



Published in final edited form as:

Pediatrics. 2025 March ; 155(3): . doi:10.1542/peds.2024-069368.

Duration of Illness in Children <18 Years Dying of Influenza in California: 2004–2023

Sophie Zhu, PhD^{1,2}, Joshua Quint, PhD, MPH², Christina Penton, MPH², Cora Hoover, MD, MPH², Erin L. Murray, PhD, MSPH²

¹Epidemic Intelligence Service, Centers for Disease Control and Prevention, Atlanta, GA

²Division of Communicable Disease Control, California Department of Public Health, Richmond, CA

Introduction

Annually, thousands of children in the United States are hospitalized and 35–200 die from influenza illness and its complications.^{1,2} Influenza vaccines are highly effective against life-threatening influenza in children.³ Even a partially effective influenza vaccine can avert symptomatic illness, hospitalization, and death, and reduce illness severity if a child is infected. The Advisory Committee on Immunization Practices began recommending annual influenza vaccination of all children aged ≥ 6 months starting in 2010–2011. Vaccination rates among children <18 years of age vary, ranging from 33.4–62.6% during 2010–2019.^{4,5} Children who die from influenza often have an underlying condition known to increase the risk of influenza-associated complications and are unvaccinated.⁶ For children with severe influenza, or illness that can result in hospitalization or death, previous vaccination ≥ 2 weeks before illness reduces disease severity and risk of death.³ We described patient, vaccination, and influenza illness characteristics by underlying condition status among children aged <18 years who died from influenza during 2004–2023 in California.

Methods

California law requires reporting pediatric influenza-associated deaths to public health authorities. This activity was reviewed by the Centers for Disease Control and Prevention (CDC), deemed not research, and was conducted consistent with applicable federal law and

Address correspondence to: Sophie Zhu, California Department of Public Health, 850 Marina Bay Parkway, Richmond, CA, 94804 [sophie.zhu@cdph.ca.gov].

Contributors Statement Page

Dr. Sophie Zhu conceptualized and designed the study, drafted the initial manuscript, carried out the analyses, and critically reviewed and revised the manuscript.

Drs. Cora Hoover and Erin L. Murray conceptualized and designed the study, coordinated and supervised data collection, and critically reviewed and revised the manuscript.

Dr. Joshua Quint critically reviewed and revised the manuscript.

Christina Penton collected the data, critically reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Conflict of Interest Disclosures: The authors have no conflicts of interest to disclose.

Clinical Trial Registration: N/A

The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views or opinions of the California Department of Public Health or the California Health and Human Services Agency.

CDC policy.[§] We included all pediatric influenza-associated deaths reported during October 9, 2004–September 30, 2023. Race and ethnicity of fatal pediatric influenza patients were determined by electronic health records and included for descriptive purposes. Duration of illness before death was calculated as the difference between symptom onset date and date of death. Clinical variables of interest included whether a patient was admitted to the intensive care unit, use of antibiotics, use of antivirals, type of medical facility, secondary bacterial infection status, pneumonia status, vaccination status, number of underlying conditions, location of death, and influenza type. Number of underlying conditions was determined by the total number of conditions known to have an association with severe influenza outcomes, including respiratory, metabolic, cardiac, renal, pulmonary, neurologic, and immunocompromising conditions. Clinical variables were determined from chart review and entered into the electronic health record.

Results

During 2004–2023, 0–46 children died from influenza and were reported to public health. There was a significant drop in deaths from 2020–2021 due to the COVID-19 pandemic. Among 245 children who died of influenza, median age was 6.3 years (range: 3 days–17 years) (Table 1). Most (59%; $n = 145$) were infected with influenza A and 18% ($n = 45$) with influenza B. Fewer than 1% ($n = 1$) were coinfecting with A and B; 22% ($n = 54$) had an unknown influenza type. Most children (62%; $n = 152$) had ≥ 1 underlying conditions (median 1; range = 1–6). Of children with known vaccination status, 27% (37/135) had documented vaccination ≥ 2 weeks before illness onset; 29% (27/92) of children with underlying conditions were vaccinated vs 23% (10/43) of previously healthy children. Many children died in the intensive care unit (58%, $n = 142/245$). Most children with underlying conditions had pneumonia (55%) and frequently received antiviral treatment (53%) (Table 1). Median duration of illness before death was 7.5 days for children with preexisting conditions and 4.0 days for healthy children. Previously healthy children accounted for 38% of the influenza deaths in California.

Discussion

Our findings demonstrate that some children with influenza can have rapid evolution to severe disease; though counterintuitive, this phenomenon is most striking in previously healthy children. Over 50% of children without underlying conditions died at home or in an emergency department; only 25% received antiviral treatment. Vaccination coverage of children dying of influenza in California was low compared to national estimates for children 6 months–17 years, which range between 43.7–63.7% depending on influenza season.^{6,7} This analysis is limited by unknown vaccination status for some children, because reporting of vaccine doses to an immunization registry was not mandatory in California until 2023; data prior to 2023 were gathered from multiple sources to improve data quality.

This analysis highlights potential missed opportunities for prevention of fatal influenza illness among children with and without underlying conditions. Future investigation should assess effects of vaccination on influenza illness severity, while accounting for other factors such as prior season vaccination, severity of preexisting conditions, and propensity to seek

healthcare. Vaccination is recommended for all children ≥ 6 months of age, and messaging directed at both clinicians and parents to support increased influenza vaccination is vital to reducing influenza burden.

§ See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Acknowledgements

We thank local health departments in California for conducting all case investigations for deaths described in this analysis.

Abbreviations:

CDPH	California Department of Public Health
CDC	Centers for Disease Control and Prevention

References

1. White EB. High Influenza Incidence and Disease Severity Among Children and Adolescents Aged 18 Years—United States, 2022–23 Season. *MMWR. Morbidity and Mortality Weekly Report*. 2023;72.
2. CDC. More than 100 Flu-Related Deaths in Children Reported This Season. Centers for Disease Control and Prevention. Published March 8, 2024. <https://www.cdc.gov/flu/spotlights/2023-2024/pediatric-flu-deaths.htm>
3. Olson SM, Newhams MM, Halasa NB, Feldstein LR, Novak T, Weiss SL, Coates BM, Schuster JE, Schwarz AJ, Maddux AB, Hall MW. Vaccine effectiveness against life-threatening influenza illness in US children. *Clinical Infectious Diseases*. 2022 Jul 15;75(2):230–8. [PubMed: 35024795]
4. Smith NM, Bresee JS, Shay DK, Uyeki TM, Cox NJ, Strikas RA. Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP)(<http://www.cdc.gov/mmwr/preview/mmwrhtml/rr55e628a1.htm>). Accessed. 2008 Aug;2.
5. Gates DM, Cohen SA, Orr K, Caffrey AR. Pediatric influenza vaccination rates lower than previous estimates in the United States. *Vaccine*. 2022 Oct 19;40(44):6337–43. [PubMed: 36167694]
6. Santibanez TA, Srivastav A, Zhai Y, Singleton JA. Trends in childhood influenza vaccination coverage, United States, 2012–2019. *Public Health Reports*. 2020 Sep;135(5):640–9. [PubMed: 32783780]
7. Centers for Disease Control and Prevention. FluVaxView | Influenza vaccination coverage, United States. Available at: <https://www.cdc.gov/flu/fluview/interactive-general-population.htm>. Accessed September 10, 2024

Article Summary

This analysis of California surveillance data documents how previously healthy children who died from influenza had rapid progression to fatal disease.

What's Known on This Subject

Annually, 35–200 children die from influenza in the United States. Certain pre-existing conditions predispose children to severe illness and death from influenza. Vaccination can protect children against severe influenza outcomes.

What This Study Adds

Previously healthy children who die from influenza can have rapid evolution to severe disease, with limited time for medical interventions. Incorporating this information into public messaging will raise awareness about the potentially fatal effects of influenza and benefits of vaccination, even in healthy children.

Table 1.
Characteristics of children dying of influenza in California, 2004–2023

	Overall	Children with underlying conditions (%)	Previously healthy children (%)
Total	245	152	93
Age (yrs)			
Median	6.3	7.8	5.4
IQR *	2.5–11.5	3.2–12.6	1.4–9.7
Race			
American Indian or Alaska Native	1	1 (0.7)	0 (0.0)
Asian	28	15 (9.9)	13 (14.0)
Black or African American	23	18 (11.8)	5 (5.4)
Native Hawaiian or Pacific Islander	3	2 (1.4)	1 (1.1)
White	132	85 (55.9)	47 (50.5)
Unknown	58	31 (20.3)	27 (29.0)
Ethnicity			
Hispanic or Latino	119	77 (50.7)	42 (45.2)
Not Hispanic or Latino	92	62 (40.8)	30 (32.3)
Unknown	34	13 (8.5)	21 (22.5)
Sex			
Female	120	70 (46.0)	50 (53.8)
Male	125	82 (54)	43 (46.2)
Influenza type			
A	145		
2009 H1N1	73	54 (35.5)	19 (20.4)
Pre-2009 H1	3	2 (1.3)	1 (1.1)
H3N2	44	21 (13.8)	23 (24.1)
Subtype not determined	25	15 (9.9)	10 (10.8)
B	45		
Victoria	3	1 (0.7)	2 (2.2)
Yamagata	2	2 (1.3)	0 (0.0)
Lineage not determined	40	20 (13.2)	20 (22.0)
A and B	1	0 (0.0)	1 (1.1)
Unknown	54	37 (24.3)	17 (18.3)
Vaccinated			
Yes	37	27 (17.8)	10 (10.8)
No	98	65 (49.3)	33 (34.7)
Unknown	110	50 (32.9)	60 (64.5)
Influenza season			
2004–05	10	10 (6.6)	0 (0.0)
2005–06	16	8 (5.3)	8 (8.6)
2006–07	5	3 (2.0)	2 (2.2)
2007–08	6	4 (2.6)	2 (2.2)
2008–09	6	3 (2.0)	3 (3.2)
2009–10	46	39 (25.7)	7 (7.5)
2010–11	15	8 (5.3)	7 (7.5)
2011–12	10	6 (3.9)	4 (4.3)
2012–13	13	6 (3.9)	7 (7.5)
2013–14	11	7 (4.6)	4 (4.3)
2014–15	9	6 (3.9)	3 (3.2)
2015–16	15	8 (5.3)	7 (7.5)
2016–17	10	6 (3.9)	4 (4.3)
2017–18	20	9 (5.9)	11 (11.9)
2018–19	16	9 (5.9)	7 (7.5)
2019–20	22	15 (9.9)	7 (7.5)
2020–21	1	1 (0.7)	0 (0.0)
2021–22	0	0 (0.0)	0 (0.0)
2022–23	14	4 (2.6)	10 (10.8)
Antiviral treatment			
Yes	103	80 (52.6)	23 (24.7)
No	101	46 (30.3)	55 (59.1)
Unknown	41	26 (17.1)	15 (16.2)

	Overall	Children with underlying conditions (%)	Previously healthy children (%)
Pneumonia			
Yes	114	84 (55.3)	30 (32.3)
No	119	61 (40.1)	58 (62.4)
Unknown	12	7 (4.6)	5 (5.3)
Secondary bacterial infection			
Yes	62	39 (25.7)	23 (24.7)
No	152	91 (59.9)	61 (65.6)
Unknown	31	22 (14.4)	9 (9.7)
Location of death			
Home or in transit to hospital	23	11 (7.2)	12 (12.9)
Emergency department	56	20 (13.2)	36 (38.7)
Inpatient ward	6	4 (2.6)	2 (2.2)
Intensive care unit	142	105 (69.1)	37 (39.8)
Unknown	18	12 (7.9)	6 (6.4)
Duration of illness before death			
Median	5	7.5	4
Mean	12.3	15.1	7.7
IQR	2–16	3–19	1–7

*
IQR = interquartile range