TECHNICAL REPORT

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

Recommendations for Prevention and Control of Influenza in Children, 2024–2025: Technical Report

Committee on Infectious Diseases

This technical report accompanies the recommendations of the American Academy of Pediatrics for the routine use of influenza vaccine and antiviral medications in the prevention and treatment of influenza in children during the 2024 to 2025 season. The rationale for the American Academy of Pediatrics recommendation for annual influenza vaccination of all children without medical contraindications starting at 6 months of age is provided. Influenza vaccination is an important strategy for protecting children and the broader community against influenza. This technical report summarizes recent influenza seasons, morbidity and mortality in children, vaccine effectiveness, and vaccination coverage and provides detailed guidance on vaccine storage, administration, and implementation. The report also provides a brief background on inactivated (nonlive) and live attenuated influenza vaccines, available vaccines for the 2024–2025 influenza season, vaccination during pregnancy and breastfeeding, diagnostic testing for influenza, and antiviral medications for treatment and chemoprophylaxis. Strategies to promote vaccine uptake are emphasized.

INTRODUCTION

This technical report accompanies the recommendations of the American Academy of Pediatrics (AAP) for the routine use of influenza vaccine and antiviral medications in the prevention and treatment of influenza in children during the 2024–2025 season.[1]

SUMMARY OF RECENT INFLUENZA ACTIVITY IN THE UNITED STATES

Recent influenza seasons in the United States have varied by severity, duration, and impact on children's health (Table 1). Influenza vaccine effectiveness has likewise varied by year, influenza type and influenza A virus subtype, and age group of the child immunized (Fig 1).

abstract

DOI: https://doi.org/10.1542/peds.2024-068508

Address correspondence to Kristina A. Bryant, MD, FAAP. Email: k0brya01@louisville.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FUNDING: No external funding.

FINANCIAL/CONFLICT OF INTEREST DISCLOSURES: Dr Bryant receives honoraria from WebMed and receives a stipend from the American Society of Nephrology.

COMPANION PAPER: A companion to this article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507.

To cite: American Academy of Pediatrics, Committee on Infectious Diseases. Recommendations for Prevention and Control of Influenza in Children, 2024–2025: Technical Report. *Pediatrics*. 2024;154(4):e2024068508

TABLE 1 Summary of Recent Influenza Seasons

	2019–2020	2020–2021	2021–2022	2022–2023[a]
Severity	Moderate	Low	Low	Moderate with high severity in children
Duration	—	—	—	—
Predominant viruses	Influenza B/Victoria – early, influenza A(H1N1)pdm09 – late	Influenza A(H3N2); influenza B (Victoria)	Influenza A(H3N2)	Influenza A(H3N2)
Vaccination coverage in children	62.3%	58.2%	57.8%	55.1%
Hospitalization rate	92.3/100 000 (0–4 y) 23.5/100 000 (5–17 y)	0.8/100 000 overall rate	32.1/100 000 (0–4 y) 14.1/100 000 (5–17 y)	125.7/100 000 (0–4 y) 45.9/100 000 (5–17 y)
Characteristics of hospitalized children	66.9% had ≥1 underlying condition: Asthma 22.9% Neurologic disorder 17.4% Obesity 14%	Not available because of low case numbers	65.7% had ≥1 underlying condition: Asthma: 28.1% Neurologic disorder 16.9% Immunocompromised condition 7%	65.5% had ≥1 underlying condition: Asthma 27.6% Neurologic disorder 15.7% Obesity 14.4%
Pediatric deaths	199: 57.4% without underlying condition 50% of pediatric deaths that were tested had a bacterial coinfection 74% of those who died were vaccine-eligible, but unvaccinated	1	44[2]: 39% without underlying condition 16% of vaccine-eligible children fully vaccinated 7 patients with SARS-CoV-2 coinfection	184: 53.5% without underlying condition Bacterial coinfection in 51.4%
Notable findings	Complicated by COVID-19 pandemic 0.5% of A(H1N1)pdm09 isolates exhibited reduced inhibition by oseltamivir and peramivir Severity considered high in children	Low severity season likely because of COVID-19 mitigation measures reducing spread of all respiratory illnesses 1 reported case of novel influenza A(H1N2) in United States	Influenza activity began to increase in November, declined in January 2022, increased again in March 2022, and remained elevated until mid-June 2022 Higher number of hospitalizations in the second wave 13 human infections with novel influenza A virus identified, including 1 case of avian influenza A(H5) virus (first in a human in the United States)	Influenza activity began in October (earlier than prior seasons)[b] Low proportion of children vaccinated at onset of season High pediatric hospitalization rates, especially in the southeast Cocirculation of SARS-CoV2 and RSV

—, not reported.

[a] Centers for Disease Control and Prevention. Preliminary estimated influenza illnesses, medical visits, hospitalizations, and deaths in the United States—2022–2023 influenza season. Available at: https://www.cdc.gov/flu-burden/php/data-vis/2022-2023.html?CDC_AAref_Val=https://www.cdc.gov/flu/about/burden/2022-2023.htm. Accessed March 20, 2023.

[b] White F, O'Halloran A, Sundaresan D, et al. High influenza incidence and disease severity among children and adolescents aged <18 y-United States, 2022–23 season. *MMWR Morb Mortal Wkly Rep.* 2023;72(41):1108–1114.

2023–2024 Influenza Season

According to the Centers for Disease Control and Prevention (CDC), the 2023–2024 influenza season was moderately severe for children in terms of outpatient medical visits, hospitalizations, and deaths.[3] Nationally, between October 1, 2023 and June 15, 2024, the CDC estimated the burden of influenza in individuals of all ages to include 35 to 65 million illnesses, 16 to 30 million influenza-related medical visits, and 390 000 to 830 000 influenza-and influenza-related hospitalizations (https://www.cdc.gov/flu/about/burden/preliminary-in-season-estimates.htm). The proportion of outpatient visits for influenza-like illness was highest in children 0 to 4 years of age, peaking at 15.49% in late December 2023. Among people younger than 65 years, hospitalization rates continued to be the highest among children <1 year of age (128.3 per 100 000). Cumulative hospitalization rates for influenza among children were comparable to the 2022–2023 season (86 per 100 000 vs 85.3 per 100 000 in patients 0 to 4 years of age and 34.5 per 100 000 vs 29.7 per 100 000 in patients 5 to 17 years of age). In a sample of hospitalized children reported to the Influenza Hospital Surveillance Network (FluSurv-NET), 70.7% had at least 1 underlying medical condition. As in prior years, the most common underlying condition observed in hospitalized children was asthma

Influenza Type/ Age Group	2018–2019 A(H1N1)pdm09 and H3N2 VE%(95% CI)	2019–2020 B/Victoria and A(H1N1)pdm09 VE%(95% CI)	2021-2022 A(H3N2) VE%(95% CI)	2022-2023 A(H3N2) VE%(95% CI)
Influenza A and B				
Overall all ages	29 (21 to 35)	39 (32 to 44)	36 (21 to 48) †	49 (36 to 60) †
6 mo–8 y	48 (37 to 58)	34 (19 to 46)	Not reported	
9–17 y	7 (–20 to 28)	40 (22 to 53)	Not reported	
Influenza A(H1N1)pdm09				
Overall all ages	44 (37 to 51)	30 (21 to 39)	Not reported	56 (28 to 72)
6 mo–8 y	59 (47 to 69)	23 (–3 to 42)	Not reported	
9–17 y	24 (–18 to 51)	29 (–7 to 52)	Not reported	
Influenza A(H3N2)				
Overall all ages	9 (–4 to 20)	Not reported	36 (20 to 49)	45 (29 to 58)
6 mo–8 y	24 (1 to 42)	Not reported	51 (19 to 70)	
9–17 y	3 (–30 to 28)	Not reported	34 (–7 to 59)	
Influenza B Victoria				
Overall all ages	Not reported	45 (37 to 52)	Not reported	Not reported
6 mo–8 y	Not reported	39 (20 to 54)	Not reported	Not reported
9–17 y	Not reported	43 (23 to 58)	Not reported	Not reported
Influenza B Yamagata				
Overall all ages	Not reported	Not reported	Not reported	Not reported
6 mo–8 y	Not reported	Not reported	Not reported	Not reported
9–17 y	Not reported	Not reported	Not reported	Not reported

FIGURE 1

Adjusted vaccine effectiveness (VE)[a] in children in the United States, by season, as reported by the Centers for Disease Control and Prevention (CDC), US Influenza Vaccine Effectiveness Network[b]. [a] VE is estimated as 100% x (1 — odds ratio [ratio of odds of being vaccinated among outpatients with CDC's real-time RT-PCR influenza-positive test results to the odds of being vaccinate among outpatients with influenza-negative test results]); odds ratios were estimated using logistic regression. Adjusted for study site, age group, sex, race and ethnicity, self-rated general health, number of days from illness onset to enrollment, and month of illness using logistic regression. [b] VE could not be assessed for 2020–2021 season because of low virus circulation. However, the A(H1N1)pdm09, A(H3N2), and B/Victoria strains that were genetically characterized were similar to the strains included in the vaccine. † Combined influenza A and B not available, only overall influenza A vaccine efficacy reported (https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2023-02/slides-02-22/influenza-03-Olson-Lewis-Tenforde-508.pdf).

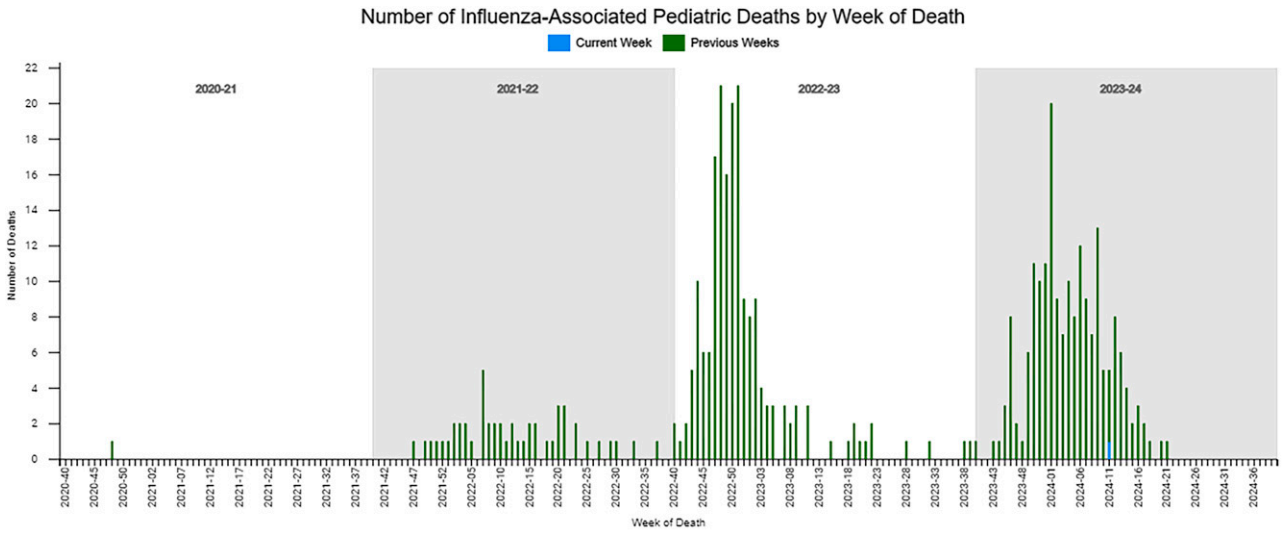
(https://gis.cdc.gov/grasp/fluview/FluHospChars.html). Other common underlying conditions in hospitalized children included neurologic disease (21.2%) and obesity (17.6%).

Through July 27, 2024, 188 influenza-related pediatric deaths were reported by the CDC[3] (Fig 2). In an interim analysis of 103 of these deaths, 38 occurred in children younger than 5 years. More than half of the pediatric deaths occurred in children without a preexisting medical condition known to be associated with a higher risk for severe influenza. Of 89 children eligible for influenza vaccination for whom vaccination status was known, 88% were not fully immunized against influenza.

Through July 6, 2024, more than 69% of the influenza viruses identified were influenza A, with a predominance of H1N1pdm09 (66.5% of isolates with subtyping performed). Most influenza A and B viruses tested were genetically and antigenically similar to viruses contained in seasonal influenza vaccines, and this was reflected in estimates of vaccine effectiveness (VE) (https://www.cdc.gov/flu/weekly/index.htm). In an interim analysis of VE during the 2023–2024 season, VE against influenza-associated acute respiratory tract infection for children 6 months through 17 years of age ranged from 59% to 67% in outpatient settings; VE was 52% to 61% against influenza-associated hospitalization.[4]

A human infection with a novel influenza A virus, an influenza A(H1N2) variant, was reported in March of 2024. The infected person was <18 years of age, had contact with swine before illness onset, and fully recovered. Person-to-person transmission of this variant virus was not detected.

Highly pathogenic avian influenza (HPAI) A (H5N1) continues to circulate among wild birds in the United States, with sporadic outbreaks in poultry and backyard flocks. Sporadic cases occur in mammals, including cattle. Human cases remain rare. In March 2024, an individual working on a dairy farm in Texas tested positive for HPAI A (H5N1); the virus was also isolated from dairy cattle and wild birds in the area.[5] Subsequently, 2 human



Seasons	Total Deaths	Deaths reported During the Week Ending 27 Jul 2024
2020-21	1	0
2021-22	49	0
2022-23	186	0
2023-24	188	1

FIGURE 2
Influenza-associated pediatric deaths by season. From: https://www.cdc.gov/flu/weekly/. Accessed July 31, 2024.

cases were identified in dairy farm workers in Michigan; both had contacts with infected cows.[6,7] In July 2024, a fourth case was identified in a dairy farm worker in Colorado.[8] Most of the infected individuals experienced only eye symptoms or conjunctivitis, and all recovered. None of the 4 cases were associated with the others, and as of June 14, 2024, there is no indication of person-to-person spread of HPAI A(H5N1) viruses. The CDC provides H5N1 situation updates at https://www.cdc.gov/bird-flu/situation-summary/index.html.

Information about influenza surveillance is available through the CDC Voice Information System (1–800-232–4636) and is posted weekly on the CDC Web site (www.cdc.gov/flu/index.htm).

INFLUENZA MORBIDITY AND MORTALITY IN CHILDREN

In a typical influenza season, the disease burden among children is substantial. Each year, an estimated 8% to 10% of US children develop symptomatic influenza virus infection.[9,10] Children infected with influenza virus are more likely to exhibit symptoms than adults. In 2 community-based prospective cohort studies conducted in Managua, Nicaragua, influenza was asymptomatic in just 6.6% infected children ≤14 years of age, although the asymptomatic fraction increased with age (1.7%, 3.5%, and 9.1% for ages 0–1, 2–4, and 5–14 years, respectively; $P < .001$).[11]

Clinical syndromes associated with influenza virus infection include a nonspecific febrile illness with or without upper respiratory symptoms, bronchiolitis, croup, or a pertussis-like illness. Bacterial complications include otitis media, pneumonia, sinusitis, and bloodstream infections. Among children <16 years of age hospitalized with laboratory-confirmed influenza at 12 Canadian hospitals, bloodstream infections occurred in 0.9% and were associated with ICU admission, need for mechanical ventilation, and longer lengths of stay.[12] *Staphylococcus aureus* and *Streptococcus pneumoniae* were the most common pathogens. Viral infections, including influenza, have previously been identified as risk factors for invasive bacterial infections, including invasive group A streptococcal infections.[13,14] According to the CDC, from 2016 to 2022, increases in invasive group A streptococcal infections coincided with seasonal peaks in respiratory syncytial virus (RSV) and influenza hospitalization rates during most years except 2021.

Neurologic complications of influenza include febrile seizures, nonfebrile seizures, and encephalopathy. Approximately 8% to 11% of hospitalized children experience neurologic complications, and these are more frequent in children with underlying neurologic conditions and children who are unimmunized.[15,16] Thromboembolic events, including stroke, occur in children with influenza but are rare.[17]

Hospitalization rates of children with influenza are highest in those younger than 5 years.[9,18] Over 9 influenza seasons in

the United States after the 2009 H1N1 pandemic, adjusted influenza-associated hospitalization incidence rates ranged from 10 to 375 per 100 000 persons <18 years of age each season; rates were highest among infants <6 months of age and decreased with increasing age.[19]

Morbidity in children hospitalized with influenza is substantial, as demonstrated by population-based surveillance for influenza-associated hospitalizations conducted by the Influenza Hospitalization Surveillance Network.[20] Between October 2019 and April 2021, 6774 children 0 through 17 years of age were hospitalized with influenza; 17.8% had pneumonia, 21.6% required admission to the ICU, and 5.3% were mechanically ventilated. Outcomes were generally similar to children admitted with coronavirus disease 2019 (COVID-19) between October 2021 and April 2022, although the median length of stay was shorter for patients with influenza (2 days versus 3 days; $P < .01$). In-hospital mortality was 0.5% of children with influenza compared with 0.7% of children with COVID-19.

Limited data suggest that children hospitalized with influenza and concurrent severe acute respiratory coronavirus 2 (SARS-CoV-2) infection have more severe disease. During the 2021–2022 influenza season, 6% of children hospitalized with influenza had concurrent SARS-CoV-2 infection. Compared with patients without coinfection, higher proportions of children with coinfections received invasive mechanical ventilation (13% vs 4%; $P = .03$) and bilevel positive air pressure or continuous positive air pressure (16% vs 6%; $P = .05$).[2]

Postdischarge respiratory sequelae occur in children hospitalized with critical respiratory illness attributable to influenza. In one study ($n = 165$), 78% of children with preexisting asthma experienced asthma symptoms in the 90 days after discharge, and 13% required readmission to the hospital.[21] Among patients without preexisting asthma, 11.1% had asthma newly diagnosed ($n = 10$).

During 12 of the last 13 influenza seasons, influenza-associated deaths in children have ranged from 37 in the 2011–2012 season to 199 in the 2019–2020 season (a single pediatric death was reported during the 2020–2021 season, coincident with very low circulation of seasonal influenza viruses).[22] According to the CDC, pediatric influenza deaths are likely underreported, as not all children whose death was related to influenza virus infection may have had viral testing.[23] Deaths from influenza occurred in children with and without other underlying medical conditions, and as in the most recent influenza season, most deaths occurred in children who are unvaccinated or incompletely vaccinated.[24]

HIGH-RISK GROUPS IN PEDIATRICS

Children younger than 5 years (especially those younger than 2 years) and children of any age with certain underlying medical conditions have a high risk of complications from influenza (see Table 4 in the policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]). These medical conditions include obesity, a condition that affects more than 14 million children and adolescents in the United States.[25] In a recent systematic review and meta-analysis, obesity increased the odds of hospitalization in children with influenza, although the definition of obesity varied among included studies.[26] Additionally, in children hospitalized for influenza, obesity was associated with a worse prognosis, including ICU admission and death.

Influenza vaccination is particularly important in these high-risk groups (see Table 4 in the policy statement) and populations disproportionately affected by severe influenza outcomes. Health disparities are apparent in both influenza diagnoses as well as influenza morbidity and mortality.[27] In one test-negative case control study conducted in an urban population of children <14 years of age, public or self-pay insurance was associated with increased risk of an influenza diagnosis.[28] In a retrospective cohort study using the National Inpatient Sample from January 1, 2008, to December 31, 2017, Hispanic (adjusted odds ratio [aOR], 1.25; 95% confidence interval [CI], 1.17 to 1.33), non-Hispanic-Black (aOR, 1.21; 95% CI, 1.17 to 1.33) and non-Hispanic other children (aOR, 1.11; 95% CI, 1.04 to 1.19) were more likely to be hospitalized with an influenza diagnosis than non-Hispanic white children, although mortality was similar.[29] In a cross-sectional study that included 10 influenza seasons, higher rates of severe influenza disease were reported in Black, Hispanic, American Indian/Alaska Native, and Asian/Pacific Islander people compared with white people, and differences were pronounced in children ≤4 years of age.[30] In this age group, hospitalization rates were higher in Black children (relative risk [RR], 2.21; 95% CI, 2.10 to 2.33), Hispanic children (RR, 1.87; 95% CI, 1.77 to 1.97), American Indian/Alaska Native children (RR, 3.00; 95% CI, 2.55 to 3.53), and Asian/Pacific Islander children (RR, 1.26; 95% CI, 1.16 to 1.38) compared with white children. Rates of ICU admission were also higher (Black children: RR, 2.74; 95% CI, 2.43 to 3.09; Hispanic children: RR, 1.96; 95% CI, 1.73 to 2.23; American Indian/Alaska Native children: RR, 3.51; 95% CI, 2.45 to 5.05). The rate of in-hospital death was threefold to fourfold higher in Black, Hispanic, and Asian/Pacific Islander children compared with white children. Disparities have also been noted in subpopulations of children with high-risk medical conditions. In pediatric solid organ transplant recipients, for example, the risk of an influenza-associated hospital encounter was higher in non-Hispanic Black patients (adjusted subdistribution hazard ratio, 1.63; 95% CI, 1.28 to 2.07; $P < .001$) and Hispanic patients (adjusted subdistribution hazard ratio, 1.57; 95% CI, 1.27 to 1.94; $P < .001$) compared with non-Hispanic white patients.[31] Importantly, factors associated with disparities observed with other respiratory viruses (eg, SARS-CoV-2 and respiratory

syncytial virus [RSV]), including lack of access to quality health care, crowded living conditions, and social vulnerability, were not evaluated in these studies.[32,33]

Although protecting all children against influenza through timely vaccination remains critically important, increased efforts are needed to eliminate barriers to immunization in all people experiencing higher rates of complications from infection with influenza viruses.

EFFECTIVENESS OF INFLUENZA VACCINATION ON MORTALITY, HOSPITALIZATION, LABORATORY-CONFIRMED INFLUENZA ILLNESS IN AMBULATORY CHILDREN, AND ANTIBIOTIC USE

Although influenza vaccination does not prevent all cases of influenza, it does offer substantial health benefits, including protection against severe and life-threatening disease and reduced health resources utilization.

Mortality

Historically, up to 80% of influenza-associated pediatric deaths have occurred in unvaccinated or incompletely vaccinated children.[24] Influenza vaccination is associated with reduced risk of laboratory-confirmed influenza-related pediatric death.[34] In one case-cohort analysis of laboratory-confirmed influenza-associated pediatric deaths in the United States from 2010 to 2014, overall VE against influenza-associated death in all children was 65% (95% CI, 54% to 74%) and 51% (95% CI, 31% to 67%) in children with underlying conditions.[34] Similarly, in a case control study conducted over 2 influenza seasons (2010 to 2012), influenza vaccination was associated with a three-quarters reduction in the risk of life-threatening influenza illness in children.[35] During the 2022–2023 season, influenza vaccination prevented an estimated 116 deaths in children 6 months through 17 years of age (https://www.cdc.gov/flu/about/burden-prevented/2022-2023.htm).

Hospitalization

A robust body of evidence supports the effectiveness of influenza vaccination in preventing hospitalization in children, even during seasons in which overall vaccine effectiveness is lower (Table 2).[36–47] According to a systematic review, VE is the highest in children younger than 5 years.[40] During the 2022–2023 season, the CDC estimates that influenza vaccination prevented 11 723 hospitalizations in children 6 months through 17 years of age (https://www.cdc.gov/flu/about/burden-prevented/2022-2023.htm). VE against influenza A-associated hospitalization was 40% (95% CI, 6% to 61%), with higher point estimates among children 6 months through 4 years of age (56%; 95% CI, 23% to 75%) compared with children 5 through 17 years of age (46%; 95% CI, 2% to 70%).[48]

Laboratory-Confirmed Influenza Illness and Medically Attended Influenza Illness in Ambulatory Settings

In an analysis of US Influenza Vaccine Effectiveness Network data that included 9 seasons (from 2011–2012 through 2019–2020), pooled VE against outpatient influenza illness was 46% (95% CI, 43 to 50).[49] VE was lowest against influenza A(H3N2)-associated illness (33% [95% CI, 27 to 39]), and estimates were similar for influenza B (54% [95% CI, 49 to 59]) and influenza A(H1N1)pdm09 (57% [95% CI: 51, 62]). VE was highest for children 6 through 59 months of age compared with older children. During the 2022–2023 season, the CDC estimates that influenza vaccination prevented 1 912 522 symptomatic flu-related illnesses and 994 512 medical visits in children 5 through 17 years of age, a group in whom adjusted VE was 45.2% (95% CI, 15.4 to 63.4) (https://www.cdc.gov/flu/about/burden-prevented/2022-2023.htm). In children 6 months through 4 years of age, adjusted VE was higher (53.6% [95% CI, 29.7 to 70.7]), resulting in an estimated 929 408 symptomatic flu-related illnesses and 622 704 medical visits prevented. Vaccination reduced the risk of influenza-associated urgent care or emergency department visits by nearly half.[48]

Antibiotic Use in Ambulatory Children

In one population-based retrospective cohort study spanning 2012 through 2017, the antibiotic prescription rate in ambulatory children declined by 3 per 1000 person-months for each 1% increase in influenza vaccination coverage.[50]

SEASONAL INFLUENZA VACCINES

The seasonal influenza vaccines licensed for children and adolescents for the 2024–2025 season are described in Table 2 in the policy statement (www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507). All 2024–2025 seasonal influenza vaccines for use in the United States are trivalent and contain hemagglutinin derived from the same influenza strains as recommended by the World Health Organization (WHO) and the US Food and Drug Administration (FDA)'s Vaccines and Related Biological Products Advisory Committee for the Northern Hemisphere (see Table 1 in the policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]).[51,52] The influenza A(H3N2) component is different this season compared with last season, whereas the influenza A (H1N) and influenza B Victoria lineage components are unchanged. Influenza B Yamagata lineage virus has not been detected globally since 2020 and has been removed from seasonal influenza vaccines in accordance with recommendations of the FDA and WHO. Different but antigenically related influenza A strains are included in this season's egg-based and cell-based or recombinant vaccines. However, they are still matched to the strains expected to circulate in the 2024–2025 season.

TABLE 2 Adjusted Influenza Vaccine Effectiveness (VE) Against Influenza Hospitalization, Representative Studies

Author/Setting[a]	Seasons Included	Population Studied	*N*	Adjusted VE Partially Vaccinated[b] (95% CI)	Adjusted VE Fully Vaccinated (95% CI)
Feldstein/US New Vaccine Surveillance Network	2015–2016	6 mo to 17 y	1653	18% (−44 to 54)	56% (34 to 71)
Israel/Segaloff	2015–2016 2016–2017 2017–2018	6 mo to 8 y	3147	25.6% (−3.0 to 47.0)	53.9% (38.6 to 68.3)
Australia/Blyth	2018	≤16 y	458	NR	86.1% (76.3 to 91.9)
United Kingdom/Pebody	2018–2019	2–17 y	986	NR	53.0% (33.3 to 66.8): A(H1N1): 63.5% (34.4 to 79.7) A(H3N2): 31.1% (53.9 to 69.2)
Systematic Review/Kalligeros	2005–2019	6 mo to 17 y	NR	33.91(21.12 to 46.69)	61.79 (54.45 to 69.13)
Japan/Shinjoh	2018–2019	6 mo to 15 y	205	NR	56% (16 to 77)[c]
Atlanta, Georgia/Yildirim	2012–2013 2013–2014 2014–2015 2016–2016 2016–2017	6 mo to 17 y	980	46.8% (23.8 to 62.8)	55.3% (31.7 to 70.7)
Hong Kong/Cowling	2023	9 mo to 17 y	1671	NR	69.6% (49.3% to 81.7%)

NR, not reported.
[a] Laboratory-confirmed influenza hospitalization.
[b] Included only patients 6 months to 8 years.
[c] Included patients with full and partial vaccination.

Inactivated Influenza Vaccine

For the 2024–2025 season, among inactivated vaccines available for children, 4 are egg-based (seed strains grown in eggs), and 1 is cell culture-based (seed strains grown in Madin-Darby canine kidney cells) (see Table 2 in policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]). All inactivated egg-based vaccines (Afluria, Fluarix, FluLaval, and Fluzone) and 1 cell culture-based based vaccine (Flucelvax) are licensed for children 6 months and older, and all are available in single-dose, thimerosal-free, prefilled syringes.[53]

A trivalent recombinant baculovirus-expressed hemagglutinin influenza vaccine (RIV3 [Flublok]) is licensed only for people 18 years and older. A trivalent high-dose inactivated (nonlive) influenza vaccine (HD-IIV3 [Fluzone High Dose) and a trivalent MF-59 adjuvanted inactivated vaccine (aIIV3 [Fluad]) are licensed for people 65 years and older.[53] In June 2022, the Advisory Committee on Immunization Practices (ACIP) recommended preferential use of a higher dose or adjuvanted influenza vaccine for adults 65 years and older.[53] Adjuvanted seasonal influenza vaccines are not licensed for children in the United States; however, studies of adjuvanted vaccines in children have been performed and evaluation is ongoing.[54–57]

Children 6 months and older can receive any licensed, age-appropriate inactivated (nonlive) influenza vaccine (IIV). Trivalent egg-based and cell culture-based IIVs contain 15 μg hemagglutinin from each strain in 0.5 mL. The recommended dose volume (and, therefore, the recommended antigen content) for younger children varies by product. The dose of Fluarix, FluLaval, and Flucelvax is 0.5 mL for all children 6 months and older.[58] Children 6 through 35 months of age can receive a 0.25 mL or 0.5 mL dose of Fluzone from a multidose vial; 0.5 mL prefilled syringes are also available.[59] These 2 doses demonstrated comparable safety and immunogenicity in a single, randomized multicenter study.[60] Children 3 years and older should receive 0.5 mL. Afluria is supplied in multidose vials and in 0.5 mL single-dose syringes. The dose of Afluria is 0.5 mL for children 3 years and older and 0.25 mL for children 6 through 35 months of age.[61] For children 6 through 35 months of age, the recommended 0.25 mL dose should be obtained from a multidose vial.

IIV Storage

The CDC has published Best Practice Guidelines (https://www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html and https://www.cdc.gov/vaccines/hcp/admin/storage/toolkit/index.html) for vaccine storage and administration. Additionally, the AAP offers guidance on the components of a written disaster plan, including a comprehensive vaccine management protocol to keep the vaccine storage temperature constant during a power failure or other disaster (see the AAP Pediatric Preparedness Resource Kit at https://downloads.aap.org/AAP/PDF/PedPreparednessKit.pdf).

IIVs for intramuscular injection are shipped and stored at 2°C to 8°C (36°F to 46°F); vaccines that are inadvertently frozen should not be used.

IIV Administration

Vaccines are administered intramuscularly into the anterolateral thigh of infants and young children and into the

deltoid muscle of older children and adults. Given that various IIV formulations are available, careful attention should be paid to ensure that each product is used according to its approved age indication, dosing, and volume of administration (see Table 2 in the policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]). For vaccines that include a multidose vial presentation, the maximum number of doses drawn from a multidose vial is specified in the package insert and should not be exceeded; residual product must be discarded regardless of the remaining volume in the vial. A 0.5 mL prefilled syringe of any IIV should not be split into 2 separate 0.25 mL doses. If a prefilled syringe of Fluzone is used for a child younger than 36 months, the dose volume will be 0.5 mL per dose.

Coadministration of Inactivated Influenza Vaccine and Other Immunizations

Recommendations for concomitant administration of influenza vaccine and other immunizations are detailed in the policy statement.[1] Influenza vaccine can be administered to children concomitantly or at any time before or after administration of nirsevimab. Influenza vaccine can also be administered concomitantly or any time before or after currently available COVID-19 vaccines.[62–65] Through June 20, 2022, reports to the Vaccine Adverse Event Reporting System after coadministration of messenger RNA (mRNA) COVID-19 and seasonal influenza vaccines in persons 6 months and older did not reveal any unusual or unexpected patterns of adverse events.[63] Reports to V-safe, a CDC-sponsored smartphone-based safety surveillance system, identified a significant increase in systemic adverse reactions in persons 12 years and older during the week after vaccination who received simultaneous administration of COVID-19 mRNA booster and seasonal influenza vaccines compared with those who received only a COVID-19 mRNA booster alone.[64] Reactions were generally mild, and pediatric-specific data were not reported. Physicians and other clinicians who provide medical care to children are encouraged to consult the most current guidance from the AAP and the CDC regarding coadministration of COVID-19 vaccines with other vaccines.[65] Overall, the benefits of timely vaccination with same-day administration of IIV and other recommended vaccines outweigh the risk of potential reactogenicity in children.

Safety of IIV

IIVs are well tolerated in children and can be used in healthy children as well as those with underlying chronic medical conditions. The most common injection site adverse reactions after administration of IIV in children are injection site pain (17% to 67%), redness (13% to 37%), and swelling (10% to 25%). The most commonly reported systemic adverse events are drowsiness (13% to 38%), irritability (14% to 54%), abnormal crying (33% to 41%), loss of appetite (11% to 32%), fatigue (10% to 20%), muscle aches (10% to 39%), headache (10% to 23%), arthralgia (10% to 13%), and gastrointestinal tract symptoms (10% to 20%). Fever can occur, especially in children 6 through 35 months of age, but is uncommon. Recombinant influenza vaccine (RIV) is well-tolerated in older adolescents and adults. In people 18 to 49 years of age, the most common injection site reactions are tenderness (48%) and pain (37%). The most common (≥10%) solicited systemic adverse reactions are headache (20%), fatigue (17%), myalgia (13%), and arthralgia (10%). Adverse reactions for each vaccine are described in package inserts. Package inserts for US-licensed vaccines are available on the FDA Web site.[58]

The AAP supports the current WHO recommendations for use of thimerosal as a preservative in multiuse vials in the global vaccine supply.[66] Thimerosal-containing vaccines are not associated with an increased risk of autism spectrum disorder in children.[67,68] Thimerosal from vaccines has not been linked to any neurologic condition. Despite the lack of evidence of harm, some states have legislation restricting the use of vaccines that contain even trace amounts of thimerosal. The benefits of protecting children against the known risks of influenza are clear. Therefore, to the extent permitted by state law, children should receive any available formulation of IIV rather than delaying vaccination while waiting for reduced-thimerosal content or thimerosal-free vaccines. IIV formulations that are free of even trace amounts of thimerosal are widely available, as described in Table 2 in the policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]. Additional information to assist clinicians in responding to parental concerns about thimerosal is available at https://www.cdc.gov/vaccinesafety/concerns/thimerosal/index.html.

Vaccination in the Setting of Immunosuppression

Nonlive vaccines, including IIVs, are safe in persons with altered immune competence, but immunogenicity may be diminished. Decreases in immunogenicity vary by underlying condition. Guidelines for the immunization of immunocompromised children and adults and have been published by the Infectious Diseases Society of America and the CDC.[69,70] Guidelines for the immunization of solid organ transplant recipients have been published by the American Society of Transplantation.[71] The CDC has published additional recommendations for influenza immunization of adult solid organ transplant recipients.[53] In June 2024, the ACIP recommended high-dose inactivated (HD-IIV3) and adjuvanted inactivated (aIIV3) influenza vaccines as acceptable options for influenza vaccination of solid organ transplant recipients aged 18 through 64 years who are on immunosuppressive medication regimens, without a preference over

other age-appropriate IIV3s or RIV3. Studies in pediatric solid organ transplant recipients are ongoing.

Live Attenuated (Intranasal) Influenza Vaccine

Overview

The history of live attenuated influenza vaccine (LAIV) use in the United States, along with a detailed discussion of vaccine efficacy over serial seasons, is available in the 2021 technical report.[72] For the 2024–2025 season, trivalent live attenuated influenza vaccine (LAIV3) has replaced quadrivalent live attenuated influenza vaccine (LAIV4) in the United States.

Storage and Administration

The cold-adapted, temperature-sensitive LAIV3 formulation is shipped and stored at 2°C to 8°C (36°F to 46°F). LAIV3 is administered intranasally in a prefilled, single-use sprayer containing 0.2 mL of vaccine. A removable dose-divider clip is attached to the sprayer to facilitate administration of 0.1 mL separately into each nostril. If the child sneezes immediately after administration, the dose should not be repeated. Administration of LAIV intranasally is not an aerosol-generating procedure; however, vaccine administrators are advised to wear gloves when administering LAIV given the potential for contact with respiratory secretions.

Coadministration of LAIV and Other Vaccines

LAIV may be administered simultaneously with other inactivated or live vaccines. If not administered simultaneously, it is recommended that administration of injectable live vaccines is separated by a 4-week interval from LAIV vaccination. Oral typhoid vaccine and oral rotavirus vaccine can be administered simultaneously with or at any interval before or after LAIV.[73]

In 2023, the US FDA accepted for review an application from Astra Zeneca to allow eligible adult patients to self-administer LAIV; caregivers would be allowed to be able to administer the vaccine to eligible children 2 years and older.[74] As of July 15, 2024, the application is still under review.

Safety of LAIV

The most commonly reported reactions of LAIV in children are runny nose or nasal congestion (32%), headache (13%), decreased activity (10%), sore throat (9%), decreased appetite (6%), muscle aches (4%), and fever (7%).[75]

LAIV and Immunocompromised Hosts

IIV (or RIV, if age-eligible) is the vaccine of choice for severely immunocompromised patients and anyone in close contact with a subset of severely immunocompromised people (ie, those requiring a protected environment). This preference is based on the theoretical risk of infection attributable to an LAIV strain in an immunocompromised contact of an LAIV-immunized person. Health care personnel (HCP) immunized with LAIV may continue to work in most units of a hospital, including the NICU and general oncology ward, using standard infection control techniques. As a precautionary measure, people recently vaccinated with LAIV should restrict contact with severely immunocompromised patients (eg, those requiring a protective environment) for 7 days after vaccination, although there have been no reports of LAIV transmission from an LAIV-vaccinated person to an immunocompromised person.[76] In the theoretical scenario in which an immunocompromised host develops a symptomatic LAIV infection, the LAIV strains are susceptible to antiviral medications.

LAIV and Asthma/Wheezing

The AAP and ACIP currently consider asthma in persons aged ≥5 years to be a precaution for LAIV. LAIV administration is contraindicated in children 2 through 4 years of age who have received a diagnosis of asthma or whose parents or caregivers report that a health care provider has told them during the preceding 12 months that their child had wheezing or asthma or whose medical record indicates a wheezing episode has occurred during the preceding 12 months.[1,53] This language differs from the LAIV package insert for the 2023–2024 season, which states, "Children younger than 5 years of age with recurrent wheezing and persons of any age with asthma may be at increased risk of wheezing after administration of FluMist." A systematic literature review that included 14 studies over 20 years[77] demonstrated that LAIV was well tolerated in children and adults 2 through 49 years of age with mild to moderate asthma or recurrent wheeze, with no safety concerns or increased risk identified for any of the respiratory outcomes measured when comparing LAIV-AA with injectable influenza vaccines or nonvaccine controls. In a study of 151 children 5 through 17 years of age with asthma who were randomized to receive IIV4 or LAIV4, LAIV4 was not associated with increased frequency of asthma exacerbations or an increase in asthma-related symptoms compared with IIV4.[78] The use of LAIV in children with asthma and wheezing deserves additional review. As of July 15, 2024, current ACIP recommendations are unchanged while data continue to accumulate and are reviewed by expert groups.

TIMING OF INFLUENZA VACCINATION AND DURATION OF PROTECTION

Although peak influenza activity in the United States typically occurs from January through March, influenza viruses can begin to circulate in early fall (October), as occurred in the 2022–2023 season. Circulation can continue to late spring (May or later), with one or more disease peaks, as was the case in the 2021–2022 season. The typical pattern of circulation was substantially

altered during the COVID-19 pandemic. Predicting the onset and duration or the severity of the influenza season with accuracy is impossible. Timely influenza vaccination is important to ensure that individuals are optimally protected before influenza viruses are circulating in the community. Thus, the AAP and CDC recommend children, especially those who need 2 doses, should be immunized as soon as a vaccine becomes available and complete influenza vaccination by the end of October. Because the duration of the influenza season is unpredictable, practices should continue to vaccinate individuals as long as influenza viruses are circulating and an unexpired vaccine is available (no influenza vaccines in the United States are labeled with an expiry date past June 30 of the prior influenza season[79]).

Immunity after influenza vaccination can wane over time.[80] Studies in adults suggest that very early vaccination (July or August) might be associated with suboptimal immunity before the end of the influenza season, and the CDC now discourages influenza vaccination in the summer months for most adults.[53] There is less evidence of waning immunity in children.[81–83] In some studies in children, VE decreased within a single influenza season, and this decrease correlated with increasing time after vaccination. However, this decay in VE was not consistent across different age groups and varied by season and virus types and influenza A virus subtypes.[81,84–91] Waning VE was more evident among older adults and younger children[85,87] and with influenza A(H3N2) viruses more than influenza A(H1N1) or B viruses.[81,86,90] Most recently, waning immunity after influenza vaccination was studied over 9 influenza seasons in Ontario, Canada.[92] In a cohort of individuals ≥6 months vaccinated during the 2011–2012 to the 2018–2019 seasons, the odds of laboratory-confirmed influenza increased 1.09 times every 28 days since vaccination, but waning immunity varied by season, influenza subtype, and age group. Unlike older persons, individuals <18 years had lower odds of influenza at subsequent intervals, and waning protection was not observed. A systematic review and meta-analysis that included 3 studies of influenza-vaccinated children found that antibody levels waned over time but remained elevated compared with prevaccination levels for 6 months after vaccination.[93] Adjuvanted vaccines, which are not currently available for children, elicited higher antibody responses than standard vaccines. In a cohort of influenza vaccine-naive patients 6 to <24 months of age in Nicaragua who received a single dose of vaccine, VE against laboratory-confirmed influenza illness declined 9% per month in the first 4 months after immunization and then plateaued.[94] Waning of immunity after 2 doses of vaccine, as is recommended in the United States, was not studied. Collectively, these studies support the current recommendation to immunize children as soon as possible after a vaccine becomes available. An early onset of the influenza season, as occurred for the 2022–2023 season, is a concern when considering delaying vaccination, and delays increase the likelihood of missing influenza vaccination altogether.[53]

Although influenza activity in the United States is typically low during the summer, influenza cases and outbreaks can occur, particularly among international travelers who may be exposed to influenza year-round, depending on destination. Influenza can occur throughout the year in the tropics. The CDC has recommended that individuals who did not receive the current seasonal influenza vaccine during the Northern Hemisphere fall and winter season, and who are traveling to parts of the world where influenza activity is ongoing, should consider seasonal influenza vaccination ≥2 weeks before departure, if available.[95] This includes persons traveling to the tropics, to destinations in the Southern Hemisphere during the Southern Hemisphere influenza season (April to September), or on cruise ships or with organized tourist groups during an influenza season.[53]

INFLUENZA VACCINE CONSIDERATIONS FOR SUBPOPULATIONS INCLUDING CONTRAINDICATIONS AND PRECAUTIONS

Contraindications and precautions to available influenza vaccines are detailed in Table 5 in the policy statement (www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507). A precaution for vaccination is a condition that might increase the risk or seriousness of a vaccine-related adverse reaction, might compromise the ability of the host to develop immunity after vaccination, or might cause diagnostic confusion.[96] Vaccination may be recommended in the presence of a precaution if the benefit of protection from the vaccine outweighs the potential risks.

Previous Allergic Reaction: Contraindication

Although a severe allergic reaction (eg, anaphylaxis) to a previous dose of any influenza vaccine is generally a contraindication to future receipt of influenza vaccines, the AAP recommends that children who have had an allergic reaction after a previous dose of any influenza vaccine be evaluated by an allergist to determine whether future receipt of the vaccine is appropriate. Children who are allergic to gelatin (very rare) should receive IIV3 instead of LAIV3. RIV3 is an option for patients with gelatin allergy who are ≥18 years of age.

Moderate or Severe Illness, Including COVID-19: Delay Is Recommended

Mild illnesses, with or without fever, are neither precautions nor contraindications to the use of influenza vaccines, including among children with mild upper respiratory infection symptoms or allergic rhinitis. In children judged by the clinician to have a moderate to severe illness, vaccination should be deferred until resolution of the illness (https://www.cdc.gov/vaccines/covid-19/clinical-considerations/interim-considerations-us.html#contraindications). Children

with an amount of nasal congestion that would notably impede vaccine delivery into the nasopharyngeal mucosa may receive IIV or should have LAIV deferred until symptom resolution.

Guillain-Barré Syndrome: Precaution

History of Guillain-Barré syndrome (GBS) after influenza vaccine is considered a precaution for the administration of influenza vaccines. GBS is rare, especially in children, and there is a lack of evidence on the risk of GBS after influenza vaccination in children. Nonetheless, regardless of age, a history of GBS less than 6 weeks after a previous dose of influenza vaccine is a precaution for administration of influenza vaccine. GBS may occur after influenza virus infection. The benefits of influenza vaccination might outweigh the risks for certain people who have a history of GBS (particularly if not temporally occurring after prior influenza vaccination) and who also are at high risk for severe complications from influenza.

Influenza Vaccines and Egg Allergy: Not a Contraindication or Precaution

There is strong evidence that individuals with egg allergy can safely receive influenza vaccine without any additional precautions beyond those recommended for any vaccine.[97,98] The presence of egg allergy in an individual is not a contraindication to receive IIV or LAIV. Vaccine recipients with egg allergy are at no greater risk for a systemic allergic reaction than those without egg allergy. Therefore, precautions, such as choice of a particular vaccine, special observation periods, or restriction of administration to particular medical settings, are not warranted and constitute an unnecessary barrier to vaccination. It is not necessary to inquire about egg allergy before the administration of any influenza vaccine, including on screening forms. Routine prevaccination questions regarding anaphylaxis after receipt of any vaccine are appropriate. Standard vaccination practice for all vaccines in children should include the ability to respond to rare acute hypersensitivity reactions.

Pregnancy: IIV Recommended, Not a Contraindication or Precaution

Influenza vaccination is recommended by the ACIP, the American College of Obstetricians and Gynecologists, and the American Academy of Family Physicians for all pregnant individuals, during any trimester of gestation, to protect against influenza and its complications.[53,99] Influenza vaccination prevents laboratory-confirmed influenza disease and its complications in pregnant individuals and protects their infants in the first months of life (up to 6 months) through transplacental passage of antibodies.[99–109] Two recently published studies reinforce the benefits of influenza vaccination during pregnancy to infants. Over 9 influenza seasons in Ontario, Canada, vaccination during any trimester was associated with reduced risk of laboratory-confirmed influenza (VE 64% [95% CI, 50% to 74%]) and influenza hospitalization (VE 67% [95% CI, 50% to 78%]) during the first 6 months of life.[110] In a prospective, test-negative case control study that analyzed data from the New Vaccine Surveillance Network (2016–2017 to 2019–2020), VE in infants younger than 6 months was 39% against influenza-associated hospitalization (95% CI, 12% to 58%) and 19% against influenza-associated emergency department (ED) visits (95% CI, −24% to 48%).[111] Effectiveness was highest among infants <3 months and infants born to mothers vaccinated during the third trimester.

Any licensed, recommended, and age-appropriate inactivated influenza vaccine may be administered to pregnant individuals during any trimester of gestation and postpartum, although experience with the use of RIV3 in pregnant individuals is limited. The AAP and ACIP consider LAIV to be contraindicated during pregnancy. This differs from the prescribing information for FluMist Quadrivalent, 2023–2024 Formula, which indicates that FluMist Quadrivalent is not absorbed systemically after intranasal administration and use during pregnancy is not expected to result in fetal exposure to the drug. Influenza vaccine may be administered during the same visit as other recommended vaccines, including RSV, COVID-19, and Tdap vaccines. Data on the safety of influenza vaccination at any time during pregnancy continue to support the safety of influenza immunization during pregnancy.[99,101–112] Most studies demonstrate that vaccination during pregnancy, including during the first trimester, is not associated with a risk of spontaneous abortion[113–116] or with the overall risk of major congenital malformations,[117–120] autism spectrum disorder, or other neurodevelopmental disorders.[121,122] Assessments of any association with influenza vaccination and preterm birth and small-for-gestational-age infants have yielded inconsistent results, with most studies reporting a protective effect or no association with these outcomes.[116,123–125]

Despite clear evidence of benefit to pregnant individuals and their infants, influenza vaccination in this population is decreasing. During the 2023–2024 influenza season, 38.1% of pregnant individuals were vaccinated through April 20, 2023.[126] Rates were highest in pregnant non-Hispanic Asian individuals (53.4%) and lowest in pregnant non-Hispanic Black individuals (21.5%). Racial disparities in uptake of influenza vaccine during pregnancy have been identified previously, with Black women consistently having the lowest rates.[111,127] Black women report a lower rate of being offered or recommended to receive influenza vaccine, despite evidence that a provider recommendation is associated with vaccine acceptance.[127] Lower influenza vaccination coverage also has been reported in Medicaid-insured pregnant women compared with privately insured women and in women residing in rural areas compared with those residing in urban areas.[128,129]

Breastfeeding: Recommended, Not a Contraindication or Precaution

Influenza vaccination with either IIV or LAIV during breastfeeding is safe for lactating individuals and their infants. Breastfeeding is strongly recommended to protect infants against influenza viruses by activating innate antiviral mechanisms, specifically type-1 interferons. Human milk from pregnant individuals vaccinated during the third trimester also contains higher levels of influenza-specific immunoglobulin A.[130] Greater exclusivity of breastfeeding in the first 6 months of life decreases the episodes of respiratory illness with fever in infants of vaccinated lactating parents. For infants whose birthing parent has confirmed influenza illness at delivery, breastfeeding is encouraged, and guidance on breastfeeding practices is available on the CDC Web site (https://www.cdc.gov/breastfeeding-special-circumstances/hcp/illnesses-conditions/flu.html and https://www.cdc.gov/flu/professionals/infectioncontrol/peri-post-settings.htm). Birthing parents may pump and feed expressed breast milk if they or their infants are too ill to breastfeed.

INFLUENZA VACCINATION COVERAGE

Influenza vaccination coverage of children decreased coincident with the COVID-19 pandemic, mirroring the declines in other routine pediatric vaccines during the pandemic.[131–134] Influenza vaccination coverage fell again during the 2023–2024 season, remaining well below the Healthy People 2030 target of 70% (Fig 3).[135,136] Through May 11, 2024, only 53.9% of children 6 months through 17 years had been vaccinated, more than 8.5 percentage points lower than in May of 2020.[136] Non-Hispanic Black children had the lowest influenza vaccine coverage (49.1%) compared with several groups with higher coverage, including non-Hispanic white children (51.1%), Hispanic children (59.6%), and children identified as other or non-Hispanic (58.8%). Coverage levels were also lower among children residing in rural areas (39.9%) compared with suburban (53.7%) or urban (59.5%) areas. National Immunization Survey-Flu data may overestimate vaccination rates in some populations.[137] Other disparities may exist. In a cross-sectional study using the Massachusetts All Payer Claims Database (2014–2018), privately insured children with asthma were significantly more likely to receive an influenza vaccination than Medicaid-insured children,[138] although vaccination coverage in both groups was low (51.3% versus 45.1%).

Factors contributing to declining influenza vaccination coverage include logistical barriers, including lack of transportation and altered school and work schedules, which may reduce access to routine medical care.[139] Hesitancy around COVID-19 vaccination may impact hesitancy toward other vaccines, including seasonal influenza vaccine. Rates of influenza vaccine hesitancy, reasons for vaccine hesitancy, and factors facilitating vaccination

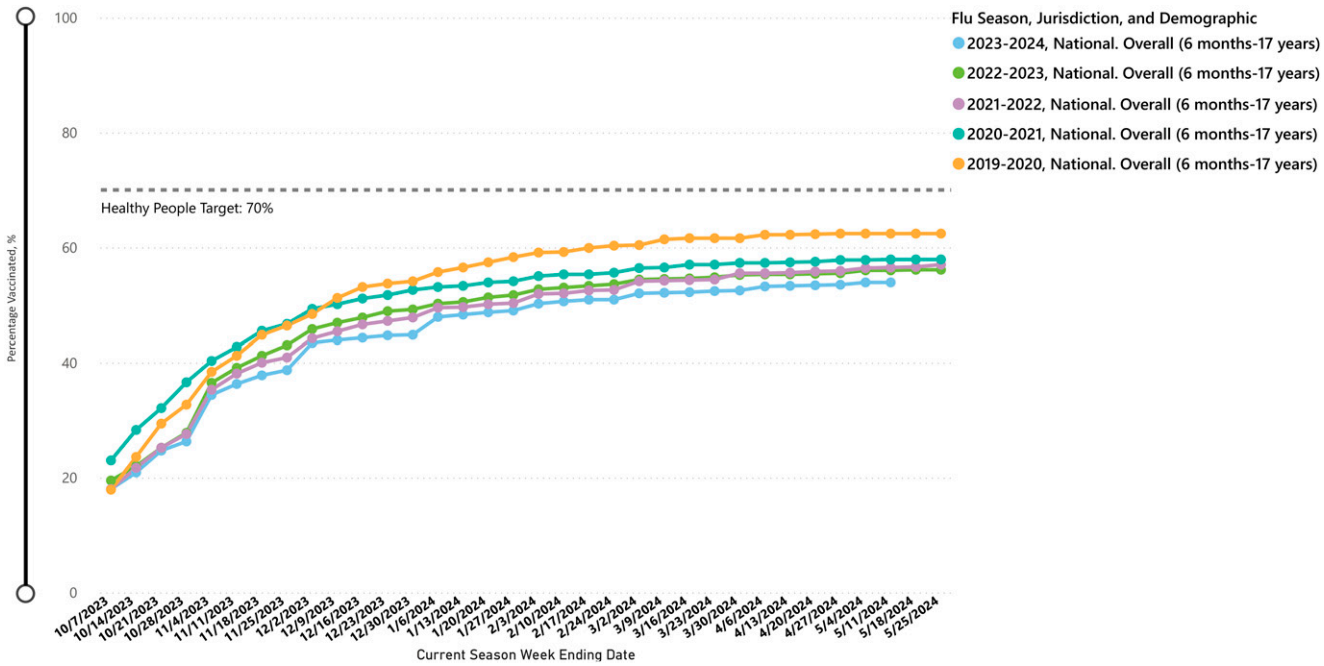


FIGURE 3

Influenza vaccination coverage in children 6 months to 17 years of age in the United States, 2019–2020 to 2023–2024. Influenza vaccination coverage in children 6 months to 17 years of age in the United States, 2019–2020 to 2023–2024 From Centers for Disease Control and Prevention. Influenza vaccination coverage, children 6 months through 17 years, United States. Data source: National Inpatient Sample-Flu. Available at: https://www.cdc.gov/flu/fluvaxview/dashboard/vaccination-doses-distributed.html. Accessed June 3, 2024.

may vary by race and ethnicity. In one small mixed methods study of parents and legal guardians presenting with their children to a pediatric emergency department during the 2021–2022 influenza season, Black caregivers expressed more hesitancy to vaccinate their children for influenza than did white caregivers (42% vs 21%; $P = .01$).[140] Black caregivers highlighted the importance of health care personnel communicating about vaccines in a transparent, nonjudgmental way. Facilitators of vaccination emphasized by Black and Hispanic caregivers included desire to protect others, employer facilitation of vaccination, and personal stories from others.

Achieving high influenza vaccination coverage of infants, children, and adolescents remains a priority to protect them against influenza disease and its complications. Multifaceted strategies are needed to increase influenza vaccination coverage, especially in vulnerable, high-risk populations.

INFLUENZA VACCINE DELIVERY AND IMPLEMENTATION STRATEGIES

Timely annual distribution of influenza vaccine to health care facilities serving children and adolescents, especially primary medical homes, may help avoid missed opportunities. Placing initial vaccine orders early and creating systems for tracking and reordering when necessary throughout the season may optimize supply. Such efforts may be particularly important when there are disruptions in vaccine delivery because of supply chain issues, inclement weather, or other unforeseen circumstances, along with prioritizing delivery to primary care settings, especially when supply is limited or delayed. The AAP has developed guidance for addressing influenza vaccine supply, payment, coding, and liability issues (https://www.aap.org/influenza).

The AAP and CDC recommend influenza vaccination at any visit to the medical home during influenza season. Influenza vaccination in the medical home is ideal, especially for the youngest children. Administering influenza vaccine in diverse locations, such as subspecialty practices, perioperative clinics, urgent care clinics, EDs, schools, and pharmacies, may help augment these efforts.[141–143] This may be particularly useful for children at high risk for influenza-related complications and children who do not have or cannot readily access their medical home, including those residing in rural areas where coverage levels are markedly lower than in suburban or urban areas. EDs, in particular, are an underutilized resource. In a recent national survey completed by 142 pediatric emergency medicine physicians representing 61 EDs, only 26 of 61 (44%) administer any influenza vaccine and 17 of 61 (28%) administered <50 vaccines annually.[144] Investigators projected that up to 18 750 additional patients could receive influenza vaccine annually if nonvaccinating EDs offered influenza vaccine to children and achieved a 10% acceptance rate.

Expanding pharmacy-based influenza vaccine administration is another strategy with the potential to increase vaccine access, as an estimated 93% of the population lives within 5 miles of a pharmacy.[145,146] The number of children immunized by pharmacists has been increasing but still remains relatively low. In one retrospective cohort study that used a claims data warehouse of commercially insured persons to analyze influenza vaccines administered to children between July 1, 2016 and June 30, 2017, only 5.2% of vaccines were administered by pharmacists.[146] State-specific restrictions on the minimum age for pharmacist-administered vaccinations vary and may limit the number of children who can be immunized in this setting.[145]

Hospitalized patients should be vaccinated before discharge, unless medically contraindicated. Historically, a substantial proportion of children hospitalized for influenza have been hospitalized previously during the same season; failure to offer vaccine administration to hospitalized children is a missed opportunity.[147] An automated, hospital-based influenza vaccination screening program integrated into the hospital medical record may increase vaccination of eligible patients.[148]

A system for reporting influenza vaccine administrations is crucial to ensure adequate communication and maintain accurate patient records across settings. Integration of immunization information systems (IISs) with electronic health record systems can enhance data accuracy and up-to-date vaccination status.[149]

For patients with a fragmented medical home or in communities where patients often receive vaccines in diverse settings, querying the IIS before administration of vaccination may prevent unnecessary vaccine administration. Use of patient portals for parents to self-report vaccination is one strategy for health systems looking to calculate influenza vaccination coverage of their patient population and to decrease unnecessary communications to patients who received vaccinations outside the medical home.

Practices should prepare in advance for their influenza vaccine campaign and leverage a range of evidence-based strategies[150,151] throughout the season to increase vaccination rates in their patient population (see Table 3 in the policy statement [www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507]). The AAP has created tools to help practices in this work (https://www.aap.org/influenza). Some practices expand their hours of operation (ie, evenings, weekends) or schedule vaccine-only clinics to increase patient access to influenza vaccine early in the season and during peak periods. Sending reminder or recall messages using a modality (ie, telephone, text, letter, e-mail, messaging via the patient

portal) that is feasible for their practice and aligns with the preferences of their patient population may improve immunization rates.[152–154] A Cochrane Review from 2018 concluded that reminder or recall improves childhood influenza vaccination with moderate certainty of evidence (RR, 1.51; 95% CI, 1.14 to 1.99).[155] Effective messages notify families of influenza vaccine availability and provide other key information, such as the child's vaccination status and where, when, and why the child should receive the vaccine. This information is beneficial early in the campaign as well as throughout the season. For example, one clinical trial[156] found that sending text message reminders to parents of children who remain unvaccinated in the late fall increased influenza vaccine uptake. Another trial[157] demonstrated the effectiveness of using text message reminders for children requiring two doses in a season, particularly when the messages embedded information regarding the need for a timely second dose. Making vaccine-related information readily available (ie, via a practice Web site, social media platform, or educational handout)[158,159] and tailoring this information for their patients and families (ie, materials in preferred language) has also been effective. Resources are available from the AAP at https://www.aap.org/en/news-room/campaigns-and-toolkits/immunizations/.

Effective influenza vaccine communication with patients and families is crucial. Messaging should be consistent across all members of the care team, including front office staff, medical assistants, nurses, physicians, and advanced practice providers (including those specializing in primary care and subspecialty care). Practices should educate their staff, physicians, and other clinicians about influenza and influenza vaccine-related topics, including the importance of annual vaccination, vaccine effectiveness and safety, the 2-dose requirement for certain children, vaccine contraindications, and common parental concerns. Care team members should use evidence-based communication strategies in their conversations with patients and families. These include offering a strong, presumptive influenza vaccine recommendation, bundling their recommendation for influenza vaccine with recommendations for other needed vaccines, and pursuing their initial recommendation when families initially decline the vaccine.[160–163] Moreover, communication should be tailored to address the specific vaccine-related concerns of patients and families. Resources regarding effective vaccine communication techniques are available on the AAP Web site at https://aap.org/vaccinecommunication.

Practices, staff, physicians, and other clinicians should consider expanding their conversations and messaging campaigns about influenza to include other preventable respiratory illnesses (ie, RSV, COVID-19). Messaging examples are available at https://www.healthychildren.org/English/tips-tools/ask-the-pediatrician/Pages/can-children-get-COVID-19.aspx. Exact language is particularly important in their discussions and messaging to patients and families. Although acknowledging that influenza can sometime cause gastrointestinal symptoms, especially in young children, referring to all viral gastrointestinal illnesses as "stomach flu," creates unnecessary confusion. In Spanish, the term "gripe" is commonly used to refer to viral influenza but is a nonprecise term referring to respiratory illnesses. Using this term may cause confusion about the actual illness prevented by influenza vaccine and result in decreased confidence about vaccine effectiveness. "Influenza" should be used rather than "la gripe" when discussing influenza and influenza vaccine with Spanish-speaking patients and families.

Strategies to reduce missed opportunities during patient visits include standardization of practice workflow to screen all patients for influenza vaccine eligibility and administer the vaccine to any patient who is due for the vaccine. This workflow could be used at all visit types, including preventive care, acute care, and mental or behavioral health visits. Influenza vaccination can be administered when patients present for other needed vaccines as well. Practices may identify influenza vaccine champion(s) within their practice to spearhead these efforts. Informatic tools can also facilitate influenza vaccination. For example, studies have shown that standing vaccine orders and vaccine prompts in the electronic health record increase influenza vaccine uptake in both inpatient and outpatient settings.[164,165] Audits and performance feedback for providers have also been shown to be effective as part of multimodal interventions.[151] Additionally, these tools can be used to identify patients who have a precaution or contraindication to a particular formulation or who need repeat vaccinations and support future dose scheduling. Practices should attempt to schedule a timely return visit for any patient identified as needing a future dose (eg, vaccine dose deferred because of concomitant moderate or severe illness or a second dose is indicated because of age). Additionally, health systems looking to identify patients at high risk for severe influenza illness can leverage information from the electronic health record to identify patients at risk and provide targeted communications. Sample value sets for use in creating electronic clinical decision support tools are presented in Table 3. Implementation can be challenging, but some institutions have used these sources. Local adaptation may be needed.

For practices that choose to offer influenza vaccine to family members and other close contacts of children and adolescent patients, the AAP technical report, "Immunizing Parents and Other Close Family Contacts in the Pediatric Office Setting," provides medical liability risk management guidance on documenting in a separate record, screening, informed consent, and National Vaccine Injury Compensations Program-required immunization administration data.[166] Guidance is provided on ascertaining whether immunizing

TABLE 3 Value Sets for Underlying Conditions of High-Risk Groups for Influenza Complications

Category	Description	Established Value Sets	Object Identifier (OID)	Code System	Steward
Underlying Condition or Treatment With Common Examples[a]					
Chronic pulmonary disease	Asthma	Asthma diagnosis ICD-10	2.16.840.1.113762.1.4.1047.308	ICD10CM	American Academy of Allergy Asthma and Immunology
		Asthma diagnosis grouping	2.16.840.1.113762.1.4.1047.309	ICD10CM ICD9CM SNOMEDCT	American Academy of Allergy Asthma and Immunology
	Cystic fibrosis	Cystic fibrosis	2.16.840.1.113883.3.464.1003.102.12.1002	ICD10CM ICD9CM SNOMEDCT	National Committee for Quality Assurance
		Cystic fibrosis lung disease	2.16.840.1.113762.1.4.1219.15	ICD10CM SNOMEDCT	CMS Documentation Requirement Lookup Service
	Compromised respiratory function (eg, requiring mechanical ventilation, tracheostomy or baseline oxygen requirement)	Mechanical ventilation	2.16.840.1.113762.1.4.1248.107	ICD10PCS SNOMEDCT	American Institutes for Research
Cardiovascular disease	Hemodynamically significant conditions (excluding hypertension alone)	No existing value set	—	—	—
Kidney disease	Dialysis Chronic kidney disease, including end-stage kidney disease	Dialysis services	2.16.840.1.113883.3.464.1003.109.11.1026	CPT	National Committee for Quality Assurance
Hepatic disease	Chronic liver disease	Chronic Liver Disease	2.16.840.1.113883.3.464.1003.199.12.1035	ICD10CM ICD9CM SNOMEDCT	National Committee for Quality Assurance
	Cirrhosis	Cirrhosis	2.16.840.1.113762.1.4.1248.149	ICD10CM SNOMEDCT	American Institutes for Research
Hematologic disease	Sickle cell disease	Sickle Cell Anemia and HB S Disease	2.16.840.1.113762.1.4.1235.222	ICD10CM SNOMEDCT	B.well Connected Health
	Other hemoglobinopathies	No existing value set	—	—	—
Metabolic disorders	Diabetes mellitus	Diabetes	2.16.840.1.113883.3.464.1003.103.12.1001	ICD10CM SNOMEDCT	National Committee for Quality Assurance
Neurologic and neurodevelopmental conditions	Cerebral palsy	Congenital or infantile cerebral palsy group	2.16.840.1.113883.3.666.5.1580	ICD10CM ICD9CM SNOMEDCT	Lantana
	Epilepsy	Epilepsy	2.16.840.1.113762.1.4.1034.51	ICD10CM ICD9CM SNOMEDCT	American Academy of Neurology
		Seizure disorder	2.16.840.1.113883.3.464.1003.105.12.1206	ICD10CM ICD9CM SNOMEDCT	National Committee for Quality Assurance
	Stroke	Stroke	2.16.840.1.113762.1.4.1248.176	ICD10CM	American Institutes for Research
	Intellectual developmental disorder	No existing value set	—	—	—

TABLE 3 Continued

Category	Description	Established Value Sets	Object Identifier (OID)	Code System	Steward
	Moderate to severe developmental delay	No existing value set	—	—	—
	Muscular dystrophy	No existing value set	—	—	—
	Spinal cord injury	Spinal cord injury	2.16.840.1.113883.3.7587.3.1009	ICD10CM ICD9CM SNOMEDCT	American Academy of Physical Medicine and Rehabilitation
Extreme obesity	BMI ≥40 for adults[b]	No existing value set	—	—	—
Immunosuppression	Receipt of immunocompromising medications	No existing value set	—	—	—
	Congenital or acquired immune deficiency, including HIV	Immunodeficiency syndromes	2.16.840.1.113762.1.4.1200.189	ICD10CM	Cliniwiz
		HIV	2.16.840.1.113883.3.464.1003.120.12.1003	ICD10CM ICD9CM SNOMEDCT	National Committee for Quality Assurance
	Asplenia	Anatomic or functional asplenia_HD_CN_ Grouping	2.16.840.1.113762.1.4.1235.219	ICD10CM ICD9CM SNOMEDCT	B.well Connected Health
Receiving treatment with aspirin or salicylate-containing therapies[c]		No existing value set	—	—	—
Pregnancy and up to 2 weeks postpartum		No existing value set	—	—	—

The sets provided are previously published value sets available at the Value Set Authority Center (a service of the National Library of Medicine) and can be accessed at https://vsac.nlm.nih.org. These sets are provided by the relevant steward listed and are not endorsed by the AAP but may serve as a starting point for organizations creating electronic clinical decision support systems. Source: Adapted from Centers for Disease Control and Prevention. Prevention and control of seasonal influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices—United States, 2024–25 influenza season. *MMWR Recomm Rep*. 2024; in press.

[a] List of examples is not exhaustive.

[b] Not well-defined in children but could consider BMI ≥95% for age.

[c] Applies to children and adolescents <19 y who may be at increased risk of Reye syndrome.

adults is covered by customary pediatric medical liability insurance policies for any adverse events not covered by the National Vaccine Injury Compensations Program; logistical and financial barriers are also addressed. Practices that participate in value-based care contracts with insurance companies should understand the plan-specific implications of immunizing parents. In some cases, immunizing a parent or adult caregiver could result in that individual being attributed to the pediatrician's roster and result in negative financial consequences. Additional resources are available at https://aap.org/immunization.

Partnership with community entities, including early childhood learning centers, schools, school-based health centers, public health agencies, pharmacies, and other organizations, can optimize influenza vaccine distribution, communication, and administration. These partnerships may be particularly important for reaching patients with limited access to care, including those residing in rural areas. For example, practices could help with outreach initiatives, such as influenza vaccine fairs or mobile vaccine vans. Partnering with faith-based organizations may be an effective intervention to increase immunization rates in communities in which mistrust and vaccine hesitancy are high.[167] Collectively, practices and partners can educate families and community members on the importance of influenza vaccination and address common concerns. The AAP has created communication resources to convey key messages and to help the public understand influenza vaccination recommendations on the AAP Web site at https://www.aap.org/en/news-room/campaigns-and-toolkits/flu-campaign-toolkit.

The AAP supports mandatory influenza vaccination programs for HCP in all settings, including outpatient locations. Optimal prevention of influenza in these settings requires that at least 90% of HCP are vaccinated. Estimated influenza vaccination coverage of HCP was only 75.9% during the 2022–2023 season, decreased from 80.6% during the 2021–2022 season.[168] Coverage levels were highest among HCP who reported an employer requirement for influenza vaccination (95.9%). Coverage levels were also higher among HCP working in hospitals (85.7%) compared with those working in long-term care and home health care settings (68.3%). Influenza vaccination programs for HCP benefit the health of employees, their patients, and members of the community, especially because HCP frequently come into contact with high-risk patients in their clinical settings. The programs reduce HCP absenteeism and may reduce disruptions in care delivery associated with personnel shortages.[169] Mandatory influenza vaccination of HCPs is considered ethical, just, and necessary to improve patient safety. For the prevention and control of influenza, HCP must prioritize the health and safety of their patients, honor the requirement of causing no harm, and act as role models for both their patients and colleagues by receiving influenza vaccination annually.

INFLUENZA TREATMENT AND CHEMOPROPHYLAXIS

Antiviral Therapy

Antiviral agents available for both influenza treatment and chemoprophylaxis in children of all ages can be found in Table 6 in the policy statement (www.pediatrics.org/cgi/doi/10.1542/peds.2024-068507) (including doses for preterm infants that have not been evaluated by the FDA) and on the CDC Web site.[170] These include the neuraminidase inhibitors (NAIs [oseltamivir, zanamivir, peramivir]) and a selective inhibitor of influenza cap-dependent endonuclease (baloxavir), all of which have activity against influenza A and B viruses.[171]

The AAP considers oral oseltamivir (Tamiflu) the antiviral drug of choice for the management of illness caused by influenza virus infections. This is the only drug recommended by the AAP for treatment of hospitalized children.* Oseltamivir is preferred because of the cumulative experience of this drug in children, relative cost, and ease of administration. Although more difficult to administer, inhaled zanamivir (Relenza) is an acceptable alternative for patients 7 years and older who do not have chronic respiratory disease. In one nationwide, population-based cohort study that included ambulatory children and adults who were treated with antiviral medications within 48 hours of a clinical diagnosis of influenza, inhaled zanamivir was not inferior to oral oseltamivir in preventing influenza-related hospitalization or death, but an exploratory subgroup analysis favored oseltamivir in children 5 through 17 years of age. This may reflect the ability of children to correctly use a zanamivir inhaler. A single dose of intravenous peramivir (Rapivab) is approved for the treatment of acute uncomplicated influenza in ambulatory children 6 months and older who have been symptomatic for no more than 2 days. The efficacy of peramivir in patients with serious influenza requiring hospitalization has not been established.[171] In a retrospective cohort study of children 0 to 5 years of age hospitalized with influenza in China, oral oseltamivir and intravenous peramivir were associated with similar clinical outcomes when used for the treatment of influenza B.[172] In children with influenza A, oseltamivir treatment was associated with improved recovery and short hospital stays (5 vs 6 days; $P = .02$). In another retrospective cohort study of 97 children 29 days to 18 years of age hospitalized with influenza and treated with peramivir, duration of fever and influenza nucleic acid positivity were shorter in children infected with influenza A H3N2 compared with children with influenza B; other outcomes were similar.[173]

Baloxavir marboxil (Xofluza) is approved for treatment of acute uncomplicated influenza in otherwise healthy

individuals as young as 5 years of age and all individuals 12 years and older, including those at high risk of developing influenza-related complications.[174,175] It is also approved by the FDA for postexposure prophylaxis of influenza for persons ≥5 years of age within 48 hours of contact with an individual with influenza. It is administered as a single dose and could be considered as an alternative to oseltamivir when compliance is a concern or there is poor tolerance of an antiviral regimen requiring multiple medication doses.

Outcomes in patients treated with baloxavir are generally similar to those for NAIs.[176,177] In a randomized controlled trial (RCT) that enrolled adolescents and adults, baloxavir had better efficacy than oseltamivir in the treatment of influenza B.[178] Some observational studies suggest more rapid resolution of fever in children treated with baloxavir compared with oseltamivir.[179,180] A post hoc analysis of a RCT demonstrated similar durations of fever in children 5 to 11 years of age treated with baloxavir or oseltamivir.[181] In a post hoc analysis of 2 open label studies[178] of baloxavir in children 1 to <12 years of age in Japan, symptom recurrence after day 4 was noted in 54.5% of treated children <6 years of age, whereas fever recurrence was noted in 50%.[182] In 2 studies, baloxavir treatment reduced the duration of viral shedding compared with oseltamivir treatment in patients infected with influenza.[181,183]

The oral suspension formulation of baloxavir was not available in the United States for the 2023–2024 influenza season, limiting use in children who were old enough to receive the drug but weigh less than 20 kg.[184] Availability of this formulation for the 2024–2025 influenza season is unknown at this time.

During the 2022–2023 influenza season, there was a shortage of generic oseltamivir. The CDC published recommendations for the prioritizing use of antiviral agents for patients at greatest risk of influenza-related complications and those who are hospitalized.[185]

The AAP, CDC, Infectious Diseases Society of America,[171] and Pediatric Infectious Diseases Society recommend treatment with oseltamivir for children with serious, complicated, or progressive disease presumptively or definitively caused by influenza, irrespective of influenza vaccination status (the circulating strains may not be well matched with vaccine strains) or whether illness began >48 hours before presentation. Earlier treatment provides better clinical responses, but treatment after 48 hours of symptoms in adults and children with moderate to severe disease or with progressive disease has been shown to provide some benefit and should be offered.[186–188] Additionally, the AAP recommends treatment of children at risk for severe complications of influenza, regardless of duration of symptoms. Children younger than 2 years are at an increased risk of hospitalization and complications attributable to influenza. The FDA has approved oseltamivir for treatment of children as young as 2 weeks of age. Given preliminary pharmacokinetic data and limited safety data, the CDC and AAP support the use of oseltamivir to treat influenza in both term and preterm infants from birth because benefits of therapy for neonatal influenza are likely to outweigh possible risks of treatment. Otherwise healthy children who have suspected influenza with an uncomplicated presentation should be considered for antiviral medication, particularly if they are in contact with other children who either are younger than 6 months (as they are not able to receive influenza vaccine) or have high-risk conditions (including age <5 years) that predispose them to complications of influenza, when influenza viruses are known to be circulating in the community. Antiviral treatment should be started as soon as possible after illness onset and should not be delayed while waiting for a definitive influenza test result because early therapy provides the best outcomes. Algorithms for interpreting positive and negative influenza tests are available (https://www.cdc.gov/flu/professionals/diagnosis/algorithm-results-circulating.htm). The balance between benefits and harms should be considered when making decisions about the use of NAIs for either treatment or chemoprophylaxis of influenza. The cost of antiviral therapy may be a barrier to treatment of some families.

If the breastfeeding parent requires antiviral agents, treatment with oral oseltamivir is preferred. The CDC does not recommend use of baloxavir for treatment of pregnant or breastfeeding individuals. There are no available efficacy or safety data in pregnant individuals, and there are no available data regarding the presence of baloxavir in human milk, the effects on the breastfed infant, or the effects on milk production.

Rationale for Influenza Treatment in Children

The rationale for influenza treatment recommendations are threefold: (1) reduce the duration of symptoms; (2) reduce complication of influenza, including hospitalization and death; and (3) potentially reduce transmission. RCTs to evaluate the efficacy of influenza antiviral medications among outpatients with uncomplicated influenza have found that timely treatment (optimally ≤2 days from symptom onset) can reduce the duration of influenza symptoms and fever in children and adults.[189–193] Observational studies in pediatric and adult populations suggest that antiviral agents are safe and could reduce the risk of certain influenza complications, including hospitalization and death.[194–198] Potential limitations of the trials conducted to date in children include the study size (the number of events might not be sufficient to assess specific outcomes in small studies), variations in the case definition of influenza illness (clinically diagnosed versus laboratory confirmed), time of treatment administration in relation to the onset of illness, and inclusion of children of varying ages and underlying health conditions. Observational studies using

administrative data may be biased by misclassification of both influenza infection status and oseltamivir exposure.[199] Several studies also suggest that treatment of index patients with influenza reduces transmission to household contacts to some extent, but the magnitude of the effect is inconsistent across published reports.[200] The totality of available evidence supports the treatment of children with influenza.

A Cochrane review of 6 RCTs involving treatment of 2356 children with clinically diagnosed influenza, of whom 1255 had laboratory-confirmed influenza, showed that in children with laboratory-confirmed influenza, oral oseltamivir and inhaled zanamivir reduced median duration of illness by 36 hours (26%; $P < .001$) and 1.3 days (24%, $P < .001$), respectively.[193] Among the studies reviewed, one trial of oseltamivir in children with asthma who had laboratory-confirmed influenza showed a nonsignificant reduction in illness duration (10.4 hours; 8%; $P = .542$). Another Cochrane review of RCTs in adults and children, which included 20 oseltamivir (9623 participants) and 26 zanamivir trials (14 628 participants)[190] found no effect of oseltamivir in reducing the duration of illness in asthmatic children, but in otherwise healthy children, there was a reduction by a mean difference of 29 hours (95% CI, 12 hours to 47 hours; $P = .001$). No significant effect was observed with zanamivir. This review did not find a significant effect of NAIs on reducing hospitalizations, pneumonia, bronchitis, otitis media, or sinusitis in children.[190] More recently, a meta-analysis of 5 new RCTs that included 1598 children with laboratory-confirmed influenza showed that treatment with oseltamivir significantly reduced the duration of illness in this population by 17.6 hours (95% CI, −34.7 hours to −0.62 hours).[191] When children with asthma were excluded, this difference was larger (−29.9 hours; 95% CI, −53.9 hours to −5.8 hours). The risk of otitis media was 34% lower in this group as well. Similarly, a meta-analysis conducted by Tejada et al showed a statistically significant reduction in the risk of acute otitis media occurrence among treated children over placebo recipients (odds ratio: 0.48; 95% CI, 0.30 to 0.77).[198] Overall, efficacy outcomes are best demonstrated in patients with laboratory-confirmed influenza.

There are no prospective, fully enrolled, completed RCTs of antiviral agents versus placebo for treatment of influenza in hospitalized children or pediatric patients with comorbidities, and prospectively collected data to determine the role of antiviral agents in treating severe influenza are limited. One RCT of oseltamivir treatment of influenza in hospitalized children in El Salvador and Panama suggested clinical benefit, but no statistically significant findings were reported because only 21% of the target sample size was enrolled, and therefore, the study was substantially underpowered.[201] Nevertheless, on the basis of information obtained from retrospective observational studies and meta-analyses conducted to date in both adults and children, most experts support the use of antiviral medications as soon as possible to treat pediatric patients with severe influenza, including hospitalized patients.[191–197,201]

In a retrospective study of 784 PICU admissions from 2009 to 2012, the estimated risk of death was reduced in 653 neuraminidase inhibitor-treated individuals (odds ratio, 0.36; 95% CI, 0.16 to 0.83).[186] In a retrospective analysis of data from the US Influenza Hospitalization Surveillance Network, administration of antiviral agents ≤2 days after illness onset was associated with shorter lengths of stay in children admitted to the ICU (adjusted hazard ratio: 1.46; $P = .007$) and in children with underlying medical conditions not admitted to the ICU (adjusted hazard ratio: 1.37; $P = .02$). In the relatively small number of patients studied, antiviral treatment ≥3 days after illness onset had no significant effect in either cohort.[202] Similarly, early antiviral treatment of children with tracheostomy hospitalized with influenza reduced length of stay by 1 day (6.4 vs 7.5 days; $P = .01$).[203] In a multicenter, retrospective cohort study involving 55 799 children hospitalized with influenza between 2007 and 2020, oseltamivir use on hospital day 0 or 1 was associated with shorter hospital stays and lower odds of readmission within 7 days, transfer to the ICU, and the composite outcome use of extracorporeal membrane oxygenation and in-hospital mortality.[204]

No additional benefit exists for double-dose neuraminidase inhibitor therapy on reduction of mortality or viral clearance, compared with standard-dose therapy, on the basis of a recent systematic review and meta-analysis of 10 published studies[205] (4 RCTs and 6 observational studies) involving 20 947 adult and pediatric patients. In a randomized, parallel-group, double-blind, placebo-controlled, superiority trial, combining baloxavir with NAIs did not result in superior clinical outcomes compared with NAIs alone in patients 12 years and older hospitalized with laboratory-confirmed influenza.[206]

Oseltamivir Adverse Effects

In adverse event data collected systematically in prospective trials, vomiting was the only adverse effect reported more often with oseltamivir compared with placebo when studied in children 1 through 12 years of age (ie, 15% of treated children versus 9% receiving placebo). Diarrhea was reported in clinical trials of oseltamivir in 7% of treated children <1 year of age. Following reports from Japan of possible oseltamivir-attributable neuropsychiatric adverse effects, a review of controlled clinical trial data and ongoing surveillance has failed to establish a link between this drug and neurologic or psychiatric events.[207,208] Neurologic and neuropsychiatric complications, including abnormal behavior, occur in children with influenza in the absence of exposure to oseltamivir.[209] In a retrospective cohort study of children 5 through 17 years

of age in Tennessee, the incidence rate of neuropsychiatric events was 51 per 100 000 person-weeks of influenza, and rates were higher among adolescents and those with risk factors for influenza complications.[210] The study did not support an association between oseltamivir and neuropsychiatric events but was unable to characterize the dose, duration, or timing of oseltamivir administration in relation to the onset of neuropsychiatric events.

Adherence to Antiviral Treatment Guidance

Despite the body of evidence supporting antiviral treatment of children hospitalized with confirmed or suspected influenza and expert guidance recommending antiviral use in children at high risk for complications, antiviral prescribing appears to be suboptimal. In a cross-sectional study of outpatient and ED prescription claims in individuals <18 years of age June 1, 2010 to June 30, 2019, there was marked variability in the use of antiviral agents for influenza. Differences were noted by age, presence of a high-risk condition, geographic region, and influenza season. Only 37% of children <2 years of age with influenza or influenza-like illness were prescribed antiviral treatment, whereas 34% of children 2 to 5 years of age received an antiviral prescription.[211] In a cross-sectional study of ambulatory children at high risk for complications, 58.1% of children diagnosed with influenza during the 2016–2019 influenza seasons received antiviral treatment.[212] Children 2 to 5 years of age, residents of chronic care facilities, and children who received care in an ED were less likely to be treated. In studies examining antiviral use in hospitalized children with influenza, half or fewer eligible children were prescribed antiviral treatment.[213,214] In a multicenter retrospective cross-sectional study conducted between 2007 and 2020 at 36 US children's hospitals participating in the Public Health Information System, oseltamivir use in children hospitalized with influenza increased over time. Use was lowest in the 2007–2008 influenza season (20.2%) and highest in the 2017–2018 influenza season (77.9%), but there was significant variability by hospital.[215] Odds of receiving oseltamivir therapy were less in children younger than 2 years and children 2 to 5 years of age compared with older children.

A recent paper suggested that use of administrative data may misclassify both patients with influenza infection and patients treated with oseltamivir.[199] In a sample of 300 patients with a discharge or death diagnosis code for influenza, 118 were inaccurately classified. Of these, the majority did not undergo influenza testing, had a negative test result, or had infection with another organism, including parainfluenza or *Haemophilus influenzae*. Prospective studies are needed to assess adherence to antiviral treatment guidelines and reasons for nonadherence. These can inform multifactorial interventions to increase or maintain adherence to antiviral treatment guidelines for children at high risk for complications of influenza, including those who are hospitalized.

INFLUENZA CHEMOPROPHYLAXIS

Antiviral medications are important adjuncts to influenza vaccination for control and prevention of influenza disease in children who are at least 3 months of age. Randomized placebo-controlled studies showed that oral oseltamivir and inhaled zanamivir were efficacious when administered as chemoprophylaxis to household contacts after a family member had laboratory-confirmed influenza.[171] The efficacy of baloxavir was demonstrated in a randomized, placebo-controlled trial in Japan conducted during the 2018–2019 influenza season. Among household members ≥5 years of age treated with a single dose of baloxavir within 48 hours of exposure to a symptomatic household contact with influenza, 2% developed influenza compared with 13% in the placebo group (adjusted rate ratio, 0.14).[216] For additional context, 73% started baloxavir within 24 hours of the index case's symptom onset, an exercise that would be difficult to replicate in practice in the United States. There are no data on intravenous peramivir for chemoprophylaxis.

Decisions on whether to administer antiviral chemoprophylaxis should include consideration of the exposed person's risk of influenza complications, vaccination status, type and duration of contact, time since exposure, recommendations from local or public health authorities, and clinical judgment. Optimally, postexposure chemoprophylaxis should only be used when antiviral agents can be started within 48 hours of exposure; the lower once-daily dosing for chemoprophylaxis with oral oseltamivir or inhaled zanamivir should not be used for treatment of children symptomatic with influenza.[171] Early, full treatment dosing (rather than once-daily chemoprophylaxis dosing) should be used in high-risk symptomatic patients without waiting for laboratory confirmation.

Toxicities may be associated with antiviral agents, and indiscriminate use might limit availability. Pediatricians should inform recipients of antiviral chemoprophylaxis that risk of influenza is lowered, but not eliminated, while taking the medication, and susceptibility to influenza returns when medication is discontinued. Chemoprophylaxis is not a substitute for vaccination, and among some high-risk people, both vaccination with IIV and antiviral chemoprophylaxis may be considered.[171] The effectiveness of LAIV but not IIV or RIV will be decreased for children receiving oseltamivir or other influenza antiviral agents.[171] Updates will be available at www.aapredbook.org and www.cdc.gov/flu/professionals/antivirals/index.htm.

ANTIVIRAL RESISTANCE

Resistance to any antiviral drug can emerge, necessitating continuous population-based assessment by the CDC. During the 2023–2024 season to date, one influenza A(H1N1)pdm09 isolate (0.05% of all viruses tested) exhibited reduced inhibition by oseltamivir; 5 influenza A(H1N1)pdm09 isolates exhibited highly reduced inhibition by oseltamivir and peramivir (0.27% of all viruses tested). Three influenza B Victoria viruses exhibited reduced inhibition by peramivir, and one exhibited reduced inhibition by zanamivir. One influenza A H3N2 virus exhibited decreased susceptibility to baloxavir (https://www.cdc.gov/flu/weekly/index.htm).

Globally, detection of viruses with reduced susceptibility to neuraminidase inhibitors was low in the 2018–2019 (0.5%) and 2019–2020 (0.6%) influenza seasons. Reduced susceptibility to baloxavir was also rarely observed (0.5% during the 2018–2019 season and 0.1% during the 2019–2020 season).[217] The rate was higher in Japan (4.5% in the 2018–2019 season), where baloxavir use is the highest.

Influenza viruses with reduced baloxavir susceptibility have been identified coincident with treatment in children. In an analysis of four pediatric trials, the incidence of subjects with treatment-emergent resistance substitutions after baloxavir use was highest in subjects <5 years of age, with a clear peak of resistance in subjects 2 to 4 years of age (https://www.fda.gov/media/162113/download). Resistance was substantially higher in subjects infected with influenza A(H3N2). Knowledge of the circulating influenza strain may influence the decision to use baloxavir.

High levels of resistance to amantadine and rimantadine persist among the influenza A viruses currently circulating; neither drug is effective against influenza B viruses. Adamantane medications are not recommended for use against influenza unless resistance patterns change.[171]

If a newly emergent antiviral-resistant virus is a concern, recommendations for alternative treatment will be available from the AAP and CDC. Resistance characteristics can change for an individual patient over the duration of a treatment course, especially in those who are severely immunocompromised. Information on current recommendations and therapeutic options can be found on the AAP Web site (www.aap.org or www.aapredbook.org), through state-specific AAP chapter websites, or on the CDC Web site (www.cdc.gov/flu/).

DIAGNOSTIC TESTS FOR INFLUENZA

Diagnostic testing for influenza may be beneficial when results will be used to inform clinical management or infection prevention measures and to distinguish from other respiratory viruses with similar symptoms. Performance characteristics of tests vary and are impacted by duration of illness in the person being tested and proper specimen collection and handling. Test results must be interpreted in the context of community influenza activity (Table 4); false-positive tests may occur during periods of low influenza activity.

Molecular assays include rapid molecular tests, reverse-transcriptase polymerase chain (RT-PCR) reaction test, and other nucleic acid amplification tests. Multiplex assays that allow for the simultaneous detection of influenza viruses plus SARS-CoV-2 or influenza viruses, SARS-CoV-2, and RSV are available. These assays can be particularly useful when these viruses are cocirculating because signs and symptoms of these viruses may be similar, clinical differentiation is difficult, and different treatment strategies are recommended. A current list of authorized tests is available at https://www.cdc.gov/flu/professionals/diagnosis/table-flu-covid19-detection.html.

Antigen detection tests include rapid influenza diagnostic tests (RIDTs) and immunofluorescence assays. Some available RIDTs detect SARS-CoV-2 as well as influenza A and B. An updated list of RIDTs is available at https://www.cdc.gov/flu/professionals/diagnosis/table-ridt.html.

Rapid molecular assays are highly sensitive and are preferred over RIDTs in ambulatory children in whom testing is performed. During periods of high community influenza activity, clinicians should consider confirming negative RIDTs with a molecular test. When influenza is circulating in the community, hospitalized patients with signs and symptoms of influenza should be tested with a molecular assay with high sensitivity and specificity.

In February 2023, the FDA issued an emergency use authorization for the first over-the-counter at-home test to diagnose both influenza A and B and SARS-CoV-2 in symptomatic individuals as young as 2 years.[218,219] The test is performed on a nasal swab that can be self-collected in persons 14 years and older. The test must be obtained by a caregiver in younger children. Results are available in 30 minutes. In individuals with symptoms, the test correctly identified 99.3% of negative and 90% of positive influenza A samples and 99.9% of negative influenza B samples. Low circulation of influenza B precluded assessment of the test's ability to detect influenza B in real-world settings. The utility of these tests in managing pediatric patients with symptoms of influenza merits exploration. At a minimum, parents of children at high risk for complications of influenza will benefit from counseling about timely communication with the medical home about the results of home tests and education that a negative test result cannot completely exclude influenza.

FUTURE DIRECTIONS

Safety and Effectiveness of Available Influenza Vaccines

Continued evaluation of the safety, immunogenicity, and effectiveness of influenza vaccines, especially for at-risk and diverse populations, is important. The duration of protection,

TABLE 4 Comparison of Types of Influenza Diagnostic Tests

Testing Category[a]	Method	Influenza Viruses Detected	Distinguishes Influenza A Virus Subtypes	Time to Results	Performance
Rapid molecular assay	Nucleic acid amplification	Influenza A or B viral RNA	No	15 — 30 minutes	High sensitivity; high specificity
Rapid influenza diagnostic test	Antigen detection	Influenza A or B virus antigens	No	10 — 15 minutes	Moderate sensitivity (higher with analyzer reader device); high specificity
Direct and indirect immunofluorescence assays	Antigen detection	Influenza A or B virus antigens	No	2 — 4 hours	Moderate sensitivity; high specificity
Molecular assays (including RT-PCR)	Nucleic acid amplification	Influenza A or B viral RNA	Yes, if subtype primers are used	1 — 8 hours	Very high sensitivity; very high specificity
Multiplex molecular assays	Nucleic acid amplification	Influenza A or B viral RNA, other viral or bacterial targets (RNA or DNA)	Yes, if subtype primers are used	1 — 2 hours	High sensitivity; high specificity
Rapid cell culture (shell vial and cell mixtures)	Virus isolation	Influenza A or B virus	Yes	1 — 3 days	High sensitivity; high specificity
Viral culture (tissue cell culture)	Virus isolation	Influenza A or B virus	Yes	3 — 10 days	High sensitivity; high specificity

[a] Negative results may not rule out influenza. Respiratory tract specimens should be collected as close to illness onset as possible for testing. Clinicians should consult the manufacturer's package insert for the specific test for the approved respiratory specimen(s). Specificities are generally high (>90%) for all tests compared with RT-PCR. Sensitivities of rapid influenza diagnostic tests vary by test and are lower compared with RT-PCR and viral culture. The typical sensitivity of a rapid test performed in a physician's office is 50% to 70%, and clinicians may wish to confirm negative test results with molecular assays, especially during peak community influenza activity. Some FDA-cleared rapid influenza diagnostic tests are CLIA-waived; most FDA-cleared rapid influenza molecular assays are CLIA-waived, depending on the complexity. Source: Uyeki[25] and https://www.cdc.gov/flu/professionals/diagnosis/overview-testing-methods.htm#tests.

potential role of previous influenza vaccination on overall VE, and VE by vaccine formulation, virus strain, timing of vaccination, and subject age and health status in preventing outpatient medical visits, hospitalizations, and deaths continue to be evaluated. Additional controlled data are needed to inform the timing, schedule, and type of influenza vaccine for optimal vaccine immunogenicity among immunocompromised children but use of high-dose IIV in selected populations is a promising strategy. In a phase 2, multicenter, double-blind, randomized, controlled trial comparing immunogenicity and safety of high-dose trivalent influenza vaccine (HD-TIV) and standard-dose quadrivalent influenza vaccine (SD-QIV) in children and adolescents 3 through 17 years of age who had received an allogeneic hematopoietic cell transplant 3 to 35 months earlier, 2 doses of HD-TIV were more immunogenic than 2 doses of SD-QIV.[220] Two doses of either vaccine were more immunogenic than a single dose. The greatest benefit of HD-TIV relative to SD-QIV was in individuals receiving their first influenza immunization 6 months or more after receiving a hematopoietic cell transplant.[221] The safety profile of vaccines was similar, although mild to moderate injection site reactions were slightly higher after the second dose of TIV.[220,221]

Influenza Vaccines in Development

Development efforts continue for universal influenza vaccines that induce broader protection and eliminate the need for annual vaccination. The success of mRNA and other novel technologies used in the development of COVID-19 vaccines may accelerate the prospects of broad influenza vaccines. Understanding the establishment of immunity against influenza in early life and developing a safe, immunogenic vaccine for infants younger than 6 months are essential. Studies on the effectiveness and safety of influenza vaccines containing adjuvants that enhance immune responses to influenza vaccines or that use novel routes of administration are needed in children. Efforts to improve the vaccine development process to allow for a shorter interval between identification of vaccine strains and vaccine production continue.

Promoting Vaccine Confidence and Increasing Vaccination Coverage

Systematic health services research is needed to examine influenza vaccination coverage, factors associated with undervaccination, and interventions to increase uptake in diverse populations. National data from 2019 found that 25.8% of parents were hesitant about influenza vaccine.[222] Children of parents who were hesitant about childhood vaccines had 25.6% lower influenza vaccination coverage in the influenza 2018–2019 season compared with children of parents not reporting hesitancy.[223] Vaccine hesitancy remains a major public health threat. Future studies should aim to improve our understanding of influenza vaccine hesitancy and identify effective strategies to address parental concerns, foster greater vaccine confidence, and increase influenza vaccine

acceptance.[161] Engagement of key stakeholder groups in this work is crucial, including patients and families, health care professionals, practices as well as health systems, public health officials, and community leaders. Enhanced collaboration may facilitate more equitable influenza vaccine supply and delivery and more effective community outreach, particularly to vulnerable populations. Novel approaches for reducing barriers to accessing preventive care services may also help to reduce disparities in influenza vaccination coverage. Ongoing efforts should include broader implementation and evaluation of mandatory HCP vaccination programs in both inpatient and outpatient settings.

Antiviral Treatment

New antiviral drugs are in various development phases, given the need to improve options for the treatment and chemoprophylaxis of influenza. Additionally, with limited data on the use of antiviral agents in hospitalized children and in children with underlying medical conditions, prospective clinical trials to inform optimal timing and efficacy of antiviral treatment in these populations are warranted, particularly as new antiviral agents or new indications for existing antiviral agents become available. Barriers to treatment of children at high risk for complications, especially hospitalized patients, must be explored.

ADDITIONAL RESOURCES

Pediatricians can remain informed of advances and other updates during the influenza season by following the CDC Influenza page (www.cdc/gov/flu) and the AAP *Red Book Online* Respiratory Illness Season News and Resources Page (www.aapredbook.org).

Lessin HR; Edwards KM; American Academy of Pediatrics, Committee on Practice and Ambulatory Medicine, Committee on Infectious Diseases. Immunizing parents and other close family contacts in the pediatric office setting. *Pediatrics*. 2012;129(1):e247

American Academy of Pediatrics, Committee on Infectious Diseases. Policy statement: Influenza immunization for all health care personnel: keep it mandatory. *Pediatrics*. 2015;136(4):809–818

American Academy of Pediatrics, Committee on Pediatric Emergency Medicine. Preparation for emergencies in the offices of pediatricians and pediatric primary care providers. *Pediatrics*. 2007;120(1):200–212. Reaffirmed June 2011

American Academy of Pediatrics, Committee on Practice and Ambulatory Medicine, AAP Committee on Infectious Diseases, AAP Committee on State Government Affairs, AAP Council on School Health, AAP Section on Administration and Practice Management. Medical versus nonmedical immunization exemptions for child care and school attendance. *Pediatrics*. 2016;138(3):e20162145

O'Leary ST, Opel DJ, Cataldi JR, Hackell JM; American Academy of Pediatrics, Committee on Infectious Diseases, Committee on Practice and Ambulatory Medicine, Committee on Bioethics. Strategies for improving vaccine communication and uptake. *Pediatrics*. 2024;153(3):e2023065483

American Academy of Pediatrics, Committee on Pediatric Emergency Medicine; American Academy of Pediatrics Committee on Medical Liability; Task Force on Terrorism. The pediatrician and disaster preparedness. *Pediatrics*. 2006;117(2):560–565. Reaffirmed September 2013

American Academy of Pediatrics. Influenza. In: Kimberlin DW, Banerjee R, Barnett ED, Lynfield R, Sawyer MH, eds. *Red Book: 2024 Report of the Committee on Infectious Diseases*. 33rd ed. American Academy of Pediatrics; 2024:511–522. Available at: http://aapredbook.org

Hackell JM, Palevsky SL, Resnick M; American Academy of Pediatrics, Committee on Practice and Ambulatory Medicine, Council on Clinical Information Technology, Section on Early Career Physicians. Immunization information systems. *Pediatrics.* 2022;150(4):e2022059281

COMMITTEE ON INFECTIOUS DISEASES, 2023–2024

Sean T. O'Leary, MD, MPH, FAAP, Chairperson
James D. Campbell, MD, MS, FAAP, Vice Chairperson
Monica I. Ardura, DO, MSCS, FAAP
Kristina A. Bryant, MD, FAAP
Mary T. Caserta, MD, FAAP
Claudia Espinosa, MD, MSc, FAAP
Robert W. Frenck, Jr, MD, FAAP
C. Mary Healy, MD
Chandy C. John, MD, MS, FAAP
Athena P. Kourtis, MD, PhD, MPH
Aaron Milstone, MD, MHS, FAAP
Angela Myers, MD, MPH, FAAP
Pia Pannaraj, MD, MPH, FAAP
Adam J. Ratner, MD, MPH, FAAP

CONTRIBUTORS

Kristina A. Bryant, MD, FAAP
Annika M. Hofstetter, MD, PhD, MPH, FAAP

PARTNERSHIP FOR POLICY IMPLEMENTATION

Juan D. Chaparro, MD, MS, FAAP
Jeremy J. Michel, MD, MHS, FAAP

EX OFFICIO

David W. Kimberlin, MD, FAAP – *Red Book* Editor
Ritu Banerjee, MD, PhD, FAAP – *Red Book* Associate Editor
Elizabeth D. Barnett, MD, FAAP – *Red Book* Associate Editor
Ruth Lynfield, MD, FAAP – *Red Book* Associate Editor
Mark H. Sawyer, MD, FAAP – *Red Book* Associate Editor

LIAISONS

Michelle Barton-Forbes, MD, Canadian Paediatric Society
Cristina V. Cardemil, MD, MPH, FAAP, National Institutes of Health

Karen M. Farizo, MD, US Food and Drug Administration
Lisa M. Kafer, MD, FAAP, Committee on Practice Ambulatory Medicine
Denee Moore, MD, FAAFP, American Academy of Family Physicians
Chinedu Okeke, MD, MPH-T, MPA, US Department of Health and Human Services
Chris Prestel, MD, Centers for Disease Control and Prevention
Manisha Patel, MD, MS, MBA, Centers for Disease Control and Prevention
Jeffrey R. Starke, MD, FAAP, American Thoracic Society
Jennifer Thompson, MD, American College of Obstetricians and Gynecologists
Juan Pablo Torres, MD, Sociedad Latinoamericana de Infectologia Pediatrica
Melinda Wharton, MD, MPH, Centers for Disease Control and Prevention
Charles R. Woods, Jr, MD, MS, FAAP, Pediatric Infectious Diseases Society

STAFF

Gillian Gibbs, MPH

ACKNOWLEDGMENTS

The Committee on Infectious Diseases gratefully acknowledges Kristina A. Bryant, MD, FAAP, and Annika M. Hofstetter, MD, PhD, MPH, FAAP, for their leadership in drafting the policy statement and technical report; Juan D. Chaparro, MD, MS, FAAP, and Jeremy J. Michel, MD, MHS, FAAP, for their significant contributions in providing input on the initial drafts on behalf of the AAP Partnership for Policy Initiative; and Jennifer Shaw for her editing assistance.

ABBREVIATIONS

AAP: American Academy of Pediatrics
ACIP: Advisory Committee on Immunization Practices
aOR: adjusted odds ratio
CDC: Centers for Disease Control and Prevention
CI: confidence interval
FDA: US Food and Drug Administration
HCP: health care personnel
IIV: inactivated (nonlive) influenza vaccine
IIV3: trivalent inactivated (nonlive) influenza vaccine
LAIV: live attenuated influenza vaccine
LAIV3: trivalent live attenuated influenza vaccine
RCT: randomized controlled trial
RIV: recombinant influenza vaccine
RIV3: trivalent recombinant influenza vaccine
VE: vaccine effectiveness
WHO: World Health Organization

REFERENCES

1. American Academy of Pediatrics. Committee on Infectious Diseases. Policy statement. Recommendations for prevention and control of influenza in children, 2024–2025. *Pediatrics*. 2024;154(4):e2024068507
2. Adams K, Tastad KJ, Huang S, et al. Prevalence of SARS-CoV-2 and influenza coinfection and clinical characteristics among children and adolescents aged <18 years who were hospitalized or died with influenza—United States, 2021-22 influenza season. *MMWR Morb Mortal Wkly Rep*. 2022;17(50):1589–1596
3. Centers for Disease Control and Prevention. More than 100 flu-related deaths in children reported so far this season. Available at: https://www.cdc.gov/flu/spotlights/2023-2024/pediatric-flu-deaths.htm. Accessed March 10, 2024
4. Frutos AM, Price AM, Harker E, et al. CDC Influenza Vaccine Effectiveness Collaborators. Interim estimates of 2023–24 seasonal influenza vaccine effectiveness—United States. *MMWR Morb Mortal Wkly Rep*. 2024;73(8):168–174
5. Centers for Disease Control and Prevention Health Alert Network. Highly pathogenic avian influenza A(H5N1) virus: identification of human infection and recommendations for investigations and response. Available at: https://emergency.cdc.gov/han/2024/han00506.asp. Accessed April 29, 2024
6. Garg S, Reed C, Davis CT, et al. Outbreak of highly pathogenic avian influenza A(H5N1) viruses in U.S. dairy cattle and detection of two human cases—United States, 2024. *MMWR Morb Mortal Wkly Rep*. 2024;73(21):501–505
7. Centers for Disease Control and Prevention. CDC confirms second human H5 bird flu case in Michigan; third case tied to dairy outbreak. Available at: https://www.cdc.gov/media/releases/2024/p0530-h5-human-case-michigan.html. Accessed June 3, 2024
8. Centers for Disease Control and Prevention. CDC reports fourth human case of H5 bird flu tied to dairy cow outbreak. Available at: https://www.cdc.gov/media/releases/2024/p-0703-4th-human-case-h5.html. Accessed June 14, 2024
9. Tokars JI, Olsen SJ, Reed C. Seasonal incidence of symptomatic influenza in the United States. *Clin Infect Dis*. 2018;66(10):1511–1518
10. Centers for Disease Control and Prevention. Estimated US Flu Disease Burden. Available at: https://www.cdc.gov/flu-burden/php/data-vis/index.html. Accessed August 18, 2024
11. Hoy G, Kuan G, López R, et al. The spectrum of influenza in children. *Clin Infect Dis*. 2023;76(3):e1012–e1020
12. Modler J, Morris SK, Bettinger JA, et al. Canadian Immunization Monitoring Program Active (IMPACT) Investigators. IMPACT. Bloodstream infections in children hospitalized for influenza, the Canadian Immunization Monitoring Program Active. *Pediatr Infect Dis J*. 2023;43(4):301–306
13. Herrera AL, Huber VC, Chaussee MS. The association between invasive group A streptococcal diseases and viral respiratory tract infections. *Front Microbiol*. 2016;7:342

14. Barnes M, Youngkin E, Zipprich J, et al. Notes from the field: increase in pediatric invasive group A Streptococcus infections—Colorado and Minnesota, October–December 2022. *MMWR Morb Mortal Wkly Rep.* 2023;72(10):265–267

15. Antoon JW, Hall M, Herndon A, et al. Prevalence, risk factors, and outcomes of influenza-associated neurologic complications in children. *J Pediatr.* 2021;239:32–38.e5

16. Frankl S, Coffin SE, Harrison JB, Swami SK, McGuire JL. Influenza-associated neurologic complications in hospitalized children. *J Pediatr.* 2021;239:24–31.e1

17. Rubino R, Imburgia C, Bonura S, Trizzino M, Iaria C, Cascio A. Thromboembolic events in patients with influenza: a scoping review. *Viruses.* 2022;14(12):2817

18. Centers for Disease Control and Prevention. Weekly US influenza surveillance report (FluView). Available at: https://www.cdc.gov/flu/weekly/. Accessed July 14, 2024

19. Kamidani S, Garg S, Rolfes MA, et al. Epidemiology, clinical characteristics, and outcomes of influenza-associated hospitalizations in U.S. children over 9 seasons following the 2009 H1N1 pandemic. *Clin Infect Dis.* 2022;75(11):1930–1939

20. Delahoy MJ, Ujamaa D, Taylor CA, et al. Comparison of influenza and coronavirus disease 2019-associated hospitalizations among children younger than 18 years old in the United States: FluSurv-NET (October-April 2017-2021) and COVID-NET (October 2020-September 2021). *Clin Infect Dis.* 2023;76(3):e450–e459

21. Maddux AB, Grunwell JR, Newhams MM, et al; PALISI Pediatric Intensive Care Influenza Network Investigators. Association of asthma with treatments and outcomes in children with critical influenza. *J Allergy Clin Immunol Pract.* 2023;11(3):836–843.e3

22. Centers for Disease Control and Prevention. 2020-2021 Flu season summary FAQ. Available at: https://www.cdc.gov/flu/season/faq-flu-season-2020-2021.htm#:~:text=During%20the%202020%2D2021%20flu%20season%2C%20there%20was%20very%20low,%5B62.5%25%5D%20influenza%20B). Accessed June 4, 2024

23. Centers for Disease Control and Prevention. 2022–2023 Estimated influenza burden. Available at: https://www.cdc.gov/flu/about/burden/2022-2023.htm#:~:text=We%20estimated%20that%20about%20500,influenza%20prevention%20measures%20among%20children. Accessed June 3, 2024

24. Shang M, Blanton L, Brammer L, Olsen SJ, Fry AM. Influenza-associated pediatric deaths in the United States, 2010-2016. *Pediatrics.* 2018;141(4):e20172918

25. Centers for Disease Control and Prevention. Prevalence of childhood obesity in the United States. Available at: https://www.cdc.gov/obesity/php/data-research/childhood-obesity-facts.html. Accessed August 18, 2024

26. Vitoratou D-I, Milas G-P, Korovessi P, Kostaridou S, Koletsi P. Obesity as a risk factor for severe influenza infection in children and adolescents: a systematic review and meta-analysis. *Eur J Pediatr.* 2023;182(1):363–374

27. Centers for Disease Control and Prevention. Racial and ethnic minority groups. Available at: https://www.cdc.gov/flu/highrisk/disparities-racial-ethnic-minority-groups.html. Accessed July 12, 2021

28. Feiler MO, Yucel R, Liu Z, et al. Trends and non-clinical predictors of respiratory syncytial virus (RSV) and influenza diagnosis in an urban pediatric population. *Int J Pediatr Res.* 2023;9(1):112

29. O'Bryant SC, Dongarwar D, Salihu HM, Gillespie S. Racial and ethnic differences of influenza-associated pediatric hospitalizations and deaths, 2008-2017. *Pediatr Allergy Immunol Pulmonol.* 2022;35(2):102–108

30. O'Halloran AC, Holstein R, Cummings C, et al. Rates of influenza-associated hospitalization, intensive care unit admission, and in-hospital death by race and ethnicity in the United States From 2009 to 2019. *JAMA Netw Open.* 2021;4(8):e2121880

31. Haddadin Z, Spieker AJ, Amarin JZ, et al. Incidence of and risk factors for influenza-associated hospital encounters in pediatric solid organ transplant recipients. *Am J Transplant.* 2023;23(5):659–665

32. Mackey K, Ayers CK, Kondo KK, et al. Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: a systematic review. *Ann Intern Med.* 2021;174(3):362–373

33. Fitzpatrick T, McNally JD, Stukel TA, et al. Family and child risk factors for early-life RSV illness. *Pediatrics.* 2021;147(4):e2020029090

34. Flannery B, Reynolds SB, Blanton L, et al. Influenza vaccine effectiveness against pediatric deaths: 2010-2014. *Pediatrics.* 2017;139(5):e20164244

35. Ferdinands JM, Olsho LE, Agan AA, et al. Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) Network. Effectiveness of influenza vaccine against life-threatening RT-PCR confirmed influenza illness in US children, 2010-2012. *J Infect Dis.* 2014;210(5):674–683

36. Olson SM, Newhams MM, Halasa NB, et al. Pediatric Intensive Care Influenza Investigators. Vaccine effectiveness against life-threatening influenza illness in US children. *Clin Infect Dis.* 2022;75(2):230–238

37. Feldstein LR, Ogokeh C, Rha B, et al. Vaccine effectiveness against influenza hospitalization among children in the United States, 2015-2016. *J Pediatric Infect Dis Soc.* 2021;10(2):75–82

38. Segaloff HE, Leventer-Roberts M, Riesel D, et al. Influenza vaccine effectiveness against hospitalization in fully and partially vaccinated children in Israel: 2015-2016, 2016-2017, and 2017-2018. *Clin Infect Dis.* 2019;69(12):2153–2161

39. Blyth CC, Cheng AC, Crawford NW, et al; Paediatric Active Enhanced Disease Surveillance (PAEDS), Influenza Complications Alert Network (FluCAN) Collaboration. The impact of new universal child influenza programs in Australia: vaccine coverage, effectiveness and disease epidemiology in hospitalised children in 2018. *Vaccine.* 2020;38(13):2779–2787

40. Kalligeros M, Shehadeh F, Mylona EK, et al. Influenza vaccine effectiveness against influenza-associated hospitalization in children: a systematic review and meta-analysis. *Vaccine.* 2020;38(14):2893–2903

41. Pebody RG, Zhao H, Whitaker HJ, et al. Effectiveness of influenza vaccine in children in preventing influenza associated hospitalisation, 2018/19, England. *Vaccine.* 2020;38(2):158–164

42. Shinjoh M, Sugaya N, Yamaguchi Y, et al. Influenza vaccine effectiveness against influenza A in children based on the results of various rapid influenza tests in the 2018/19 season. *PLoS One.* 2021;16(3):e0249005

43. Yildirim I, Kao CM, Tippett A, et al. A retrospective test-negative case-control study to evaluate influenza vaccine effectiveness in preventing hospitalizations in children. *Clin Infect Dis.* 2021;73(10): 1759–1767

44. Tran D, Vaudry W, Moore D, et al; Members of the Canadian Immunization Monitoring Program Active. Hospitalization for influenza A versus B. *Pediatrics.* 2016;138(3):e20154643

45. Campbell AP, Ogokeh C, Weinberg GA, et al. New Vaccine Surveillance Network (NVSN). Effect of vaccination on preventing influenza-associated hospitalizations among children during a severe season associated with B/Victoria viruses. *Clin Infect Dis.* 2019-2020;73(4):e947–e954

46. Chung JR, Rolfes MA, Flannery B, et al; US Influenza Vaccine Effectiveness Network; the Influenza Hospitalization Surveillance Network; and the Assessment Branch, Immunization Services Division, Centers for Disease Control and Prevention. Effects of influenza vaccination in the United States during the 2018-2019 influenza season. *Clin Infect Dis.* 2020;71(8):e368–e376

47. Cowling BJ, Kwan MYW, Murphy C, et al. Influenza vaccine effectiveness against influenza-associated hospitalization in Hong Kong children aged 9 months to 17 years, March-June 2023. *J Pediatric Infect Dis Soc.* 2023;12(11):586–589

48. Adams K, Weber ZA, Yang D-H, et al. Vaccine effectiveness against pediatric influenza-A-associated urgent care, emergency department, and hospital encounters during the 2022-2023 season: VISION Network. *Clin Infect Dis.* 2024;78(3):746–755

49. Hood N, Flannery B, Gaglani M, et al. Influenza vaccine effectiveness among children: 2011-2020. *Pediatrics.* 2023;151(4):e2022059922

50. Younas M, Royer J, Winders HR, et al. Temporal association between influenza vaccination coverage and ambulatory antibiotic use in children. *Pediatr Infect Dis J.* 2022;41(7):600–602

51. World Health Organization. Recommended composition of influenza virus vaccines for use in the 2024-2025 northern hemisphere influenza season. Available at: https://www.who.int/publications/m/item/recommended-composition-of-influenza-virus-vaccines-for-use-in-the-2024-2025-northern-hemisphere-influenza-season. Accessed March 18, 2024

52. US Food and Drug Administration. Use of trivalent influenza vaccines for the 2024-2025 U.S. influenza season. Available at: https://www.fda.gov/vaccines-blood-biologics/lot-release/use-trivalent-influenza-vaccines-2024-2025-us-influenza-season. Accessed March 15, 2024

53. Grohskopf LA, Alyanak E, Broder KR, et al. Prevention and control of influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices, United States, 2024–25 influenza season. *MMWR Morb Mortal Wkly Rep.* 2024; in press

54. Kim JH, Drame M, Puthanakit T, et al. Immunogenicity and safety of AS03-adjuvanted H5N1 influenza vaccine in children 6-35 months of age. *Pediatr Infect Dis J.* 2021;40(9):e333–e339

55. Vesikari T, Kirstein J, Devota Go G, et al. Efficacy, immunogenicity, and safety evaluation of an MF59-adjuvanted quadrivalent influenza virus vaccine compared with non-adjuvanted influenza vaccine in children: a multicentre, randomised controlled, observer-blinded, phase 3 trial. *Lancet Respir Med.* 2018;6(5): 345–356

56. Palladino G, Ferrari A, Music N, Settembre EC, Wen Y. Improved immunologic responses to heterologous influenza strains in children with low preexisting antibody response vaccinated with MF59-adjuvanted influenza vaccine. *Vaccine.* 2021;39(38):5351–5357

57. Chanthavanich P, Versage E, Van Twuijver E, Hohenboken M. Antibody responses against heterologous A/H5N1 strains for an MF59-adjuvanted cell culture-derived A/H5N1 (aH5N1c) influenza vaccine in healthy pediatric subjects. *Vaccine.* 2021;39(47): 6930–6935

58. US Food and Drug Administration. Vaccines licensed for use in the United States. Available at: https://www.fda.gov/vaccines-blood-biologics/vaccines/vaccines-licensed-use-united-states. Accessed June 3, 2024

59. US Food and Drug Administration. Fluzone quadrivalent, fluzone high-dose quadrivalent, fluzone, intradermal quadrivalent, fluzone quadrivalent southern hemisphere. Available at: https://www.fda.gov/vaccines-blood-biologics/vaccines/fluzone-quadrivalent. Accessed May 2, 2022

60. Robertson CA, Mercer M, Selmani A, Klein NP, Jeanfreau R, Greenberg DP. Safety and immunogenicity of a full-dose, split-virion, inactivated, quadrivalent influenza vaccine in healthy children 6-35 months of age: a randomized controlled clinical trial. *Pediatr Infect Dis J.* 2019;38(3):323–328

61. US Food and Drug Administration. Afluria quadrivalent, afluria quadrivalent Southern Hemisphere. Available at: https://www.fda.gov/vaccines-blood-biologics/vaccines/afluria-quadrivalent. Accessed June 24, 2019

62. Janssen C, Mosnier A, Gavazzi G, et al. Coadministration of seasonal influenza and COVID-19 vaccines: a systematic review of clinical studies. *Hum Vaccin Immunother.* 2022;18(6):2131166

63. Moro PL, Zhang B, Ennulat C, et al. Safety of co-administration of mRNA COVID-19 and seasonal inactivated influenza vaccines in the vaccine adverse event reporting system (VAERS) during July 1, 2021-June 30, 2022. *Vaccine.* 2023;41(11):1859–1863

64. Hause AM, Zhang B, Yue X, et al. Reactogenicity of simultaneous COVID-19 mRNA booster and influenza vaccination in the US. *JAMA Netw Open.* 2022;5(7):e2222241

65. Centers for Disease Control and Prevention. Interim clinical considerations for use of COVID-19 vaccines currently authorized in the United States. Available at: https://www.cdc.gov/vaccines/covid-19/clinical-considerations/covid-19-vaccines-us.html. Accessed July 14, 2024

66. World Health Organization, Global Advisory Committee on Vaccine Safety. Thimerosal in vaccines. *Wkly Epidemiol Rec.* 2012; 87:277–288

67. Verstraeten T, Davis RL, DeStefano F, et al; Vaccine Safety Datalink Team. Safety of thimerosal-containing vaccines: a two-phased study of computerized health maintenance organization databases. *Pediatrics.* 2003;112(5):1039–1048

68. Stehr-Green P, Tull P, Stellfeld M, Mortenson PB, Simpson D. Autism and thimerosal-containing vaccines: lack of consistent evidence for an association. *Am J Prev Med.* 2003;25(2):101–106

69. Rubin LG, Levin MJ, Ljungman P, et al; Infectious Diseases Society of America. 2013 IDSA clinical practice guideline for vaccination of the immunocompromised host. *Clin Infect Dis*. 2014;58(3):309–318

70. Centers for Disease Control and Prevention. Altered immunocompetence: general best practice guidelines for immunization. Available at: https://www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html. Accessed June 6, 2023

71. Danziger-Isakov L, Kumar D.; AST ID Community of Practice. Vaccination of solid organ transplant candidates and recipients: guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. *Clin Transplant*. 2019;33(9):e13563

72. American Academy of Pediatrics, Committee on Infectious Diseases. Technical report. Recommendations for prevention and control of influenza in children, 2021–2022. *Pediatrics*. 2021;148(4):e2021053745

73. Centers for Disease Control and Prevention. General recommendations on immunization. Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep*. 1994;43(RR-1):1–38

74. Harris E. FDA will evaluate first self-administered FluMist vaccine. *JAMA*. 2023;330(20):1945

75. US Food and Drug Administration. FluMist package insert. Available at: https://www.fda.gov/media/160349/download. Accessed June 6, 2023

76. Centers for Disease Control and Prevention. Live Attenuated Influenza Vaccine [LAIV} (The Nasal Spray Flu Vaccine). Available at: https://www.cdc.gov/flu/prevent/nasalspray.htm#:~:text=People%20with%20weakened%20immune%20systems,getting%20the%20nasal%20spray%20vaccine. Accessed August 19, 2024

77. Bandell A, Ambrose CS, Maniaci J, Wojtczak H. Safety of live attenuated influenza vaccine (LAIV) in children and adults with asthma: a systematic literature review and narrative synthesis. *Expert Rev Vaccines*. 2021;20(6):717–728

78. Sokolow AG, Stallings AP, Kercsmar C, et al. Safety of live attenuated influenza vaccine in children with asthma. *Pediatrics*. 2022;149(4):e2021055432

79. Weir JP, Gruber MF. An overview of the regulation of influenza vaccines in the United States. *Influenza Other Respir Viruses*. 2016;10(5):354–360

80. Petrie JG, Ohmit SE, Truscon R, et al. Modest waning of influenza vaccine efficacy and antibody titers during the 2007-2008 influenza season. *J Infect Dis*. 2016;214(8):1142–1149

81. Radin JM, Hawksworth AW, Myers CA, Ricketts MN, Hansen EA, Brice GT. Influenza vaccine effectiveness: Maintained protection throughout the duration of influenza seasons 2010-2011 through 2013-2014. *Vaccine*. 2016;34(33):3907–3912

82. Powell LN, Bégué RE. Influenza vaccine effectiveness among children for the 2017-2018 season. *J Pediatric Infect Dis Soc*. 2020;9(4):468–473

83. Sahni LC, Naioti EA, Olson SM, et al. Sustained within-season vaccine effectiveness against influenza-associated hospitalization in children: evidence from the New Vaccine Surveillance Network, 2015-2016 through 2019-2020. *Clin Infect Dis*. 2023;76(3):e1031–e1039

84. Ferdinands JM, Fry AM, Reynolds S, et al. Intraseason waning of influenza vaccine protection: evidence from the US influenza vaccine effectiveness network, 2011-2012 through 2014-2015. *Clin Infect Dis*. 2017;64(5):544–550

85. Castilla J, Martinez-Baz I, Martinez-Artola V, et al; Network for Influenza Surveillance in Hospitals of Navarre; Primary Health Care Sentinel Network. Decline in influenza vaccine effectiveness with time after vaccination, Navarre, Spain, season 2011/12. *Euro Surveill*. 2013;18(5):20388

86. Kissling E, Valenciano M, Larrauri A. Low and decreasing vaccine effectiveness against influenza A(H3) in 2011/12 among vaccination target groups in Europe: results from the I-MOVE multicentre case-control study. *Euro Surveill*. 2013;18(5):20390

87. Belongia EA, Sundaram ME, McClure DL, Meece JK, Ferdinands J, VanWormer JJ. Waning vaccine protection against influenza A (H3N2) illness in children and older adults during a single season. *Vaccine*. 2015;33(1):246–251

88. Puig-Barbera J, Mira-Iglesias A, Tortajada-Girbes M, et al; Valencia Hospital Network for the Study of Influenza and other Respiratory Viruses (VAHNSI, Spain). Waning protection of influenza vaccination during four influenza seasons, 2011/2012 to 2014/2015. *Vaccine*. 2017;35(43):5799–5807

89. Ray GT, Lewis N, Klein NP, et al. Intraseason waning of influenza vaccine effectiveness. *Clin Infect Dis*. 2019;68(10):1623–1630

90. Kissling E, Nunes B, Robertson C, et al. I-MOVE multicentre case-control study 2010/11 to 2014/15: Is there within-season waning of influenza type/subtype vaccine effectiveness with increasing time since vaccination?. *Euro Surveill*. 2016;21(16)

91. Pebody R, Andrews N, McMenamin J, et al. Vaccine effectiveness of 2011/12 trivalent seasonal influenza vaccine in preventing laboratory-confirmed influenza in primary care in the United Kingdom: evidence of waning intra-seasonal protection. *Euro Surveill*. 2013;18(5):20389

92. Hannah C, Campitelli Michael A, Buchan Sarah A, et al; Canadian Immunization Research Network (CIRN) Provincial Collaborative Network (PCN) Investigators. Measuring waning protection from seasonal influenza vaccination during nine influenza seasons, Ontario, Canada, 2010/11 to 2018/19. *Euro Surveill*. 2024;29(8):2300239

93. Doyon-Plourde P, Przepiorkowski J, Young K, Zhao L, Sinilaite A. Intraseasonal waning immunity of seasonal influenza vaccine—a systematic review and meta-analysis. *Vaccine*. 2023;41(31):4462–4471

94. Wagner AL, Sanchez N, Kubale J, et al. Single-dose vaccination among infants and toddlers provides modest protection against influenza illness, which wanes after 5 months. *J Infect Dis*. 2023;227(1):87–91

95. Centers for Disease Control and Prevention. *CDC Yellow Book: Health Information for International Travel*. Centers for Disease Control and Prevention; 2024

96. Kroger A, Bahta L, Long S, Sanchez P. General best practice guidelines for immunization. Best practices guidance of the Advisory Committee on Immunization Practices (ACIP). Available at:

https://www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html. Accessed June 4, 2024

97. Kelso JM, Greenhawt MJ, Li JT; Task Force on Joint Parameters. Update on influenza vaccination of egg allergic patients. *Ann Allergy Asthma Immunol.* 2013;111(4):301–302

98. Greenhawt M, Turner PJ, Kelso JM. Administration of influenza vaccines to egg allergic recipients: a practice parameter update 2017. *Ann Allergy Asthma Immunol.* 2018;120(1):49–52

99. American C, Of O, Gynecologists. ACOG committee opinion no. 732: influenza vaccination during pregnancy. *Obstet Gynecol.* 2018;131(4):e109–e114

100. Robison SG, Osborn AW. The concordance of parent and child immunization. *Pediatrics.* 2017;139(5):e20162883

101. Zaman K, Roy E, Arifeen SE, et al. Effectiveness of maternal influenza immunization in mothers and infants. *N Engl J Med.* 2008;359(15):1555–1564

102. Tapia MD, Sow SO, Tamboura B, et al. Maternal immunization with trivalent inactivated influenza vaccine for prevention of influenza in infants in Mali: a prospective, active controlled, observer blind, randomized phase 4 trial. *Lancet Infect Dis.* 2016;16(9):1026–1035

103. Madhi SA, Cutland CL, Kuwanda L, et al; Maternal Flu Trial (Matflu) Team. Influenza vaccination of pregnant women and protection of their infants. *N Engl J Med.* 2014;371(10):918–931

104. Steinhoff MC, Katz J, Englund JA, et al. Year round influenza immunization during pregnancy in Nepal: a phase 4, randomized, placebo controlled trial. *Lancet Infect Dis.* 2017;17(9):981–989

105. Shakib JH, Korgenski K, Presson AP, et al. Influenza in infants born to women vaccinated during pregnancy. *Pediatrics.* 2016;137(6):e20152360

106. Nunes MC, Madhi SA. Influenza vaccination during pregnancy for prevention of influenza confirmed illness in the infants: a systematic review and meta-analysis. *Hum Vaccin Immunother.* 2018;14(3):758–766

107. Thompson M, Kwong J, Regan A, et al; PREVENT Workgroup. Influenza vaccine effectiveness in preventing influenza-associated hospitalizations during pregnancy: a multi-country retrospective test negative design study, 2010-2016. *Clin Infect Dis.* 2019;68(9):1444–1453

108. Nunes MC, Madhi SA. Prevention of influenza related illness in young infants by maternal vaccination during pregnancy. *F1000Res.* 2018;7:122

109. Omer SB, Clark DR, Aqil AR, et al; for BMGF Supported Maternal Influenza Immunization Trials Investigators Group. Maternal influenza immunization and prevention of severe clinical pneumonia in young infants: analysis of randomized controlled trials conducted in Nepal, Mali and South Africa. *Pediatr Infect Dis J.* 2018;37(5):436–440

110. Fell DB, Russell M, Fung SG, et al. Effectiveness of maternal influenza vaccination during pregnancy against laboratory-confirmed seasonal influenza among infants under 6 months of age in Ontario, Canada. *J Infect Dis.* 2023;230(1):e80–e92

111. Sahni LC, Olson SM, Halasa NB, et al; New Vaccine Surveillance Network collaborators. Maternal vaccine effectiveness against influenza-associated hospitalizations and emergency department visits in infants. *JAMA Pediatr.* 2023;178(2):176–184

112. Munoz FM, Jackson LA, Swamy GK, et al. Safety and immunogenicity of seasonal trivalent inactivated influenza vaccines in pregnant women. *Vaccine.* 2018;36(52):8054–8061

113. Chambers CD, Johnson DL, Xu R, et al; OTIS Collaborative Research Group. Safety of the 2010-11, 2011-12, 2012-13, and 2013-14 seasonal influenza vaccines in pregnancy: birth defects, spontaneous abortion, preterm delivery, and small for gestational age infants, a Study From the Cohort Arm of VAMPSS. *Vaccine.* 2016;34(37):4443–4449

114. Donahue JG, Kieke BA, King JP, et al. Association of spontaneous abortion with receipt of inactivated influenza vaccine containing H1N1pdm09 in 2010-11 and 2011-12. *Vaccine.* 2017;35(40):5314–5322

115. Donahue JG, Kieke BA, King JP, et al. Inactivated influenza vaccine and spontaneous abortion in the Vaccine Safety Datalink in 2012-13, 2013-14, and 2014-15. *Vaccine.* 2019;37(44):6673–6681

116. Robinson C, Oberye J, van Boxmeer J, et al. A prospective cohort study on pregnancy outcomes of persons immunized with a seasonal quadrivalent inactivated influenza vaccine during pregnancy. *Vaccines (Basel).* 2022;10(10):1577

117. Sheffield JS, Greer LG, Rogers VL, et al. Effect of influenza vaccination in the first trimester of pregnancy. *Obstet Gynecol.* 2012;120(3):532–537

118. Polyzos KA, Konstantelias AA, Pitsa CE, Falagas ME. Maternal influenza vaccination and risk for congenital malformations: a systematic review and meta-analysis. *Obstet Gynecol.* 2015;126(5):1075–1084

119. Peppa M, Thomas SL, Minassian C, et al. Seasonal influenza vaccination during pregnancy and the risk of major congenital malformations in live-born infants: a 2010-2016 historical cohort study. *Clin Infect Dis.* 2021;73(11):e4296–e4304

120. Palmsten K, Suhl J, Conway KM, et al; National Birth Defects Prevention Study. Influenza vaccination during pregnancy and risk of selected major structural congenital heart defects, National Birth Defects Prevention Study 2006-2011. *Birth Defects Res.* 2023;115(1):88–95

121. Becerra-Culqui TA, Getahun D, Chiu V, Sy LS, Tseng HF. Prenatal influenza vaccination or influenza infection and autism spectrum disorder in offspring. *Clin Infect Dis.* 2022;75(7):1140–1148

122. Foo D, Sarna M, Pereira G, Moore HC, Regan AK. Association between maternal influenza vaccination and neurodevelopmental disorders in childhood: a longitudinal, population based linked cohort study. *Arch Dis Child.* 2023;108(8):647–653

123. Chambers CD, Johnson D, Xu R, et al; OTIS Collaborative Research Group. Risks and safety of pandemic H1N1 influenza vaccine in pregnancy: birth defects, spontaneous abortion, preterm delivery, and small for gestational age infants. *Vaccine.* 2013;31(44):5026–5032

124. Nordin JD, Olshen Kharbanda E, Vazquez Benitez G, et al; Vaccine Safety Datalink. Maternal influenza vaccine and risks for preterm or small for gestational age birth. *J Pediatr.* 2014;164(5):1051–1057.e2

125. Duque J, Howe AS, Azziz-Baumgartner E, Petousis-Harris H. Multi-decade national cohort identifies adverse pregnancy and birth outcomes associated with acute respiratory hospitalisations during the influenza season. *Influenza Other Respir Viruses.* 2023;17(1):e13063

126. Centers for Disease Control and Prevention. FluVax view. Pregnant persons coverage. Available at: https://www.cdc.gov/flu/fluvaxview/dashboard/vaccination-coverage-pregnant.html. Accessed May 8, 2023

127. Callahan AG, Coleman-Cowger VH, Schulkin J, Power ML. Racial disparities in influenza immunization during pregnancy in the United States: a narrative review of the evidence for disparities and potential interventions. *Vaccine*. 2021;39(35):4938–4948

128. Moll K, Wong HL, Fingar K, et al. Vaccine exposure during pregnancy among privately and publicly insured women in the United States, 2016-2018. *Vaccine*. 2021;39(41):6095–6103

129. Kaur R, Callaghan T, Regan AK. Disparities in maternal influenza immunization among women in rural and urban areas of the United States. *Prev Med*. 2021;147:106531

130. Schlaudecker EP, Steinhoff MC, Omer SB, et al. IgA and neutralizing antibodies to influenza A virus in human milk: a randomized trial of antenatal influenza immunization. *PLoS One*. 2013;8(8):e70867

131. Ackerson BK, Sy LS, Glenn SC, et al. Pediatric vaccination during the COVID-19 pandemic. *Pediatrics*. 2021;148(1):e2020047092

132. Bramer CA, Kimmins LM, Swanson R, et al. Decline in child vaccination coverage during the COVID-19 pandemic — Michigan Care Improvement Registry, May 2016-May 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(20):630–631

133. O'Leary ST, Trefren L, Roth H, Moss A, Severson R, Kempe A. Number of childhood and adolescent vaccinations administered before and after the COVID-19 outbreak in Colorado. *JAMA Pediatr*. 2021;175(3):305–307

134. Santoli JM, Lindley MC, DeSilva MB, et al. Effects of the COVID-19 pandemic on routine pediatric vaccine ordering and administration—United States, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(19):591–593

135. US Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Healthy people 2030. Vaccination. Available at: https://health.gov/healthypeople/objectives-and-data/browse-objectives/vaccination. Accessed June 4, 2024

136. Centers for Disease Control and Prevention. Influenza vaccination coverage, children 6 months through 17 years, United States. Available at: https://www.cdc.gov/flu/fluvaxview/dashboard/vaccination-coverage-race.html. Accessed July 15, 2024

137. Gates DM, Cohen SA, Orr K, Caffrey AR. Pediatric influenza vaccination rates lower than previous estimates in the United States. *Vaccine*. 2022;40(44):6337–6343

138. Geissler KH, Shieh M-S, Evans V, et al. Influenza vaccinations among privately and publicly insured children with asthma. *Acad Pediatr*. 2023;23(7):1368–1375

139. Fogel B, Schaefer EW, Hicks SD. Early influenza vaccination rates decline in children during the COVID-19 pandemic. *Vaccine*. 2021;39(31):4291–4295

140. Baumer-Mouradian SH, Hart RJ, Visotcky A, et al. Understanding influenza and SARS-CoV-2 vaccine hesitancy in racial and ethnic minority caregivers. *Vaccines (Basel)*. 2022;10(11):1968

141. Hofstetter AM, Schaffer S. Childhood and adolescent vaccination in alternative settings. *Acad Pediatr*. 2021;21(4S):S50–S56

142. Hart RJ, Paul RI, Levine A, Sikes K, Bryant K, Stevenson MD. Parent intent and willingness to immunize children against influenza in the pediatric emergency department. *Pediatr Emerg Care*. 2019;35(7):493–497

143. Meyer AJ, Smith JR, Wright TL, Engler LJ, Bigham MT, Bhalla T. Pediatric influenza vaccination in the perioperative setting: a quality improvement project. *Paediatr Anaesth*. 2024;34(2):167–174

144. Hart R, Feygin Y, Kluthe T, Quinn KG, Rao S, Baumer-Mouradian SH. Emergency departments: an underutilized resource to address pediatric influenza vaccine coverage. *Vaccine*. 2023;41(47):7026–7032

145. Westrick SC, Patterson BJ, Kader MS, Rashid S, Buck PO, Rothholz MC. National survey of pharmacy-based immunization services. *Vaccine*. 2018;36(37):5657–5664

146. Gates DM, Cohen SA, Orr K, et al. Demographic and clinical predictors of pharmacist-administered pediatric influenza immunization. *J Pharm Pract*. 2024;37(3):612–624

147. Zerr DM, Englund JA, Robertson AS, et al. Hospital-based influenza vaccination of children: an opportunity to prevent subsequent hospitalization. *Pediatrics*. 2008;121(2):345–348

148. Pollack AH, Kronman MP, Zhou C, Zerr DM. Automated screening of hospitalized children for influenza vaccination. *J Pediatric Infect Dis Soc*. 2014;3(1):7–14

149. Stockwell MS, Natarajan K, Ramakrishnan R, et al. Immunization data exchange with electronic health records. *Pediatrics*. 2016;137(6):e20154335

150. Stokley S, Kempe A, Stockwell MS, Szilagyi PG. Improving pediatric vaccination coverage in the United States. *Acad Pediatr*. 2021;21(4S):S1–S2

151. Cataldi JR, Kerns ME, O'Leary ST. Evidence-based strategies to increase vaccination uptake: a review. *Curr Opin Pediatr*. 2020;32(1):151–159

152. Clark SJ, Butchart A, Kennedy A, Dombkowski KJ. Parents' experiences with and preferences for immunization reminder/recall technologies. *Pediatrics*. 2011;128(5):e1100–e1105

153. Daley MF, Barrow J, Pearson K, et al. Identification and recall of children with chronic medical conditions for influenza vaccination. *Pediatrics*. 2004;113(1 Pt 1):e26–e33

154. Tuckerman J, Harper K, Sullivan TR, et al. Short message service reminder nudge for parents and influenza vaccination uptake in children and adolescents with special risk medical conditions: the Flutext-4U randomized clinical trial. *JAMA Pediatr*. 2023;177(4):337–344

155. Jacobson Vann JC, Jacobson RM, Coyne-Beasley T, Asafu-Adjei JK, Szilagyi PG. Patient reminder and recall interventions to improve immunization rates. *Cochrane Database Syst Rev*. 2018;1(1):CD003941

156. Hofstetter AM, Vargas CY, Camargo S, et al. Impacting delayed pediatric influenza vaccination: a randomized controlled trial of text message reminders. *Am J Prev Med*. 2015;48(4):392–401

157. Stockwell MS, Hofstetter AM, DuRivage N, et al. Text message reminders for second dose of influenza vaccine: a randomized controlled trial. *Pediatrics*. 2015;135(1):e83–e91

158. Scott VP, Opel DJ, Reifler J, et al. Office-based educational handout for influenza vaccination: a randomized controlled trial. *Pediatrics*. 2019;144(2):e20182580

159. Daley MF, Narwaney KJ, Shoup JA, Wagner NM, Glanz JM. Addressing parents' vaccine concerns: a randomized trial of a social media intervention. *Am J Prev Med*. 2018;55(1):44–54

160. Hofstetter AM, Robinson JD, Lepere K, Cunningham M, Etsekson N, Opel DJ. Clinician-parent discussions about influenza vaccination of children and their association with vaccine acceptance. *Vaccine*. 2017;35(20):2709–2715

161. Limaye RJ, Opel DJ, Dempsey A, et al. Communicating with vaccine-hesitant parents: a narrative review. *Acad Pediatr*. 2021; 21(4S):S24–S29

162. Stephens AB, Hofstetter AM, Stockwell MS. Influenza vaccine hesitancy: scope, influencing factors, and strategic interventions. *Pediatr Clin North Am*. 2023;70(2):227–241

163. O'Leary ST, Opel DJ, Cataldi JR, Hackell JM; Committee on Practice and Ambulatory Medicine; Committee on Bioethics; Committee on Infectious Diseases. Strategies for improving vaccine communication and uptake. *Pediatrics*. 2024;153(3): e2023065483

164. Rao S, Ziniel SI, Khan I, Dempsey A. Be influential: evaluation of a multifaceted intervention to increase influenza vaccination rates among pediatric inpatients. *Vaccine*. 2020;38(6): 1370–1377

165. Stockwell MS, Catallozzi M, Camargo S, et al. Registry-linked electronic influenza vaccine provider reminders: a cluster-crossover trial. *Pediatrics*. 2015;135(1):e75–e82

166. Lessin HR, Edwards KM; Committee on Practice and Ambulatory Medicine; Committee on Infectious Diseases. Immunizing parents and other close family contacts in the pediatric office setting. *Pediatrics*. 2012;129(1):e247–e253

167. Corley AMS, Gomes SM, Crosby LE, et al. Partnering with faith-based organizations to offer flu vaccination and other preventive services. *Pediatrics*. 2022;150(3):e2022056193

168. Centers for Disease Control and Prevention. Influenza vaccination coverage among health care personnel—United States, 2022–23 influenza season. Available at: https://www.cdc.gov/flu/fluvaxview/hcp-coverage_22-23-estimates.htm#:~:text=The%20Advisory%20Committee%20on%20Immunization,and%20their%20patients%20(1). Accessed June 3, 2024

169. Frederick J, Brown AC, Cummings DA, et al. Protecting healthcare personnel in outpatient settings: the influences of mandatory versus nonmandatory influenza vaccination policies on workplace absenteeism during multiple respiratory virus seasons. *Infect Control Hosp Epidemiol*. 2018;39(4):452–461

170. Centers for Disease Control and Prevention. Influenza antiviral medications. Available at: www.cdc.gov/flu/professionals/antivirals/index.htm. Accessed April 14, 2022

171. Uyeki TM, Bernstein HH, Bradley JS, et al. Clinical practice guidelines by the Infectious Diseases Society of America (IDSA): 2018 update diagnosis, treatment, chemoprophylaxis and institutional outbreak management of seasonal influenza. *Clin Infect Dis*. 2019;68(6):e1–e47

172. Xu M, Cai T, Yue T, et al. Comparative effectiveness of oseltamivir versus peramivir for hospitalized children (aged 0-5 years) with influenza infection. *Int J Infect Dis*. 2023;128:157–165

173. Wang J, Chen H, Zhuo L, et al. Effectiveness of intravenous peramivir for the treatment of influenza A/H3N2 and influenza B/Victoria in hospitalized children. *J Infect Chemother*. 2023;29(9):843–848

174. Heo YA. Baloxavir: first global approval. *Drugs*. 2018;78(6):693–697

175. US Food and Drug Administration. Approval package for XOFLUZA. Available at: https://www.accessdata.fda.gov/drugsatfda_docs/nda/2019/2108540rig1s001.pdf. Accessed May 29, 2022

176. Baker J, Block SL, Matharu B, et al. Baloxavir marboxil single-dose treatment in influenza-infected children: a randomized, double-blind, active controlled phase 3 safety and efficacy trial (miniSTONE-2). *Pediatr Infect Dis J*. 2020;39(8):700–705

177. Taieb V, Ikeoka H, Wojciechowski P, et al. Efficacy and safety of baloxavir marboxil versus neuraminidase inhibitors in the treatment of influenza virus infection in high-risk and uncomplicated patients – a Bayesian network meta-analysis. *Curr Med Res Opin*. 2021;37(2):225–244

178. Ison MG, Portsmouth S, Yoshida Y, et al. Early treatment with baloxavir marboxil in high-risk adolescent and adult outpatients with uncomplicated influenza (CAPSTONE-2): a randomised, placebo-controlled, phase 3 trial. *Lancet Infect Dis*. 2020;20(10): 1204–1214

179. Kakuya F, Haga S, Okubo H, Fujiyasu H, Kinebuchi T. Effectiveness of baloxavir marboxil against influenza in children. *Pediatr Int*. 2019;61(6):616–618

180. Nezu K, Hayashida S, Nagano N, Udagawa S, Morioka I. Early fever resolution in early childhood influenza treated with baloxavir marboxil: a retrospective study compared with those with oseltamivir. *Medicina (Kaunas)*. 2023;59(9):1543

181. Baker JB, Block SL, Cagas SE, et al. Safety and efficacy of baloxavir marboxil in influenza-infected children 5-11 years of age: a post hoc analysis of a phase 3 study. *Pediatr Infect Dis J*. 2023;42(11):983–989

182. Hirotsu N, Sakaguchi H, Fukao K, et al. Baloxavir safety and clinical and virologic outcomes in influenza virus-infected pediatric patients by age group: age-based pooled analysis of two pediatric studies conducted in Japan. *BMC Pediatr*. 2023;23(1):35

183. Ison MG, Portsmouth S, Yoshida Y, Shishido T, Hayden F, Uehara T. LB16. Phase 3 trial of baloxavir marboxil in high-risk influenza patients (CAPSTONE-2 Study). *Open Forum Infect Dis*. 2018; 5(suppl_1):S764–S765

184. US Food and Drug Administration. Baloxavir package insert. Available at: https://www.gene.com/download/pdf/xofluza_prescribing.pdf. Accessed August 22, 2022

185. Centers for Disease Control and Prevention; Health Alert Network. Interim guidance for clinicians to prioritize antiviral treatment of influenza in the setting of reduced availability of oseltamivir. Available at: https://emergency.cdc.gov/han/2022/han00482.asp. Accessed April 11, 2023

186. Louie JK, Yang S, Samuel MC, Uyeki TM, Schechter R. Neuraminidase inhibitors for critically ill children with influenza. *Pediatrics*. 2013;132(6):e1539–e1545

187. Katzen J, Kohn R, Houk JL, Ison MG. Early oseltamivir after hospital admission is associated with shortened hospitalization: a 5-year analysis of oseltamivir timing and clinical outcomes. *Clin Infect Dis.* 2019;69(1):52–58

188. Ramirez J, Peyrani P, Wiemken T, Chaves SS, Fry AM. A randomized study evaluating the effectiveness of oseltamivir initiated at the time of hospital admission in adults hospitalized with influenza-associated lower respiratory tract infections. *Clin Infect Dis.* 2018;67(5):736–742

189. Dobson J, Whitley RJ, Pocock S, Monto AS. Oseltamivir treatment of influenza in adults: a meta-analysis of randomised controlled trials. *Lancet.* 2015;385(9979):1729–1737

190. Jefferson T, Jones MA, Doshi P, et al. Neuraminidase inhibitors for preventing and treating influenza in healthy adults and children. *Cochrane Database Syst Rev.* 2014;2014(4):CD008965

191. Malosh RE, Martin ET, Heikkinen T, Brooks WA, Whitley RJ, Monto AS. Efficacy and safety of oseltamivir in children: systematic review and individual patient data meta-analysis of randomized controlled trials. *Clin Infect Dis.* 2018;66(10):1492–1500

192. Uyeki TM. Oseltamivir treatment of influenza in children. *Clin Infect Dis.* 2018;66(10):1501–1503

193. Wang K, Shun-Shin M, Gill P, Perera R, Harnden A. Neuraminidase inhibitors for preventing and treating influenza in children (published trials only). *Cochrane Database Syst Rev.* 2012;2012(4):CD002744

194. Domínguez A, Romero-Tamarit A, Soldevila N, et al; Surveillance of Hospitalized Cases of Severe Influenza in Catalonia Working Group. Effectiveness of antiviral treatment in preventing death in severe hospitalized influenza cases over six seasons. *Epidemiol Infect.* 2018;146(7):799–808

195. Hsu J, Santesso N, Mustafa R, et al. Antivirals for treatment of influenza: a systematic review and meta-analysis of observational studies. *Ann Intern Med.* 2012;156(7):512–524

196. Muthuri SG, Venkatesan S, Myles PR, et al; PRIDE Consortium Investigators. Effectiveness of neuraminidase inhibitors in reducing mortality in patients admitted to hospital with influenza A H1N1pdm09 virus infection: a meta-analysis of individual participant data. *Lancet Respir Med.* 2014;2(5):395–404

197. Venkatesan S, Myles PR, Leonardi-Bee J, et al. Impact of outpatient neuraminidase inhibitor treatment in patients infected with influenza A(/H1N1)pdm09 at high risk of hospitalization: an individual participant data metaanalysis. *Clin Infect Dis.* 2017;64(10):1328–1334

198. Tejada S, Tejo AM, Peña-López Y, Forero CG, Corbella X, Rello J. Neuraminidase inhibitors and single dose baloxavir are effective and safe in uncomplicated influenza: a meta-analysis of randomized controlled trials. *Expert Rev Clin Pharmacol.* 2021;114(7):901–918

199. Bassett HK, Coon ER, Mansbach JM, Snow K, Wheeler M, Schroeder AR. Misclassification of both influenza infection and oseltamivir exposure status in administrative data. *JAMA Pediatr.* 2024;178(2):201–203

200. Hayden FG, Asher J, Cowling BJ, et al. Reducing influenza virus transmission: the potential value of antiviral treatment. *Clin Infect Dis.* 2022;74(3):532–540

201. Dawood FS, Jara J, Gonzalez R, et al. A randomized, double-blind, placebo-controlled trial evaluating the safety of early oseltamivir treatment among children 0-9 years of age hospitalized with influenza in El Salvador and Panama. *Antiviral Res.* 2016;133:85–94

202. Campbell AP, Tokars JI, Reynolds S, et al. Influenza antiviral treatment and length of stay. *Pediatrics.* 2021;148(4):e2021050417

203. Miyakawa R, Barreto NB, Kato RM, Neely MN, Russell CJ. Early use of anti-influenza medications in hospitalized children with tracheostomy. *Pediatrics.* 2019;143(3):e20182608

204. Walsh PS, Schnadower D, Zhang Y, Ramgopal S, Shah SS, Wilson PM. Association of early oseltamivir with improved outcomes in hospitalized children with influenza, 2007-2020. *JAMA Pediatr.* 2022;176(11):e223261

205. Li L, Liu J, Qin K. Comparison of double-dose versus standard-dose oseltamivir in the treatment of influenza: a systematic review and meta-analysis. *J Clin Pharmacol.* 2020;45(5):918–926

206. Kumar D, Ison MG, Mira JP, et al. Combining baloxavir marboxil with standard-of-care neuraminidase inhibitor in patients hospitalised with severe influenza (FLAGSTONE): a randomised, parallel-group, double-blind, placebo-controlled, superiority trial. *Lancet Infect Dis.* 2022;22(5):718–730

207. Howard A, Uyeki TM, Fergie J. Influenza-associated acute necrotizing encephalopathy in siblings. *J Pediatric Infect Dis Soc.* 2018;7(3):e172–e177

208. Takeuchi S, Tetsuhashi M, Sato D. Oseltamivir phosphate—lifting the restriction on its use to treat teenagers with influenza in Japan (commentary). *Pharmacoepidemiol Drug Saf.* 2019;28(4):434–436

209. Toovey S, Prinssen EP, Rayner CR, et al. Post-marketing assessment of neuropsychiatric adverse events in influenza patients treated with oseltamivir: an updated review. *Adv Ther.* 2012;29(10):826–848

210. Antoon JW, Williams DJ, Bruce J, et al. Population-based incidence of influenza-associated serious neuropsychiatric events in children and adolescents. *JAMA Pediatr.* 2023;177(9):967–969

211. Antoon JW, Sarker J, Abdelaziz A, et al. Trends in outpatient influenza antiviral use among children and adolescents in the United States. *Pediatrics.* 2023;152(6):e2023061960

212. Antoon JW, Hall M, Feinstein JA, et al. Guideline-concordant antiviral treatment in children at high risk for influenza complications. *Clin Infect Dis.* 2023;76(3):e1040–e1046

213. Hamdan L, Probst V, Haddadin Z, et al. Influenza clinical testing and oseltamivir treatment in hospitalized children with acute respiratory illness, 2015-2016. *Influenza Other Respir Viruses.* 2022;16(2):289–297

214. Mehta K, Morris SK, Bettinger JA, et al; Canadian Immunization Monitoring Program Active (IMPACT) Investigators. Antiviral use in Canadian children hospitalized for influenza. *Pediatrics.* 2021;148(4):e2020049672

215. Walsh PS, Schnadower D, Zhang Y, Ramgopal S, Shah SS, Wilson PM. Assessment of temporal patterns and patient factors associated with oseltamivir administration in children hospitalized with influenza, 2007-2020. *JAMA Netw Open.* 2022;5(9):e2233027

216. Ikematsu H, Hayden FG, Kawaguchi K, et al. Baloxavir marboxil for prophylaxis against influenza in household contacts. *N Engl J Med*. 2020;383(4):309–320

217. Govorkova EA, Takashita E, Daniels RS, et al. Global update on the susceptibilities of human influenza viruses to neuraminidase inhibitors and the cap-dependent endonuclease inhibitor baloxavir, 2018-2020. *Antiviral Res*. 2022;200:105281

218. Lucira Health Inc. Fact sheet for healthcare professionals. Lucira COVID-19 & Flu Home Test. Available at: https://www.fda.gov/media/163456/download. Accessed April 24, 2023

219. US Food and Drug Administration. FDA authorizes first over-the-counter at-home test to detect both influenza and COVID-19 viruses. Available at: https://www.fda.gov/news-events/press-announcements/fda-authorizes-first-over-counter-home-test-detect-both-influenza-and-covid-19-viruses. Accessed August 18, 2024

220. Schuster JE, Hamdan L, Dulek DE, et al; Pediatric HCT Flu Study Group. Influenza vaccine in pediatric recipients of hematopoietic-cell transplants. *N Engl J Med*. 2023;388(4):374–376

221. Schuster JE, Hamdan L, Dulek DE, et al; Pediatric HCT Flu Study. The durability of antibody responses of two doses of high-dose relative to two doses of standard-dose inactivated influenza vaccine in pediatric hematopoietic cell transplant recipients: a multi-center randomized controlled trial. *Clin Infect Dis*. 2024;78(1):217–226

222. Kempe A, Saville AW, Albertin C, et al. Parental hesitancy about routine childhood and influenza vaccinations: a national survey. *Pediatrics*. 2020;146(1):e20193852

223. Santibanez TA, Nguyen KH, Greby SM, et al. Parental vaccine hesitancy and childhood influenza vaccination. *Pediatrics*. 2020;146(6):e2020007609