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Influenza Hospitalizations And Census Tract Ses In Ct 2013-2018

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Abstract - *Background*: Influenza hospitalizations are a costly outcome of influenza infection. Socioeconomic status (SES) is not typically collected through routine public health surveillance methods, but understanding SES allows for targeted interventions.

***Methods*:** Surveillance data from the CT Emerging Infections Program's US Influenza Hospitalization Surveillance Network (FluSurv-Net) component was used to identify cases of laboratory confirmed influenza-associated hospitalizations in the 5 influenza seasons from 2013-2018. Case-patient home addresses were geocoded and linked to census tract level factors from the U.S. Census Bureau. Both census tract level poverty and crowding were broken into 4 categories: low, medium low, medium high, and high. Trends by decreasing SES category were measured by chi square for trend; incidence rate ratios (IRR) of the lowest to highest SES group were used to measure the magnitude of any trend associations found.

***Results*:** Decreasing SES was significantly ($p<0.05$ for trend) associated with increasing influenza-associated hospitalization incidence for both census tract level poverty and crowding. The findings were stronger for poverty than for crowding (IRR 2.39 vs 1.39). Poverty findings were consistent across characteristics examined with one exception: 0-4 year olds, where the association was not significant. Compared to previous studies, the magnitude of the association with poverty decreased (IRR for children <18 years: 2.21 vs 3.64; and for adults: 2.48 vs 2.96).

***Conclusions*:** The previously described association between higher census tract level poverty and crowding and higher influenza-associated hospitalization incidence has decreased, particularly in young children. This may be due in part to changing access to healthcare, new daycare vaccine requirements, enhanced awareness following previous studies, and changes in influenza screening practices at hospitals. Continued efforts to reduce this disparity are needed.

Introduction

In the United States, the Centers for Disease Control and Prevention (CDC) estimates that there have been between 140,000-960,000 influenza-associated hospitalizations annually since 2010.[1] In order to better understand the influenza burden each year, the US Influenza Hospitalization Surveillance Network (FluSurv-Net) component of the CDC Emerging Infections Program (EIP) conducts population-based surveillance of laboratory-confirmed influenza hospitalizations.[2] The Connecticut EIP site conducts influenza-associated hospitalization surveillance of residents of New Haven and Middlesex counties.[3]

Socioeconomic status (SES) is not typically collected through routine surveillance or medical chart review due in part to the multidimensional nature of the metric, lack of standard measures in medical charts, and discrepancies in the self-reporting of sensitive information. However, information on SES can lead to an understanding of healthcare disparities and potential interventions for targeting at-risk populations. Area-based SES indicators gathered by linking patient addresses, which are routinely collected in healthcare settings and through routine surveillance, to geocoded census tract information have been shown to effectively detect and monitor SES disparities in health outcomes.[4–6] By using geocoded data, SES inequalities can be examined through routine surveillance as we gain an understanding of both cases captured through surveillance and the population in the catchment area, allowing for detailed analysis.[7] The Harvard Public Health Disparities Geocoding Project (PHDGP) found that using census-derived area-based SES measures is reliable and useful due to feasibility, interpretability, and ability to consistently detect SES gradients in health outcomes.[7] After examining different area sizes (census blocks, zip codes, and census tracts), the PHDGP recommended the use of census tracts for maximal geocoding and linkage to census data.[7] Previous studies of influenza-associated hospitalizations in Connecticut using FluSurv-Net data prior to 2012 showed a correlation between both higher census tract level poverty and higher census tract level crowding with increased influenza-associated hospitalization incidence.[8–10] This study examines how the relationship between area-based SES and influenza-associated hospitalizations has changed, using data from the 2013-2014 through the 2017-2018 influenza seasons.

Influenza is a contagious viral respiratory infection that causes illnesses that can range from mild to severe. The infection is spread from person to person through respiratory droplets. Common symptoms include fever, sore throat, cough and respiratory issues, fatigue, runny or stuffy nose, and muscle and body aches. In addition to typical symptomology, influenza can manifest with severe complications, such as pneumonia, myocarditis, encephalitis, organ failure, and sepsis; complications may be caused by the influenza virus itself or by secondary infections that occur in an influenza patient and can lead to death.[11] Certain groups are at higher risk of severe influenza complications, such as the elderly, the very young, pregnant women, and individuals with various underlying medical conditions.[11] Influenza surveillance is important, as it allows us to understand risk groups to properly target effective interventions towards populations that need them. FluSurv-Net is especially valuable, as conducting surveillance on influenza-related hospitalizations allows for estimations of influenza severity throughout each influenza season as severe illnesses requiring hospitalizations are monitored rather than infection alone.

Influenza is a vaccine-preventable disease; higher vaccination rates have been shown to result in lower influenza-associated hospitalization rates.[12–14] Studies have shown a variety of individual-level SES variables to be associated with decreased influenza vaccination uptake.[15,16] Furthermore, census tracts with greater poverty levels have demonstrated lower vaccination rates, which may lead to further disparities in influenza outcomes in these census tracts.[8] In 2010, the state of Connecticut implemented new regulations requiring that children aged 6 months to 59 months be vaccinated against influenza with at least one dose of the vaccine each year in order to attend a licensed child care program.[17] Initial data following the 2012-2013 influenza season in Connecticut indicated that this intervention may have reduced severe influenza in the state by increasing vaccine uptake; after implementation, the decrease in the influenza-related hospitalization incidence in children under 5 years old was larger in the Connecticut EIP catchment area than at any other EIP site.[18] Years after initial implementation, this intervention may have had further impact on influenza-associated hospitalizations in Connecticut.

Many underlying medical conditions serve as additional risk factors for severe influenza, leading to increased hospitalizations.[19,20] Some of these conditions include asthma and lung diseases, immunocompromising conditions, heart disease, neurological and neurodevelopmental conditions, obesity, and endocrine, metabolic, liver, and kidney disorders.[20] Targeting prevention through vaccination in these populations as well as understanding the differences in vaccine uptake between different SES groups is especially important.[20] This study will use data collected from the Connecticut EIP's FluSurv-Net component with geocoded home addresses linked to census tract level SES indicators of poverty and crowding to assess incidence of influenza-associated hospitalizations in New Haven and Middlesex counties in the 5 influenza seasons from 2013-2018 and determine whether previously found disparities by these SES measures persist.

Methods

The data for this study were collected by the Connecticut EIP's FluSurv-Net component through population-based surveillance of laboratory confirmed influenza-associated hospitalizations using medical record review and physician and/or patient interviews to confirm vaccination status from the 2013-2014 through the 2017-2018 influenza seasons. Each influenza season ranged from October 1st of the earlier year through April 30th of the following year. All case-patients were residents of New Haven or Middlesex counties in Connecticut and were hospitalized in Connecticut with influenza-related illness. New Haven and Middlesex counties make up 2 of Connecticut's 8 counties and encompass 227 census tracts with a population of 1,028,153 per the U.S. Census Bureau's Decennial Census 2010 Summary File 1.

The home addresses of all laboratory-confirmed case-patients were geocoded using ArcGIS version 10.4.1. These data were linked to census tract level SES data, including poverty (percent of the population in a census tract living below the federal poverty level) and crowding (percent of households within a census tract with more than one occupant per room) variables, which were obtained from the U.S. Census Bureau's 2013-2017 American Community Survey (ACS) 5-year estimates. Census tract level demographic denominator data for age, sex, and race/ethnicity group variables were obtained from the U.S. Census Bureau's Decennial Census 2010 Summary File 1. Census tract level poverty was broken down into the following four levels that are accepted poverty level divisions[5,6]: 0% to 4.9% (low), 5% to 9.9% (medium low), 10% to 19.9% (medium high), and ≥20% (high). Census tract level crowding was broken down into the following four levels that have previously been used in similar studies in Connecticut[9,10]: 0% to 0.9% (low), 1% to 2.9% (medium low), 3% to 4.9% (medium high), and ≥5% (high).

Age-specific and age-adjusted incidence rates by SES categories were determined and stratified by age group (0-4, 5-17, 18-49, 50-64 and ≥65 years), sex, race/ethnicity, and influenza season and analyzed for trends. Trends by decreasing SES category were measured by chi square (χ^2) for trend, and incidence rate ratios (IRR) of the lowest to highest SES group were used to measure the magnitude of any trend associations found. Statistical analysis was conducted using SAS version 9.4 for most analyses and Epi Info version 7.2 to calculate chi square for trend values.

Results

Of the 5,276 cases of influenza-associated hospitalizations captured, 5,129 (97%) were included in age-adjusted analysis due to missing address or age data. When examining census tract level poverty across all 5 influenza seasons included in this study, there was a distinct trend ($p<0.001$, χ^2 for trend) and gradient of increasing incidence of age-adjusted influenza-associated hospitalizations as poverty level increases (Figure 1). A gradient was defined as a consistent increase or consistent decrease in influenza-associated hospitalization incidence at each census tract poverty or crowding level increase. For census tract poverty, both the trend and increasing gradient were present in all adult age categories, but the magnitude of association between increasing influenza-associated hospitalization incidence and increasing poverty level decreased compared to past studies (IRR 2.48 vs. 2.96) (Table 1 and Table 7). In children aged 0-4, there was no statistically significant association identified. In children aged 5-17, a statistically significant trend was identified ($p<0.001$, χ^2 for trend), but the gradient of increasing incidence with increasing poverty level flattened between the two highest poverty groups (Table 1). Additionally, the magnitude of association in children (combined 0-17) decreased compared to past studies (IRR 2.21 vs. 3.64) (Table 7). Statistically significant trends ($p<0.001$, χ^2 for trend) and increasing gradients were seen in both males and females. All race/ethnicity categories examined, Hispanic, non-Hispanic White, and non-Hispanic black, exhibited statistically significant trends of increasing incidence of influenza-associated hospitalizations among increasing poverty levels ($p<0.001$, χ^2 for trend), but the gradient was inconsistent among non-Hispanic blacks. When stratified by influenza season, all 5 seasons exhibited statistically significant trends of increasing influenza-associated hospitalization incidence among increasing poverty levels ($p<0.001$, χ^2 for trend), but the 2014-2015 season did not exhibit a consistent gradient.

Examining the magnitude of association between influenza-associated hospitalizations and census tract level poverty using the IRR comparing the lowest poverty group to the highest poverty group for each characteristic, we found that the lowest magnitude of association was in the 0-4 age group, and this was not statistically significant at the alpha=0.05 level (Table 1). The highest magnitude of association was seen in the 50-64 age group, with both the 50-64 age group and the 18-49 age group displaying a greater than 4 times increase in hospitalization incidence from the lowest to highest poverty level (Table 1). Across all 5 study seasons, the IRR was 2.39 with a low of 1.78 in the 2014-2015 season and a high of 3.08 in the 2015-2016 season with no clear trend in IRR from 2013-2018 (Table 1).

Although all characteristics examined with census tract level crowding, except for the 2014-2015 influenza season and the ≥65 age group, displayed statistically significant trends with increasing age-adjusted incidence of influenza-associated hospitalizations as census-tract crowding level increased ($p<0.05$, χ^2 for trend), a consistently increasing gradient of increasing incidence of hospitalizations among increasing crowding level was only seen in the 18-49 age group, both male and female sex categories, and in the 2015-2016 influenza season (Table 2). There was a significant trend in the ≥65 age group, but this was a reverse trend, with higher hospitalization incidence as crowding level decreased (Table 2). Analysis of all 5 study seasons in aggregate did not display a gradient increase in hospitalization incidence by census tract crowding level (Figure 2). All crowding measures displayed a lower magnitude of association than poverty measures, with the exception of the 0-4 age group (IRR 1.48 in poverty vs. 1.97 in crowding), and the 0-4 age group association was statistically significant in crowding but not in poverty (Tables 1 and 2). Both children (0-17) and adults (≥18) displayed a lower magnitude of association between influenza-associated hospitalization incidence and crowding compared with Connecticut studies prior to 2012[9,10] (IRR for children 2.32 v. 3.56, IRR for adults 1.29 vs 2.02) (Table 2 and Table 7).

No trend was observed in the percentage of cases with at least one underlying condition or pregnancy with either increasing census tract poverty level or census tract crowding level (Table 3). An increasing trend was observed in the percentage of case-patients with asthma as census tract poverty increased, but no consistent trend was observed with census tract crowding (Table 3).

Of the 5,129 cases included in analysis, 4,673 (91%) of them had available data on influenza vaccine history. Decreasing trends were observed in the percentage of case-patients that received the influenza vaccine as both census tract poverty level and census tract crowding level increased ($p<0.001$, χ^2 for trend) (Table 4). However, when stratified by age, the percentage of those hospitalized who received the influenza vaccine only followed this decreasing trend in ≥65 age group for poverty (Table 5) and the 5-17 age group for crowding (Table 6); this trend was only significant in the ≥65 age group for poverty ($p<0.001$, χ^2 for trend). Although a clear gradient was not seen, a statistically significant trend between increasing census tract crowding and decreasing vaccination levels was seen in the ≥65 age group ($p<0.001$, χ^2 for trend) (Table 6). In the 0-4 age group, a significant trend between increasing census tract poverty and increasing vaccination levels (more vaccination in higher poverty levels) was seen ($p<0.001$, χ^2 for trend) (Table 5).

Discussion

An association between increasing incidence of influenza-associated hospitalizations and increasing census tract level SES measures of poverty and crowding is still present in the state of Connecticut. However, the current study displays a decrease in the magnitude of association comparing the incidence of influenza-associated hospitalizations and high versus low census tract level SES measures compared to previous pre-2012 studies[9,10], indicating a decrease in these SES disparities in recent years. This decrease was especially prominent in young children, suggesting that a 2010 requirement that children aged 6 months to 59 months be vaccinated against influenza in order to attend a licensed daycare program may have reduced disparities in severe influenza incidence between different SES levels through increased vaccination coverage in children. Higher prevalence of asthma in poorer and more crowded census tracts may also contribute to the differences observed. The only age group displaying a statistically significant trend in decreasing vaccination percentage by increasing poverty or crowding level was the ≥65 group, which displays high influenza incidence and is likely driving the overall trend in vaccination before stratifying by age. Children age 0-4 even displayed the opposite significant trend, with higher vaccination percentages in higher poverty groups. Assuming the hospitalized population reflects the general population in terms of relative vaccination rates between groups, the reverse trend in children and lack of significant trend in other age groups indicate a lack of strong disparities by SES level in the percentage of the population that is vaccinated against influenza. These findings have implications for future prevention and research efforts.

Our analysis identified an association between increasing incidence of influenza-associated hospitalization and increasing census tract poverty level. All characteristics examined displayed statistically significant trends between increasing census tract poverty level and increasing influenza-associated hospitalization incidence except for among the 0-4 age group, which may be influenced by the 2010 State of Connecticut regulation requiring an annual seasonal influenza vaccine in children aged 6 months to 59 months attending a licensed child care or day care setting.[17] With this regulation in practice, more children in the 0-4 year old age group were likely to have received the influenza vaccine, which may have altered differences between SES levels in this age group in the general population, changing the demographics of children hospitalized with influenza. Remaining characteristics displayed a clear gradient of increasing incidence of influenza-associated hospitalization as poverty level increased except for the 5-17 age group, non-Hispanic black group, and the 2014-2015 influenza season. Significant trends in these groups are likely explained by a significant overall increase in incidence from the low poverty group to the high poverty group. These overall gradients largely agree with the gradients seen in previous studies of adults[9] and children[10] in previous influenza seasons, but with decreases in the overall magnitude of association (IRR for children <18 years: 2.21 vs. 3.64; IRR for adults: 2.48 vs. 2.96)

Crowding was chosen as a variable of interest in previous studies examining incidence of influenza-associated hospitalizations in Connecticut due to its potential association with influenza transmission because of implied closer contact between those living in the same household and the airborne mode of person to person transmission.[10] Past studies in Connecticut observed a gradient increase in the incidence of influenza-associated hospitalizations in both adults (2007-2011) and children (2003-2010) as census tract crowding level increased, with each increase in crowding level displaying an increase in incidence.[9,10] In our analysis, this gradient increase in incidence as crowding level increased was only present in male and female sex categories, the 18-49 age group, and the 2015-2016 season, and the magnitude of association with crowding was much lower than with poverty. All characteristics examined, except for the 2014-2015 season, do, however, show statistically significant trends between the incidence of influenza-associated hospitalization and increasing crowding level.

The observed trend may be due to a threshold effect, with the ≥5% crowding level having a high enough increase in incidence to drive the trend.

No clear association was observed between the presence of underlying medical conditions and increasing census tract poverty or crowding levels, indicating that differences in the prevalence of at least one underlying condition cannot explain the association of incidence with poverty or crowding. There was also no association between the SES measures and pregnancy in our case-patients. Asthma did display a clear increase as poverty level increased. An increase in the percentage of case-patients with asthma also occurred as crowding level increased from low to medium high, but a small decrease in the percentage occurred between medium-high crowding and high crowding. This suggests that differences in the prevalence of asthma by SES may contribute to the observed disparity in influenza-associated hospitalization incidence.

An association was also seen between those who received an influenza vaccine and census tract poverty and crowding levels; as census tract poverty and census tract crowding levels increased, the percentage of case-patients vaccinated decreased, following a significant trend. However, when stratified by age group, this decreasing gradient trend across SES levels was only seen at a statistically significant level in the ≥65 age group for poverty. Although lacking a consistent gradient, statistically significant trends were also seen in the ≥65 age group for increasing census tract poverty and decreasing percentage vaccinated and in the 0-4 age group with increasing census tract poverty and increasing percentage vaccinated. The trend in the 0-4 age group is especially interesting; this trend indicates that poor children age 0-4 have the highest influenza vaccination levels. It is important to note that all case-patients in this analysis were hospitalized with severe influenza, meaning that those vaccinated represent vaccine failures and that the percentages presented do not represent vaccination levels in the population as a whole; however, we assume that SES level does not alter vaccine effectiveness itself, and thus does not alter the likelihood of a vaccine failure by SES, so the hospitalized case-patients in this analysis should approximately reflect relative vaccination rates at each SES level in the population. This trend in children may be due to a variety of factors, including the previously mentioned 2010 State of Connecticut regulation requiring an annual influenza vaccine in children aged 6 months to 59 months attending a licensed child care or daycare setting.[17] Additionally, results of the pre-2012 studies[9,10] of influenza-associated hospitalization incidence with SES measures were publicized in Connecticut, which may have resulted in enhanced efforts to vaccinate low SES populations. Overall, the lack of a statistically significant trend of decreasing vaccination percentage in census tracts with higher poverty or crowding levels in most age groups and the increase of vaccination percentage in census tracts with higher poverty levels in young children indicates that overall vaccination disparities by SES level may be decreasing in the Connecticut population as a whole, and the overall significant trend without stratifying by age group is likely driven by the trend in the elderly population with a high incidence of influenza.

Another reason for the observed changes between our study and previous studies examining influenza seasons in 2007-2011[9] and 2003-2010[10] may be the introduction of the Affordable Care Act (ACA). The ACA was signed into law in 2010, and by July 2017, Connecticut saw a 45% reduction of uninsured individuals under the age of 65.[21] With an increase in insured residents, more residents were likely to have access to primary care, potentially reducing the percentage of influenza cases that progressed to severe influenza requiring hospitalization. Increased access to care could result in a decrease in delayed care, an increase in the control of underlying medical conditions that serve as risk factors to severe influenza, and improved access to influenza vaccinations, together reducing the overall disease burden, but more research to validate these hypotheses is needed.

Implications

By understanding disparities in severe influenza by SES measures, targeted interventions can be designed. Our study illustrated associations between influenza-associated hospitalizations and census tract poverty; monitoring SES disparities through census tract poverty is a useful tool for continued examination. It is important that these results be publicized to further encourage interventions; publicity could include developing model influenza vaccination guidelines to better serve the poor. It will also be important to continue to monitor these efforts and study the results. The presence of health disparities by SES in general demonstrates a continued need for improved access to healthcare.

Limitations

This study does have important limitations to consider. First, we examined influenza-associated hospitalizations rather than influenza infections themselves, meaning that we cannot draw conclusions regarding whether or not an individual of lower SES is more likely to become infected with influenza or if they are more likely to become hospitalized once infected; we can only comment on the hospitalized population. Surveillance data were collected from multiple Connecticut hospitals in the catchment area, and different hospitals serve different communities and have different influenza screening protocols, potentially resulting in ascertainment bias both between SES groups and over time.

Additionally, census tract level SES was evaluated, not individual SES, which may alter outcomes. The ACS is made of data from a sample of the U.S. population rather than the population as a whole, potentially resulting in the misclassification of census tract level variables. Using census tract data reflects a census snap shot of the population that may not accurately reflect the population in each individual influenza season in the study. The U.S. Census Bureau's Decennial Census 2010 Summary File 1 used to calculate age, sex, and race/ethnicity population denominators was between 3 and 8 years old, depending on the study season. Although the population may have shifted in those years, census tracts are relatively stable, so potential changes were unlikely to have major impacts on results.

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Appendix

Table 1: Age-adjusted incidence of influenza-associated hospitalization by census tract poverty level, New Haven and Middlesex Counties, CT, 2013-2018.

Characteristic	No. Cases[a]	Age-adjusted incidence of influenza-associated hospitalization by census tract poverty level per 100,000 person-years				χ^2 trend	Incidence rate ratio (≥20%/<5%)
Poverty Level		<5%	5-<10%	10-<20%	≥20%		
All Cases 2013-2014 through 2017-2018 seasons	5,129	65.49	79.71	94.77	156.55	<0.001	2.39
Age Group[b]							
0-4	182	50.68	62.85	70.38	75.04	0.065	1.48
5-17	117	7.35	11.63	21.18	20.37	<0.001	2.77
18-49	681	15.15	23.54	32.31	61.86	<0.001	4.09
50-64	1059	48.65	74.19	130.79	285.01	<0.001	5.87
65+	3090	365.91	404.14	405.45	601.00	<0.001	1.65
Sex							
Male	2,209	66.18	78.32	93.03	146.04	<0.001	2.21
Female	2,920	64.78	81.18	96.27	166.63	<0.001	2.58
Race/ethnic group							
Hispanic (H)	495	66.70	87.57	110.75	155.31	<0.001	2.32
Non-H White	3,321	60.44	71.75	75.89	101.42	<0.001	1.68
Non-H Black	881	124.77	179.46	157.78	209.64	<0.001	1.67
Influenza Season (October 1 through April 30)							
2013-2014	987	55.45	75.12	101.35	159.55	<0.001	2.88
2014-2015	1,010	73.86	86.17	81.75	131.35	<0.001	1.78
2015-2016	688	40.55	51.30	64.45	124.99	<0.001	3.08
2016-2017	1,060	63.01	84.72	103.26	157.48	<0.001	2.50
2017-2018	1,384	94.58	101.23	123.04	209.38	<0.001	2.21

[a] 5,129 of 5,276 cases of hospitalized influenza were included in analysis due to missing address and/or age information preventing geocoding and/or age-adjustment

[b] age groups presented with age-specific incidence rather than age-adjusted incidence

Table 2: Age-adjusted incidence of influenza-associated hospitalization by census tract crowding level, New Haven and Middlesex Counties, CT, 2013-2018.

Characteristic	No. Cases[a]	Age-adjusted incidence of influenza-associated hospitalization by census tract crowding level per 100,000 person-years				χ^2 trend	Incidence rate ratio (≥5%/<1%)
Crowding Level		<1%	1-<3%	3-<5%	≥5%		
All Cases 2013-2014 through 2017-2018 seasons	5,129	82.33	98.40	82.76	114.32	<0.001	1.39
Age Group[b]							
0-4	182	46.82	78.13	97.09	92.21	<0.001	1.97
5-17	117	8.86	17.18	24.90	22.86	<0.001	2.58
18-49	681	24.05	31.16	48.90	63.17	<0.001	2.63
50-64	1059	81.80	114.73	109.60	183.47	<0.001	2.25
65+	3090	426.88	459.17	254.27	369.40	<0.001	0.87
Sex							
Male	2,209	76.91	89.26	91.97	132.26	<0.001	1.72
Female	2,920	77.27	100.35	106.63	132.44	<0.001	1.71
Race/ethnic group							
Hispanic (H)	495	109.49	113.80	85.57	159.57	<0.001	1.46
Non-H White	3,321	67.42	72.80	66.28	104.81	<0.001	1.56
Non-H Black	881	151.05	203.39	202.33	194.02	0.021	1.28
Influenza Season (October 1 through April 30)							
2013-2014	987	72.20	103.57	96.90	120.26	<0.001	1.68
2014-2015	1,010	86.15	102.91	57.55	82.54	0.420	0.95
2015-2016	688	54.72	59.34	70.50	103.11	<0.001	1.89
2016-2017	1,060	90.42	89.56	84.38	122.18	<0.001	1.35
2017-2018	1,384	107.93	136.62	104.49	143.50	<0.001	1.33

[a] 5,129 of 5,276 cases of hospitalized influenza were included in analysis due to missing address and/or age information preventing geocoding and/or age-adjustment

[b] age groups presented with age-specific incidence rather than age-adjusted incidence

Table 3: Number and percentage of case-patients with influenza-associated hospitalization with specified underlying conditions, New Haven and Middlesex Counties, CT, 2013-2018.

	No. Cases	Underlying Condition, No. (%)[a]	Asthma, No. (%)	Pregnant, No. (%)[b]
Low	1418	1254 (87.9)	172 (12.1)	11 (17.7)
Medium low	1340	1182 (87.9)	188 (14.0)	20 (26.3)
Medium high	1107	983 (88.0)	252 (22.6)	19 (18.1)
High	1264	1146 (89.8)	425 (41.0)	44 (24.2)
Low	2497	2216 (88.3)	390 (15.5)	29 (18.4)
Medium low	1726	1554 (89.2)	372 (21.4)	34 (24.3)
Medium high	294	259 (87.5)	91 (30.7)	10 (22.2)
High	613	536 (86.9)	184 (29.8)	21 (25.6)

[a] Underlying medical conditions may consist of asthma, chronic lung disease, chronic metabolic disease (including diabetes), blood disorders or hemoglobinopathy, chronic cardiovascular disease, neuromuscular disorder, neurologic disorder, history of Guillain-Barre Syndrome, immunosuppressive condition, renal disease, abnormality of the upper airway in pediatric patients, history of febrile seizures in pediatric patients, long-term aspirin therapy in children, and/or premature birth in pediatric patients under the age of two years

[b] The percentage of pregnant case-patients calculation was limited to females between the ages of 15 and 49 within each respective poverty and crowding level

Table 4: Number and percentage of case-patients that received the influenza vaccine, New Haven and Middlesex Counties, CT, 2013-2018.

	No. Cases	No. Cases with Available Vaccine Data	Received Influenza Vaccine, No. (%)[a]	χ^2 trend[b]	Incidence rate ratio (≥20%/<5%)[b]
Poverty Level					
Low	1418	1296	814 (62.8)	<0.001	0.77
Medium low	1340	1243	734 (59.1)		
Medium high	1107	999	505 (50.6)		
High	1264	1135	546 (48.1)		
Crowding Level					
Low	2497	2280	1317 (57.8)	<0.001	0.79
Medium low	1726	1574	909 (57.8)		
Medium high	294	272	148 (54.4)		
High	613	547	249 (45.5)		

[a] Percentage of case-patients that received the influenza vaccine was calculated using the number of cases with available vaccine data as the denominator

[b] Calculated using the number of cases with available vaccine data rather than total number of cases; incidence rate ratio is incidence of vaccination in cases

Table 5: Number and percentage of case-patients with influenza-associated hospitalization that received an influenza vaccine by age and poverty level, New Haven and Middlesex Counties, CT, 2013-2018.

	No. Cases[a]	No. Cases with Available Vaccine Data[a]	Received Influenza Vaccine, No. (%)	χ^2 trend	Incidence rate ratio (high/low)
Age Group					
0-4					
Low Poverty	42	16	6 (37.5)	<0.001	1.75
Medium Low Poverty	41	24	12 (60.0)		
Medium High Poverty	49	26	12 (46.2)		
High Poverty	931	855	563 (65.8)		
5-17					
Low Poverty	23	20	12 (60.0)	0.370	0.74
Medium Low Poverty	24	20	11 (55.0)		
Medium High Poverty	37	27	9 (33.3)		
High Poverty	33	25	11 (44.4)		
18-49					
Low Poverty	104	96	29 (30.2)	0.940	1.06
Medium Low Poverty	126	116	41 (35.3)		
Medium High Poverty	173	153	48 (31.4)		
High Poverty	278	250	80 (32.0)		
50-64					
Low Poverty	203	182	86 (47.3)	0.468	1.03
Medium Low Poverty	218	204	93(45.6)		
Medium High Poverty	268	238	100 (42.0)		
High Poverty	370	321	156 (48.6)		
65+					
Low Poverty	1046	945	661 (69.9)	<0.001	0.82
Medium Low Poverty	931	855	563 (65.8)		
Medium High Poverty	580	517	315 (60.9)		
High Poverty	533	477	274 (57.4)		

[a] Values may not add to those in Table 4 due to missing age data, preventing inclusion of all cases with available vaccine data in vaccine by age analysis

Table 6: Number and percentage of case-patients with influenza-associated hospitalization received an influenza vaccine by age and crowding level, New Haven and Middlesex Counties, CT, 2013-2018.

	No. Cases[a]	No. Cases with Available Vaccine Data[a]	Received Influenza Vaccine, No. (%)	χ^2 trend	Incidence rate ratio (high/low)
Age Group					
0-4					
Low	66	26	10 (38.5)	0.699	1.23
Medium Low	68	43	21 (48.8)		
Medium High	20	12	5 (41.7)		
High	29	19	9 (47.4)		
5-17					
Low	39	33	17 (51.5)	0.424	0.78
Medium Low	45	32	15 (46.9)		
Medium High	14	12	5 (41.7)		
High	19	15	6 (40.0)		
18-49					
Low	260	236	65 (27.5)	0.472	1.18
Medium Low	213	191	71 (37.2)		
Medium High	67	62	21 (33.9)		
High	141	126	41 (32.5)		
50-64					
Low	451	411	177 (43.1)	0.796	0.99
Medium Low	367	324	167 (51.5)		
Medium High	71	62	28 (45.2)		
High	170	148	63 (42.6)		
65+					
Low	1681	1517	1015 (66.9)	<0.001	0.82
Medium Low	1033	940	614 (65.3)		
Medium High	122	114	62 (54.4)		
High	254	223	122 (54.7)		

[a] Values may not add to those in Table 4 due to missing age data, preventing inclusion of all cases with available vaccine data in vaccine by age analysis

Table 7: Comparison of the magnitude of association (incidence rate ratio[a]) between the current study of the 5 influenza seasons from 2013-2018 and past studies of pre-2012 seasons in children[10] and adults[9] in Connecticut[b]

	Poverty		Crowding	
	Pre-2012[9,10]	2013-2018	Pre-2012[9,10]	2013-2018
0-4	x[c]	1.48	x[c]	1.97*
5-17	x[c]	2.77*	x[c]	2.58*
All children[c]	3.64*	2.21*	3.56*	2.32*
All adults[d]	2.96*	2.48*	2.02*	1.29*

* represents a statistically significant result at the alpha=0.05 level

[a] Incidence rate ratios represent the incidence rate of the highest poverty/crowding group compared with the lowest poverty/crowding group

[b] Pre-2012 influenza seasons examined a FluSurv-Net catchment area of only New Haven County, while the 5 seasons from 2013-2018 examined a catchment area of New Haven and Middlesex counties

[c] A breakdown of associations within childhood age groups was not presented in the previous study; data were presented as the entire 0-17 age group[10]

[d] Incidence rate ratios for adults are age-adjusted by three age groups: 18-49, 50-64, and ≥65

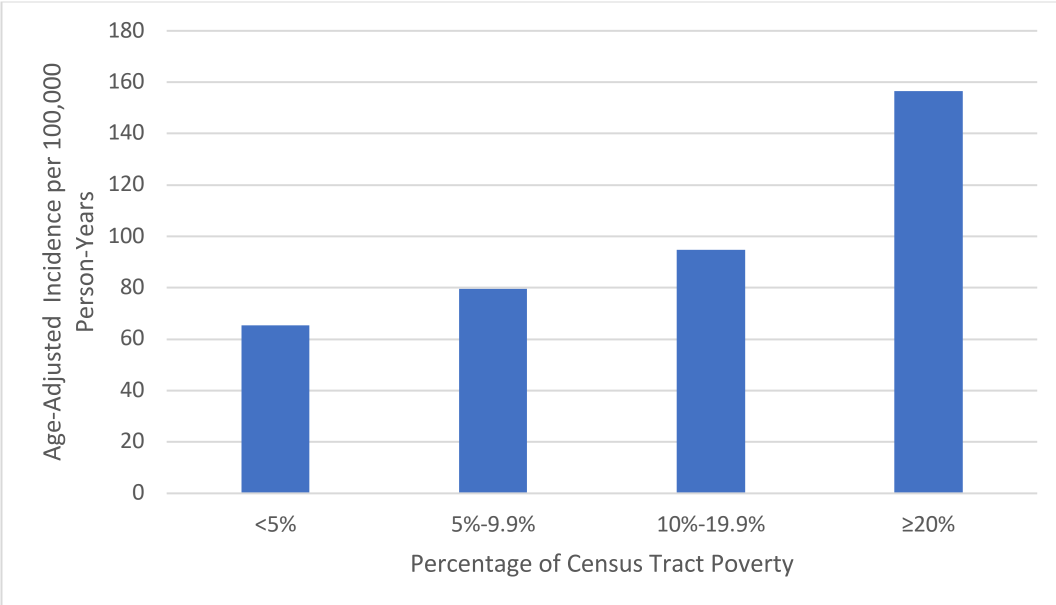

Figure 1: Age-adjusted incidence of influenza-associated hospitalization by census tract poverty level, all seasons: New Haven and Middlesex counties, CT, 2013-2018.

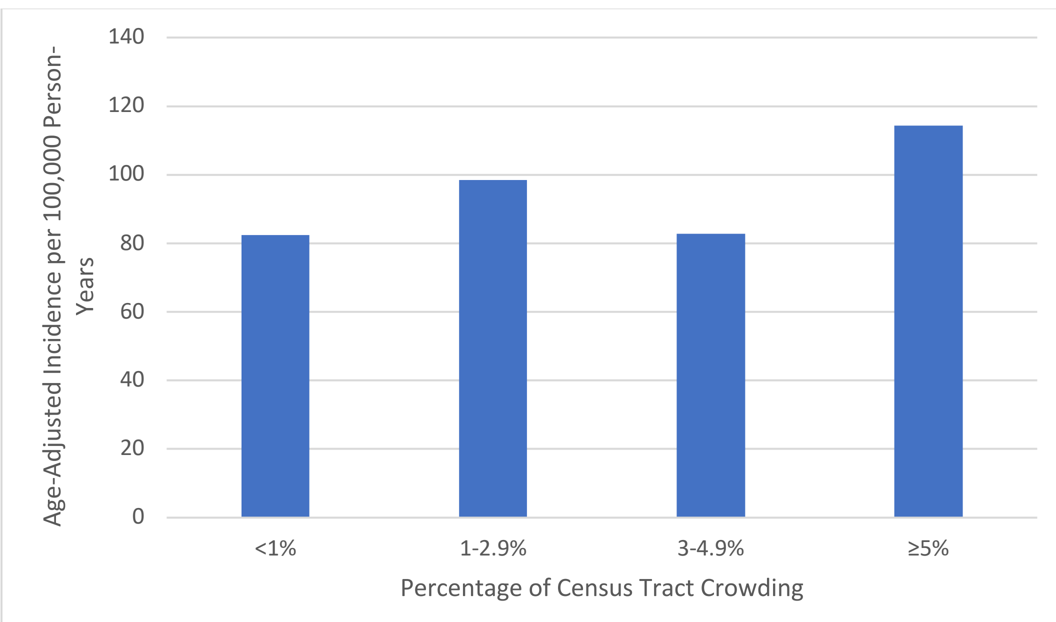

Figure 2: Age-adjusted incidence of influenza-associated hospitalization by census tract crowding level, all seasons: New Haven and Middlesex counties, CT, 2013-2018.