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Early influenza vaccination rates decline in children during the COVID-19 pandemic

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A B S T R A C T

Background: This investigation sought to determine whether early season rates of pediatric influenza vaccination changed in a season when there was a concurrent COVID-19 pandemic.
Methods: This study used cohort and cross sectional data from an academic primary care division in Southcentral Pennsylvania that serves approximately 17,500 patients across 4 practice sites. Early season (prior to November 1) vaccination rates in 2018, 2019 and 2020 were recorded for children, age 6 months to 17 years. To explore the impact of COVID-19 on vaccination, we fit a model with a logit link (estimated via generalized estimating equations to account for clustering by patient over time) on calendar year, adjusted for race, ethnicity, age, and insurance type. We examined interaction effects of demographic covariates with calendar year.
Results: Early vaccination rates were lower in 2020 (29.7%) compared with 2018 and 2019 (34.2% and 33.3%). After adjusting for covariates and accounting for clustering over time, the odds of early vaccination in 2020 were 19% lower compared to 2018 (OR 0.81, 95% CI: 0.78–0.85). In 2020, children with private insurance were more likely to receive early vaccination than in 2018 (OR 1.51, 95% CI: 1.04–1.15), whereas children with public insurance were less likely to receive early vaccination in 2020 than in 2018 (OR 0.62, 95% CI: 1.38–1.65).
Conclusions: Early influenza vaccination rates declined in a year with a concurrent COVID-19 pandemic. Modeling that accounts for individual trends and demographic variables identified specific populations with lower odds of early vaccination in 2020. Additional research is needed to investigate whether the COVID-19 pandemic impacted parental intent to obtain the influenza vaccine, or introduced barriers to healthcare access.

1. Introduction

The influenza vaccine is the most effective preventative measure against influenza infection [1]. There have been extensive efforts to understand the factors impacting influenza vaccine uptake [2,3]. Vaccine hesitancy is common [4,5], and may change from year to year [6]. Previously, we reported that a surprising number (35–50%) of children received the influenza vaccine in one season, but not in the preceding or subsequent seasons [7]. Parents’ decision to vaccinate their child against influenza may be influenced by the severity of recent flu seasons [8], the time of year in which a child’s annual well check-up occurs [9], and the guidance delivered by health care providers [10].

Multiple groups have published on a significant reduction in the number of routine (non-influenza) vaccination doses ordered and administered in the United States due to the COVID-19 pandemic [11,12]. This may have occurred because the COVID-19 pandemic introduced new factors that influence parents’ decision to vaccinate their children. A review of barriers to influenza vaccination between 2005 and 2016 identified lack of confidence and inconvenience as two of the most important factors inhibiting vaccine uptake [13]. The COVID-19 pandemic may have amplified both of these barriers. It is possible that fear of contracting the SARS-CoV-2 virus in a medical office could dissuade families from seeking medical care, including yearly influenza vaccinations [14]. Likewise, it is possible that the COVID-19 pandemic poses novel logistical barriers to care access (e.g., concerns about public transportation, altered school/work schedules). Desire for influenza vaccination could also be lower during the COVID-19 pandemic due to decreased perceived risk of contracting influenza when pandemic
safety measures such as masking and social distancing are in place [15]. Surveys of individuals have revealed substantial hesitancy regarding the efficacy and safety of the COVID-19 vaccine [16,17], and this could unintentionally increase parental hesitancy about influenza vaccination [18].

Alternatively, it is possible that fear of the SARS-CoV-2 virus could drive more families to seek influenza vaccines for their children, given that preventing influenza symptoms could help avoid uncomfortable nasopharyngeal testing or lengthy quarantine protocols. There have been reports that co-infection with both influenza and SARS-CoV-2 may increase risk of mortality [19]. In light of these potentially synergistic effects, and the additive burden that severe influenza infections may place on hospital resources, optimizing influenza vaccination rates in the 2020–2021 season has been suggested as a critical task [20]. Assessment of influenza vaccination rates early in the 2020–2021 season provides an opportunity to seek alternative public health strategies promoting influenza vaccination if the COVID-19 pandemic suppresses vaccination or leads to vaccination disparities [21]. In addition to early vaccination being recommended by the CDC, vaccination rates prior to the onset of the influenza season provide the clearest picture of how the COVID-19 pandemic (as opposed to the current influenza season) influences vaccination rates.

This study examined early influenza vaccination rates among children (age 6 months to 17 years) during 2018, 2019 and 2020 at four tertiary care-affiliated primary care practice sites. The goal of the study was to assess whether the concurrent COVID-19 pandemic may have influenced influenza vaccination rates in 2020. We hypothesized that the odds of early influenza vaccination would be reduced during the 2020 COVID-19 pandemic, and the reduction would be even more pronounced among racial, ethnic, and socioeconomic groups at risk for pandemic-related disruptions in healthcare access.

2. Methods

2.1. Study population

This study included active primary care patients in four primary care practice sites affiliated with a tertiary medical center early in the 2018–19, 2019–20 and 2020–21 influenza vaccination seasons. At any given time, the practice sites serve approximately 17,500 patients from south central Pennsylvania. Early influenza vaccination seasons were defined as September 1 through October 31, consistent with the recommendation from the Center for Disease Control and Prevention (CDC) to administer the influenza vaccine “by the end of October” [22]. Inclusion criteria for each influenza season was 1) age ≥ 6 months and < 18 years on September 1st of that season (beginning of the influenza vaccination season); and 2) active patients (defined as children with a clinical visit of any type in the 18 months prior to the season start, or at any point during that season). The 6 month age cutoff was set to exclude infants who would not have been eligible for an influenza vaccine at the start of the season, and would thus lack full access to the early vaccination period. The 18 year cutoff was selected to exclude college age adolescents with increased rates of on-campus influenza vaccine administration. Only patients active in all three years were included in analyses in order to allow for unbiased tracking of patient behavior over time. Data were collected through interrogation of the electronic medical record (EMR), and patient level information, including demographic characteristics, date of vaccine receipt, and type of influenza vaccination was collected for all eligible participants. Flu vaccination status is assessed and vaccines are offered if needed at both well- and sick-visits seven days a week beginning in early September in each season. In addition, the clinics offered “immunization visits” for flu-vaccine administration, which included after hours appointments (5 pm through 8 pm weekdays and 8 am through 12 pm weekends). There is no targeted outreach to patients in need of influenza vaccinations. There is no out of pocket cost to patients or prior insurance authorization required for influenza vaccinations. This study was approved by the Independent Review Board at the Penn State College of Medicine.

2.2. Vaccination rates

The total clinic population was defined as all children who met inclusion criteria, whether or not they had received an influenza vaccination. All documented influenza vaccinations for children who met inclusion criteria were abstracted from the EMR. Vaccinations documented in our EMR but received outside of our clinic locations were also included, although the vast majority of documented vaccinations (>99%) were administered at our clinic locations. Early vaccination rate was defined as the number of children vaccinated prior to November 1st divided by total clinic population for that season. In our prior study, a random sample of 200 patients over two years of age without a documented record of vaccination identified only one child (0.5%) with a record of influenza vaccination at an external site in the Pennsylvania Statewide Immunization Information System [7]. We therefore assume that the vast majority of our clinic population receives either influenza vaccines at our clinic location or notifies our clinic of receipt elsewhere.

2.3. Data analysis

We first report the proportion of the population 6 months to 17 years of age who received an influenza vaccine prior to November 1st in each of the three seasons of interest. The effect of the COVID-19 pandemic on early season influenza vaccination rates was assessed by fitting a model as a function of calendar year (“unadjusted model”). The model contained a logit link, which is appropriate for binary outcomes, and was estimated via generalized estimating equations (GEE) to account for repeated measures over time (clustering) within the same individual. Odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were reported for the model.

We then fit a model that included age, sex, race, ethnicity, and insurance status in addition to calendar year (“adjusted model”). The demographic characteristics were chosen a priori because they are commonly reported by the CDC and have known associations with influenza vaccination patterns [23]. Ethnicity was characterized as Hispanic or not-Hispanic. Race was characterized according to CDC reporting standards of Black, White, Asian and other (CDC reports American Indian/Alaskan Native as well but we did not have a large enough sample of this group to include them independently). Age was characterized categorically according to CDC standard reporting as pre-school aged (6 months–4 years), school aged (5–12 years) and adolescent (13–17 years). All children < 18 years old in Pennsylvania are eligible for some type of insurance and all individuals who present to our clinic without insurance are helped to obtain insurance by our social worker. Thus, all patients seen in our clinic have insurance. In light of this, insurance was dichotomized as Public (Medicaid), or Private. Finally, we explored interaction effects between calendar year and demographic variables, to examine whether rates of vaccination differed over time by demographic characteristics.
3. Results

3.1. Clinic population characteristics

There were a total of 19,645 unique children in the clinic population over the three influenza seasons. 10,544 children met study criteria, had observations in all three years and were included in analyses. Demographic information by year is presented in Table 1. Demographics were generally similar across calendar years with the exception that a smaller proportion of children had public insurance in 2018 and the cohort increased in age over time. While public insurance rates were similar to the national average, the proportion of Black, Asian and Hispanic children were about half of that seen nationally [24,25].

3.2. Influenza vaccination rates

The proportion of children with an early influenza vaccination was 34.2% (3,608) in 2018, 33.3% (3,515) in 2019 and 29.7% (3,136) in 2020. In the unadjusted model that accounted for clustering by patient over time, the odds of getting an early influenza vaccine compared with the reference year of 2018 were 0.96 (95% CI: 0.92–1.01, p = 0.08) in 2019, and 0.81 (95% CI: 0.78–0.85, p < 0.001) in 2020.

3.3. Factors influencing vaccination rates

Odds ratios from the adjusted model are presented in Table 2, and demonstrate lower odds of early influenza vaccination in 2020, as in the unadjusted model. Lower odds of early influenza vaccination were seen in Hispanic children, children with public insurance, and teens and school aged children (relative to preschoolers), regardless of the calendar year. Compared with white children, Asian children had higher odds of early influenza vaccination, and Black children had lower odds of early influenza vaccination.

We evaluated potential interactions between calendar year and all demographic variables that demonstrated a significant effect in the adjusted model. The only significant interaction effect was between calendar year and insurance (p < 0.001). From 2018 to 2020, patients with private insurance had 51% increased odds of early vaccination (OR = 1.51, 95% CI: 1.38–1.65). Fig. 1 shows the interaction across all years using estimated probabilities calculated from the model.

### Table 1

Demographics for individuals included in each year.

| Site (location) | 2018 (N = 10544) | 2019 (N = 10544) | 2020 (N = 10544) |
|-----------------|-----------------|-----------------|-----------------|
| Site 1          | 7316 (69.4%)    | 7301 (69.2%)    | 7339 (69.6%)    |
| Site 2          | 1050 (10.0%)    | 1102 (10.5%)    | 1082 (10.3%)    |
| Site 3          | 1835 (17.4%)    | 1848 (17.5%)    | 1829 (17.3%)    |
| Site 4          | 343 (3.3%)      | 293 (2.8%)      | 294 (2.8%)      |
| Sex             |                 |                 |                 |
| Female          | 5202 (49.3%)    | 5202 (49.3%)    | 5202 (49.3%)    |
| Male            | 5342 (50.7%)    | 5342 (50.7%)    | 5342 (50.7%)    |
| Age in years    |                 |                 |                 |
| Mean (SD)       | 7.2 (4.4)       | 8.2 (4.4)       | 9.2 (4.4)       |
| Age             |                 |                 |                 |
| Preschool (<5 years old) | 4131 (39.2%) | 3266 (31%) | 2358 (22.4%) |
| School (>5 to <13 years old) | 5013 (47.5%) | 5313 (50.4%) | 5583 (52.9%) |
| Teen (>13 to < 18 years old) | 1400 (13.3%) | 1965 (18.6%) | 2603 (24.7%) |
| Race            |                 |                 |                 |
| Asian           | 309 (2.9%)      | 309 (2.9%)      | 308 (2.9%)      |
| Black           | 557 (5.3%)      | 557 (5.3%)      | 559 (5.3%)      |
| Other           | 2796 (26.5%)    | 2796 (26.5%)    | 2793 (26.5%)    |
| White           | 6882 (65.3%)    | 6882 (65.3%)    | 6884 (65.3%)    |
| Ethnicity       |                 |                 |                 |
| Hispanic        | 932 (8.8%)      | 931 (8.8%)      | 933 (8.8%)      |
| Not Hispanic    | 9612 (91.2%)    | 9613 (91.2%)    | 9611 (91.2%)    |
| Insurance       |                 |                 |                 |
| Private         | 7731 (73.3%)    | 7032 (66.7%)    | 7092 (67.3%)    |
| Public          | 2813 (26.7%)    | 3512 (33.3%)    | 3452 (32.7%)    |

Fig. 1. Estimated probabilities (and 95% confidence intervals) of an early vaccine by insurance status (public vs private) and calendar year from fitted model.

4. Discussion

To our knowledge, this is the first study to examine early influenza vaccination rates in children during the COVID-19 pandemic.
and shows a decrease in early vaccination rates compared to prior years. The overall early vaccination rate is useful for practice managers and public health officials who need to know how many vaccines to order and what percent of the population is likely to be protected in a given year. A model that accounted for clustering of individuals over time demonstrated a similar and significant decline in odds of early influenza vaccination in 2020, and the findings were similar after adjusting for age, sex, race, ethnicity, and insurance status. Individual children in our practice displayed a 19% decrease in odds of early influenza vaccination compared to earlier years (15% decrease when adjusted for demographic factors). In particular, we note that children with public insurance (vs public) were dramatically less likely to receive an early influenza vaccine in 2020, especially compared to 2019 and 2018. Given the disproportionate burden of SARS-CoV-2 illness among minority and socioeconomically disadvantaged populations [21], this disparity is particularly concerning. It underscores the importance of fostering vaccine confidence and implementing creative measures to enhance care access for individuals with public insurance during the COVID-19 pandemic.

There are several reasons that children with consistent care at our practice sites may have been less likely to receive an early influenza vaccination during the COVID-19 pandemic. Families who elect to vaccinate their child against influenza one year, but decline the vaccine in a subsequent year often do so for passive reasons (e.g., “I didn’t have an appointment during flu season”, “My doctor didn’t remind me”), rather than making an active decision to decline the vaccine [26]. This could be especially true during the COVID-19 pandemic, when many individuals deferred medical care out of fear of SARS-CoV-2 infection [27]. Perceived lower risk of contracting influenza with pandemic-related safety measures in place may have also played a role [15].

A strength of this study is its reliance on documented influenza vaccinations linked to individual medical records. This is in contrast to the CDC methodology which relies on parental report of vaccination status. The ability to track individual medical records over several years allowed the analysis to account for clustering that would not be possible in other data sets. One limitation of the current study is that its retrospective design and lack of qualitative data prevent examination of individual motives for early vaccination (or non-vaccination) during the COVID-19 pandemic. Although prior studies provide some insight into individual motives for influenza vaccination [26,28], we cannot definitively conclude that rates of early influenza vaccination in 2020 are solely attributable to the COVID-19 pandemic, or related disruptions in care access. However, it is notable that there was little difference in odds of vaccination in the two years before the COVID-19 pandemic (2018 and 2019). In addition, odds of early influenza vaccination rates were most pronounced among groups that are historically vulnerable to barriers to medical care [29], such as those introduced by the COVID-19 pandemic.

The study is limited by its restriction to a single academic medical center with only 4 practice sites. The proportion of children from racial and ethnic minority groups are under-represented in our clinic population, which may reduce generalizability to other settings. We have attempted to control for these factors in our adjusted model. In addition, we note that early influenza vaccination rates at our clinic (34.2%) lag the CDC-reported rates for 2018 (44.9%; the most recent year for which CDC reports early vaccination rates). This discrepancy may result from differences in data collection methods; the CDC data is generated through phone-based parental reports, while our data was collected through interrogation of the EMR in order to reduce recall bias. Finally, our data is limited to patients seeking regular care at a primary care practice and these patients likely have higher vaccination rates than those who do not seek regular care.

It is important to note that during the three year study period there were no significant changes to the hours of operation, availability of influenza vaccines, or advertisement of influenza vaccinations at our four practice sites. In addition, no quality improvement initiatives were undertaken to boost influenza vaccination rates during the three year period. This also applies to the 2020 calendar year, when we offered the same number of influenza vaccination clinics with the same hours, despite the COVID-19 pandemic. Other than the increase in public insurance (which occurred prior to the COVID-19 pandemic) we observed no significant demographic shifts among our clinic population.

We acknowledge that not all children who received an influenza vaccine outside of our practice sites were captured by our data collection approach. However, in prior studies we have documented these children through manual interrogation of the Pennsylvania Statewide Immunization Information System and found that they account for < 1% of our clinic population. Although it is possible that the COVID-19 pandemic led to an increase in influenza vaccinations at retail pharmacies, such vaccinations are only available to older age groups, and we saw no significant interaction between age and calendar year.

Our data suggest that compared with prior years, practice site managers and public health practitioners should expect declining influenza vaccination rates during the COVID-19 pandemic. In addition, our data shows disparities in vaccination rates by race, ethnicity and insurance status and indicates that disparities by insurance status have been exacerbated in 2020. Further studies are needed to determine if these trends persist over the full 2020–2021 influenza season, and to define and address the specific barriers to influenza vaccination among at-risk groups.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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