of eligible influenza vaccine doses was 911,988.

September through January were the peak months of influenza immunization season across all years, with 83.8% (764,523) of all doses administered during this time (Figure 1). A similar trend existed among first influenza doses, with 86.2% (363,470) of first doses administered in these months (Figure 1). Fewer children born in 2009 received a first dose of vaccine through age 23 months (50.9%) than any other birth year (Figure 2). Overall, 56.4% (421,793) of the study population received a first dose of vaccine through age 23 months (Figure 3, Table 1). Race/ethnicity data were available for 42.1% (315,131) of the study population. White, non-Hispanic children comprised 27.2% (203,442) of the study population and 33.0% (139,227) of those immunized (Table 1). Children born within New York state comprised 78.5% (587,251) of the study population and 87.6% (369,586) of the immunized group (Table 1).

Despite eligibility for influenza vaccine during the entirety of their second immunization season, children born between August and October were least likely to receive a first influenza vaccine dose by 23 months (Figure 3, Table 2, Appendix A). September births accounted for the lowest percentage (51.2%) of receipt of a first influenza vaccine dose by 23 months of age of any birth month (Figure 3, Table 2). Therefore, September births were used as the reference group for all risk ratio calculations. The unadjusted risk of receiving a first vaccine dose was significantly higher for all non-September births compared to September births (RR range: 1.03-1.20, all p <0.001) (Table 2). The risk of receipt of a first dose rises from October through April before falling in May and continuing to decline through August.

Adjusted risk ratios were estimated for the risk of receiving a first influenza vaccine dose through age 23 months to account for differences in vaccine uptake by race/ethnicity. White, non-Hispanic children have a higher percentage of receipt of a first vaccine dose by age 23 months for every birth month compared to other groups (Table 3). Across all race/ethnicity categories, the trend of the relationship between birth month and receipt of a first dose of influenza vaccine was consistent (Figure 5). Risk ratios were generally highest for March through May birth months compared to all other months (Table 3, Figure 5). All estimated RRs were significant for these birth months (all p<0.001) (Table 3). Generally, the risk of receipt of a first dose for August through November births was not significantly different compared to September births (Table 3). Among all race/ethnicity groups, the risk of vaccination among December births was increased compared to preceding months (Table 3, Figure 5).

Children born in spring months were also more likely to receive a first vaccine dose during the first eligible immunization season (Table 2, Figure 5). The unadjusted risk of a child born in March receiving a first influenza vaccine dose during the first eligible immunization season was 4.06 times that among children born in September (RR: 4.06, p<0.001)(Table 2). Receipt of the first dose during the first season of eligibility declines from the birth months May through December (Figure 5). December births were 96% less likely to receive a first dose during the first eligible season compared to September births (RR: 0.04, p<0.001) (Table 2). Among those who wait to receive the first dose of vaccine during the second or third season of eligibility, the median age at first dose is 13 months (IQR: 12-16).

As October-December births become eligible for the first dose of vaccine towards the end of the defined immunization season, a sensitivity analysis for this group redefined the season from April-March (opposed to July-June). With this change, the declining trend of receipt of vaccine in the first eligible season dissipates. Nearly all infants who receive any influenza dose through age 23 months do so during the first eligible immunization season (Supplementary Figure 1).

The trend of receipt of a second dose by birth month is similar to that of receipt of the first dose, generally increasing from October-April before falling in May (Table 4). Among children who received a first dose through age 23 months, 66.2% received a second dose in the same immunization season (Table 4).

Among all children, 37.4% received a first dose through age 23 months and a second dose in the same immunization season (Figure 6). Another 19.0% of children received a first dose without a second dose in the same season (Figure 6). August (30.9%) and September (32.1%) births have the lowest proportions of receipt of a first and second dose in the same immunization season (Figure 6). These children were less likely to receive a first dose, do so in the first eligible immunization season, and receive the recommended second dose; they fell behind their peers born in other months and did not catch up in the first 23 months of life. Similarly, August-November births have the lowest first dose uptake, regardless of timing for the second dose (Figure 6).

The risk of a missed clinical opportunity for influenza immunization trends upwards from October to August birth months (Table 5). Among October births, 0.4% experienced a missed opportunity. Among August births, 23.5% received a dose of DTaP during the influenza immunization season but receive a first dose of influenza at a later date (Table 5). For severe missed clinical opportunities, there is an upward trend between January-August birth months.

Among January births, 6.5% received a dose of DTaP during the influenza immunization season but received no dose of influenza vaccine before age 23 months (Table 5). Among August births, 26.1% experienced a severe missed clinical opportunity for influenza immunization (Table 5).

Once restricted to the first eligible influenza immunization season, January births experience the least missed clinical opportunities (1.4%) and August births experience the most (23.3%) (Table 5). Among severe missed opportunities during the first eligible immunization season, August births experienced a higher percentage (22.2%) than any other birth month (Table 5).

Discussion

This is the first study to investigate the association between infant birth month and receipt of influenza vaccine. Infants born in early spring months (March and April) were most likely to receive a first dose by age 23 months, do so in their first eligible immunization season, and receive a second dose in their first immunization season compared to other birth months. These results aligned with our hypothesis, as children born in March and April have well-child visits during the traditional peak immunization months of October and November (Appendix A).[6] Additionally, these infants are eligible for influenza vaccine for more person-months during the peak immunization months compared to their peers born in August-October (Appendix A). Conversely, children born in August and September have 6 month well-child visits during the months considered to be "late-season" for immunization activity (February and March, respectively).[6,21] Their 1-year well-child visits fall in the months immediately preceding when influenza vaccine stock is widely available. This timing may explain why these children have lower uptake compared to other birth months. However, given that October births have a 1-year well-child visit during the peak immunization month; this timing does not explain the low uptake among these children (Figure 1).

Our missed clinical opportunities analysis highlights that young children present to clinical settings as expected per well-child visit and routine vaccination recommendations. Again, late summer/early fall births have the highest risk of all missed clinical opportunities. August births are at the greatest risk for severe missed clinical opportunities.

We conducted sensitivity analyses to evaluate the effect of redefining the immunization season as starting in April and ending in March. Upon doing so, October through December births appear to have a high probability of receipt of the first dose in the first eligible season, more similar to January through March births. We also conducted a sensitivity analysis to investigate the effect of classifying DTaP doses administered year-round as missed clinical opportunities if the child was eligible for influenza vaccine. Taken together, these two analyses suggest that if late-season vaccination were prioritized, coverage and timeliness of vaccination would increase. Administering just a single dose of influenza vaccine to young children in the late months of their first eligible immunization season would prime their immune systems and result in the need for one dose in the subsequent season.[17] Continuing to vaccinate through May would offer coverage to a greater proportion of the population eligible for vaccine through the months when influenza virus is in circulation, which may extend into the late spring months. For example, in the 2015-2016 influenza season, elevated influenza activity was detected in early April.[38] Benefits to encouraging late-season immunization include decreasing the risk of transmission to individuals ineligible for vaccine. This group includes infants under age 6 months, for whom there is no currently licensed product.[17]

There are several strengths and limitations to our study. As of 2013, NYSIIS's inclusion of births occurring within its geopolitical region was estimated to be nearly 100%.[14] The state laws that mandate reporting of all vaccine doses to NYSIIS make our data the most complete source for this population. Our study did not rely on parental recall. Limitations of the study include that all dates were assumed to be the 15th of the month. Fluctuations in dates may change coverage estimates within sub-groups. If a substantial proportion of the population was born in the second half of a given month, there is a risk that some doses given before age 24 months were truncated from our analyses. However, generally these fluctuations would be expected to cancel out for the overall estimates of effect. For children not born in New York state, date of relocation was not available. Another limitation was that vaccine financing information was only available for children who received vaccine and therefore could not be used for adjustment. Socioeconomic indicators were possibly key unmeasured confounders within our analysis.

Our findings illustrate that not all children have an equal probability of being vaccinated according to ACIP recommendations in the first 2 years of life. Our findings further validate previous research that show that late-season vaccination is under-utilized.[5] This study corroborates with others that suggest that more late-season immunization would increase both first and second dose coverage. One study found that vaccine coverage increased by 0.6% for each additional 10 days into the immunization season in which vaccine was offered.[39]

We reinforce the need for providers, policy-makers, and other key stakeholders in the immunization community to maintain vigilance in making seasonal influenza vaccine available to all pediatric patients. Delivery of seasonal influenza vaccine presents challenges to distribution and administration systems not seen with other vaccines. These challenges underscore the opportunity for clinical decision support (CDS) among health information systems, including IIS and electronic health records, to aid providers in increasing influenza immunization coverage among young children. Timely and accurate CDS is an ongoing initiative of the CDC. However, providers must use and respond to their health information systems at the point of care to make use of this functionality.[39,40] Beyond health information systems, immunization providers should encourage parents to accept late-season influenza immunization for their children by communicating existing evidence-based guidelines and providing a strong recommendation for vaccine.[17]

Future studies should assess which strategies may best assist providers in increasing patient demand for influenza vaccine into the late-season months. Specifically, additional work is needed to determine effective strategies for practices in rural areas and for large practices with high patient volumes. Such work is critical to ensure maximum protection during years with high amounts of late-season influenza activity and among high-risk populations.

Figures and Tables

Figure 1. Influenza Doses Administered between 2009-2015 to Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System, by Administration Month

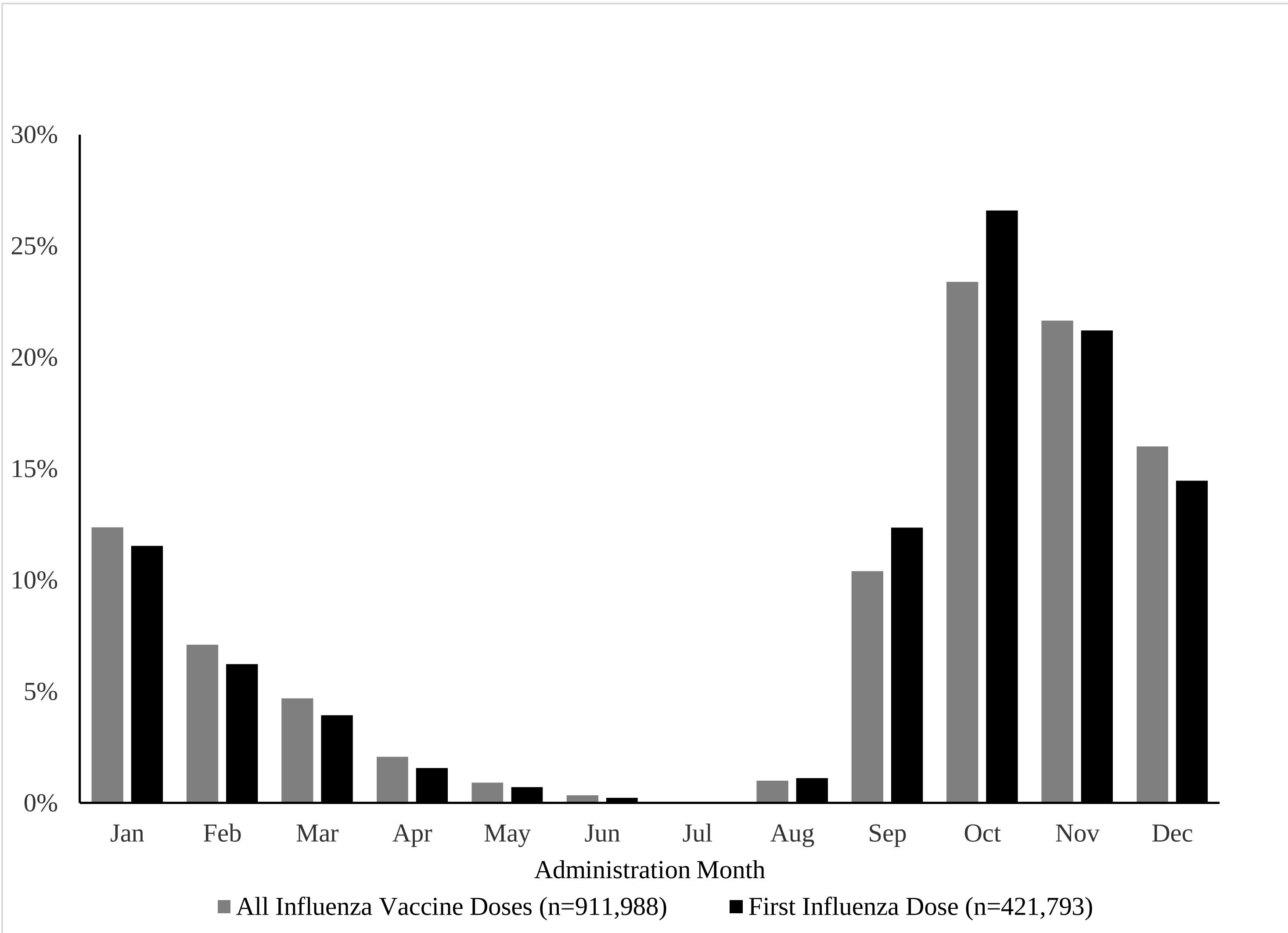


Figure 2. Receipt of First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System, by Birth Year (n=747,854)

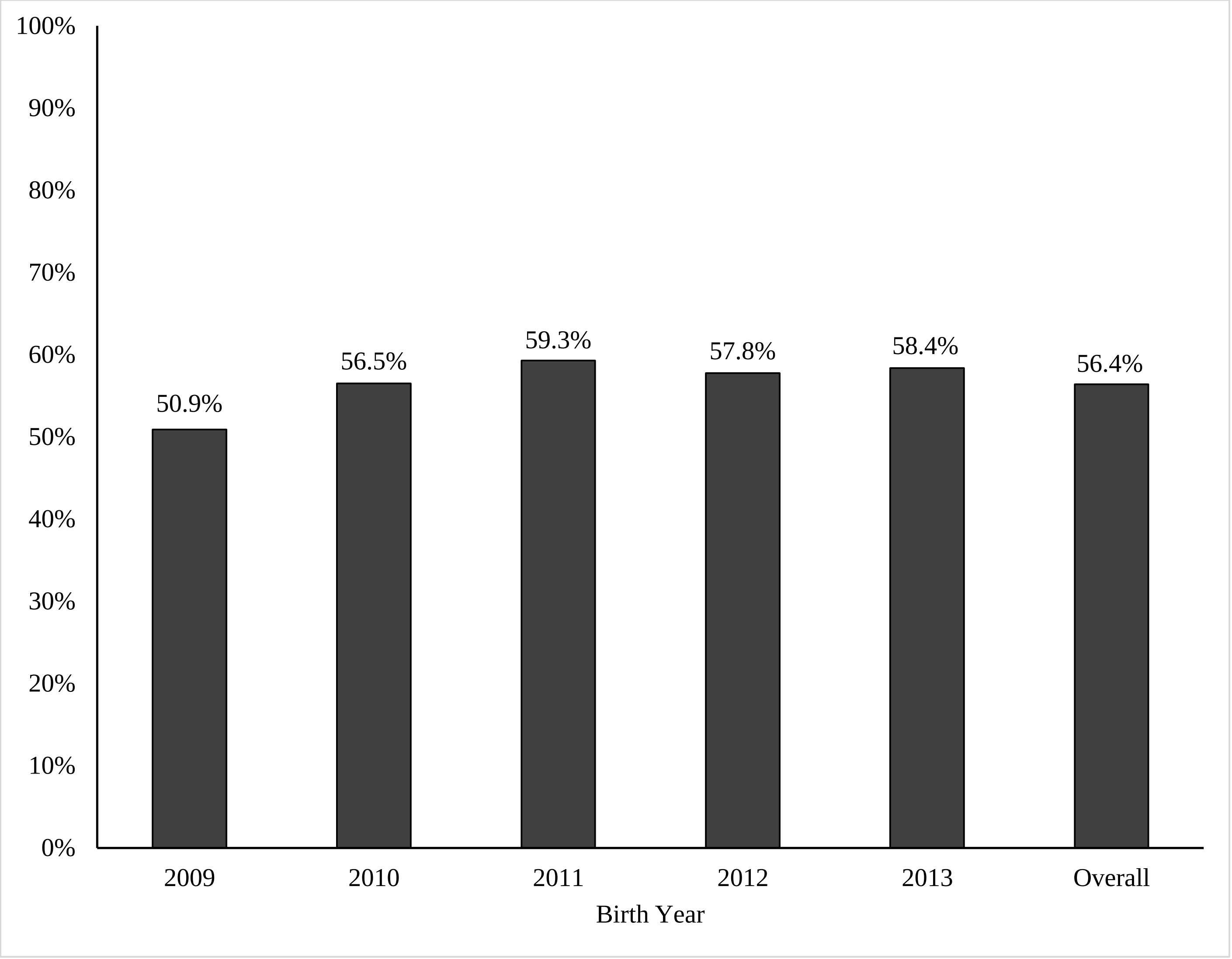


Figure 3. Receipt of First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System, by Birth Month (n=747,854)

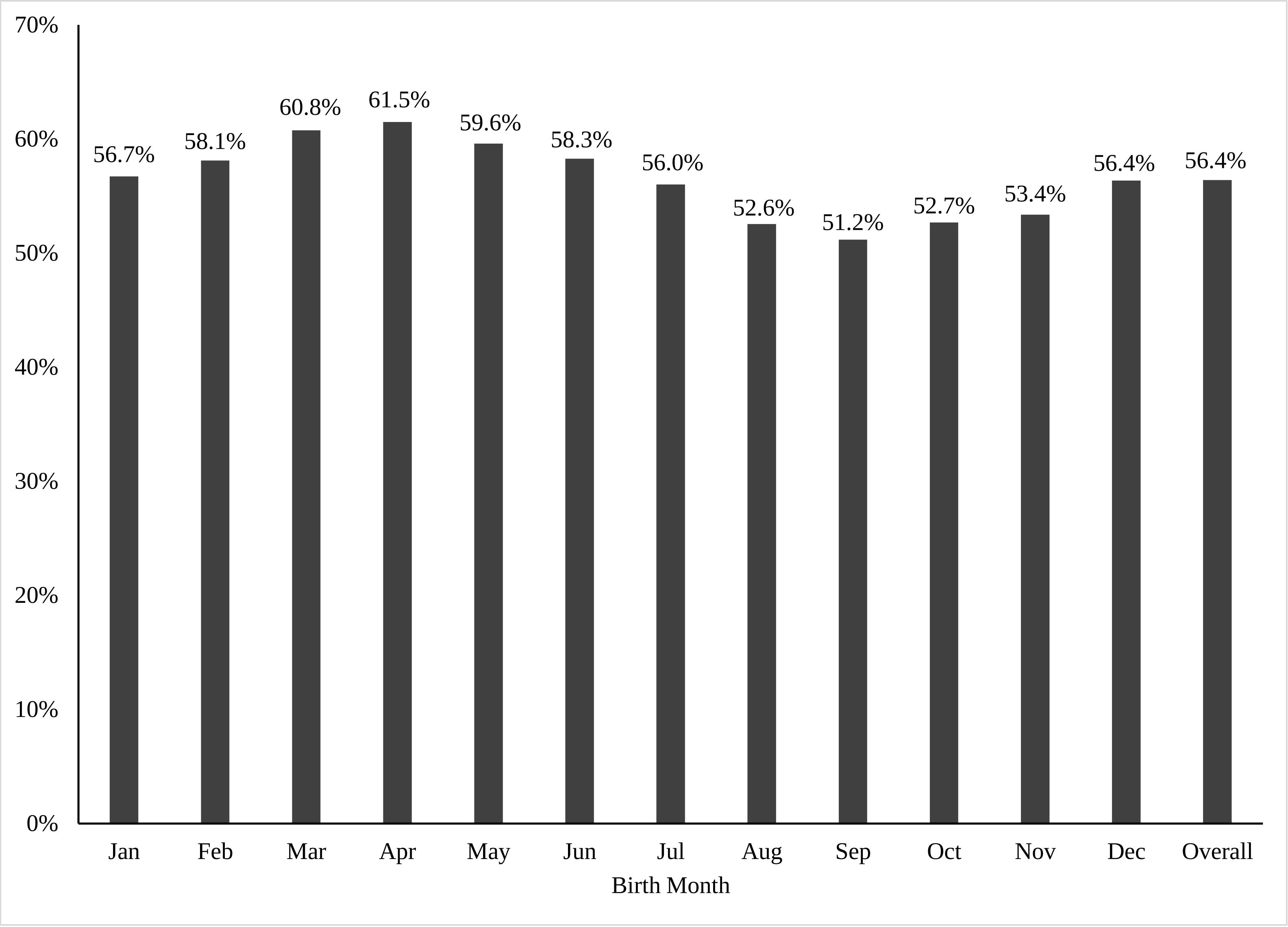


Figure 4. Estimated Adjusted Risk Ratios (aRR) for Risk of Receiving First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System, by Race/Ethnicity (n=315,131)

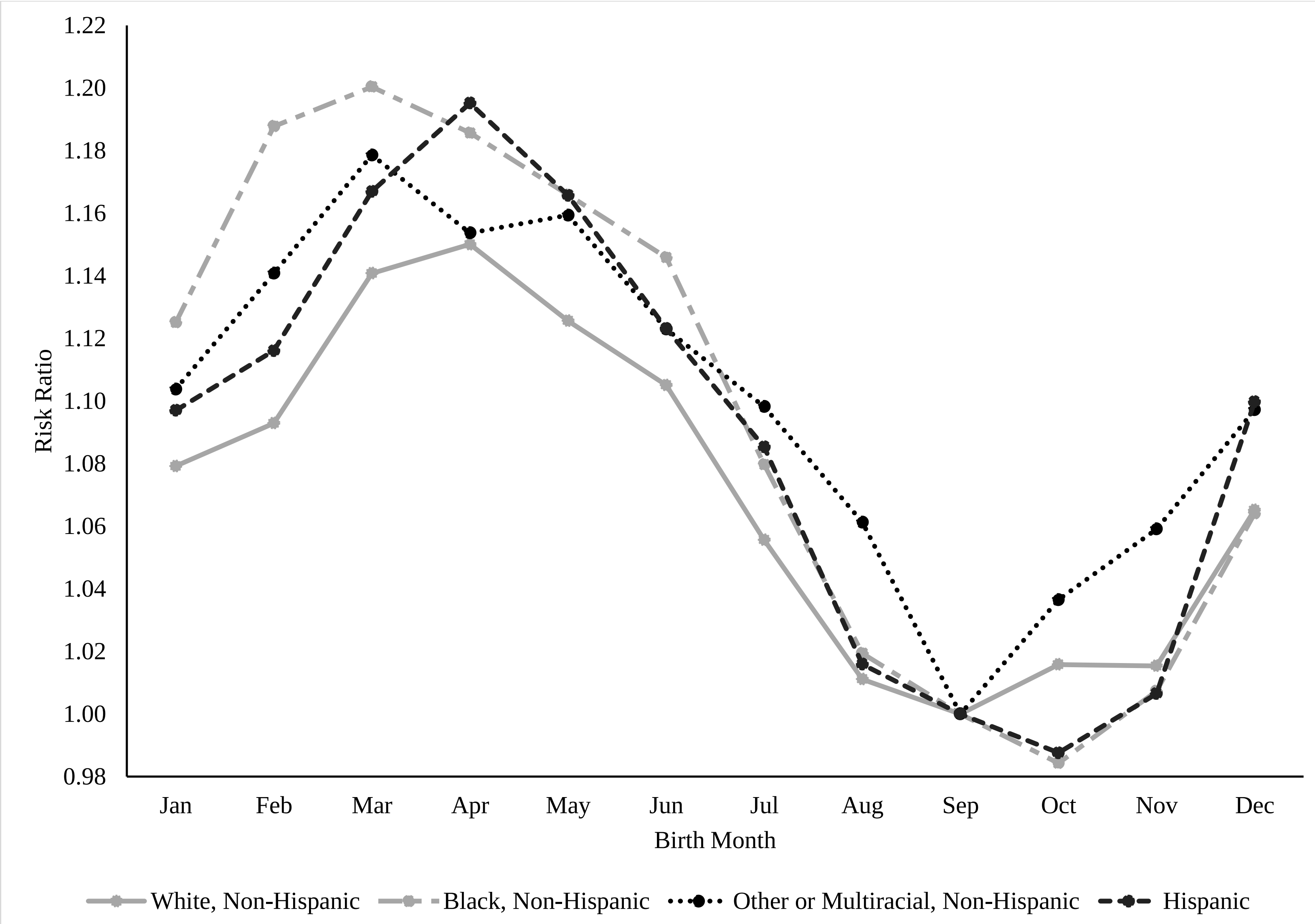


Figure 5. Receipt of First Influenza Vaccine Dose in the First Eligible Immunization Season Among Children in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System (n=747,854)

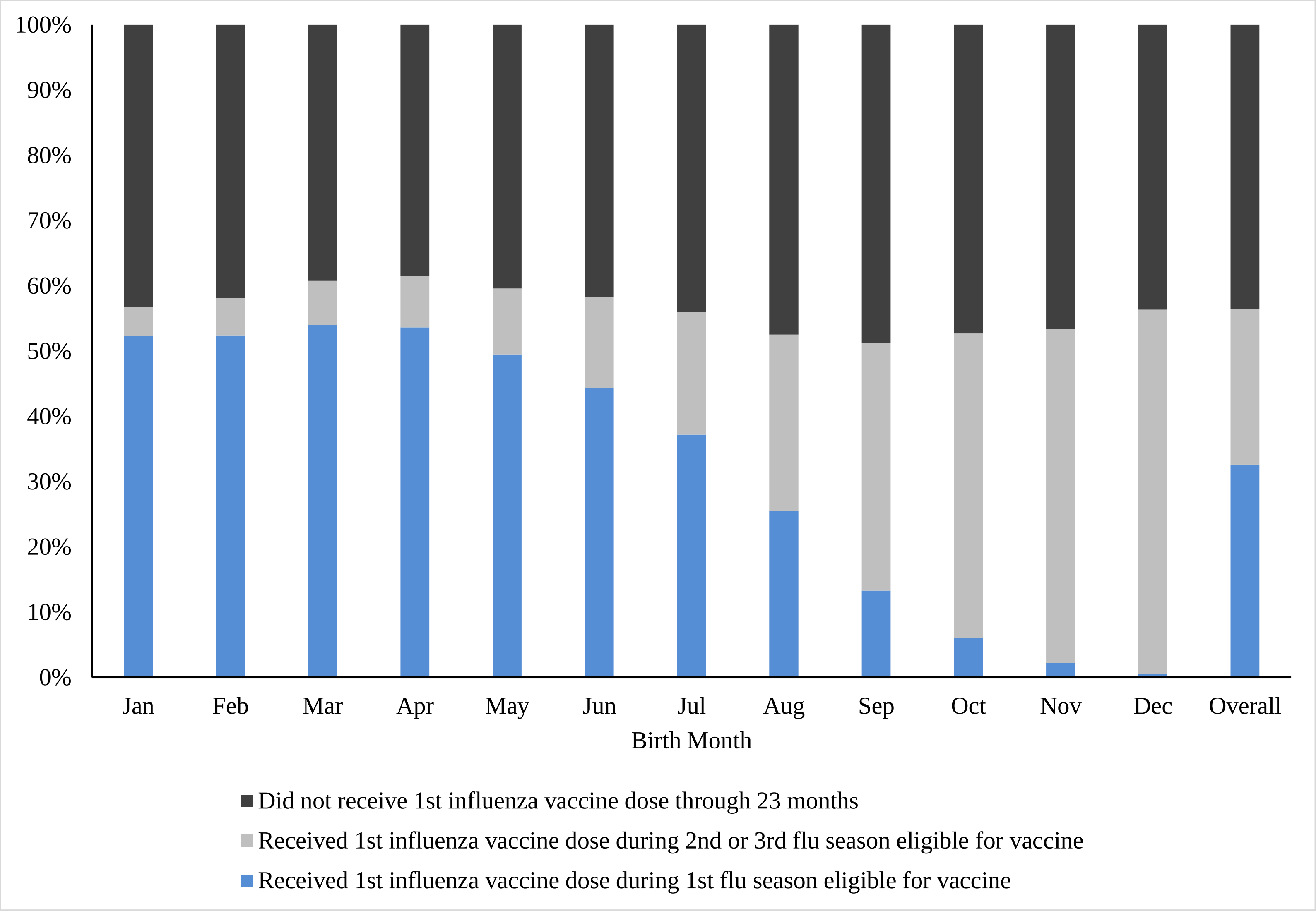


Figure 6. Influenza Vaccination Status at Immunization Season of First Dose: Fully Vaccinated vs Partially Vaccinated vs Unvaccinated Among Children in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System (n=747,854)

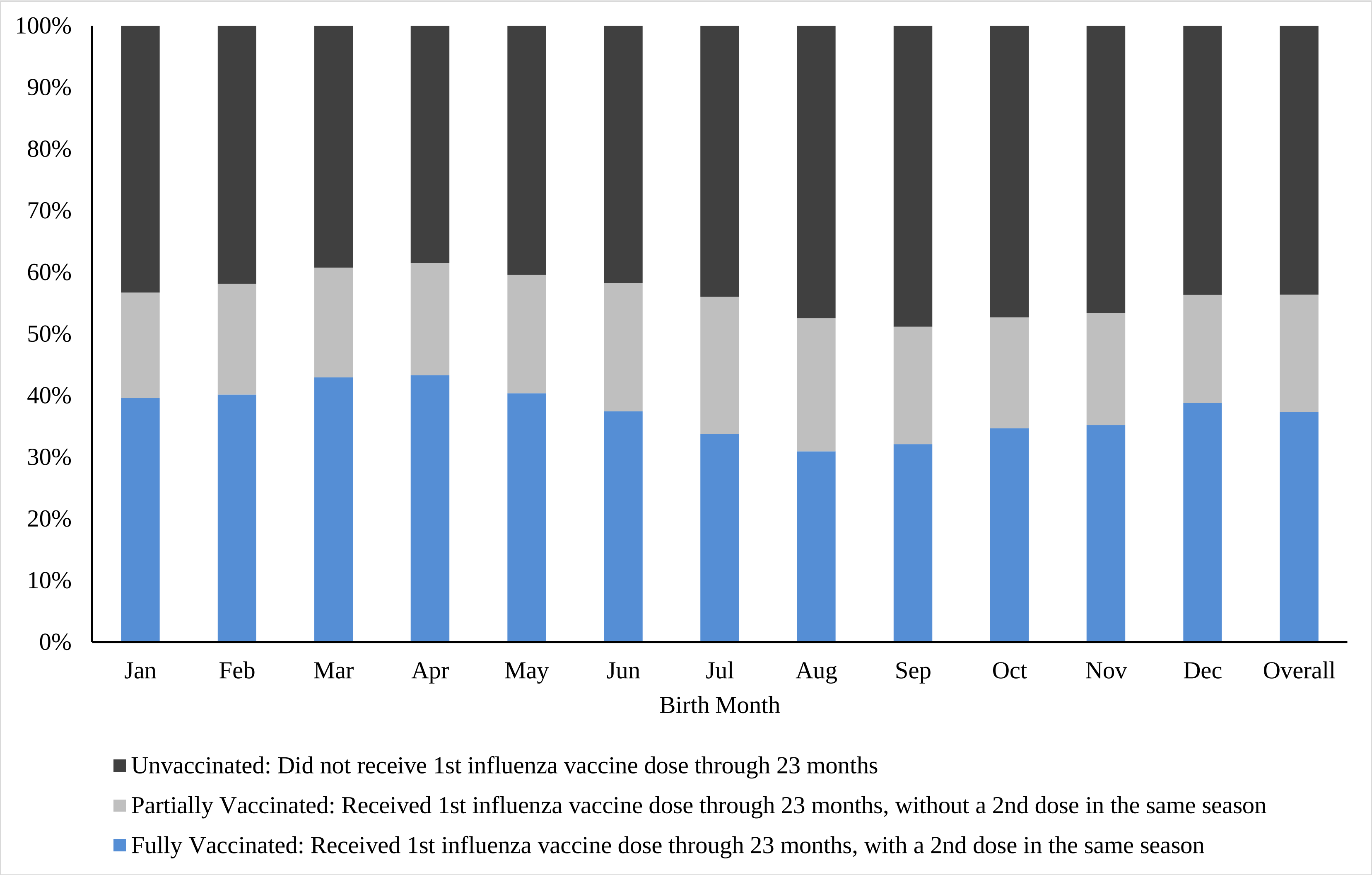


Table 1. Characteristics of 2009-2013 Birth Cohort by Influenza Vaccination Status as Recorded in the New York State Immunization Information System[a]

	Eligible Children (n=747,854)		Received 1st influenza vaccine dose through 23 months (n=421,793)		Did not receive 1st influenza vaccine dose through 23 months (n=326,061)	
Characteristic	**No.**	**%**	**No.**	**%**	**No.**	**%**
Birth month						
January	60,463	8.1	34,298	8.1	26,165	8.0
February	56,434	7.6	32,806	7.8	23,628	7.3
March	62,500	8.4	37,973	9.0	24,527	7.5
April	61,051	8.2	37,539	8.9	23,512	7.2
May	64,493	8.6	38,446	9.1	26,047	8.0
June	64,327	8.6	37,490	8.9	26,837	8.2
July	66,439	8.9	37,222	8.8	29,217	9.0
August	66,486	8.9	34,938	8.3	31,548	9.7
September	64,179	8.6	32,853	7.8	31,326	9.6
October	62,515	8.4	32,941	7.8	29,574	9.1
November	58,927	7.9	31,451	7.5	27,476	8.4
December	60,040	8.0	33,836	8.0	26,204	8.0
Birth year						
2009	166,170	22.2	84,559	20.1	81,611	25.0
2010	149,695	20.0	84,599	20.1	65,096	20.0
2011	144,224	19.3	85,515	20.3	58,709	18.0
2012	145,660	19.5	84,158	20.0	61,502	18.9
2013	142,105	19.0	82,962	19.7	59,143	18.1
Gender						
Female	363,533	48.6	205,511	48.7	158,022	48.5
Male	383,005	51.2	216,072	51.2	166,933	51.2
Missing	1,316	0.2	210	0.1	1,106	0.3
Race/Ethnicity						
White, Non-Hispanic	203,442	27.2	139,227	33.0	64,215	19.7
Black or African-American, Non-Hispanic	33,281	4.5	20,811	4.9	12,470	3.8
Other Race or Multiracial, Non-Hispanic	28,539	3.8	18,821	4.5	9,718	3.0
Hispanic or Latino	49,869	6.7	33,093	7.9	16,776	5.2
Missing	432,723	57.9	209,841	49.8	222,882	68.4
Born in New York State[a]						
Yes	587,251	78.5	369,586	87.6	217665	66.8
No	160,603	21.5	52,207	12.4	108,396	33.2

[a] New York State, excluding New York City

Table 2. Estimated Risk Ratios (RR) and 95% Confidence Intervals (CI) for Risk of Receiving a First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System

	Estimated Risk Ratios (RR) and 95% Confidence Intervals (CI) for the Risk of Receiving a 1st Influenza Vaccine Dose through Age 23 Months							Estimated Risk Ratios (RR) and 95% Confidence Intervals (CI) for the Risk of Receiving a 1st Influenza Vaccine Dose in First Eligible Immunization Season						
	Received 1st influenza vaccine dose through age 23 months N	Total N	%	RR	95% CI		p-value	Received 1st influenza vaccine dose in first eligible immunization season N	Total N	%	RR	95% CI		p-value
Birth Month														
Jan	34,298	60,463	56.7%	1.11	1.10	1.12	<0.001	31,650	60,463	52.3%	3.94	3.86	4.02	<0.001
Feb	32,806	56,434	58.1%	1.14	1.12	1.15	<0.001	29,578	56,434	52.4%	3.94	3.86	4.03	<0.001
Mar	37,973	62,500	60.8%	1.19	1.18	1.20	<0.001	33,741	62,500	54.0%	4.06	3.98	4.15	<0.001
Apr	37,539	61,051	61.5%	1.20	1.19	1.21	<0.001	32,736	61,051	53.6%	4.03	3.95	4.12	<0.001
May	38,446	64,493	59.6%	1.16	1.15	1.18	<0.001	31,934	64,493	49.5%	3.73	3.65	3.81	<0.001
Jun	37,490	64,327	58.3%	1.14	1.13	1.15	<0.001	28,561	64,327	44.4%	3.34	3.27	3.41	<0.001
Jul	37,222	66,439	56.0%	1.09	1.08	1.11	<0.001	24,727	66,439	37.2%	2.80	2.74	2.86	<0.001
Aug	34,938	66,486	52.5%	1.03	1.02	1.04	<0.001	16,953	66,486	25.5%	1.92	1.87	1.96	<0.001
Sep[a]	32,853	64,179	51.2%	1.00				8,530	64,179	13.3%	1.00			
Oct	32,941	62,515	52.7%	1.03	1.02	1.04	<0.001	3,808	62,515	6.1%	0.46	0.44	0.48	<0.001
Nov	31,451	58,927	53.4%	1.04	1.03	1.05	<0.001	1,309	58,927	2.2%	0.17	0.16	0.18	<0.001
Dec	33,836	60,040	56.4%	1.10	1.09	1.11	<0.001	329	60,040	0.5%	0.04	0.04	0.05	<0.001
Gender														
Female[a]	205,511	363,533	56.5%	1.00				119,019	363,533	32.7%	1.00			
Male	216,072	383,005	56.4%	1.00	0.99	1.00	0.31	124,733	383,005	32.6%	0.99	0.99	1.00	0.11
Race/ Ethnicity														
White, Non-Hispanic[a]	139,227	203,442	68.4%	1.00				81,214	203,442	39.9%	1.00			
Black or African-American, Non-Hispanic	20,811	33,281	62.5%	0.91	0.91	0.92	<0.001	11,990	33,281	36.0%	0.90	0.89	0.92	<0.001
Other Race or Multiracial, Non-Hispanic	18,821	28,539	65.9%	0.96	0.96	0.97	<0.001	11,119	28,539	39.0%	0.98	0.96	0.99	0.002
Hispanic or Latino	33,093	49,869	66.4%	0.91	0.89	0.93	<0.001	19,420	49,869	38.9%	0.98	0.96	0.99	<0.001
Born in New York State[b]														
Yes[a]	369,586	587,251	62.9%	1.00				216,580	587,251	36.9%	1.00			
No	52,207	160,603	32.5%	0.52	0.51	0.52	<0.001	27,276	160,603	17.0%	0.46	0.46	0.47	<0.001

[a] Reference group

[b] New York State, excluding New York City

Table 3. Estimated Adjusted Risk Ratios (aRR) and 95% Confidence Intervals (CI) for Risk of Receiving First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System, Stratified by Race/Ethnicity

	White, Non-Hispanic							Black, Non-Hispanic						
	Received 1st influenza vaccine dose through age 23 months N	Total N	%	aRR	95% CI		p-value	Received 1st influenza vaccine dose through age 23 months N	Total N	%	aRR	95% CI		p-value
Birth Month														
Jan	10,949	15,877	69.0%	1.08	1.06	1.10	<0.001	1,845	2,869	64.3%	1.13	1.08	1.17	<0.001
Feb	10,441	14,950	69.8%	1.09	1.08	1.11	<0.001	1,681	2,476	67.9%	1.19	1.14	1.24	<0.001
Mar	12,322	16,902	72.9%	1.14	1.12	1.16	<0.001	1,825	2,660	68.6%	1.20	1.15	1.25	<0.001
Apr	12,357	16,813	73.5%	1.15	1.13	1.17	<0.001	1,754	2,588	67.8%	1.19	1.14	1.24	<0.001
May	12,683	17,632	71.9%	1.13	1.11	1.14	<0.001	1,762	2,644	66.6%	1.17	1.12	1.22	<0.001
Jun	12,511	17,717	70.6%	1.11	1.09	1.12	<0.001	1,809	2,762	65.5%	1.15	1.10	1.19	<0.001
Jul	12,381	18,354	67.5%	1.06	1.04	1.07	<0.001	1,778	2,881	61.7%	1.08	1.03	1.13	<0.001
Aug	11,733	18,160	64.6%	1.01	1.00	1.03	0.16	1,695	2,909	58.3%	1.02	0.98	1.07	0.39
Sep[a]	11,174	17,486	63.9%	1.00				1,677	2,934	57.2%	1.00			
Oct	11,145	17,169	64.9%	1.02	1.00	1.03	0.05	1,595	2,835	56.3%	0.98	0.94	1.03	0.49
Nov	10,428	16,071	64.9%	1.02	1.00	1.03	0.06	1,608	2,793	57.6%	1.01	0.96	1.05	0.75
Dec	11,103	16,311	68.1%	1.07	1.05	1.08	<0.001	1,782	2,930	60.8%	1.06	1.02	1.11	0.004
Total	139,227	203,442	68.4%					20,811	33,281	62.5%				

	Other or Multiracial, Non-Hispanic							Hispanic						
	Received 1st influenza vaccine dose through age 23 months N	Total N	%	aRR	95% CI		p-value	Received 1st influenza vaccine dose through age 23 months N	Total N	%	aRR	95% CI		p-value
Birth Month														
Jan	1,561	2,359	66.2%	1.10	1.06	1.15	<0.001	2,692	4,018	67.0%	1.10	1.06	1.13	<0.001
Feb	1,545	2,259	68.4%	1.14	1.09	1.19	<0.001	2,475	3,631	68.2%	1.12	1.08	1.15	<0.001
Mar	1,700	2,406	70.7%	1.18	1.13	1.23	<0.001	2,893	4,059	71.3%	1.17	1.13	1.20	<0.001
Apr	1,577	2,280	69.2%	1.15	1.11	1.20	<0.001	2,879	3,944	73.0%	1.20	1.16	1.23	<0.001
May	1,630	2,345	69.5%	1.16	1.11	1.21	<0.001	2,968	4,169	71.2%	1.17	1.13	1.20	<0.001
Jun	1,595	2,369	67.3%	1.12	1.08	1.17	<0.001	2,988	4,356	68.6%	1.12	1.09	1.16	<0.001
Jul	1,665	2,529	65.8%	1.10	1.05	1.15	<0.001	2,937	4,431	66.3%	1.09	1.05	1.12	<0.001
Aug	1,611	2,532	63.6%	1.06	1.02	1.11	0.007	2,797	4,508	62.0%	1.02	0.98	1.05	0.35
Sep[a]	1,494	2,492	60.0%	1.00				2,675	4,380	61.1%	1.00			
Oct	1,515	2,438	62.1%	1.04	0.99	1.08	0.12	2,535	4,203	60.3%	0.99	0.95	1.02	0.47
Nov	1,442	2,271	63.5%	1.06	1.01	1.11	0.01	2,519	4,098	61.5%	1.01	0.97	1.04	0.71
Dec	1,486	2,259	65.8%	1.10	1.05	1.15	<0.001	2,735	4,072	67.2%	1.10	1.07	1.14	<0.001
Total	18,821	28,539	65.9%					33,093	49,869	66.4%				

[a] Reference group

Table 4. Received Second Influenza Vaccine Dose in the Same Immunization Season as First Influenza Vaccine Dose Among Children Ages 6-23 Months in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System

	Received 2nd influenza vaccine dose in same season as 1st dose N	**Received 1st Dose N**	**%**	**RR**	**95% CI**		**p-value**
Birth Month							
Jan	23,937	34,298	69.8%	1.11	1.10	1.12	<0.001
Feb	22,671	32,806	69.1%	1.10	1.09	1.11	<0.001
Mar	26,854	37,973	70.7%	1.13	1.11	1.14	<0.001
Apr	26,441	37,539	70.4%	1.12	1.11	1.13	<0.001
May	26,049	38,446	67.8%	1.08	1.07	1.09	<0.001
Jun	24,083	37,490	64.2%	1.02	1.01	1.03	<0.001
Jul	22,417	37,222	60.2%	0.96	0.95	0.97	<0.001
Aug	20,573	34,938	58.9%	0.94	0.93	0.95	<0.001
Sep[a]	20,623	32,853	62.8%	1.00			
Oct	21,694	32,941	65.9%	1.05	1.04	1.06	<0.001
Nov	20,740	31,451	65.9%	1.05	1.04	1.06	<0.001
Dec	23,313	33,836	68.9%	1.10	1.09	1.11	<0.001
Total	279,395	421,793	66.2%				

[a] Reference group

Table 5. All Missed Clinical Opportunities for Influenza Vaccination Based on Receipt of at Least One Dose of DTaP Vaccine Administered between October-March in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System ± ǂ

Missed Clinical Opportunities

Birth Month	Received at least one dose of DTaP before receipt of first dose of influenza vaccine N	Total N	%	RR	95% CI		p-value	Received at least one dose of DTaP before first dose of influenza vaccine in first season eligible immunization season N	Total N	%	RR	95% CI		p-value
Jan	897	60,463	1.5%	0.07	0.06	0.07	<0.001	865	60,463	1.4%	0.07	0.06	0.07	<0.001
Feb	1,351	56,434	2.4%	0.11	0.10	0.11	<0.001	1,299	56,434	2.3%	0.11	0.10	0.11	<0.001
Mar	4,302	62,500	6.9%	0.31	0.30	0.32	<0.001	4,236	62,500	6.8%	0.31	0.30	0.32	<0.001
Apr	9,456	61,051	15.5%	0.70	0.68	0.72	<0.001	9,417	61,051	15.4%	0.71	0.69	0.72	<0.001
May	9,497	64,493	14.7%	0.67	0.65	0.68	<0.001	9,454	64,493	14.7%	0.67	0.66	0.69	<0.001
Jun	10,274	64,327	16.0%	0.72	0.71	0.74	<0.001	10,189	64,327	15.8%	0.73	0.71	0.74	<0.001
Jul	12,307	66,439	18.5%	0.84	0.82	0.86	<0.001	12,193	66,439	18.4%	0.84	0.82	0.86	<0.001
Aug	15,624	66,486	23.5%	1.06	1.04	1.09	<0.001	15,510	66,486	23.3%	1.07	1.05	1.09	<0.001
Sep[a]	14,179	64,179	22.1%	1.00				14,016	64,179	21.8%	1.00			
Oct	277	62,515	0.4%	0.02	0.02	0.02	<0.001	Children born Oct-Dec did not qualify to have doses of DTaP qualify as missed clinical opportunities in their first season of flu vaccine eligibility according to study definition (i.e. any doses of DTaP administered between Apr-Aug did not qualify.)						
Nov	486	58,927	0.8%	0.04	0.03	0.04	<0.001							
Dec	745	60,040	1.2%	0.06	0.05	0.06	<0.001							
Total	79,395	747,854	10.6%					77,179	566,372	13.6%				

Severe Missed Clinical Opportunities

Birth Month	Received at least one dose of DTaP but no dose of influenza vaccine through age 23 months N	Total N	%	RR	95% CI		p-value	Received at least one dose of DTaP but no dose of influenza vaccine in first eligible immunization season N	Total N	%	RR	95% CI		p-value
Jan	3,942	60,463	6.5%	0.30	0.29	0.31	<0.001	3136	60,463	5.2%	0.35	0.33	0.36	<0.001
Feb	4,671	56,434	8.3%	0.38	0.37	0.39	<0.001	3630	56,434	6.4%	0.43	0.41	0.45	<0.001
Mar	8,471	62,500	13.6%	0.62	0.60	0.64	<0.001	6996	62,500	11.2%	0.75	0.73	0.77	<0.001
Apr	12,315	61,051	20.2%	0.92	0.90	0.94	<0.001	11572	61,051	19.0%	1.26	1.23	1.30	<0.001
May	13,845	64,493	21.5%	0.98	0.96	1.00	0.08	12841	64,493	19.9%	1.33	1.30	1.36	<0.001
Jun	14,829	64,327	23.1%	1.05	1.03	1.08	<0.001	13440	64,327	20.9%	1.39	1.36	1.43	<0.001
Jul	16,481	66,439	24.8%	1.13	1.11	1.16	<0.001	14552	66,439	21.9%	1.46	1.43	1.50	<0.001
Aug	17,370	66,486	26.1%	1.19	1.17	1.22	<0.001	14776	66,486	22.2%	1.48	1.45	1.52	<0.001
Sep[a]	14,032	64,179	21.9%	1.00				9617	64,179	15.0%	1.00			
Oct	6,388	62,515	10.2%	0.47	0.45	0.48	<0.001	Children born Oct-Dec did not qualify to have doses of DTaP qualify as missed clinical opportunities in their first season of flu vaccine eligibility according to study definition (i.e. any doses of DTaP administered between Apr-Aug did not qualify.)						
Nov	5,839	58,927	9.9%	0.45	0.44	0.47	<0.001							
Dec	4,874	60,040	8.1%	0.37	0.36	0.38	<0.001							
Total	123,057	747,854	16.5%					90,560	566,372	16.0%				

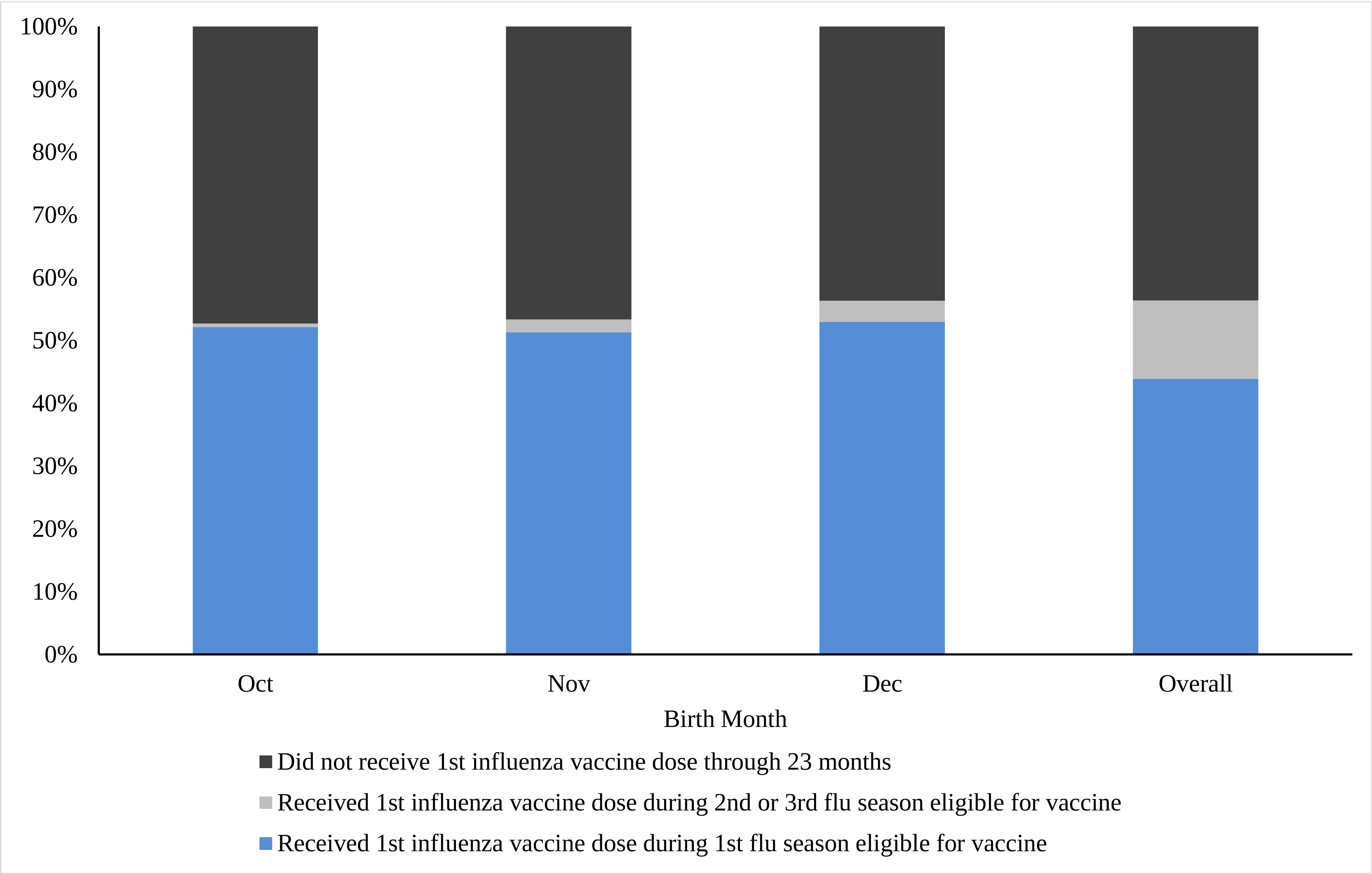
[a]Reference group

±Only DTaP doses administered between months of October-March included in analysis

ǂOnly DTaP doses administered on or after the date of first eligibility for flu vaccine included in analysis

Supplementary Figures and Tables

Supplementary Figure 1. Sensitivity Analysis of Receipt of First Influenza Vaccine Dose in the First Eligible Immunization Season Among Children in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System (n=181,482)



Supplementary Table 1. All Missed Clinical Opportunities for Influenza Vaccination Based on Receipt of at Least One Dose of DTaP Vaccine in the 2009-2013 Birth Cohort as Recorded in the New York State Immunization Information System ǂ

Missed Clinical Opportunities

Birth Month	Received at least one dose of DTaP before first dose of influenza vaccine N	Total N	%	RR	95% CI		p-value	Received at least one dose of DTaP before first dose of influenza vaccine in first season eligible immunization season N	Total N	%	RR	95% CI		p-value
Jan	30,650	60,463	50.7%	1.38	1.36	1.40	<0.001	30,521	60,463	50.5%	1.41	1.39	1.43	<0.001
Feb	24,588	56,434	43.6%	1.19	1.17	1.20	<0.001	24,461	56,434	43.3%	1.21	1.19	1.23	<0.001
Mar	16,053	62,500	25.7%	0.70	0.69	0.71	<0.001	15,869	62,500	25.4%	0.71	0.70	0.72	<0.001
Apr	9,853	61,051	16.1%	0.44	0.43	0.45	<0.001	9,589	61,051	15.7%	0.44	0.43	0.45	<0.001
May	9,963	64,493	15.4%	0.42	0.41	0.43	<0.001	9,695	64,493	15.0%	0.42	0.41	0.43	<0.001
Jun	10,869	64,327	16.9%	0.46	0.45	0.47	<0.001	10,614	64,327	16.5%	0.46	0.45	0.47	<0.001
Jul	13,330	66,439	20.1%	0.55	0.54	0.56	<0.001	13,070	66,439	19.7%	0.55	0.54	0.56	<0.001
Aug	17,977	66,486	27.0%	0.74	0.73	0.75	<0.001	17,655	66,486	26.6%	0.74	0.73	0.75	<0.001
Sep[a]	23,546	64,179	36.7%	1.00				23,008	64,179	35.8%	1.00			
Oct	27,754	62,515	44.4%	1.21	1.19	1.23	<0.001	26,628	62,515	42.6%	1.19	1.17	1.20	<0.001
Nov	28,346	58,927	48.1%	1.31	1.29	1.33	<0.001	25,797	58,927	43.8%	1.22	1.20	1.24	<0.001
Dec	31,097	60,040	51.8%	1.41	1.39	1.43	<0.001	18,918	60,040	31.5%	0.88	0.87	0.89	<0.001
Total	244,026	747,854	32.6%					225,825	747,854	30.2%				

Severe Missed Clinical Opportunities

Birth Month	Received at least one dose of DTaP but no dose of influenza vaccine through age 23 months N	Total N	%	RR	95% CI		p-value	Received at least one dose of DTaP but no dose of influenza vaccine in first eligible immunization season N	Total N	%	RR	95% CI		p-value
Jan	15,326	60,463	25.3%	0.83	0.82	0.85	<0.001	14,662	60,463	24.2%	0.90	0.89	0.92	<0.001
Feb	13,684	56,434	24.2%	0.79	0.78	0.81	<0.001	13,035	56,434	23.1%	0.86	0.84	0.88	<0.001
Mar	13,723	62,500	22.0%	0.72	0.71	0.73	<0.001	12,867	62,500	20.6%	0.77	0.75	0.78	<0.001
Apr	12,989	61,051	21.3%	0.70	0.68	0.71	<0.001	12,100	61,051	19.8%	0.74	0.72	0.75	<0.001
May	14,680	64,493	22.8%	0.75	0.73	0.76	0.08	13,566	64,493	21.0%	0.78	0.77	0.80	<0.001
Jun	15,915	64,327	24.7%	0.81	0.80	0.82	<0.001	14,501	64,327	22.5%	0.84	0.82	0.86	<0.001
Jul	17,918	66,439	27.0%	0.88	0.87	0.90	<0.001	16,221	66,439	24.4%	0.91	0.89	0.93	<0.001
Aug	20,037	66,486	30.1%	0.99	0.97	1.00	0.11	17,913	66,486	26.9%	1.00	0.99	1.02	0.76
Sep[a]	19,601	64,179	30.5%	1.00				17,244	64,179	26.9%	1.00			
Oct	18,510	62,515	29.6%	0.97	0.95	0.99	<0.001	15,259	62,515	24.4%	0.91	0.89	0.93	<0.001
Nov	17,094	58,927	29.0%	0.95	0.93	0.97	<0.001	12,889	58,927	21.9%	0.81	0.80	0.83	<0.001
Dec	15,822	60,040	26.4%	0.86	0.85	0.88	<0.001	7,319	60,040	12.2%	0.45	0.44	0.47	<0.001
Total	195,299	747,854	26.1%					167,576	747,854	22.4%				

[a]Reference group

ǂOnly DTaP doses administered on or after the date of first eligibility for influenza vaccine included in analysis

Appendices

Appendix A. Influenza Immunization Eligible Relative to Peak Immunization Season, by Birth Month (Shown for 2009 Birth Cohort)

BIRTH MONTH

	Jan 2009	Feb 2009	Mar 2009	Apr 2009	May 2009	Jun 2009	Jul 2009	Aug 2009	Sep 2009	Oct 2009	Nov 2009	Dec 2009
Jan 2009	Born											
Feb 2009		Born										
Mar 2009			Born									
Apr 2009				Born								
May 2009					Born							
Jun 2009						Born						
Jul 2009	Eligible						Born					
Aug 2009		Eligible						Born				
Sep 2009			Eligible						Born			
Oct 2009				Eligible						Born		
Nov 2009					Eligible						Born	
Dec 2009						Eligible						Born
Jan 2010	12 months						Eligible					
Feb 2010		12 months						Eligible				
Mar 2010			12 months						Eligible			
Apr 2010				12 months						Eligible		
May 2010					12 months						Eligible	
Jun 2010						12 months						Eligible
Jul 2010	18 months						12 months					
Aug 2010		18 months						12 months				
Sep 2010			18 months						12 months			
Oct 2010				18 months						12 months		
Nov 2010					18 months						12 months	
Dec 2010	23 Months					18 months						12 months
Jan 2011		23 Months					18 months					
Feb 2011			23 Months					18 months				
Mar 2011				23 Months					18 months			
Apr 2011					23 Months					18 months		
May 2011						23 Months					18 months	
Jun 2011							23 Months					18 months
Jul 2011								23 Months				
Aug 2011									23 Months			
Sep 2011										23 Months		
Oct 2011											23 Months	
Nov 2011												23 Months

Legend:

- Peak influenza immunization months
- Putative influenza season months
- Infant age 6-23 months (with 12 and 18 month milestones presented for reference)

Appendix B. CVX Codes Used for the Identification of Influenza and DTaP Vaccine Doses

Season Influenza Vaccine Type	Seasonal Influenza CVX Code	DTaP Vaccine Type	DTaP CVX Code
Influenza-Whole Virus	16	DTP	1
Flu, unspecified formulation	88	DTaP	20
Flu trivalent nasal	111	DTP-Hib	22
Flu high dose seasonal	135	DT-Peds	28
Flu seasonal intradermal p-free	144	DTaP-Hib	50
Flu quadrivalent nasal	149	DTaP,5 pertussis antigens	106
Flu quadrivalent injectable p-free	150	DTaP, unspecified formulation	107
Flu nasal, unspecified formulation	151	DTAP/Polio/Hep B	110
Flu injectable MDCK p-free	153	DtaP-Hib-IPV	120
Flu recombinant injectable p-free	155	DTaP-IPV	130
Flu quadrivalent injectable	158		
Flu quadrivalent injectable p-free peds	161		
Flu, intradermal quad inject p-free	166		
Flu trivalent injectable	168		
Flu trivalent injectable p-free	168		

CHAPTER III: PUBLIC HEALTH IMPLICATIONS

We have demonstrated the significant relationship between birth month and receipt of influenza immunization in children ages 6-23 months. Children born in fall months are less likely to receive a first dose of influenza vaccine compared to their peers born in spring months. In our study, overall receipt of a first dose of influenza vaccine among all birth months through age 23 months was 56.4%. Despite ACIP recommendation since 2004, annual influenza immunization coverage among this high-risk population continues to lag behind the Healthy People 2020 coverage goal of 70%.[7,11] In order to provide the most protection for young children in the United States, influenza immunization must be administered into late-season months. A strong provider recommendation to parents and strategic use of health information systems may help increase influenza vaccination coverage.

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