Comparison of influenza and COVID-19–associated hospitalizations among children < 18 years old in the United States — FluSurv-NET (October–April 2017–2021) and COVID-NET (October 2020–September 2021)

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Abstract

Background: Influenza virus and SARS-CoV-2 are significant causes of respiratory illness in children.

Methods: Influenza and COVID-19-associated hospitalizations among children <18 years old were analyzed from FluSurv-NET and COVID-NET, two population-based surveillance systems with similar catchment areas and methodology. The annual COVID-19-associated hospitalization rate per 100 000 during the ongoing COVID-19 pandemic (October 1, 2020–September 30, 2021) was compared to influenza-associated hospitalization rates during the 2017–18 through 2019–20 influenza seasons. In-hospital outcomes, including intensive care unit (ICU) admission and death, were compared.

Results: Among children <18 years old, the COVID-19-associated hospitalization rate (48.2) was higher than influenza-associated hospitalization rates: 2017–18 (33.5), 2018–19 (33.8), and 2019–20 (41.7). The COVID-19-associated hospitalization rate was higher among adolescents 12–17 years old (COVID-19: 59.9; influenza range: 12.2-14.1), but similar or lower among children 5–11 (COVID-19: 25.0; influenza range: 24.3-31.7) and 0–4 (COVID-19: 66.8; influenza range: 70.9-91.5) years old. Among children <18 years old, a higher proportion with COVID-19 required ICU admission compared with influenza (26.4% vs 21.6%; p<0.01). Pediatric deaths were uncommon during both COVID-19- and influenza-associated hospitalizations (0.7% vs 0.5%; p=0.28).

Conclusions: In the setting of extensive mitigation measures during the COVID-19 pandemic, the annual COVID-19-associated hospitalization rate during 2020–2021 was higher among adolescents and similar or lower among children <12 years old compared with influenza during the three seasons before the COVID-19 pandemic. COVID-19 adds substantially to the existing burden of pediatric hospitalizations and severe outcomes caused by influenza and other respiratory viruses.

Keywords: COVID-19; influenza; children; SARS-CoV-2; surveillance

Introduction

Influenza virus and SARS-CoV-2 are significant causes of respiratory illness and can cause severe illness including death in children [1–5]. Annual influenza vaccination is approved and recommended for persons ≥ 6 months old without contraindications [6], whereas COVID-19 vaccines are currently authorized or approved for persons ≥ 5 years old [7]. Influenza-associated hospitalization rates are typically highest among adults aged ≥ 65 years, followed during some seasons by adults aged 50–64 years and during others by children 0–4 years old [8]. COVID-19-associated hospitalization rates are similarly higher among adults compared with children [9]. However, data comparing influenza versus COVID-19-associated hospitalizations among children are limited [10,11]. Such data are useful for evaluating the impact of mitigation measures and for interpreting disease burden measures, which can provide useful context to inform COVID-19 vaccine recommendations for children < 5 years old. We compared hospitalization rates, clinical characteristics, and outcomes among children < 18 years old hospitalized with influenza or COVID-19 in the United States.

Methods

The Influenza Hospitalization Surveillance Network (FluSurv-NET) [8] and the Coronavirus Disease 2019-Associated Hospitalization Surveillance Network (COVID-NET) [12,13] conduct population-based surveillance for laboratory-confirmed influenza- and COVID-19-associated hospitalizations, respectively. FluSurv-NET was initiated in 2003–04. COVID-NET was initiated in March 2020 using FluSurv-NET infrastructure [12]. During 2017–18 through 2020–21, FluSurv-NET was conducted in select counties in 14 states participating in the Emerging Infections Program (California, Colorado, Connecticut, Georgia, Maryland [Baltimore Metropolitan Area], Minnesota, New Mexico, New York, Oregon, and Tennessee) or the Influenza Hospitalization Surveillance Project (Iowa [2020–21 only], Michigan, Ohio, and Utah), with a catchment population of approximately 29 million persons. COVID-NET conducts surveillance in

all FluSurv-NET counties and state-wide in Maryland, with a catchment population of approximately 32 million persons.

FluSurv-NET surveillance is conducted during each influenza season (October 1 through April 30) and COVID-NET surveillance is conducted year-round [8,13]. A FluSurv-NET or COVID-NET case is defined as a hospitalized patient who is a resident of the system's catchment area, with a positive influenza (rapid antigen detection, molecular assay, direct or indirect immunofluorescence assay, or viral culture) or SARS-CoV-2 (rapid antigen detection or molecular assay) test during or ≤ 14 days before hospitalization. Influenza virus or SARS-CoV-2 testing is performed at the discretion of healthcare practitioners or according to hospital testing practices. Trained surveillance staff identify all catchment area residents hospitalized with influenza or COVID-19 using laboratory, hospital, and reportable conditions databases.

Medical records are abstracted using standardized data collection forms to obtain information on demographics, clinical characteristics, interventions (invasive mechanical ventilation [IMV] and extracorporeal membrane oxygenation), and outcomes (intensive care unit [ICU] admission, pneumonia, and death from any cause) during an influenza- or COVID-19-associated hospitalization.

Obesity status was determined using body mass index (≥ 95th percentile for sex and age), ICD-10-CM discharge diagnosis codes, and problem lists. Acute symptoms at admission were abstracted from history and physical exam notes; the list of abstracted symptoms varied by surveillance platform and year. Acute respiratory or febrile symptoms (fever, congestion/runny nose, cough, shortness of breath, sore throat, upper respiratory illness or influenza-like illness, and wheezing) were abstracted for all FluSurv-NET seasons and for COVID-NET. Additional symptoms abstracted for FluSurv-NET by season and for COVID-NET are detailed in Table 1 and Supplementary Table 1.

Monthly hospitalization counts were determined for influenza (October–April during the 2017–18 through 2020–21 influenza seasons) and COVID-19 (March 2020–September 2021). Unadjusted

influenza and COVID-19-associated hospitalization rates per 100 000 children were calculated by dividing the total number of hospitalizations by National Center for Health Statistics population denominators [14]. The COVID-19-associated hospitalization rate was calculated for a 1-year period (October 1, 2020–September 30, 2021). This annual rate was compared with influenza-associated hospitalization rates during October 1–April 30 of each of the 2017–18 through 2019–20 influenza seasons. Influenza occurs seasonally in the United States with low detection during May–September [15,16], suggesting few influenza-associated hospitalizations are missed outside the October–April surveillance window. Thus, influenza-associated hospitalization rates during October–April were used to represent annual rates. Weekly hospitalization rates per 100 000 children were calculated for influenza (overall and by influenza virus type) and COVID-19.

In a *post hoc* analysis, preliminary influenza- and COVID-19-associated hospitalization rates per 100 000 children during the current season, October 1, 2021–April 9, 2022, were calculated.

The frequencies of select characteristics and outcomes were calculated for children hospitalized with influenza (2017–18 through 2019-20 influenza seasons), and COVID-19 (October 1, 2020–September 30, 2021).

Children with laboratory-confirmed influenza or COVID-19 may have been hospitalized primarily for other reasons but found incidentally to have influenza or COVID-19. We conducted sensitivity analyses to determine whether severe outcomes differed by symptom status (presence of ≥ 1 symptom at admission) for both influenza and COVID-19, and by admission reason for COVID-19 (these data were not available in FluSurv-NET). For COVID-NET, the primary admission reason was determined from the chief complaint and history of present illness.

P values were calculated using Pearson chi-square or Wilcoxon rank sum tests. Statistical significance was set at $\alpha = .05$; all tests were 2-sided. For hospitalization rates and select analyses of characteristics

and outcomes, 95% Confidence Intervals (CI) for binomial proportions were calculated using the Clopper-Pearson method. Statistical analyses were performed in SAS version 9.4 (SAS Institute).

FluSurv-NET and COVID-NET surveillance activities were reviewed by CDC and conducted consistent with applicable federal law and CDC policy (e.g., 45 CFR. Part 46.102(l)(2), 21 CFR part 56; 42 USC. §241(d); 5 USC §552a; 44 USC §3501 et seq). Sites participating in FluSurv-NET and COVID-NET obtained human subjects and ethics approvals from their respective state and local health department and academic partner Institutional Review Boards as needed.

Results

From October 2017 until February 2020, monthly influenza-associated hospitalization counts followed a typical seasonal pattern (Figure 1); during March–April 2020, influenza-associated hospitalizations decreased abruptly, coinciding with the March 16, 2020 release of national guidance for slowing the spread of COVID-19, which included school closures and other mitigation measures [17]. Subsequently, during October 1, 2020–April 30, 2021, only 9 influenza-associated hospitalizations among children were reported to FluSurv-NET. Starting in March 2020 (when COVID-NET surveillance was initiated) through September 2021, COVID-19-associated hospitalizations were identified in children each month (range: 22–470 hospitalizations).

Among all children, influenza-associated hospitalization rates during the three seasons before the COVID-19 pandemic (2017–18 through 2019–20; rate range: 33.5–41.7; 95% CI of highest-burden season [2019–20]: 40.2–43.3) were lower than one annual COVID-19-associated hospitalization rate observed during October 2020–September 2021 of the ongoing COVID-19 pandemic (48.2; 95% CI: 46.6–49.8) (Figure 2; Supplementary Table 2). However, differences were observed by age. Among children 0–4 years old, the influenza-associated hospitalization rate for the 2019–20 season (91.5) was higher than, and for the 2017–18 season (71.0) and 2018-19 season (70.9) were similar to, the COVID-19-associated

hospitalization rate (66.8). Influenza- (2017–18 through 2019–20: 24.3–31.7) and COVID-19- (25.0) associated hospitalization rates were similar among children 5–11 years old. Among adolescents (12–17 years old), influenza-associated hospitalization rates (2017–18 through 2019–20: 12.2–14.1) were lower than the COVID-19-associated hospitalization rate (59.9).

During October 1, 2021–April 9, 2022, the preliminary COVID-19-associated hospitalization rate among all children was higher than influenza-associated hospitalization rates during October–April of 2017–18 through 2021–22 and was also higher than the annual COVID-19-assocated hospitalization rate during October 2020–September 2021 (Supplementary Figure 2A). Increases in the COVID-19-associated hospitalization rate were largely driven by increased rates among infants 0–6 months old (Supplementary Figure 2B).

Weekly influenza-associated hospitalization rates peaked in February during all three seasons before the COVID-19 pandemic (peak weekly rate range: 2.4–4.0). Rates varied by influenza virus type (Supplementary Figure 1). The highest weekly rate of COVID-19 during October 2020–September 2021 (1.8) occurred in September 2021.

Among 6774 children hospitalized with influenza during 2017–18 through 2019–20 and 3461 children hospitalized with COVID-19 during October 2020–September 2021, the median age was lower for influenza (3 years; interquartile range [IQR]: 1–7) than COVID-19 (9 years; IQR: 1–15) (Table 1). Other demographic characteristics were similar. Overall, 6564 children with influenza (96.9%) and 2760 children with COVID-19 (79.7%) had ≥ 1 symptom at admission. A higher proportion of children with influenza had ≥ 1 respiratory or febrile symptom compared to those with COVID-19 (95.6% vs 64.8%). Other common symptoms among children with influenza versus COVID-19 included nausea/vomiting (40.1% vs 34.4%), fatigue (29.1% vs 19.0%), and diarrhea (13.8% vs 15.8%) (Supplementary Table 1).

Overall, 3774 children hospitalized with influenza (55.7%) and 1857 children hospitalized with COVID-19 (53.7%) had ≥ 1 underlying medical condition (Table 2). Asthma/reactive airway disease, neurologic disorder, and obesity were the most prevalent conditions for influenza and COVID-19. A higher proportion of children with influenza compared with COVID-19 had asthma (23.6% vs 16.3%) or chronic lung disease (6.0% vs 3.3%), but lower proportions had diabetes (1.2% vs 3.8%) or obesity (17.5% vs 35.0%).

The median hospital length of stay was lower for children with influenza compared with COVID-19 (2 vs 3 days, p<0.01) (Table 2). A higher proportion of children with influenza compared with COVID-19 had pneumonia (17.8% vs 13.3%; p<0.01), but lower proportions required IMV (5.3% vs 6.2%; p=0.04) or ICU admission (21.6% vs 26.4%; p<0.01). The proportion of children with influenza vs COVID-19 who died during hospitalization was similar (0.5% vs 0.7%, p=0.28).

In sensitivity analyses, proportions experiencing severe outcomes were similar when examining the following hospitalization categories: all influenza or COVID-19-associated hospitalizations, influenza or COVID-19-associated hospitalizations with ≥ 1 symptom at admission (96.9% of 6774 influenza hospitalizations and 79.7% of 3461 COVID-19 hospitalizations), and COVID-19-associated hospitalizations with COVID-19 as the primary admission reason (74.9% of COVID-19-associated hospitalizations) (Table 3). Among COVID-19-associated hospitalizations, proportions with pneumonia or ICU admission increased modestly with increasing age when restricted to hospitalizations with ≥ 1 symptom at admission or COVID-19 as the primary admission reason. However, other severe outcomes such as IMV and in-hospital death were similar across the hospitalization categories.

Discussion

Among children <18 years old, the COVID-19-associated hospitalization rate during one year of the ongoing COVID-19 pandemic was higher than influenza-associated hospitalization rates during each of

the three seasons before the pandemic, with differences observed by age group. Severe outcomes such as ICU admission, IMV, and in-hospital death were generally similar among children with COVID-19 compared with influenza. Influenza has long been recognized as an important cause of severe respiratory illness in children in the United States and globally [1,18]. These data add to the growing literature demonstrating that COVID-19 is also an important cause of severe disease among children.

Prevention measures such as physical distancing, mask usage, and virtual learning likely contributed to historically low levels of influenza circulation during the 2020–21 influenza season in the United States [19] and globally [20]. The influenza- and COVID-19-associated hospitalization rates among children during 2020–21 would likely have been higher without mitigation measures. While influenza activity typically displays a seasonal pattern, peaking during December–March in the northern hemisphere [15,19], COVID-19-associated hospitalizations occurred throughout 2020–2021 and no distinct seasonality can yet be distinguished. During the 2009 influenza A H1N1 pandemic (April 2009–April 2010), the H1N1pdm09 virus similarly circulated without distinct seasonality, resulting in spring and fall activity waves. Notably, H1N1pdm09-associated hospitalization and death rates were highest among children and younger adults [21]. In subsequent seasons, H1N1pdm09 displayed a typical seasonal circulation pattern, with decreasing pediatric burden as population immunity levels increased. Given the relatively condensed annual period during which seasonal influenza viruses circulate, peak weekly hospitalization rates were higher for influenza during 2017–2020 compared with COVID-19 during October 2020–September 2021, despite similar annual hospitalization rates. Co-circulation of influenza and SARS-CoV-2, along with other respiratory viruses, could exacerbate winter surges in pediatric hospitalizations, posing challenges to healthcare capacity [22,23].

While >95% of hospitalized children with influenza had a respiratory or febrile symptom, approximately one-third of children with COVID-19 did not, and overall, one in five children with COVID-19 did not have any symptoms at admission. Large proportions of children with influenza or COVID-19 had non-

respiratory symptoms, highlighting a range of symptom presentations among children hospitalized with influenza and COVID-19. Relying on respiratory or febrile symptoms alone could result in missed opportunities to detect influenza or SARS-COV-2 infections. Respiratory virus testing can help distinguish between these viruses and guide treatment and infection prevention decisions [24–26]. There were also differences in the prevalence of underlying conditions among children with influenza versus COVID-19, which may in part be driven by differences in median age. The prevalence of obesity was approximately double among children with COVID-19 compared with influenza. Notably, the proportion of children with COVID-19 who were obese (35%) was similar to findings from another study of hospitalized children with COVID-19 (32%) [27] and higher than the national obesity prevalence among persons 2–19 years old (22% in 2020) [28].

Our analysis and others demonstrate that both influenza and COVID-19 can cause severe disease in children [4,5]. Among hospitalized children, 22% with influenza and 26% with COVID-19 required ICU admission, and 5% with influenza and 6% with COVID-19 required IMV. Proportions experiencing severe outcomes were generally similar when restricting to those with ≥1 symptom of influenza or COVID-19 at admission. Another analysis of COVID-19 hospitalizations among children < 18 years old during July–August 2021, when the B.1.617.2 (Delta) variant of SARS-CoV-2 was predominant, showed similar findings with 29.5% requiring ICU admission and 7.9% requiring IMV [27]. Data on COVID-19 treatment in children are limited, but treatment may be indicated for hospitalized children who have an emergent or increasing need for supplemental oxygen [26]. To decrease the risk of severe complications, early antiviral treatment is recommended for children with suspected influenza who are hospitalized or at higher risk for influenza-associated complications, including children <5 years old and those with underlying medical conditions [29].

Influenza vaccines are safe and effective at preventing hospitalizations, and were available to children ≥ 6 months old during all seasons included in this analysis [6,30]. Based on national survey data,

influenza vaccination coverage estimates among children ≥ 6 months old ranged from 51–63% during the 2012–13 to 2018–19 seasons [31]. During 2019–20, influenza vaccination averted an estimated 13,798 hospitalizations among children ≥ 6 months old [30]. Adolescents were the only children eligible to receive COVID-19 vaccination for a portion of the time-period covered in this analysis: approvals differed over time by age (12–15 and 16–17 years) [7]. As of September 30, 2021, 47% of U.S. adolescents were considered up to date with all recommended COVID-19 doses [32]. COVID-19 vaccines are both safe and effective at preventing hospitalizations among adolescents and children 5–11 years old [33–36]. Increased COVID-19 vaccination coverage among children following the emergency use authorization for COVID-19 vaccines in children 5–11 years old in October 2021 may contribute to differences in the relative rates of pediatric COVID-19 vs influenza-associated hospitalizations over time.

Several limitations should be considered. First, FluSurv-NET and COVID-NET cases may have been hospitalized for reasons other than influenza or COVID-19 [2]. This may have been more common for COVID-19 due to SARS-CoV-2 screening practices, which were universal among hospitalized patients at some facilities during certain time periods. While influenza or COVID-19 may not have been the primary reason for admission for all hospitalizations, such cases were included in rate calculations because use of a standard and consistent surveillance case definition allows for robust monitoring of trends over time. Among cases with influenza or SARS-CoV-2 incidentally identified, it is unclear what impact the infection had on the decision to hospitalize a patient, the hospitalization course, or in-hospital outcomes. In sensitivity analyses limited to hospitalizations with ≥1 symptom at admission or COVID-19 as the primary reason for admission, proportions of children with severe outcomes were similar to proportions when all hospitalizations were included. Second, COVID-19- and influenza-associated hospitalizations might have been missed because case identification was reliant on clinician-directed or facility-based testing practices and test availability. Under-detection of influenza was likely greater than COVID-19 due to under-utilization of seasonal influenza testing [30]. Third, the impact of extensive mitigation measures

during the COVID-19 pandemic, and differential availability of COVID-19 vaccines by age group and time-period could not be measured, and likely affects the comparison of influenza versus COVID-19-associated hospitalization rates. Fourth, only deaths occurring during hospitalizations were captured, which may miss out-of-hospital deaths associated with influenza or COVID-19 [37]. Fifth, the FluSurv-NET and COVID-NET catchment areas include approximately 9–10% of the U.S. population and findings may not be generalizable to the entire country. Last, this analysis assessed COVID-19-associated hospitalization rates during a single year of the ongoing COVID-19 pandemic and did not capture rate fluctuations that have occurred due to the changing epidemiology of SARS-CoV-2, including the emergence of variants of concern.

The omicron variant of SARS-CoV-2 emerged rapidly during December 2021 and resulted in a peak COVID-19 weekly hospitalization rate approximately five times as high as the peak hospitalization rate during the period of Delta variant predominance among children 0–4 years old, a group not yet eligible for COVID-19 vaccination [38]. Indeed, in a *post hoc* analysis that included months during which the omicron variant was predominant in the United States, preliminary COVID-19–associated hospitalization rates among children during October 2021–April 2022 were higher than COVID-19-associated hospitalization rates observed during October 2020–September 2021 and influenza-associated hospitalization rates observed during the 2017–18 through 2021–22 seasons.

Influenza and SARS-CoV-2 are important causes of severe disease among children. Vaccines can help prevent illness and attenuate disease severity for both influenza and COVID-19. Prevention and mitigation measures, including vaccination of all eligible persons, are crucial to protect children, including those who are not yet eligible for or are too young for vaccination. Without such measures, co-circulation of influenza virus and SARS-CoV-2, along with other respiratory viruses, could exacerbate hospitalization surges and overwhelm healthcare capacity, particularly during winter months.

Notes

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Table 1. Demographic and clinical characteristics of children <18 years old hospitalized with influenza or COVID-19 – FluSurv-NET[1] and COVID-NET[2]

	FluSurv-NET			COVID-NET			FluSurv-NET	COVID-NET
	0–4 years	**5–11 years**	**12–17 years**	**0–4 years**	**5–11 years**	**12–17 years**	**0–17 years**	**0–17 years**
	(N = 3906)	(N = 2013)	(N = 855)	(N = 1293)	(N = 698)	(N = 1470)	(N = 6774)	(N = 3461)
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Age (median, IQR)	1 (0.6–2)	7 (6–9)	14 (13–16)	1 (0.1–2)	8 (6–10)	15 (14–17)	3 (1–7)	9 (1–15)
Sex								
Male	2231 (57.1)	1166 (57.9)	419 (49.0)	694 (53.7)	379 (54.3)	625 (42.5)	3816 (56.3)	1698 (49.1)
Female	1674 (42.9)	847 (42.1)	436 (51.0)	599 (46.3)	319 (45.7)	845 (57.5)	2957 (43.7)	1763 (50.9)
Race/Ethnicity[3]								
AI/AN, NH	61 (1.6)	20 (1.0)	11 (1.3)	15 (1.2)	7 (1.0)	18 (1.2)	92 (1.4)	40 (1.2)
Asian/PI, NH	267 (6.8)	93 (4.6)	46 (5.4)	76 (5.9)	28 (4.0)	51 (3.5)	406 (6.0)	155 (4.5)
Black, NH	1065 (27.3)	575 (28.6)	216 (25.3)	394 (30.5)	258 (37.0)	482 (32.8)	1856 (27.4)	1134 (32.8)
Hispanic	1022 (26.2)	445 (22.1)	195 (22.8)	350 (27.1)	186 (26.6)	407 (27.7)	1662 (24.5)	943 (27.2)
White, NH	1155 (29.6)	748 (37.2)	333 (38.9)	362 (28.0)	188 (26.9)	436 (29.7)	2236 (33.0)	986 (28.5)
Insurance status								
Private Insurance	1459 (37.4)	933 (46.3)	380 (44.4)	569 (44.0)	271 (38.8)	626 (42.6)	2772 (40.9)	1466 (42.4)
Federal insurance	2588 (66.3)	1212 (60.2)	513 (60.0)	791 (61.2)	460 (65.9)	908 (61.8)	4313 (63.7)	2159 (62.4)
Other Insurance	45 (1.2)	15 (0.7)	5 (0.6)	37 (2.9)	29 (4.2)	42 (2.9)	65 (1.0)	108 (3.1)
Uninsured	79 (2.0)	49 (2.4)	19 (2.2)	47 (3.6)	10 (1.4)	50 (3.4)	147 (2.2)	107 (3.1)
Symptoms								
Symptom onset to admission (days: median, IQR)	3 (1–5)	3 (1–5)	2 (1–4)	2 (1–4)	3 (1–5)	4 (2–7)	3 (1–5)	3 (1–6)
Any Symptom(s)	3810 (97.5)	1948 (96.8)	806 (94.3)	1104 (85.4)	596 (85.4)	1060 (72.1)	6564 (96.9)	2760 (79.7)
Fever	3364 (86.1)	1705 (84.7)	655 (76.6)	781 (60.4)	380 (54.4)	531 (36.1)	5724 (84.5)	1692 (48.9)
Congestion	2693 (68.9)	1101 (54.7)	404 (47.3)	583 (45.1)	149 (21.3)	267 (18.2)	4198 (62.0)	999 (28.9)
Cough	3129 (80.1)	1561 (77.5)	626 (73.2)	531 (41.1)	247 (35.4)	475 (32.3)	5316 (78.5)	1253 (36.2)
Shortness of breath	1694 (43.4)	745 (37.0)	316 (37.0)	325 (25.1)	137 (19.6)	444 (30.2)	2755 (40.7)	906 (26.2)
Sore throat[4]	92 (10.0)	396 (19.7)	283 (33.1)	18 (9.6)	103 (14.8)	231 (15.7)	771 (20.4)	352 (14.9)

Upper respiratory illness[5]	591 (15.1)	277 (13.8)	139 (16.3)	85 (6.6)	11 (1.6)	35 (2.4)	1007 (14.9)	131 (3.8)
Wheezing	661 (16.9)	346 (17.2)	132 (15.4)	110 (8.5)	47 (6.7)	47 (3.2)	1139 (16.8)	204 (5.9)
Any febrile or respiratory symptom	3770 (96.5)	1924 (95.6)	780 (91.2)	989 (76.5)	483 (69.2)	769 (52.3)	6474 (95.6)	2241 (64.8)
Altered mental state/confusion	133 (3.4)	121 (6.0)	68 (8.0)	35 (2.7)	46 (6.6)	75 (5.1)	322 (4.8)	156 (4.5)
Seizure	330 (8.4)	123 (6.1)	34 (4.0)	55 (4.3)	43 (6.2)	31 (2.1)	487 (7.2)	129 (3.7)
Other symptom(s)[6]	836 (66.8)	490 (79.9)	257 (83.4)	818 (63.3)	490 (70.2)	922 (62.7)	1583 (72.9)	2230 (64.4)
No Symptoms	96 (2.5)	65 (3.2)	49 (5.7)	189 (14.6)	102 (14.6)	410 (27.9)	210 (3.1)	701 (20.3)

1 FluSurv-NET = Influenza Hospitalization Surveillance Network; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network; IQR = interquartile range

1. FluSurv-NET data include the 2017–2018, 2018–2019, and 2019–2020 seasons. Surveillance is conducted during October 1–April 30 each season. The FluSurv-NET catchment area includes California, Colorado, Connecticut, Georgia, Maryland (Baltimore Metropolitan Area), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah. Detailed clinical data on hospitalized cases from Maryland were unavailable for the 2019–20 influenza season and were not included.

2. COVID-NET data during October 1, 2020–September 30, 2021 are included. The COVID-NET catchment area includes California, Colorado, Connecticut, Georgia, Iowa, Maryland (entire state), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.

3. NH = Non-Hispanic, AI = American Indian, AN = Alaska Native; Asian race includes Pacific Islander.

4. Data on sore throat were collected for children of all ages but reported only among children ages ≥ 3 years (for FluSurv-NET: N = 920 children ages 3–4 and N = 3788 ages 3–17 years; for COVID-NET: N = 188 ages 3–4 and N = 2356 ages 3–17 years).

5. Upper respiratory illness was included as a symptom if there was a note in the medical chart referring to a patient having "upper respiratory illness" or "influenza-like illness".

6. Symptoms listed above this row were collected by COVID-NET and by FluSurv-NET during all seasons. Other symptoms collected by COVID-NET were: myalgia, chest pain, loss of taste, loss of smell, diarrhea, conjunctivitis, fatigue, headache, rash, nausea/vomiting, abdominal pain, and hemoptysis; for children < 2 years old symptoms also included apnea, cyanosis, decreased vocalization/stridor, dehydration, hypothermia, inability to eat/poor feeding, and lethargy. Other symptoms collected by FluSurv-NET only during the 2017–18 season were: myalgia, chest pain, diarrhea, conjunctivitis, fatigue, headache, nausea/vomiting, and rash. Denominators for percentages for other symptoms for FluSurv-NET for the 2017–2018 season were: for ages 0–4 (N = 1251), ages 5–11 (N = 613), ages 12–17 (N = 308), and ages 0–17 years (N = 2172). No additional symptoms were collected for FluSurv-NET during the 2018–19 or 2019–20 seasons.

Table 2. Underlying medical conditions, interventions, and outcomes of children <18 years old hospitalized with influenza or COVID-19–FluSurv-NET[1] and COVID-NET[2]

	FluSurv-NET			COVID-NET			FluSurv-NET	COVID-NET	
	0–4 years	5–11 years	12–17 years	0–4 years	5–11 years	12–17 years	0–17 years	0–17 years	
	(N = 3906)	(N = 2013)	(N = 855)	(N = 1293)	(N = 698)	(N = 1470)	(N = 6774)	(N = 3461)	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	*P* value[6]
Underlying Medical Conditions									
Any underlying medical condition(s)	1722 (44.1)	1383 (68.7)	669 (78.2)	476 (36.8)	468 (67.0)	913 (62.1)	3774 (55.7)	1857 (53.7)	0.05
Asthma/reactive airway disease	554 (14.2)	723 (35.9)	321 (37.5)	63 (4.9)	161 (23.1)	340 (23.1)	1598 (23.6)	564 (16.3)	<0.01
Chronic lung disease	192 (4.9)	141 (7.0)	72 (8.4)	39 (3.0)	35 (5.0)	41 (2.8)	405 (6.0)	115 (3.3)	<0.01
Chronic metabolic disease	82 (2.1)	93 (4.6)	96 (11.2)	31 (2.4)	46 (6.6)	128 (8.7)	271 (4.0)	205 (5.9)	<0.01
Diabetes mellitus	8 (0.2)	28 (1.4)	45 (5.3)	9 (0.7)	26 (3.7)	97 (6.6)	81 (1.2)	132 (3.8)	<0.01
Blood disorders/hemoglobinopathy	152 (3.9)	153 (7.6)	88 (10.3)	51 (3.9)	68 (9.7)	64 (4.4)	393 (5.8)	183 (5.3)	0.29
Sickle cell disease	103 (2.6)	116 (5.8)	63 (7.4)	33 (2.6)	52 (7.4)	44 (3.0)	282 (4.2)	129 (3.7)	0.29
Cardiovascular disease	289 (7.4)	135 (6.7)	63 (7.4)	133 (10.3)	75 (10.7)	104 (7.1)	487 (7.2)	312 (9.0)	<0.01
Congenital heart disease	186 (4.8)	71 (3.5)	28 (3.3)	69 (5.3)	28 (4.0)	24 (1.6)	285 (4.2)	121 (3.5)	0.08
Neurologic disorder	474 (12.1)	423 (21.0)	211 (24.7)	127 (9.8)	154 (22.1)	207 (14.1)	1108 (16.4)	488 (14.1)	<0.01
Immunocompromised condition	149 (3.8)	187 (9.3)	118 (13.8)	45 (3.5)	62 (8.9)	72 (4.9)	454 (6.7)	179 (5.2)	<0.01
Renal disease	47 (1.2)	57 (2.8)	29 (3.4)	13 (1.0)	12 (1.7)	38 (2.6)	133 (2.0)	63 (1.8)	0.62
Gastrointestinal/liver disease	21 (0.5)	26 (1.3)	14 (1.6)	21 (1.6)	24 (3.4)	30 (2.0)	61 (0.9)	75 (2.2)	<0.01
Obesity[3]	168 (13.6)	304 (18.6)	157 (21.7)	36 (15.1)	167 (30.7)	458 (41.4)	629 (17.5)	661 (35.0)	<0.01
Premature[4]	374 (12.5)	0	0	142 (12.9)	0	0	374 (12.5)	142 (12.9)	0.78
No underlying medical conditions	2184 (55.9)	630 (31.3)	186 (21.8)	817 (63.2)	230 (33.0)	557 (37.9)	3000 (44.3)	1604 (46.3)	0.05
Interventions and Outcomes									
Hospital length of stay (days: median, IQR)	2 (1-3)	2 (1-4)	2 (1-4)	2 (1-4)	3 (2-6)	3 (2-6)	2 (1-4)	3 (2-5)	<0.01
Pneumonia[5]	687 (17.6)	378 (18.8)	143 (16.7)	89 (6.9)	93 (13.3)	279 (19.0)	1208 (17.8)	461 (13.3)	<0.01
ICU admission	810 (20.7)	425 (21.1)	229 (26.8)	304 (23.5)	203 (29.1)	406 (27.6)	1464 (21.6)	913 (26.4)	<0.01
IMV	209 (5.4)	92 (4.6)	55 (6.4)	76 (5.9)	50 (7.2)	90 (6.1)	356 (5.3)	216 (6.2)	0.04
ECMO	14 (0.4)	10 (0.5)	4 (0.5)	4 (0.3)	1 (0.1)	9 (0.6)	28 (0.4)	14 (0.4)	0.95
Died during hospitalization	19 (0.5)	12 (0.6)	6 (0.7)	10 (0.8)	3 (0.4)	12 (0.8)	37 (0.5)	25 (0.7)	0.28

FluSurv-NET = Influenza Hospitalization Surveillance Network; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network; IQR = interquartile range; ICU = intensive care unit; IMV = invasive mechanical ventilation; ECMO = extracorporeal membrane oxygenation

1. FluSurv-NET data include the 2017–2018, 2018–2019, and 2019–2020 seasons. Surveillance is conducted during October 1–April 30 each season. The FluSurv-NET catchment area includes California, Colorado, Connecticut, Georgia, Maryland (Baltimore Metropolitan Area), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah. Detailed clinical data on hospitalized cases from Maryland were unavailable for the 2019–20 influenza season and were not included.

2. COVID-NET data during October 1, 2020–September 30, 2021 are included. The COVID-NET catchment area includes California, Colorado, Connecticut, Georgia, Iowa, Maryland (entire state), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.

3. Obesity status is determined for non-pregnant persons ≥ 2 years old by: calculated BMI (≥ 95th percentile for sex and age), obesity or morbid obesity selected as an underlying medical condition, or ICD-10-CM code E66.0, E66.09, E66.1, E66.8, E66.9, E66.01, E66.2, or Z68.4 entered as a discharge diagnosis. Percentages for obesity are calculated for pediatric cases with non-missing obesity data for FluSurv-NET: ages 2–4 (N = 1233), ages 5–11 (N = 1631), ages 12–17 (N = 723), ages 2–17 years (N = 3587); and for COVID-NET: ages 2–4 (N = 239), ages 5–11 (N = 544), ages 12–17 (N = 1107), ages 2–17 years (N = 1890).

4. Percentages for premature are calculated for children ages 0–2 years for FluSurv-NET (N = 2986) and for COVID-NET (N = 1105).

5. A standardized pneumonia case definition is used, which includes a combination of radiographic findings of bronchopneumonia, air space opacity, consolidation, lobar or interstitial infiltrate within 3 days of hospital admission for FluSurv-NET and at any time during hospitalization for COVID-NET, and either an ICD-10-CM-coded discharge diagnosis of pneumonia or documentation of pneumonia on hospital discharge summary.

6. *P* values are for the comparison of children aged 0–17 years in FluSurv-NET versus COVID-NET

1

Table 3. Interventions and outcomes among children <18 years old hospitalized with influenza or COVID-19 by symptom status and reason for admission, FluSurv-NET[1] and COVID-NET[2]

Interventions and Outcomes	COVID-NET all hospitalizations		COVID-NET ≥1 symptom at admission[3]		COVID-NET admission primarily for COVID-19[4]		FluSurv-NET all hospitalizations		FluSurv-NET ≥1 symptom at admission[3]	
	n	% (95% CI)[5]	n	% (95% CI)[5]	n	% (95% CI)[5]	n	% (95% CI)[5]	n	% (95% CI)[5]
Ages 0–17	**(N = 3461)**		**(N = 2760)**		**(N = 2594)**		**(N = 6774)**		**(N = 6564)**	
Hospital LOS (median, IQR)		3 (2–5)		3 (2–5)		3 (2–5)		2 (1–4)		2 (1–4)
Pneumonia[6]	461	13.3 (12.2–14.5)	457	16.6 (15.2–18.0)	452	17.4 (16.0–18.9)	1208	17.8 (16.9–18.8)	1200	18.3 (17.4–19.2)
ICU admission	913	26.4 (24.9–27.9)	811	29.4 (27.7–31.1)	781	30.1 (28.3–31.9)	1464	21.6 (20.6–22.6)	1419	21.6 (20.6–22.6)
IMV	216	6.2 (5.5–7.1)	162	5.9 (5.0–6.8)	146	5.6 (4.8–6.6)	356	5.3 (4.7–5.8)	341	5.2 (4.7–5.8)
ECMO	14	0.4 (0.2–0.7)	12	0.4 (0.2–0.8)	12	0.5 (0.2–0.8)	28	0.4 (0.3–0.6)	28	0.4 (0.3–0.6)
Died in Hospital	25	0.7 (0.5–1.1)	18	0.7 (0.4–1.0)	18	0.7 (0.4–1.1)	37	0.5 (0.4–0.8)	35	0.5 (0.4–0.7)
Ages 0–4	**(N = 1293)**		**(N = 1104)**		**(N = 1106)**		**(N = 3906)**		**(N = 3810)**	
Hospital LOS (median, IQR)		2 (1–4)		2 (1–4)		2 (1–4)		2 (1–3)		2 (1–3)
Pneumonia[6]	89	6.9 (5.6–8.4)	88	8.0 (6.4–9.7)	89	8.0 (6.5–9.8)	687	17.6 (16.4–18.8)	684	18.0 (16.7–19.2)
ICU admission	304	23.5 (21.2–25.9)	270	24.5 (21.9–27.1)	269	24.3 (21.8–27.0)	810	20.7 (19.5–22.0)	788	20.7 (19.4–22.0)
IMV	76	5.9 (4.7–7.3)	59	5.3 (4.1–6.8)	58	5.2 (4.0–6.7)	209	5.4 (4.7–6.1)	201	5.3 (4.6–6.0)
ECMO	4	0.3 (0.1–0.8)	3	0.3 (0.1–0.8)	3	0.3 (0.1–0.8)	14	0.4 (0.2–0.6)	14	0.4 (0.2–0.6)
Died in Hospital	10	0.8 (0.4–1.4)	8	0.7 (0.3–1.4)	9	0.8 (0.4–1.5)	19	0.5 (0.3–0.8)	19	0.5 (0.3–0.8)
Ages 5–11	**(N = 698)**		**(N = 596)**		**(N = 573)**		**(N = 2013)**		**(N = 1948)**	
Hospital LOS (median, IQR)		3 (2–6)		3 (2–6)		3 (2–6)		2 (1–4)		2 (1–4)
Pneumonia[6]	93	13.3 (10.9–16.1)	92	15.4 (12.6–18.6)	93	16.2 (13.3–19.5)	378	18.8 (17.1–20.6)	375	19.3 (17.5–21.1)
ICU admission	203	29.1 (25.7–32.6)	193	32.4 (28.6–36.3)	191	33.3 (29.5–37.4)	425	21.1 (19.3–23.0)	408	20.9 (19.2–22.8)
IMV	50	7.2 (5.4–9.3)	39	6.5 (4.7–8.8)	36	6.3 (4.4–8.6)	92	4.6 (3.7–5.6)	89	4.6 (3.7–5.6)
ECMO	1	0.1 (0.0–0.8)	1	0.2 (0.0–0.9)	1	0.2 (0.0–1.0)	10	0.5 (0.2–0.9)	10	0.5 (0.2–0.9)
Died in Hospital	3	0.4 (0.1–1.3)	2	0.3 (0.0–1.2)	1	0.2 (0.0–1.0)	12	0.6 (0.3–1.0)	10	0.5 (0.2–0.9)
Ages 12–17	**(N = 1470)**		**(N = 1060)**		**(N = 915)**		**(N = 855)**		**(N = 806)**	
Hospital LOS (median, IQR)		3 (2–6)		3 (2–6)		3 (2–6)		2 (1–4)		2 (1–4)
Pneumonia[6]	279	19.0 (17.0–21.1)	277	26.1 (23.5–28.9)	270	29.5 (26.6–32.6)	143	16.7 (14.3–19.4)	141	17.5 (14.9–20.3)
ICU admission	406	27.6 (25.3–30.0)	348	32.8 (30.0–35.7)	321	35.1 (32.0–38.3)	229	26.8 (23.8–29.9)	223	27.7 (24.6–30.9)
IMV	90	6.1 (5.0–7.5)	64	6.0 (4.7–7.6)	52	5.7 (4.3–7.4)	55	6.4 (4.9–8.3)	51	6.3 (4.7–8.2)
ECMO	9	0.6 (0.3–1.2)	8	0.8 (0.3–1.5)	8	0.9 (0.4–1.7)	4	0.5 (0.1–1.2)	4	0.5 (0.1–1.3)
Died in Hospital	12	0.8 (0.4–1.4)	8	0.8 (0.3–1.5)	8	0.9 (0.4–1.7)	6	0.7 (0.3–1.5)	6	0.7 (0.3–1.6)

FluSurv-NET = Influenza Hospitalization Surveillance Network; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network; LOS = length of stay; IQR = interquartile range; IMV = invasive mechanical ventilation; ECMO = Extracorporeal Membrane Oxygenation

1. FluSurv-NET data include the 2017–2018, 2018–2019, and 2019–2020 seasons. Surveillance is conducted during October 1–April 30 each season. The FluSurv-NET catchment area includes California, Colorado, Connecticut, Georgia, Maryland (Baltimore Metropolitan Area), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah. Detailed clinical data on hospitalized cases from Maryland were unavailable for the 2019–20 influenza season and were not included.

2. COVID-NET data during October 1, 2020–September 30, 2021 are included. The COVID-NET catchment area includes California, Colorado, Connecticut, Georgia, Iowa, Maryland (entire state), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.

3. Includes COVID-NET or FluSurv-NET hospitalized patients who had ≥ 1 symptom present at hospital admission. The list of symptoms collected varied by surveillance platform and year. Acute respiratory or febrile symptoms were abstracted for all FluSurv-NET seasons and for COVID-NET and are defined as fever, congestion/runny nose, cough, shortness of breath, sore throat, upper respiratory illness or influenza-like illness, and wheezing. Other symptoms abstracted for all FluSurv-NET seasons and for COVID-NET are altered mental state/confusion and seizure. Other symptoms collected by COVID-NET were: myalgia, chest pain, loss of taste, loss of smell, diarrhea, conjunctivitis, fatigue, headache, rash, nausea/vomiting, abdominal pain, and hemoptysis; for children <2 years symptoms also included apnea, cyanosis, decreased vocalization/stridor, dehydration, hypothermia, inability to eat/poor feeding, and lethargy. Other symptoms collected by FluSurv-NET during the 2017–18 season were: myalgia, chest pain, diarrhea, conjunctivitis, fatigue, headache, nausea/vomiting, and rash.

4. Reason for admission is only collected in COVID-NET and includes the following categories: COVID-19 as the primary reason for admission, obstetrics/labor and delivery, inpatient surgery or procedures, psychiatric admission needing acute medical care, trauma, other, or unknown. If the chief complaint or history of present illness documents fever/respiratory illness, COVID-19-like illness, or a suspicion for COVID-19, a case is categorized as having COVID-19 as the primary reason for admission. If the chart specifically indicates that the positive SARS-CoV-2 test was an incidental finding or that the admission was likely not COVID-19-related, the "other, specify" reason for the admission is marked and the admission is noted as "admission likely not COVID-19-related per notes". For other cases where the "other, specify" reason for admission is marked, an algorithm was developed which incorporates physician review of the free text provided to determine if COVID-19 was likely a primary reason for admission.

5. Exact 95% Confidence Intervals for binomial proportions were calculated using the Clopper-Pearson method

6. A standardized pneumonia case definition is used, which includes a combination of radiographic findings of bronchopneumonia, air space opacity, consolidation, lobar or interstitial infiltrate within 3 days of hospital admission, and either an ICD-10-CM-coded discharge diagnosis of pneumonia or documentation of pneumonia on hospital discharge summary.

Figure 1. Counts of COVID-19- and influenza-associated hospitalizations by month among children <18 years old, FluSurv-NET[1] and COVID-NET[2], October 2017–September 2021

1

2 FluSurv-NET = Influenza Hospitalization Surveillance Network; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network

1 The 9 influenza-associated hospitalizations reported to FluSurv-NET during October 1, 2020–April 30, 2021 are circled to improve visibility. The FluSurv-NET catchment area includes California, Colorado, Connecticut, Georgia, Iowa (2020–21 season only), Maryland (Baltimore Metropolitan Area), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.

2 The COVID-NET catchment area includes California, Colorado, Connecticut, Georgia, Iowa, Maryland (entire state), Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.

3 Guidance for slowing the spread of COVID-19 was released on March 16, 2020, after which school closures began. See, e.g., https://www.cdc.gov/mmwr/volumes/69/wr/mm6915e2.htm.

3

4

5 **Figure 2. Cumulative influenza- and COVID-19-associated hospitalization rates per 100,000 children <18 years old, by age group – FluSurv-**

6 **NET[1] and COVID-NET[2], 2017–2021**

7 FluSurv-NET = Influenza Hospitalization Surveillance Network; COVID-NET = COVID-19-Associated Hospitalization Surveillance Network

1 Each season, FluSurv-NET surveillance is conducted from MMWR week 40 (around October 1) of one year to MMWR week 18 (around April 30) of the subsequent year. The grayed-out area on each panel indicates weeks during which FluSurv-NET surveillance was not conducted but COVID-NET surveillance was conducted. FluSurv-NET rate lines were extended beyond week 18 for ease of comparison with COVID-NET rate lines.

2 The COVID-NET surveillance period of October 2020–September 2021 begins at MMWR week 40 of year 2020 and ends at MMWR week 39 of year 2021.

3 MMWR Week 53 for year 2020 is combined with MMWR Week 52 for consistency with other years.

8

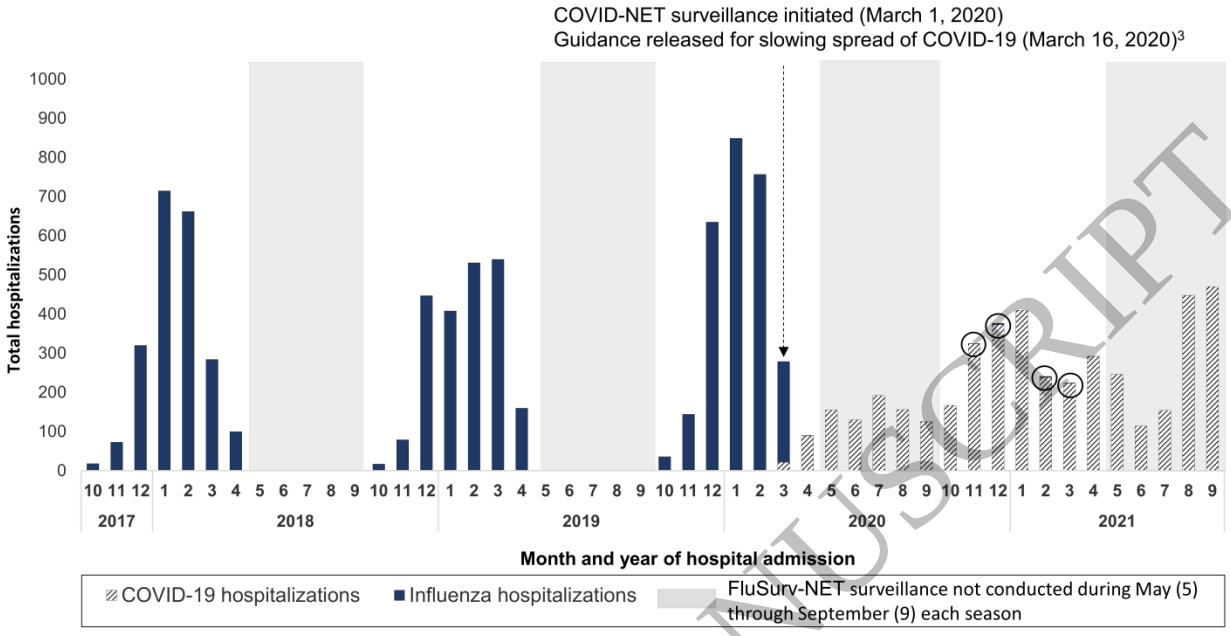

Figure 1
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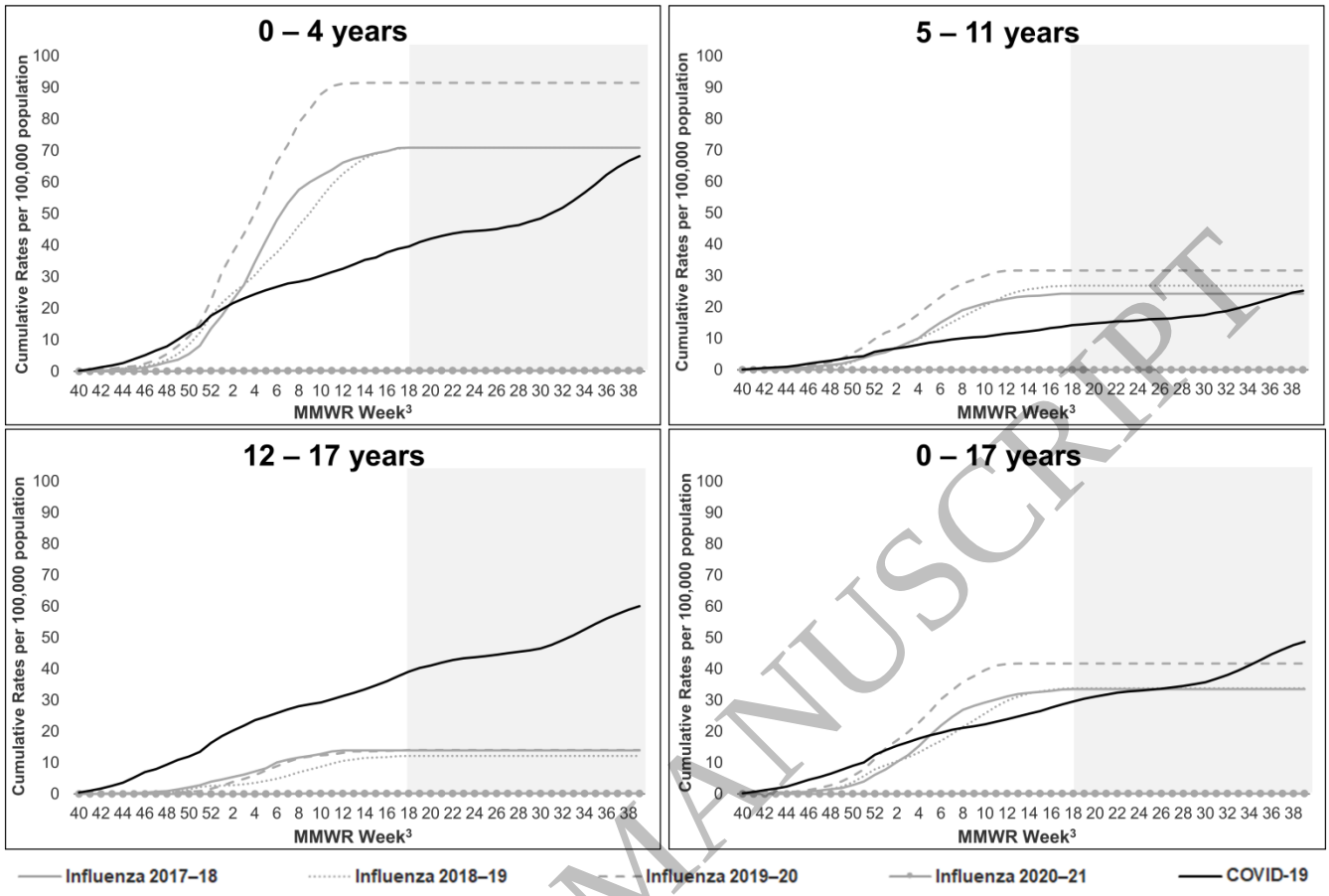

Figure 2
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