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Vaccine 40 (2022) 6391–6396

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Declining influenza vaccination rates in an underserved pediatric primary care center during the COVID-19 pandemic

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ARTICLE INFO

Article history:
Received 24 June 2022
Received in revised form 18 August 2022
Accepted 2 September 2022
Available online 12 September 2022

Keywords:
Influenza
Vaccination
Pediatrics
Social determinants of health
COVID-19 pandemic

ABSTRACT

Background: Influenza vaccination rates are decreasing in the United States. Disinformation surrounding COVID-related public health protections and SARS-CoV-2 vaccine roll-out may have unintended consequences impacting pediatric influenza vaccination. We assessed influenza vaccination rates before and during the COVID-19 pandemic in one pediatric primary care center, serving a minoritized population.
Methods: A cross-sectional study assessed influenza vaccination rates for children aged 6 months to 12 years over the following influenza seasons (September-May): 1) 2018–19 and 2019–20 (pre-pandemic), and 2) 2020–21 and 2021–22 (intra-pandemic). Demographics and responses to social risk questionnaires were extracted from electronic health records. Total tetanus vaccinations across influenza seasons served as approximations of general vaccination rates. Generalized linear regression models with robust standard errors evaluated differences in demographics, social risks, and influenza vaccination rates by season. Multivariable logistic regression with robust standard errors evaluated associations between influenza season, demographics, social risks, and influenza vaccination.
Results: Most patients were young (mean age ~ 6 years), non-Hispanic Black (~80%), and publicly insured (~90%). Forty-two percent of patients eligible to receive the influenza vaccine who were seen in 2019–20 influenza season received the influenza vaccine, compared to 30% in 2021–22. Influenza and tetanus vaccination rates decreased during the COVID-19 pandemic ($p < 0.01$). The 2020–21 and 2021–22 influenza seasons, older age, Black race, and self-pay were associated with decreased influenza vaccine administration ($p < 0.05$).
Conclusions: Influenza vaccination rates within one pediatric primary care center decreased during the COVID-19 pandemic and have not rebounded, particularly for older children, those identifying as Black, and those without insurance.

1. Introduction

Influenza is associated with significant morbidity and mortality among children, placing infected individuals at risk for pneumonia, dehydration, sinusitis, otitis media, and even death. For every 100 influenza-positive children, there are an annual average of 6–15 outpatient visits and 3–9 antibiotic courses for concomitant bacterial illnesses, as reported over a 19-year study period. [1] Hospitalizations for influenza infection among children < 5 years old in the United States vary depending on the influenza season, ranging from 7,000 to 26,000 between the 2010–11 and 2019–20 influenza seasons. [2] Although rare, children still die from influenza in the United States. Between 2010 and 2016, 675 influenza-related pediatric deaths occurred, with 69% of those children eligible, but not vaccinated against influenza. [3] Indeed, influenza vaccination is an important, effective preventative intervention that reduces

Abbreviations: **PPCC**, Pediatric Primary Care Center; SEs, standard errors; CDC, Centers for Disease Control.

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https://doi.org/10.1016/j.vaccine.2022.09.016
0264-410X/

morbidity and mortality. Influenza vaccination prevents influenza-related clinic visits, hospitalizations, and death in the pediatric population.

Despite this, influenza vaccine hesitancy is more prominent than hesitancy for other pediatric vaccines. In 2019, approximately 25% of parents were hesitant about the influenza vaccine compared to 7% hesitancy for other childhood vaccinations, with the main concerns related to side effects and efficacy. [4] Over time, influenza vaccination uptake has varied, with older children and adolescents having lower rates of vaccine coverage than younger children. [5] This highlights the need to address vaccine hesitancy and declining influenza vaccination rates and reiterate the importance of, and benefits from, influenza vaccination for children.

During the COVID-19 pandemic, when availability of healthcare supplies and personnel was limited, the importance of influenza vaccination was highlighted as one strategy to reduce overall healthcare utilization. [6] Anxiety about potential illness has previously been described as a possible motivating factor to receive influenza vaccination. For instance, influenza vaccination rates were higher in 2018–2019, the year after a deadlier than average influenza season. [6] However, the COVID-19 pandemic has not led to more positive attitudes toward the influenza vaccine

rather, the pandemic intensified pre-existing preferences and concerns regarding influenza vaccination. [7] Decreasing vaccination rates may have been exacerbated by reduced pediatric primary care visits in 2020 compared to 2018, with visits 17% to 60% lower depending on the month. [8] A recent study showed that decreased routine immunization rates have followed this decrease in pediatric primary care visits

however, this study did not assess rates of influenza vaccine administration. [8] In addition, some assert that the controversy, misinformation, disinformation, and politicization of the novel SARS-CoV-2 virus and the COVID-19 vaccine may raise concerns surrounding vaccines in general. [9] These incomplete and conflicting data leave experts questioning the impact of the COVID-19 pandemic on pediatric influenza vaccination rates.

Thus, we pursued a study in a large, urban, academic pediatric primary care center (PPCC) that serves a primarily low-income, predominantly non-Hispanic Black population with significant medical, social, and economic disparities to better understand the impact of the COVID-19 pandemic on our population's receipt of influenza vaccines. Our primary aim was to assess influenza vaccination rates before and during the COVID-19 pandemic.

2. Methods

2.1. Study design

We performed a cross-sectional study to investigate influenza vaccination rates in our PPCC during influenza seasons before (2018–19 and 2019–20) and during (2020–21 and 2021–22) the COVID-19 pandemic.

2.2. Study population

All patients at the PPCC ages 6 months up to 12 years were included in the data analysis. The PPCC serves a population of approximately 17,000 patients with the following demographic characteristics

80% Black, 15% white, 85% with public insurance, 5% self-pay (no insurance), and 10% with private insurance. Patients<6 months of age were excluded since they are not yet eligible to receive the influenza vaccine. Patients older than 12 years of age were excluded as there are fewer adolescent patients who seek care in our primary care center

many transition to our hospital's teen health center.

2.3. Primary outcome

Influenza vaccination rates in the PPCC over the following four influenza seasons (September-May) were calculated

1) 2018–2019 and 2019–2020 (influenza seasons prior to the COVID-19 pandemic), and 2) 2020–2021 and 2021–2022 (influenza seasons during the COVID-19 pandemic). Tetanus vaccinations administered during each influenza season were used as a proxy for general vaccination rates, as clinic visit volumes varied due to COVID-related restrictions. Data were accessed using the electronic health record (EHR). Influenza vaccination percentages were calculated with the numerator being the total number of children meeting our inclusion criteria who received influenza vaccination, and the denominator being all children meeting inclusion criteria who came into clinic for a visit during the influenza season. We also calculated the percentage of those patients who received influenza vaccination out of the total number of patients of all ages on the clinic's active registry (seen for any visit within the last 24 months), whether or not they came in for a visit, to ascertain population-level influenza vaccination rates.

2.4. Predictor variables and covariates

Our primary predictor variable was influenza season as defined above. Additional predictor variables and covariates were obtained from the EHR. Specifically, we included demographic characteristics including patient age (continuous variable defined by mean and standard deviation), gender (number and percentage), race (number and percentage of those identifying as Black, white, other, or unknown/refused), type of insurance (number and percentage of those with public insurance, private insurance, or self-pay), and information from our standard PPCC social risk screening questionnaire (number and percentage with a positive screen). The social risk screening questionnaire assessed the following topics

food insecurity, issues with public benefits (e.g., supplemental nutrition assistance program, medical insurance, daycare vouchers), housing conditions or insecurity, medication and healthcare costs, transportation issues, and caregiver depression. A positive social risk screen was defined as answering "yes" to at least one of the questions on the questionnaire (**Appendix 1**). In addition, specific diagnoses associated with increased morbidity from influenza (e.g., asthma, prematurity, and developmental delay) were extracted from the problem list of each patient. We chose this set of diagnoses as the Advisory Committee on Immunization Practices highlights each as increasing the risk of influenza-related complications. [10] We also determined whether a social work note and/or referral to our medical-legal partnership was placed within three days of a clinic visit to assess if an intervention was taken to address social risks identified on the social risk screen or during the encounter. A deprivation index score, based on a geocoded child's home census tract, was used to assess the degree of socioeconomic disadvantage in the child's surroundings. [11].

2.5. Statistical analyses

Descriptive statistics enumerate the distribution of patient demographic characteristics, social risks, and overall rates of influenza and tetanus vaccinations for each influenza season. Generalized linear regression models with robust standard errors (SEs) evaluated differences in demographic characteristics, social risks, and influenza vaccination rates by influenza season by specifying an appropriate distribution and link function for each factor. In a subgroup of patients with clinic visits in both 2018–19 and 2020–21 influenza seasons, influenza vaccine rates were compared

using the McNemar test. Multivariable logistic regression models with robust SEs evaluated associations between influenza season, demographics, social risks, and influenza vaccination.

3. Results

3.1. Demographic characteristics

Most patients were young (mean age of ~ 6 years), predominantly non-Hispanic Black (~80%), and publicly insured (~90%) (Table 1), representative of our overall PPCC population. The mean patient age of influenza-vaccinated patients increased significantly across the four influenza seasons (from 5.5 years to 6.2

$p < 0.01$). Similarly, any positive response to the social risk screen significantly increased across influenza seasons from 13% to 27% ($p < 0.01$). There were no significant differences in race or insurance distribution among vaccinated patients across influenza seasons, with almost 90% of patients being on public insurance each year. Statistically significant differences across influenza seasons were noted in relation to presence of reported social risks ($p < 0.01$) and neighborhood social deprivation ($p = 0.02$), both of which increased across influenza seasons. In other words, during the study period, the percentage of patients with an identified social risk increased, as did the mean socioeconomic deprivation of patients' home census tracts. There was no significant difference in the presence of chronic diagnoses.

3.2. Influenza and tetanus vaccination rates across seasons

Both influenza and tetanus vaccination rates significantly decreased among patients seen in clinic for an office visit and among the total population across the included seasons. Among all patients with any clinic visit, influenza vaccine uptake decreased from 42% (2019–20) to 30% (2021–22). Among all patients within the clinic registry, regardless of whether they attended a visit during the season, influenza vaccination decreased from 20% (2019–20) to 15% (2021–22) (Table 2). Tetanus vaccination also significantly differed across each season, with lower uptake during the COVID-19 pandemic among patients with any clinic visit (48% to 37%

$p < 0.01$) and among those who were active on the PPCC registry regardless of whether or not they had a clinic visit (25% to 19%

$p < 0.01$).

Of the 3805 pediatric patients who were seen in both the 2018–19 and the 2021–22 influenza seasons, 43% received their influenza vaccine in the 2018–19 influenza season (pre-pandemic) compared to 31% of those same patients receiving the vaccine during the 2021–22 influenza season (intra-pandemic) ($p < 0.01$).

We found that older patient age (OR 0.98[0.97–0.99]), Black race (OR 0.59[0.55–0.62]), and self-pay insurance status (OR 0.77 [0.66–0.90]) were associated with lower odds of influenza vaccination at any point in time. We also found that the 2019–20 influenza season was associated with increased odds of influenza vaccination (OR 1.14[1.07–1.21]), while the influenza seasons during the COVID-19 pandemic were associated with lower odds of vaccination (2020–21 (OR 0.88[0.82–0.93]), 2021–22 (OR 0.70[0.65–0.74])). Of note, a positive social risk screen (OR 0.97[0.92–1.03]) and public insurance status (OR 0.96[0.89–1.04]) were not associated with influenza vaccination (Table 3).

4. Discussion

In our PPCC, which serves a predominantly non-Hispanic Black, publicly insured population, influenza vaccination rates have declined since the onset of the pandemic. The continued decline in influenza vaccination rates into the 2021–22 influenza season is perhaps best exemplified within a cohort who presented to clinic both in the 2018–19 and 2021–22 seasons. We found a 12% absolute decline in influenza vaccination within this group. This highlights a significant decrease in pediatric influenza vaccine uptake during the COVID-19 pandemic, even amongst patients who had previously received the vaccine.

Our findings are similar to the trends reported by the Centers for Disease Control and Prevention (CDC), with a decrease in influenza vaccination uptake from the 2019–20 to the 2020–21 influenza seasons. [5] In addition, in one academic PPCC in Pennsylvania, influenza vaccination rates prior to November in each influenza season decreased from 2018 to 2020. [12] However, they did not assess for how the rates of influenza vaccination compared within the full 2020–21 and 2021–22 seasons. The CDC reported that the numbers of influenza vaccine doses in children 6–24 months of age and 2–4 years of age in 2020 also decreased by over 10% compared to the average rate across the 2018 and 2019 influenza seasons. [13] These decreases in national pediatric influenza vaccination are in contrast to the increased vaccine uptake amongst adults ages 18–64 years during the COVID-19 pan-

Table 1
Demographic and clinical characteristics by influenza season since 2018–19.

	2018–2019 flu season (n = 9367)	2019–2020 flu season (n = 8582)	2020–2021 flu season (n = 8062)	2021–2022 flu season (n = 8197)	P-value
Age in years, mean (SD)	5.5 (3.6)^{A}	5.7 (3.6)^{B}	6.0 (3.6)^{C}	6.2 (3.6)^{D}	<0.01
Male gender, n (%)	4808 (51%)	4385 (51%)	4166 (52%)	4190 (51%)	0.87
Race, n (%)					0.03
Black	7191 (77%)^{A}	6620 (77%)^{A}	6343 (79%)^{B}	6397 (78%)^{AB}	
White	1609 (17%) ^{A}	1432 (17%) ^{AB}	1264 (16%) ^{B}	1326 (16%) ^{AB}	
Other	225 (2%) ^{A}	198 (2%) ^{A}	161 (2%) ^{AB}	153 (2%) ^{B}	
Unknown/refused	342 (4%) ^{A}	332 (4%) ^{A}	294 (4%) ^{A}	321 (4%) ^{A}	
Insurance, n (%)					<0.01
Medicaid	8160 (87%)^{A}	7367 (86%)^{B}	7149 (89%)^{C}	7302 (89%)^{C}	
Private Insurance	887 (9%)^{AB}	883 (10%)^{B}	736 (9%)^{AC}	692 (8%)^{C}	
Self-Pay	320 (3%)^{A}	332 (4%)^{A}	177 (2%)^{B}	203 (2%)^{B}	
Social Risk Indicators					
Social Risk Screen positive, n (%)	1264 (13%)^{A}	1906 (22%)^{B}	1989 (25%)^{C}	2108 (26%)^{C}	<0.01
Deprivation index score, mean (SD)	0.49 (0.13) ^{A} [n = 8985]	0.50 (0.13) ^{AB} [n = 8230]	0.50 (0.13) ^{B} [n = 7725]	0.50 (0.13) ^{B} [n = 7845]	0.02
Social Work/Legal Aid Referral, n (%)	342 (4%)^{A}	327 (4%)^{A}	303 (4%)^{A}	397 (5%)^{B}	<0.01
Diagnosis of Asthma, Prematurity, or Developmental Delay, n (%)	3266 (35%)	2949 (34%)	2726 (34%)	2725 (33%)	0.13

A,B,C,D – estimates that share a common superscript in a given row do not differ at $p < 0.05$.

Table 2
Percentages of patients receiving influenza and tetanus vaccination by influenza season.

	2018–2019 flu season % (95% CI)	2019–2020 flu season % (95% CI)	2020–2021 flu season % (95% CI)	2021–2022 flu season % (95% CI)	P-value
Flu Received					
Patients with any visit					
Percentage	38.8% (37.8% to 39.8%)[A]	41.6% (40.5% to 42.6%)[B]	35.2% (34.2% to 36.3%)[C]	30.2% (29.2% to 31.2%)[D]	**<0.01**
Proportion	3635/9367	3566/8582	2839/8062	2473/8197	
All active patients					
Percentage	20.0% (19.4% to 20.6%)[A]	19.7% (19.2% to 20.3%)[A]	16.6% (16.1% to 17.2%)[B]	15.2% (14.6% to 15.7%)[C]	**<0.01**
Proportion	3635/18160	3566/18064	2839/17070	2473/16147	
DTap/Tdap Received					
Patients with any visit					
Percentage	47.6% (46.6% to 48.6%)[A]	38.0% (37.0% to 39.0%)[B]	38.7% (37.6% to 39.7%)[B]	37.3% (36.3% to 38.4%)[B]	**<0.01**
Proportion	4455/9367	3259/8582	3118/8062	3061/8197	
All active patients					
Percentage	24.5% (23.9% to 25.2%)[A]	18.0% (17.5% to 18.6%)[B]	18.3% (17.7% to 18.9%)[B]	18.8%(18.2% to 19.4%)[B]	**<0.01**
Proportion	4455/18160	3259/18064	3118/17070	3061/16147	

A,B,C,D – estimates that share a common superscript in a given row do not differ at $p < 0.05$.

Table 3
Multivariable logistic regression model for influenza vaccine received.

	OR (95% CI)
Age, per year	0.98 (0.97 to 0.99)
Male gender	0.97 (0.93 to 1.01)
Study influenza season year	
2018–2019	Reference
2019–2020	1.14 (1.07 to 1.21)
2020–2021	0.88 (0.82 to 0.93)
2021–2022	0.70 (0.65 to 0.74)
Race	
Black	0.59 (0.55 to 0.62)
Other	1.71 (1.45 to 2.02)
Unknown/refused	1.11 (0.98 to 1.26)
White	Reference
Insurance	
Medicaid	0.96 (0.89 to 1.04)
Self-pay	0.77 (0.66 to 0.90)
Private Insurance	Reference
Social Risk Indicators	
Social Risk Screen positive	0.97 (0.92 to 1.03)
Deprivation index score, per point	0.82 (0.68 to 0.98)

demic. However, in their assessment, Roman et al. looked at vaccinations only during the months of September-December of each season, leaving the later winter and early spring months out of their analysis. [13] We used data from September through May of each influenza season, the entire influenza vaccine period, providing a more holistic recognition of vaccine uptake throughout the entirety of each influenza season. Additionally, our population is also unique in that our clinic patients traditionally have been more vaccine hesitant with significant social and financial hardships faced.

Certain demographic and social factors were associated with decreasing rates of influenza vaccination in our PPCC. We found that older patient age, Black race, and self-pay insurance status were associated with decreased rates of receiving the influenza vaccine. Similarly, a recent study highlighted that only 36% of non-Hispanic Black adults accepted influenza vaccination for themselves, compared to 47% of white adults, and those without insurance had a lower odds of receiving the influenza vaccine. [14] We also found that influenza seasons during the COVID-19 pandemic were associated with a lower odds of receiving the influenza vaccine, compared to the season prior to the pandemic. This was even seen among the cohort of patients who had received the influenza vaccine in the year prior to the pandemic. One possible factor contributing to decreased vaccination during the COVID-19 pandemic includes the influence of social determinants of health, and we saw that positive social risk screens increased during the COVID-19 pandemic. Survey data from more than 1000 families conducted in April 2020 revealed that 76% reported concerns of financial stability, 43% about employment, 31% about housing stability, and 36% about healthcare access. [15] In our patient population with pre-pandemic socioeconomic disadvantage, [16] we postulate that the increased social and economic burdens families faced during the pandemic could have influenced access to and priority for receiving influenza vaccinations. Although we did not identify an association between reported social risks and influenza vaccination, this could be due to the relatively high rates of risks present within our population. That is, such a link could be further investigated in a population that more fully reflects the diversity of our society.

The COVID-19 pandemic has been associated with disproportionately higher rates of morbidity and mortality in the Black community. [17] We also found that patients identifying as Black were less likely to receive influenza vaccine. Diminished trust in healthcare, emergent from generations of structural racism, could certainly play an important role. Looking at the decreasing rate of vaccination of those in the active registry in our clinic, it could be that members of this community were attempting to protect themselves from exposure to the virus by decreasing exposures to others and reducing their clinic appointments. Financial instability could also make it difficult for families to afford transportation to and from clinic to receive vaccinations. Our findings highlight the significant social complexity of addressing decreasing influenza vaccinations, which has been intensified by the COVID-19 pandemic.

We also suspect that the COVID-19 pandemic has affected beliefs and attitudes toward the importance of influenza vaccination, though our study did not directly assess opinions or perceptions regarding vaccine acceptance in our cohort. Public health measures emphasizing a new SARS-CoV-2 vaccine have been associated with increased discomfort and uncertainty in receiving the vaccines for themselves, let alone their own children. We presume that this uncertainty has extended to decisions around influenza vaccination and would be a next step for further exploration in our cohort. A recent study highlighted mistrust of the COVID-19

vaccine and lower perceived seriousness of COVID-19 infection as the primary determinants of COVID-19 vaccine hesitancy in an adult cohort involving four of the most populated cities in the United States. [18] Another study highlighted that routine childhood vaccine hesitancy has increased during the COVID-19 pandemic due to an increased perception of risk associated with routine immunizations. [19] These results align with our finding of decreased tetanus vaccinations over time, in addition to decreased influenza vaccinations. Therefore, underlying beliefs about the COVID-19 vaccine itself may have negative consequences that extend to other childhood vaccines.

Another possible explanation for decreased influenza vaccine uptake may be related to vaccine fatigue during the COVID-19 pandemic. Vaccine fatigue, defined as a person's inaction toward vaccine information or instruction from perceived burden or burnout, [20] can be due to multiple factors, including vaccine side effects, misconceptions about the severity of an infection and need for vaccination, and lack of trust in policymakers. This phenomenon affects the general public, caregivers, and healthcare workers. In fact, a recent study highlighted that healthcare workers had a statistically significant decrease in influenza vaccination uptake during the COVID-19 pandemic, which may also be due to uncertainty surrounding co-administration of both COVID-19 and influenza vaccinations. [21] Though the CDC highlights the safety of co-administration of COVID-19 vaccines with other routine vaccines in children, including influenza vaccine, on the same day or even within 14 days of each vaccine, [22] vaccine fatigue may have led to decreased uptake.

To assess general vaccination trends of routine immunizations, we also looked at tetanus vaccination rates over time. We chose tetanus vaccinations for comparison as they have historically been a less controversial routine childhood vaccine. We found that tetanus vaccination uptake also decreased over the time of the COVID-19 pandemic. A recent systematic review stated that the majority of studies conducted prior to May 2021 showed decreased routine immunization rates during the COVID-19 pandemic, including tetanus vaccinations. [23] This could be due to COVID-related clinic shutdowns that occurred in an effort to minimize exposures to the virus, causing a delay in routine childhood vaccines. However, even within the most recent influenza season of 2021–22 when clinic visit rates had returned to pre-pandemic baselines, rates of tetanus vaccination remained lower. Based on this information, it leads us to question how the COVID-19 pandemic and its associated new vaccine development and approval could potentially be contributing to overall declines in immunizations.

Our study has several limitations. First, this study occurred at one PPCC site, which could limit generalizability to other clinics. However, as many academic pediatric primary care sites serve predominantly publicly-insured, socioeconomically disadvantaged populations, we feel that this study can advance the knowledge of caring for children at similar sites. Second, we reviewed the total number of any type of tetanus vaccination across each influenza season, and we did not assess for individual variation of age-eligible patients across seasons. However, our clinic has the same relative proportions of ages across time, which led us to believe that using the total numbers of tetanus vaccination within each influenza season would be a reasonable comparison.

This study highlights the need for initiatives that improve influenza vaccination uptake in pediatric primary care, particularly in disadvantaged settings, during the COVID-19 pandemic and beyond. Clinicians and educators need to embrace a variety of interventions to increase vaccination uptake. Since parents who received an educational handout about influenza disease using both local and national data had greater odds of pediatric influenza vaccine uptake compared to those randomized to standard care, traditional methods of information-sharing should remain, but are likely not sufficient alone. [24] We need to utilize novel methods of training to enhance clinician experience and competency in communication skills. In 2015, a virtual reality curriculum teaching pediatric residents communication skills to combat influenza vaccine hesitancy demonstrated improved vaccination rates, with refusal rates going from 37% to 28%. [25] We also need to consider sources that families trust and ensure that evidence-based information exists at these locations, including community centers and churches. [26] The change in influenza vaccination rates during the COVID-19 pandemic provides an opportunity to continue effective practices of the past, augment training to utilize more novel approaches, and work with community members and organizations to ensure patients and families receive high-quality recommendations from trusted sources.

5. Conclusion

Influenza vaccination uptake has declined in our PPCC over the COVID-19 pandemic and has not rebounded. Further investigation to understand the role social risks and disparities have on influenza vaccination uptake are warranted. Initiatives focused on vaccine education and access with patients and families, both within our clinical encounters and at the larger community and national levels, are needed to promote influenza vaccination uptake, especially in vulnerable populations that are at risk for significant morbidity and mortality.

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.

Acknowledgements

We would like to acknowledge that this project was funded by the Research Innovation in Support of Excellence (RISE) resident research grant at Cincinnati Children's Hospital Medical Center. We also greatly appreciate the Pediatric Primary Care Center at Cincinnati Children's Hospital for supporting this project.

Research Funding

This project was funded by the Research Innovation in Support of Excellence (RISE) resident research grant at Cincinnati Children's Hospital Medical Center.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.09.016.

References

[1] Neuzil KM, Mellen BG, Wright PF, Mitchel EF, Griffin MR. The effect of influenza on hospitalizations, outpatient visits, and courses of antibiotics in children. N Engl J Med 2000;342(4):225–31.
[2] https://www.cdc.gov/flu/highrisk/children.htm. Page last reviewed October 25, 2021. Content source Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases (NCIRD).
[3] Shang M, Blanton L, Brammer L, Olsen SJ, Fry AM. Influenza-associated pediatric deaths in the united states, 2010–2016. Pediatrics 2018 Apr;141(4):. https://doi.org/10.1542/peds.2017-2918e20172918.
[4] Kempe A, Saville AW, Albertin C, Zimet G, Breck A, Helmkamp L, et al. Parental hesitancy about routine childhood and influenza vaccinations a national survey. Pediatrics 2020 Jul;146(1):e20193852.
[5] Flu Vaccination Coverage, United States, 2020–21 Influenza Season. Centers for Disease Control and Prevention, National Center for Immunization and

Respiratory Diseases (NCIRD). Page last reviewed October 7, 2021. https://www.cdc.gov/flu/fluvaxview/coverage-2021estimates.htm.
[6] Jaklevic MC. Flu Vaccination Urged During COVID-19 Pandemic. JAMA 2020;324(10):926–7. https://doi.org/10.1001/jama.2020.15444.
[7] RL, Sokol AH, Grummon, COVID-19 and Parent Intention to Vaccinate Their Children Against Influenza. *Pediatrics*. 2020 Dec;146(6):e2020022871. Doi 10.1542/peds.2020-022871. Epub 2020 Sep 30. PMID 32999011 PMCID PMC7706108.
[8] Schweiberger K, Patel SY, Mehrotra A, Ray KN. Trends in pediatric primary care visits during the coronavirus disease of 2019 Pandemic. Academic Pediatrics 2021;21(8):1426–33.
[9] Bolsen T, Palm R. Politicization and COVID-19 vaccine resistance in the U.S. Prog Mol Biol Transl Sci 2022;188(1):81–100. https://doi.org/10.1016/bs.pmbts.2021.10.002.
[10] CB, Bridges SA, Harper K, Fukuda TM, Uyeki NJ, Cox JA, Singleton, Prevention and control of influenza recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2003;52(RR-8):1-34. [Erratum, MMWR Morb Mortal Wkly Rep 2003;52:526.].
[11] Brokamp C, Beck AF, Goyal NK, Ryan P, Greenberg JM, Hall ES. Material community deprivation and hospital utilization during the first year of life an urban population-based cohort study. Ann Epidemiol 2019;30:37–43.
[12] Fogel B, Schaefer EW, Hicks SD. Early influenza vaccination rates decline in children during the COVID-19 pandemic. *Vaccin*e 2021 Jul 13;39(31):4291–5. https://doi.org/10.1016/j.vaccine.2021.06.041. Epub 2021 Jun 17 PMID 34172330.
[13] PC, Roman K, Kirtland Zell ER, et al. Influenza Vaccinations During the COVID-19 Pandemic — 11 U.S. Jurisdictions, September–December 2020. MMWR Morb Mortal Wkly Rep 2021;70:1575–1578. DOI http://dx.doi.org/10.15585/mmwr.mm7045a3external icon.
[14] Sanders-Jackson A, Gonzalez M, Adams RB, Rhodes N. Social determinants of flu vaccine uptake among racial/ethnic minorities in the United States. Prev Med Rep 2021 Aug;12(24):. https://doi.org/10.1016/j.pmedr.2021.101516. PMID 34976601 PMCID PMC8683944101516.
[15] Sharma SV, Chuang R, Rushing M, Naylor B, Ranjit N, Pomeroy M, et al. Social Determinants of Health-Related Needs During COVID-19 Among Low-Income Households With Children. Prev Chronic Dis 2020;17:. https://doi.org/10.5888/pcd17.200322external icon200322.
[16] Beck AF, Henize AW, Qiu T, Huang B, Zhang Y, Klein MD, et al. Reductions in hospitalizations among children referred to a primary care-based medical-legal partnership. Health Aff (Millwood) 2022 Mar;41(3):341–9. https://doi.org/10.1377/hlthaff.2021.00905. PMID 35254924.
[17] Vasquez RM. The Disproportional Impact of COVID-19 on African Americans. Health Hum Rights 2020;22(2):299–307.
[18] Gerretsen P, Kim J, Caravaggio F, Quilty L, Sanches M, Wells S, et al. Individual determinants of COVID-19 vaccine hesitancy. PLoS ONE 2021 Nov 17;16(11):e0258462. https://doi.org/10.1371/journal.pone.0258462. PMID 34788308 PMCID PMC8598046.
[19] He K, Mack WJ, Neely M, Lewis L, Anand V. Parental Perspectives on Immunizations Impact of the COVID-19 Pandemic on Childhood Vaccine Hesitancy. J Community Health 2022;47(1):39–52. https://doi.org/10.1007/s10900-021-01017-9.
[20] Su Z, Cheshmehzangi A, McDonnell D, da Veiga CP, Xiang YT. Mind the "Vaccine Fatigue". Front Immunol 2022 Mar;10(13):. https://doi.org/10.3389/fimmu.2022.839433. PMID 35359948 PMCID PMC8960954839433.
[21] Pascucci D, Nurchis MC, Lontano A, Marziali E, Vetrugno G, Cambieri A, et al. Flu and COVID-19 Vaccination what happens to the Flu Shot When the Campaigns Overlap? Experience from a Large Italian Research Hospital. Vaccines (Basel) 2022 Jun 19;10(6):976. https://doi.org/10.3390/vaccines10060976. PMID 35746583 PMCID PMC9228127.
[22] Interim Guidance for Routine and Influenza Immunization Services During the COVID-19 Pandemic. Centers for Disease Control & Prevention, National Center for Immunization and Respiratory Diseases. Page last reviewed April 15, 2021. https://www.cdc.gov/vaccines/pandemic-guidance/index.html.
[23] S, SeyedAlinaghi A, Karimi H, Mojdeganlou et al. Impact of COVID-19 pandemic on routine vaccination coverage of children and adolescents A systematic review. *Health Sci Rep. 2022;5(2):e00516. Published 2022 Feb 18. doi:10.1002/hsr2.516.*
[24] VP, Scott DJ, Opel J, Reifler S, Rikin K, Pethe A, Barrett Stockwell MS. Office-Based Educational Handout for Influenza Vaccination A Randomized Controlled Trial. Pediatrics. 2019 Aug;144(2):e20182580. Doi 10.1542/peds.2018-2580. Epub 2019 Jul 10. PMID 31292219.
[25] Real FJ, DeBlasio D, Beck AF, Ollberding NJ, Davis D, Cruse B, et al. A virtual reality curriculum for pediatric residents decreases rates of influenza vaccine refusal. Academic Pediatrics 2017;17(4):431–5.
[26] R, Zhang S, Qiao B, McKeever B, Olatosi X, Li "Where the truth really lies" Listening to voices from African American communities in the Southern States about COVID-19 vaccine information and communication. medRxiv 2022.03.21.22272728 doi https://doi.org/10.1101/2022.03.21.22272728.