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# Incidence By Area-Based Socioeconomic Indicators

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# Examination of Influenza Incidence by Area-Based Socioeconomic Indicators, Connecticut, 2006-2012

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## Abstract

Objective: To examine the relationship between area-based socioeconomic (SES) measures and incidence of all laboratory-confirmed influenza, laboratory-confirmed non-hospitalized influenza, influenza-associated hospitalizations, and influenza-associated deaths, in Connecticut.

Methods: Laboratory-confirmed influenza cases in Connecticut from October 1, 2006 to April 30, 2012 were geocoded, and in accordance with the methods of Harvard's Public Health Disparities Geocoding Project, linked to census tract measures of SES. Total and seasonal incidence rates were determined for each of the four influenza-associated health outcomes by SES measure. For each outcome, a relative rate ratio was calculated between the highest and the lowest percent quantile of each SES measure. For the poverty and crowding variables, this relative rate was then calculated by season for each of the four influenza outcomes, and compared to overall seasonal incidence.

Results: When laboratory-confirmed influenza incidence is examined by measures of SES, there is a positive linear relationship between the four percent quantiles of each SES measure and incidence of each outcome. For all laboratory-confirmed influenza, within each season the quantiles of each SES measure are significantly linearly related to total incidence. However, it is not clear whether or not the change in poverty or crowding high versus low incidence rate ratios correlates with the seasonal fluctuations in overall incidence rates.

Conclusions: Laboratory-confirmed influenza incidence varies by area-based SES. Continued evaluation of the relationship between influenza-associated health outcomes and census tract SES allows for public health interventions to more effectively target vulnerable populations. In addition, routine use of these methods may help elucidate previously unrecognized disparities in public health surveillance data.

## Table of Contents



## List of Tables (Appendix A)



## List of Figures (Appendix B)

Introduction

One of the most recent pandemic influenza strains to cause significant mobilization of the public health community was 2009 H1N1 Pandemic, officially termed A(H1N1)pdm09 by the WHO.[1] This influenza A virus had similar epidemiological characteristics to the 1918 Spanish Influenza, which affected generally young, healthy people at higher than average rates.[2] It is well known that there was an initial shortage in A(H1N1)pdm09 vaccine availability due to vaccine production procedures and so administration of the vaccine was targeted to priority groups, including all children and adults ages 0-24 years old, but not to persons 65 years old and older, a group typically emphasized in seasonal influenza vaccination campaigns.[3] The CDC indicates that other known strains have the potential to become pandemic, including highly pathogenic avian influenza A (H5N1) virus, which has the potential to cause much higher rates of mortality if it genetically mutates to become transmissible between people.[4]

Since March of this year (2013) the public health community has been anxiously following the news of the H7N9 influenza outbreak in China. On April 24th, an article in the New York Times announced that an H7N9 influenza case has been confirmed in Taiwan and that this person had no known contact with poultry, the suspected reservoir for the virus.[5] In addition, there have been reports of children in China who have tested positive for H7N9 influenza, but show no symptoms of the illness.[6] Both the possibility that this strain is spread from person to person, as the Taiwan case suggests, and the fact that there may be human carriers of the virus, are reasons to be concerned. In anticipation of the next flu pandemic, public health agencies are advising everyone to be prepared.

According to the CDC, "the federal government cannot prepare for or respond to the challenge of a flu pandemic alone."[7] In addition, although many resources for communities, faith-based organizations and individuals are available, there is a clear focus on pandemic response and individual preparedness actions, such as stocking up on food and water.[7] What is not apparently discussed, in terms of preparedness or vaccination priorities, is the relationship between SES, demographics, including race/ethnicity, age and gender, and influenza incidence patterns. There is a longstanding tradition among public health agencies to analyze surveillance data by these demographics. However, an influenza prevention intervention targeted to a specific race/ethnicity or gender might be ineffective. As new pandemic strains continue to emerge, such as the H7N9 strain, it is important to conduct influenza-specific public health interventions. The focus of which should be on reducing SES disparities, because they are measurable, can be addressed and/or targeted for policy change, and because they can put individuals at greater risk for severe health outcomes from influenza infection.

Research indicates that SES contributes to, and race correlates with, influenza transmission and subsequent severe health outcomes.[8-9] For example, in October 2009, there was a disproportionate number of deaths due to influenza among American Indians and/or Alaska Natives in New Mexico and Arizona.[8] Closer examination of surveillance data indicated that this particular group had four times the risk of death due to the A(H1N1)pdm09 strain compared to all other race/ethnicity groups.[8-9] In addition, several studies have uncovered the relationship between commonly understood SES determinants of health and influenza, including education and poverty.[9,10] Yet, few studies have examined these SES and demographic factors by a range of potential health outcomes resulting from influenza infection.

Analysis of public health surveillance data by area-based SES measures can elucidate these previously unrecognized disparities.[10] For influenza related public health interventions, the analysis of SES measures at the census tract level is "essential for public health officials to make informed decisions."[11] During the A(H1N1)pdm09 pandemic, there were not enough vaccines to go around. The reportedly unequal distribution of the available vaccines left unchecked in the future could contribute to the spread of an epidemic if vaccination and other public health interventions do not reach those populations most vulnerable.[12] In addition, scientists now recognize the value of geographically specific data on SES factors in the planning and implementation of policies and public health interventions.[13] For example, the findings of a recent study indicate that "a social determinants approach to promoting public health is an essential component of pandemic planning, and is crucial for mitigating the burden of severe influenza illness."[9]

Public Health efforts to limit the spread and health consequences of pandemic influenza are increasingly important.[14] According to the Connecticut Department of Public Health, 2009 A(H1N1)pdm09 infections accounted for 44% of all positive influenza laboratory results, 78% of all influenza hospitalizations and 35 out of 36 total deaths caused by influenza in the state during the 2009-2010 season.[15] In fact, although laboratory-confirmed influenza cases that do not have an influenza-associated hospitalization or death outcome are much less likely to be subtyped than those that do, 14% of laboratory-confirmed A(H1N1)pdm09 cases were hospitalized, while only 3% of non-A(H1N1)pdm09 cases were hospitalized.[15] A(H1N1)pdm09 raised much concern about the potentially devastating effects of a pandemic influenza and, even though it is now considered to have resulted in a relatively mild pandemic compared to what was feared, it identified the need for pandemic mitigation strategy development in the public health community.

However, even in years where a pandemic does not occur, influenza is a significant cause of morbidity and mortality in Connecticut and nationwide.[16] Therefore, any seasonal influenza mitigation strategy may not only lessen the burden of disease overall, but also lessen the effects of a later pandemic influenza. In addition, the ability to monitor intervention progress on a seasonal basis would allow for continual evaluation of the effectiveness of the intervention, which is not easily determined for pandemic preparedness given that pandemics do not generally occur according to regular time intervals.

Recent research indicates that incidence of influenza-associated pediatric hospitalizations correlates with poverty and crowding at the census tract level in New Haven County, Connecticut.[17] This study seeks to examine the relationship between area-based SES measures and incidence of all laboratory-confirmed influenza in Connecticut, outpatient laboratory-confirmed influenza, influenza-associated hospitalizations, and influenza-associated deaths in Connecticut between October 1, 2006 and April 30, 2012. Furthermore, the study seeks to determine if a relationship between laboratory-confirmed influenza and other area-based SES measures exists as well.

This study examines laboratory-confirmed influenza by area-based SES measures. The laboratory-confirmed influenza cases, can be further divided into three categories of influenza outcome: non-hospitalized laboratory-confirmed influenza, influenza-associated hospitalizations and/or influenza-associated deaths. All influenza outcomes are analyzed by census tract level SES in Connecticut, a state in which researchers have already demonstrated the value of examining surveillance data by census tract SES.[17,18,19] The difference in influenza incidence rates by census tract SES will better inform public health professionals and policy makers in efforts to target interventions to census tracts with characteristics most closely correlated with higher incidence of influenza-related health outcomes.

<u>Methods</u>

Records of influenza-positive laboratory tests are routinely collected by the Connecticut Department of Public Health. The list of reportable diseases is published annually in the *Connecticut Epidemiologist* newsletter and updated as needed throughout the year, in accordance with the Connecticut General Statutes 19a-2a.[20] Influenza-associated hospitalization and death cases were only available for the 2009-2010, 2010-2011 and 2011-2012 seasons, because surveillance for these had not been done on a state-wide basis up until October, 2009. The 2009-2010 season prompted Connecticut to adjust its list of reportable diseases to include all hospitalizations and deaths due to influenza infection.[21] For analyses specific to New Haven County, Connecticut, there is a combination of active and passive surveillance for influenza-associated hospitalizations led by the Yale Emerging Infections Program.

For this study, records were obtained from the Connecticut Electronic Disease Surveillance System (CEDSS) database for a span of six influenza seasons (October 1, 2006 to April 30, 2012). An influenza surveillance season is typically from October 1 through April 30. However, the 2009-2010 season started on April 15, 2009 and lasted through April 30, 2010.

Case records included date of influenza laboratory specimen collection, date of hospitalization and death (if applicable), address, age, race/ethnicity, and gender. Residential case addresses were used to geocode each case to its respective census tract with ArcGIS version 10.1 (ESRI, Redlands, CA). Using the determined census tracts, cases were then linked to census tract level population data from the U.S. 2010 Census and the 2011 5-year American Community Survey (ACS) following the methods of the Harvard Public Health Disparities Geocoding Project.[22] This allowed for the examination of laboratory-confirmed influenza incidence by measures of SES collected in the U.S. Census, whereas relying only on information included in surveillance records would limit the analysis to race/ethnicity, which is only a proxy for SES.[17] A case was excluded from this study if it could not be geocoded to the state of Connecticut.

For each of the census tracts, mean annual incidence was calculated using the 2010 U.S. Census Summary File 1 population data as a denominator for each of the four influenza outcomes. In addition, for each outcome, mean annual incidence was calculated by race/ethnicity, age and gender. Mean incidence was also calculated for each outcome by season, according to total incidence, race/ethnicity, age and gender. For this calculation, all seasons were defined as May 1 through April 30, except the 2006-2007 season, because data is available starting in October 2006. This allowed for the 108 non-hospitalized cases that occurred from May through October outside of the 2009 season to be incorporated into the analysis.

The study population was compared to the general population of Connecticut based on race/ethnicity, age and gender, using a chi-square test for significance ($p < 0.05$). Relative rate ratios were then calculated to show the relative incidence among race categories, age categories and gender categories for each of the four influenza-associated health outcomes. For race/ethnicity categories, the laboratory-confirmed influenza incidence rates among both the non-Hispanic Black and Hispanic population were separately divided by the incidence rate among the non-Hispanic White population to give the relative incidence rate ratio for each group compared to the reference group, or the non-Hispanic White population. The same process is followed to determine the relative incidence rate ratio between both cases under 18 years old and those 65 years or older, compared to the reference age category of adults age 18 to 64 years old. For gender, the relative incidence rate ratio is calculated as the incidence among females divided by the incidence among males.

For each influenza-associated health outcome, race and gender incidence values are likely low because of missing data. Race was identified for 46.5% (13,081 out of 28,121) of all laboratory-confirmed influenza cases, 42.7% (11,139 out of 26,060) of non-hospitalized laboratory-confirmed influenza cases, 94.2% (1,889 out of 2,005) of influenza-associated hospitalization cases, and 94.6% (53 out of 56) of influenza-associated death cases. Gender was identified for 98.6% (27,720 out of 28,212) of all cases, 98.5% (25,670 out of 26,060) of non-hospitalized laboratory-confirmed influenza cases, 99.5% (1,994 out of 2,005) of influenza-associated hospitalization cases, and 100% of influenza-associated death cases.

Incidence of each of the four influenza outcomes was then compared by census tract level measures of percent poverty, crowding, unemployment, urban area, children, adults aged 65 years and older, and population who experience a language barrier as they reportedly speak Spanish at home and speak English less than "very well." All seven population level census tract measures were obtained from the 2011 5-year ACS (U.S. Census Bureau).

The U.S. Census defines poverty as the sum of unrelated individuals and people in families whose incomes fell below the poverty threshold, as defined by the Census Bureau's two-dimensional matrix, which takes into account family size and presence of children in the household.[23] Poverty has been included in this analysis because several studies recommend its use as a standard area-based SES measure, suggest it is a robust indictor with high external validity and demonstrate that it has a direct relationship with disease incidence at the census tract level.[10,17,24] This analysis looks at the whole state and all age groups. The poverty quantiles were selected based on those used in published research.[17,22.23] This was done so that results are comparable to the published research and expand the current understanding of the relationship between laboratory-confirmed influenza incidence and poverty in Connecticut. Census tracts in the low poverty category are those where the percent of poverty, or people living below the Federal Poverty Level, is less than 5%. The percent range for medium low poverty is from greater than or equal to 5 to less than 10%. For medium high poverty, the percent range is from greater than or equal to10% and less than 20%. For the high poverty category, the percent of people living in poverty is greater than or equal to 20%.

The U.S. Census defines crowding as housing units with greater than one person per room, which is determined by dividing the total number of people by the total number of rooms in each occupied housing unit.[23] Crowding has been included in this analysis because influenza is spread through respiratory droplets and therefore presumably best where people are in close proximity.[10,17,25-26] In addition, census tract level crowding has been found to correlate with pediatric influenza hospitalizations.[17] This analysis looks at the whole state and all age groups, but bases the crowding quantiles on those used in an analysis of pediatric influenza-associated hospitalization incidence by crowding for New Haven County, CT.[17] Census tracts with a low crowding are those where the percent of crowding, or households with more than one person per room, is less than 1%. The percent range for medium low crowding is from greater than or equal to 1 to less than 2.9%. For medium high crowding, the percent range is from greater than or equal to 2.9% to less than 4.9%. For the high crowding category, the percent of people living in a crowded residence is greater than or equal to 4.9%.

The U.S. Census defines unemployment as the percent of all civilians aged 16 years and over who were not at work and/or did not have a job during the week of their interview, and who were actively seeking work within four week's time and able to start a job if offered one.[23] A recent study of unemployment in the U.S. from 1999-2010 has found that as much as a 1% increase in unemployment increases the odds of increased influenza incidence both nationally and regionally.[27] This study includes analysis of influenza outcomes by unemployment percent at the census tract level to explore this relationship further. For unemployment, quartiles are used to determine the percent categories. For the low percent category, the percent unemployment is less than 5.5%. For medium low unemployment, the percent range is from greater than or equal to 5.5% to less than 7.4%. For medium high unemployment the percent range is from greater than or equal to 7.4% to less than 11%. For the high unemployment category, the percent of census tract unemployment is 11% or greater.

The U.S. Census defines the ability to speak English as less than "very well" when survey respondents 5 years and over answer "well," "not well," or "not at all" to the question of how they would rate their own English speaking ability.[23] For this analysis, the ability to speak English less than "very well" is examined only for those respondents who reportedly primarily speak Spanish at home, and is hereafter referred to as a language barrier.[23] The analysis was limited to Spanish exclusively because in the state of Connecticut the Hispanic population is the 2nd largest out of all race/ethnicity groups, representing 13.4% of the population.[28] Comparatively, non-Hispanic Blacks comprise 9.4% and non-Hispanic Whites make up 71.2% of the state population.[M10] Therefore, should the data uncover a relationship between language barriers and influenza incidence, targeted public health interventions to make influenza prevention services more available to Spanish speaking persons might effect the most change in incidence among all people who face language barriers in the state.[29] For the population that experiences a language barrier, as defined, the quartiles are used to determine percent categories. For the low percent category, the percent of people facing a language barrier is less than 2.3%. For the medium low category, the percent range is from greater than or equal to 2.3% to less than 4.9%. For the medium high category, the percent range is from greater than or equal to 4.9% to less than 11.35%.  For the high category, the percent of people in a census tract facing a language barrier is 11.35% or greater.

The U.S. Census defines urban as either an urban area, in which there are 50,000 or more people residing, or as an urban cluster, in which between 2,500 and 50,000 people are residing.[30] For this analysis, percent urban area is defined as the cumulative percent of a census tract that is classified as either an urban area or as an urban cluster.  Percent Urban is therefore equal to the percent of the census tract population not living in a rural area.  According to the 2010 Census, 88% of Connecticut's population resides in either an urban area or an urban cluster.[31]  Research examining the spread of avian influenza in large cities indicates that urban areas and clusters are uniquely challenged during a pandemic.[32] Therefore, this study sought to examine if incidence varies by urbanization of geographic areas in Connecticut.  For urban area, the quartiles are used to determine the percent categories.  For low urban area, the percent of people living in an urban area is less than 7.7%.  For medium low urban area, the percent range is from greater than or equal to 7.7% to less than 47.5%.  For medium high urban area, the percent range is from greater than or equal to 47.5% to less than 93.2%.  For the high category, the percent of people in a census tract living in an urban area is 93.2% or greater.

The U.S. Census defines age as the number of complete years that have elapsed since a person's birth date at the time of the interview.[23]  Age is a recognized risk factor for complications from influenza infection; specifically children and the elderly are generally found to be at increased risk of hospitalization and death.[16] This study sought to confirm that by examining incidence in Connecticut, and to compare the risk for hospitalization and/or death outcomes with the non-hospitalized outcomes by age group.  For the population under 18 years old, quartiles are used to determine the percent categories.  For the low category, the percent of the population less than 18 years old is less than 20.1%. For the medium low category, the percent range is from greater than or equal to 20.1% to less than 22.6%. For the medium high category, the percent range is from greater than or equal to 22.6% to less than 25.9%. For the high category, the percent of the census tract population that is less than 18 years old is 25.9% or greater. For the population that is 65 years or older, quartiles are used to determine the percent categories. For the low category, the percent of the population 65 years old or older is less than 10.7%. For the medium low category the range is from greater than or equal to 10.7% to less than 13.9%. For the medium high category the range is from greater than or equal to 13.9% to less than 17.3%. For the high category, the percent of the census tract population of people age 65 and older is 17.3% or greater.

For each of the seven ACS variables, the relative rate was calculated between the highest and the lowest percent quartile by dividing the highest percent quartile incidence rate by the lowest percent quartile incidence rate for each variable. A chi-square test for trend was used to evaluate the significance of the gradient, based on all four percent categories, for all four influenza outcomes. For the poverty and crowding variables, this relative rate was then calculated by season for each of the four influenza outcomes, and tested for significance with the chi-square for trend test. Finally, each of the seven ACS variables was individually examined for correlation with each of the four categories of influenza outcomes. A Pearson correlation statistic (r) and p-value were used to describe this relationship and its significance.

All statistical analysis was completed in SAS version 9.2 (SAS Institute Inc. Cary, NC) or Epi Info version 7 (Centers for Disease Control and Prevention, Atlanta, GA). This study was reviewed and approved by both the Yale Human Investigation Committee and the State of Connecticut Department of Public Health Human Investigation Committee.

## Results

*Geocoding Results*

There were 30,200 laboratory-confirmed influenza cases reported to the Connecticut Department of Public health (October 1, 2006 – April 30, 2012). There were a total of 30,200 cases for which laboratory confirmed influenza were available. Of those, 2,061 cases had been hospitalized, and among the hospitalized cases, 59 had died. Out of the total sample, 1,296 were excluded because an address was not provided or was incomplete, 105 were excluded because the address given was a P.O. box, 143 were excluded because the reported address was not within the state of Connecticut, and 535 were excluded because the addresses could not be geocoded successfully.

The final sample included a total of 28,121 cases with an influenza-positive lab test. Of those, 26,060 were non-hospitalized cases, 2,005 were hospitalized, non-death cases, and 56 were death cases. In this study, all analyses are stratified by these four influenza outcome categories.

As of 2010, Connecticut has a total of 833 census tracts, five of which are unpopulated. Only one populated census tract had zero cases of influenza during the study period. There were 827 census tracts with non-hospitalized cases, 633 census tracts with influenza-associated hospitalization cases and 52 census tracts with influenza-associated death cases.

*The study population compared to the general population of Connecticut*

For all laboratory-confirmed influenza cases in Connecticut (2006-2012), the study population was significantly different ($p < 0.0001$) than the general population of Connecticut in distribution of race/ethnicity, age and gender (Table 1). When the study population is examined by influenza outcome, the study population is also significantly different than the general population of the state for non-hospitalized influenza cases and influenza-associated hospitalization cases ($p < 0.0001$). For influenza-associated death cases, age distribution is significantly different than that of the general state population ($p < 0.0001$) but race/ethnicity and gender are not.

For all influenza outcomes except death, the proportion of non-Hispanic Black and Hispanic people in the study group was significantly greater than the respective population in the general population of Connecticut, while the non-Hispanic White population in the study group population was significantly less. For influenza-associated deaths, the study population did not differ significantly from the general population in terms of race/ethnicity percent distribution.

For all laboratory-confirmed influenza cases, the percent of the study population that is under 18 years old was significantly greater than the percent of the general population that is under 18 years old. In contrast, the percent of the study population which is age 18 to 64 and which is over 65 was significantly less than the percent of the respective age group in general population. This relationship is true for non-hospitalized influenza cases as well, but reverses for hospitalized cases in both the under 18 and over 65 age groups. Influenza-associated death cases have a similar age distribution compared to the general population as the hospitalized cases, but the 18-64 age group proportion is not significantly different between the two populations.

In terms of gender, the percent of males in the study population is significantly less than the percent of males in the general population for all non-death influenza outcomes. For influenza-associated deaths, the gender distribution of the study population is not significantly different from that of the general population in Connecticut.

*Incidence of influenza in Connecticut (2006-2012) by race/ethnicity, age and gender*

For all laboratory-confirmed influenza, incidence rates among Hispanics and non-

Hispanic Blacks were 1.6 and 1.9 times higher, respectively, than they were among non-Hispanic Whites (Table 2A). These incidence rates are approximately the same for non-hospitalized laboratory-confirmed influenza (1.6 and 1.8, respectively), but become increasingly proportionally greater than the incidence rates among non-Hispanic Whites for the non-hospitalized laboratory-confirmed influenza and the influenza-associated hospitalization outcomes (1.9 and 2.4, respectively). Among the cases of influenza-associated death, incidence in the Hispanic population approximated incidence in the non-Hispanic White population, while for the non-Hispanic Black population, incidence is 1.7 times that of the non-Hispanic White population.

Compared to adults aged 18-64, incidence in children under 18 years old among all influenza cases and all non-hospitalized cases is 3.1 to 3.3 times greater, respectively. This relative rate ratio decreases among hospitalization- and influenza-associated death cases (0.9 and 0.2, respectively). Incidence among adults aged 65 and older compared to adults 18-64 is 1.1 times greater for all laboratory-confirmed influenza, decreases for non-hospitalization cases, and then increases for hospitalization- and influenza-associated death (3.2 and 3.6, respectively).

The incidence of all influenza outcomes was between 1.1 and 1.3 times higher for the female population than the male population.

*Influenza incidence by U.S. Census measures, Connecticut 2006-2012*

When influenza incidence is examined by U.S. Census measures of SES, there is a clear difference between influenza incidence rates in census tracts in the lowest versus those in the highest SES categories (Table 2B).

For all cases, incidence among census tracts with the highest percent category of poverty, crowding and unemployment were 1.4 times the incidence in census tracts with the lowest respective percent category ($\chi^2$ for trend $p < 0.001$). Incidence was similarly elevated in census tracts with highest percent of people facing a language barrier, in an urban area, and children in the population (Relative rate = 1.5, 1.7 and 1.6, respectively, $\chi^2$ for trend $p < 0.0001$). However, in census tracts with a high proportion of people age 65 and older incidence is relatively lower than in census tracts with low proportions of people of that age group (Relative rate = 0.8, $\chi^2$ for trend $p < 0.0001$).

For non-hospitalized cases, incidence among census tracts with the highest levels of poverty and crowding were 1.3 times the incidence in census tracts with the lowest levels ($\chi^2$ for trend $p < 0.001$). Incidence in census tracts with the highest percent of unemployment and percent of the population facing a language barrier were 1.4 times the incidence in census tracts with the lowest respective percent ($\chi^2$ for trend $p < 0.001$). Incidence in census tracts with the highest percent category of urban area and percent of the children in the population were 1.6 times the incidence in census tracts with the lowest respective percent category ($\chi^2$ for trend $p < 0.001$). However, in census tracts with a high proportion of people age 65 years and older incidence is relatively lower than in census tracts with low proportions of people of that age group (Relative rate = 0.9 $\chi^2$ for trend $p < 0.0001$).

For influenza-associated hospitalizations, incidence in census tracts with the highest poverty and unemployment were 2.5 times the incidence in census tracts with the lowest respective percent category ($\chi^2$ for trend $p < 0.001$). Incidence was similarly elevated in census tracts with the highest percent of poverty, people facing a language barrier, urban area, and children in the population (Relative rate = 3.1, 2.8, and 4.1, respectively. $\chi^2$ for trend $p < 0.0001$). Incidence in census tracts with a high proportion of children is elevated compared to census tracts with a low proportion of children, but not significantly so (Relative rate = 1.1 $\chi^2$ for trend p = 0.7174). In addition, in census tracts with a high proportion of people age 65 incidence is relatively lower than in census tracts with low proportions of people of that age group (Relative rate = 0.7, $\chi^2$ for trend $p < 0.0001$).

For influenza-associated death cases, incidence among census tracts with the highest percent category of poverty was approximately the same as incidence within census tracts with the lowest percent of poverty ($\chi^2$ for trend p = 0.0324). For all other variables, there is no significant trend across the four categories.

*Influenza incidence by percent of census tract poverty and crowding, Connecticut 2006-2012*

In general, as the percent of census tract poverty or crowding increases, the incidence of laboratory-confirmed influenza increases significantly in all outcome categories except influenza-associated deaths (Figures 1 and 2, respectively).

Although the chi squared for trend indicates a significant linear relationship between percent categories of census tract poverty, for the two influenza outcome categories of all laboratory confirmed influenza and non-hospitalized laboratory confirmed influenza, a visual analysis of the incidence rates suggests otherwise (Table 2C). For these two outcomes the incidence rates increase from medium low to medium high to high percent poverty. However, in low poverty census tracts the incidence rates are higher than for the medium low census tracts. This is not evident in the relationship between crowding and these influenza outcomes, but a similar pattern is also true of the percent of a census tract that is urban ($\chi^2$ for trend $p < 0.0001$).

*Influenza incidence by season in Connecticut, 2006-2012*

For all outcome categories, the 2009-2010 season incidence rates are the highest, which is likely a direct result of A(H1N1)pdm09. During that season there were over four thousand laboratory confirmed influenza cases during the months of May through September alone, whereas for the other five seasons combined, there were only a little over 100 cases during this five month window (Table 3A).

For all laboratory-confirmed influenza, there were approximately 321 per 100,000 people in Connecticut who tested positive for influenza during the six-year study period. For non-hospitalized laboratory-confirmed influenza cases, there were approximately 295 per 100,000 people in Connecticut who tested positive for influenza. Approximately 25 out of every 100,000 people in Connecticut who tested positive for influenza were hospitalized with influenza. Finally, approximately 1 person per 100,000 people in Connecticut who tested positive for influenza had an influenza-associated death.

For all influenza outcomes the 2011-2012 season incidence rates are consistently the lowest of all seasons (approximately 27 per 100,000, 20 per 100,000, 7 per 100,000 and <1 per 100,000, respectively). There is no consistent pattern in incidence rates for the non-hospitalized lab tests across the first three seasons, 2006-2007, 2007-2008 and 2008-2009 (approximately 55 per 100,000, 144 per 100,000 and 107 per 100,000, respectively).

*Influenza incidence according to census tract poverty by season in Connecticut, 2006-2012*

When the seasonal variance in laboratory-confirmed influenza incidence is examined further, it appears there is an inverse relationship between laboratory-confirmed influenza and high versus low census tract poverty when each is graphed by season (Figure 3A).

As Table 3B indicates, all laboratory-confirmed incidence in high versus low census tract poverty rate ratios ranged from 1.66 in the 2006-2007 season, to 1.27 in the 2009-2010 season, to 1.79 in the 2011-2012 season. For each season, the chi-squared test for trend on high versus low census tract poverty, which takes into account all four poverty percentage categories, is significant ($p < 0.0001$).

Non-hospitalized influenza incidence in high poverty versus low poverty census tracts ranged from 1.66 in the 2006-2007 season, to 1.15 in the 2009-2010 season. In the 2011-2012 season, the rate ratio (1.41) was slightly less than for the previous season (1.42). For each season, the chi-squared test for trend, which takes into account all four poverty percentage categories, is significant ($p < 0.0001$), except for the 2009-2010 season ($p = 0.071$).

However, for influenza-associated hospitalization incidence in the high poverty versus low poverty census tracts, this inverse relationship seems to disappear. The rate ratios were relatively high in 2009-2010 (3.81) and 2011-2012 (3.86) compared to the 2010-2011 season (2.33). Chi-square test for trend on high versus low census tract poverty values are significant for each season ($p > 0.0001$).

Influenza-associated death incidence in the high poverty versus low poverty census tracts was 1.33 in the 2009-2010 season and 0.61 in the 2010-2011 season ($p = 0.041$, $p = 0.604$, respectively). There was only one influenza-associated death case in the 2011-2012 season, so a census tract level comparison of high versus low poverty could not be performed.

*Influenza incidence according to census tract crowding by season in Connecticut, 2006-2012*

It is not clear that the relationship between seasonal incidence of laboratory-confirmed influenza and high versus low census tract crowding follows the same pattern. In fact, high versus low census tract crowding rate ratios appear to follow the general trend of increasing and decreasing seasonal influenza (Figure 3B).

However, as Table 3C shows, the greatest high versus low crowding rate ratio is not during the 2009-2010 season, which has the highest overall seasonal incidence, but during the 2010-2011 season. In fact, these are the only seasons for which the high versus low crowding rate ratio increases relative to the previous season. In addition, these are the only two seasons for which total incidence of laboratory-confirmed influenza increases or decreases by more than 190 people per 100,000 population. The next greatest relative change in seasonal incidence is a decrease of 104 per 100,000 people between the 2010-2011 season and the 2011-2012 season.

Non-hospitalized influenza incidence in high crowding versus low crowding census tracts follows the same pattern as the high versus low census tract crowding ratio for all laboratory-confirmed influenza by season. The rate ratio ranged from 1.19 in the 2008-2009 season to 1.57 in the 2010-2011 season. However, the influenza-associated hospitalization incidence in the high crowding versus low crowding census tracts did follow the pattern of decreasing incidence with the highest rate ratio (3.02) was in the 2009-2010 season, and the lowest rate ratio (1.95) occurred in the 2011-2012 season. For these three non-death outcomes, the chi-square test for trend values for high versus low census tract crowding are significant for each season ($p > 0.0001$).

Influenza-associated death incidence in the high crowding versus low crowding census tracts was 1.37 in the 2009-2010 season and 1.12 in the 2010-2011 season ($p = 0.246$, $p = 0.570$, respectively). There was only one influenza-associated death case in the 2011-2012 season, so a census tract level comparison of high versus low crowding could not be performed.

*Influenza incidence correlation with poverty and crowding in Connecticut, 2006-2012*

As is shown in Table 4, for the state of Connecticut, a Pearson Correlation demonstrates that all variables, poverty, crowding, unemployment, urban areas, facing a language barrier, age under 18 years and age 65 or older, correlate significantly with incidence of all laboratory-confirmed influenza, except for the proportion of the census tract population that is over 65 years old ($p < 0.0001$ and $p = 0.0864$, respectively). R-values for significant variables range from 0.28, for the percent of the census tract population that is under 18 years old, to 0.16, for the percent of the census tract population that faces a language barrier.

All variables correlate significantly with incidence of non-hospitalized laboratory-confirmed influenza except for the proportion of the census tract population that is over 65 years old ($p < 0.0001$ and $p = 0.1123$, respectively). R-values for significant variables range from 0.28, for the percent of the census tract population that is under 18 years old, to 0.14, for the percent of census tract crowding and of the population that faces a language barrier.

All variables correlate significantly with incidence of influenza-associated hospitalization except for the proportion of the census tract population that is over 65 years old ($p = .0225$ for population under 18 years old, $p = 0.075$ for population over 65 years old, and $p < 0.0001$ for all other variables). R-values for significant variables range from 0.40, for the percent of census tract unemployment, to 0.08, for the percent of the census tract population that is under 18 years old.

The only variable that correlates significantly with incidence of influenza-associated death is the proportion of the census tract population that is over 65 years old ($R= 0.07$ $p = 0.0322$). R-values for variables that have insignificant correlation range from -0.02, for the percent of the census tract that faces a language barrier, to 0.07, for the percent of the census tract that is urban and for the percent of the population that is over 65 years old.

For New Haven County, Connecticut, whether non-hospitalized, influenza-associated hospitalization or influenza-associated death, the correlation R-values are different (Table 4). All variables correlate significantly with incidence of all laboratory-confirmed influenza ($p = 0.0232$ for percent census tract population that is over 65 years old and $p < 0.0001$ for all other variables). R-values range from 0.51, for the percent of the census tract unemployed, to -0.16, for the percent of the census tract population that is over 65 years old.

All variables correlate significantly with incidence of non-hospitalized laboratory-confirmed influenza ($p = 0.0194$ for percent census tract population that is over 65 years old and $p < 0.0001$ for all other variables). R-values range from 0.50, for the percent of the census tract unemployed, to -0.17, for the percent of the census tract population that is over 65 years old.

All variables correlate significantly with incidence if influenza-associated hospitalization except for the percent of the population under 18 years old and the percent of the census tract population that is over 65 years old ($p = 0.0997$ for population under 18 years old, $p = 0.176$ for population over 65 years old, and $p < 0.0001$ for all other variables). R-values for significant variables range from 0.45, for the percent of census tract unemployment, to 0.21, for the percent of the census tract that is urban.

No variable correlates significantly with incidence influenza-associated death. R-values range from -0.02, for the percent of the census tract that lives below the federal poverty line, to 0.07, for the percent of the census tract that is urban.

## Discussion

### *Race/Ethnicity, Age and Gender*

The data indicate a significant difference between the proportion of each race category in the study group compared to its respective percent in the general population of the state of Connecticut, consistent across all influenza outcomes categories except for influenza-associated deaths. The majority of the population of Connecticut is non-Hispanic White, and yet the incidence of laboratory-confirmed influenza is consistently greater among both non-Hispanic Black and Hispanic populations compared to incidence in the non-Hispanic White population.[28]

These incidence rates point out that the general make-up of the study group, in terms of the proportion of each race/ethnicity, age and gender group, was not the same as that of the state population.  However, a recent study in New Haven, CT, demonstrates that the relative proportions of each race/ethnicity and gender category in influenza-associated pediatric hospitalizations is similarly different from those of the total general population, as reported in this study's Table 1.[17]  The fact that incidence differs by race/ethnicity may be an indication that race/ethnicity is a risk factor for influenza.  Yet, the definition of race/ethnicity is not consistent across all hospitals or case reporting practices, and is based on patient self-identified race/ethnicity, which may change over time on an individual basis.[33]  In addition, even if the definition were consistent, only 46.5% of laboratory-confirmed influenza cases have an identified race/ethnicity, and this percent varies by season.  For example, only approximately 36% of cases have a reported a race/ethnicity in the 2009-2010 season.  Although there is no reason to believe that there was differential reporting of race/ethnicity despite this change, there is no practical way to test if this occurred.  Furthermore, during the 2009-2010 season, persons of Hispanic descent may have been tested for influenza infection systematically differently than persons of other race/ethnicity given that the first outbreak of human cases caused by the A(H1N1)pdm09 strain circulating in 2009 was suspected to have occurred in Mexico.

It is important to note that most public health agencies do analyze epidemiologic data by race/ethnicity. Yet, a public health intervention targeted to one race/ethnicity would neither be feasible nor appropriate.  For all of these reasons, it was deemed more appropriate to focus on analyzing laboratory-confirmed influenza incidence based on SES and not race/ethnicity for this study.

In addition, although nearly all cases reported gender (98%), the proportion of each gender group is significantly different in the study population compared to the general state population, and in this study incidence among females is as much as 1.3 times that of males for hospitalizations, and 1.1 times as much for the three other outcomes. Gender is not a known risk factor for influenza and therefore influenza incidence was not analyzed by gender. That is not to say that it is not actually or will not be discovered to be a risk factor.

In terms of age, groups differ proportionally in the study group compared to the general population across all outcomes except influenza-associated death, where adults age 18 to 64 are not proportionally different between the two groups. Both children and also adults age 65 and older have long been recognized to be at increased risk for influenza-associated health outcomes because of immune system development and co-morbidities, respectively.[17,34] With 100% of age reported among the study sample of laboratory-confirmed influenza, it is likely accurate to conclude that the increased proportion of persons 65 and older in the study population compared to the general population for both hospitalization- and influenza-associated death indicates increased risk. However, the data show a decreased proportion of people aged 65 and over having laboratory-confirmed influenza. This may suggest that despite the relative increased risk for severe influenza-associated health outcomes for persons of this age group, there is either disproportionate testing, meaning that persons of this age group are tested at a disproportionate rate for influenza, or that this age group has a relatively lower incidence rate than the others, but that for this group severe outcomes due to infection occur more often, comparatively.

For non-hospitalized laboratory-confirmed influenza, children are represented in greater proportion within the study compared to the general population. This indicates that children may be being tested for influenza at a higher rate, which may result from regular attendance at school and thus exposure to virus on a regular basis.[35] It is also possible that children actually do have increased incidence of influenza compared to the other age groups, but that severe outcomes from infection occur less often, comparatively.

*Socioeconomic Measures*

The use of race/ethnicity for analysis of disease incidence has been questioned on many levels, including appropriateness and validity.[33] Not only are race/ethnicity categories inconsistently defined, but at best they serve as a proxy for SES influences of disease.[17,33] In addition, analysis by race/ethnicity can be confusing, divisive, and stigmatizing.[17] Therefore, utilizing SES measures is preferable, providing an all-inclusive target for public health interventions. This study examines influenza incidence across four influenza-related health outcomes by census tract population-level SES measures, among all of which there is a positive linear relationship between the SES measure and all influenza outcomes except influenza-associated death.

When laboratory-confirmed influenza is analyzed by poverty at the census tract level, it is clear that a significant positive linear relationship exists, meaning that as percent of census tract poverty increases, incidence of the non-death outcomes increases. This directly supports research findings on influenza-associated hospitalization incidence among children in New Haven County, CT.[17] This relationship could stem from a high prevalence of underlying co-morbidities in people living in areas of high poverty, but research indicates that this is not the case.[17] Access to care, whether in terms of health insurance, means of transportation or ability to seek care outside of work, or even vaccination rates may shed more light on the driving factors of this relationship. However, analysis would require population level data at the census tract level on the percent of people with health insurance and the percent of people vaccinated for influenza.

When laboratory-confirmed influenza is analyzed by crowding at the census tract level, it is apparent that a positive linear relationship between crowding and laboratory-confirmed influenza incidence exists. As percent of census tract crowding increases, the incidence of laboratory-confirmed influenza increases. This may indicate that crowded households have increased transmission of influenza because people are living in close proximity. Research indicates a relationship between crowding and asthma in children, as well.[17,36] Asthma is a known risk factor for complications due to influenza infection and incidence of asthma is generally higher in poor neighborhoods, where crowding is presumably higher.[37-38] That said, research does not indicate that poverty in children directly relates to incidence of asthma in children who are hospitalized with influenza.[17] The potential connection between crowding and influenza incidence is clear, but analysis of how asthma or other underlying medical conditions fit into this relationship warrants further investigation. This would require census-tract level data on chronic illness, which is not currently available.

The significantly positive direct relationship between laboratory-confirmed influenza and percent of census tract unemployment is not surprising. People without an income will likely avoid expenditures they don't view as imperative, such as influenza vaccines, have likely lost health insurance for themselves and potentially all of their dependents, and therefore may also delay seeking medical care when they do become ill.[27] In addition, one study looking at national and regional influenza incidence in the U.S. finds that unemployment rates tend to parallel influenza activity on a seasonal basis.[27] Although the change in seasonal unemployment rates is not examined in comparison to influenza incidence in the state of Connecticut in this study, the significant trend of increasing incidence with increasing unemployment suggests that rates of both unemployment and laboratory-confirmed influenza may correspond over time.

When laboratory-confirmed influenza is analyzed at the census tract level by presence of language barrier, laboratory-confirmed influenza incidence increases as the percent of the population with a language barrier increases. Language barriers have consistently affected health by limiting healthcare access or services.[29,39-40] A study of an elderly Hispanic population found that language was a significant barrier to receiving an influenza vaccine.[39-40] However, when looking at infectious disease incidence in general, it becomes clear that not only the elderly Hispanic population who prefers to speak Spanish over English is affected. There is also a huge health disparity faced by young adults who are recent Latina immigrants to the U.S., which is only exacerbated in communities that have not traditionally experienced migration and so are unequipped to provide services to this population.[29] The population of Connecticut is predominantly non-Hispanic white, which may limit the number of people who see the benefit of a public health campaign to reduce the language barrier to healthcare and influenza vaccination. Yet given the significant, positive relationship between the incidence of laboratory-confirmed influenza and percentage of a census tract facing a language barrier, and the widely acknowledged continuing growth of the Hispanic population, this sort of initiative would likely decrease either the incidence of laboratory-confirmed influenza or influenza-associated hospitalization resulting from complications or co-morbidities left untreated.[34]

Poverty and crowding are most significant in urban areas, and most of the state's racial and ethnic minorities reside in urban areas, according to the Connecticut State Data Center.[41] Furthermore, Connecticut's population in general resides primarily in urban areas (88%) to a greater extent than the U.S. population overall (79%).[31] Research has indicated that even cities considered moderately prepared for a pandemic situation face challenges in implementing interventions that reach and/or are accessible to the entire populous.[32] Over the seasons examined in this study, Connecticut has consistently had higher rates of laboratory-confirmed influenza than the national average, whether non-hospitalized, influenza-associated hospitalization or influenza-associated death.[42] This indicates that the urban environment most of the population lives in may in some way be affecting influenza incidence rates. Perhaps it is not just crowding within one's home or household that correlates with an increased risk of laboratory-confirmed influenza, but also living in highly populated areas.

The pattern of laboratory-confirmed influenza incidence for both the population of children under 18 years old, and the population of adults age 65 and older, follows the general pattern of incidence of influenza in each respective age group across the U.S.[16] In essence, incidence of laboratory-confirmed influenza increase as the percent of the population of each age group increases. In addition, as is described on a national level, both children and also adults age 65 and older are at increased risk for hospitalization- and influenza-associated death, compared to adults aged 18-64, but it is the adults aged 65 and older who represent the greatest incidence of both severe outcomes, comparatively.[16] This is potentially concerning given that current research calls into question the effectiveness of the influenza vaccine for people of age 65 or older, when the vaccine is currently the most efficacious prevention tool available against influenza infection.[43] Therefore, it is imperative that public health officials are able to adjust interventions according to which influenza-related health outcome they seek to target.

For all the SES and demographic measures mentioned, influenza-associated death incidence does not relate linearly. For example, as percent of census tract poverty increases, incidence of influenza-associated death does not necessarily increase. This is not an entirely unexpected finding, because the people who have an influenza-associated death typically also have additional health problems, which exacerbate the strain on their health caused by an influenza infection.[34] In addition, there are a multitude of other factors that contribute to ill health in general, outside of SES factors, such as genetic predisposition to chronic illness and past injuries or health events.[34]

The results of this study suggest that it is not clear how SES affects the influenza-related health outcome of people with other co-morbidities. However, it is important to note that there is a relatively small number of influenza-associated deaths and so the results may not be indicative of the true relationship between SES and influenza-associated deaths.

*Incidence Compared to Census Tract Poverty and Crowding Over Time*

Incidence of influenza varies from season to season. During the seasons in this study there is an initial increase in incidence of all laboratory-confirmed influenza, followed by a decrease of approximately half as much, and then a spike in incidence during the 2009-2010 season, when the A(H1N1)pdm09 strain was circulating. For the remaining two seasons, incidence consistently declined. When compared to poverty and crowding in terms of the high versus low percent of census tract rate ratio, two interesting relationships appear.

High versus low percent of census tract poverty appears to have a roughly inverse pattern seasonally compared with incidence of laboratory-confirmed influenza over the same time period (Figure 3). As incidence increases, the disparity in incidence between census tracts with a high percentage of poverty and those with a low percentage of poverty decreases. This would imply that in a pandemic situation SES factors have less of an impact on health.

However, it is important to note that although this is what the results may indicate is true for laboratory-confirmed influenza, not everyone who has influenza is getting tested. This could be because people who can afford to take the time to wait at a busy doctor's office get tested in these situations, and in so essentially utilize the resources that would typically be available to those living in the poorest census tracts, such as emergency room facilities. On the other hand, it may be that certain doctors or practices are testing for influenza for every influenza-like illness that presents, while others rarely test anyone presenting with symptoms at all. It will be valuable to look further into whether incidence of influenza follows the same pattern as described for laboratory-confirmed influenza.

High versus low percent of census tract crowding might at first glance appear to roughly parallel the pattern of laboratory-confirmed influenza incidence over time (Figure 4). However, the results indicate that only an increase or decrease of laboratory-confirmed influenza incidence by greater than 190 people per 100,000 corresponds to an increase in the high vs. low census tract crowding rate ratio. This change happens to occur between the 2009-2010 season and the seasons preceding and following it. Although one might infer that this indicates a disparity exists between census tracts with high crowding and those with low crowding during the pandemic season. However, the high versus low rate ratio did not peak in the 2009-2010 season, which suggests this is not the case. In terms of influenza incidence, the U.S. measure of crowding has not been extensively studied. However, the fact that census tracts with high crowding see an increase in incidence when general seasonal incidence increases or decreases drastically, indicates that it would be a valuable subject of further investigation, especially in the context of pandemic influenza.

There are a couple of reasons why high versus low percent of census tract poverty and crowding may have different relationships with laboratory-confirmed influenza incidence over time. First, surveillance does not catch every case. Second, an outside factor may have influenced these relationships. For example, perhaps the economic recession that occurred over several of the seasons examined caused a change in the poverty levels among census tracts. In fact, according to the Bureau of Labor and Statistics, the recession began in 2007 ended in June

2009, which is approximately when the high vs. low percent census tract poverty disparity began to increase again.[44] Increasing poverty in census tracts across the board may have decreased the difference between laboratory-confirmed influenza incidence in high and low census tracts during the pandemic 2009-2010 season, especially. This potential change in the population living in poverty could not be examined given the data used is a 5-year ACS estimate. However, an increase in the population living in poverty would decrease the incidence rate if the number of laboratory-confirmed influenza cases stayed about the same. More investigation of the relationship between census tract poverty and laboratory-confirmed influenza incidence is necessary.

The recession ending in 2009 could have also affected the relationship between census tract crowding and laboratory-confirmed influenza incidence. The increase in the high versus low percent census tract crowding between the 2008-2009 and 2010-2011 coincides with the end of the recession and returns the rate ratio to slightly above the level rate ratio for the 2006-2007 season. It could be that as time elapses since the end of the recession, the population living in crowded residences decreases in number, effectively increasing the incidence in census tracts within the high crowding category. On the other hand, the increase in the rate ratio between the 2008-2009 season and the 2009-2010 season could be connected to the pandemic flu in circulation that season. Given that crowding may influence the spread of influenza, this is not surprising, but further investigation of both SES measures and also their relationship to influenza incidence is necessary.

*Correlation*

Pearson correlation analysis indicates that the percent of census tract poverty and the percent of census tract crowding have a weak, but significant linear correlation with all laboratory-confirmed influenza. This does not contradict the finding that both SES measures, when divided into four categories of increasing percent, have significant linear relationships with all laboratory-confirmed influenza, non-hospitalized influenza and influenza-associated hospitalization. Rather it confirms that, absent percent quantiles, each measure likely has a more positive curvilinear relationship with laboratory-confirmed influenza incidence. Given the potentially exponential relationship between high to low percent of census tract crowding and laboratory-confirmed influenza incidence, a significant but not exactly linear relationship makes sense. It is interesting that out of all four influenza-related health outcomes in this study, both poverty and crowding SES measures correlate best with influenza-associated hospitalization (R=0.39 and 0.30, respectively). An R of 0.3 represents a moderately linear relationship.[45] It would have been more informative to have additional years of data for influenza-associated hospitalizations in order to examine this relationship by season. Influenza-associated deaths do not show any linear relationship with either census tract poverty or crowding.

The correlation between census tract poverty and crowding and all laboratory-confirmed influenza and non-hospitalized influenza becomes moderately strong when the analysis is repeated for New Haven County compared to when analyzed at the state level. The R for percent of census tract poverty does not differ substantially from the R for the state. However, for percent of census tract crowding, the R is 0.42, which clearly indicates a more linear relationship between percent of census tract crowding in New Haven County than is present at the state level. Influenza-associated deaths do not show any linear relationship with either census tract poverty or crowding for New Haven County.

New Haven County is somewhat unique in that with the Yale Emerging Infections Program, which conducts both active surveillance for laboratory-confirmed influenza hospitalization in addition to the passive surveillance relied on across the state, in this study the county accounts for 30.5% of all laboratory-confirmed cases, 29.7% of all non-hospitalized cases, 41.8% of all influenza-associated hospitalization and 41.1% of all influenza-associated death.[46] There is no evidence that the New Haven County population is generally less healthy than the Connecticut population. It is likely that more flu cases are identified in surveillance here because of the active component of influenza surveillance in this county. This has a couple of implications for the results. First of all, the state-wide results may not be representative of the actual incidence of influenza given the varying level of surveillance. Second, there may be actual geographic differences between populations at the county level that determine how each SES measure relates to influenza incidence. Both possibilities support the need for further analysis at the county level, but to successfully do so would require all counties to conduct surveillance in the same manner, which may not be possible in the short term.

*Regression Considered*

The goals of this study were to gain a better understanding of laboratory-confirmed influenza incidence in Connecticut in terms of SES measures and to examine these relationships to determine if an explanatory model for laboratory-confirmed influenza could be, at least in part, developed. There were significant barriers to the latter objective.

For one, what is true of census tract measures of poverty and crowding is generally true of the other SES measures found to have a significant trend of increasing laboratory-confirmed influenza incidence by percent quartiles. That is, despite the significant linear trend among percent quartiles of unemployment, language barrier, urban area, population of children and population of adults age 65 and older, the results of this study indicate that there is not a strong linear relationship between each measure and incidence (Figure 4).

Another consideration is the lack of data on underlying illness and/or risk factors, such as asthma, among the study sample. Co-morbidities are known contributors to severe health outcomes such as hospitalization- and/or influenza-associated death.[17] Furthermore, there are currently no data sources with vaccination rates and/or health insurance coverage rates at the census tract level. Finally, even should these all be available, there is a significant surveillance bias across counties in the state of Connecticut, and likely nationwide, which may skew results significantly.

For these reasons building a linear regression model to explain and/or predict laboratory confirmed influenza was deemed inappropriate for this study. Perhaps if examined for a sample of New Haven County laboratory-confirmed cases, in which health insurance, co-morbidity and vaccination status could be determined, an appropriate model could be developed.

Conclusions

Incidence among all laboratory-confirmed influenza varies by influenza-associated health outcome when examined by census-tract level SES measures. A recent study finds that influenza-associated pediatric hospitalizations in New Haven County, CT, correlate with census tract poverty and crowding. The results of this study confirm, for the seasons examined, that all laboratory-confirmed influenza cases in Connecticut also correlate with percent of census tract poverty and crowding. It is also clear that this correlation is significant for all influenza-associated outcomes except death.

Other area-based SES measures analyzed, including unemployment, language barrier, urban area, and age, both those under 18 years old and those 65 years and older, show a similarly significant relationship to incidence of each of the four influenza-associated health outcomes as do poverty and crowding. For each SES measure, linear correlation with incidence of each outcome is significant, but generally weak.

Continued evaluation of the relationship between influenza-associated health outcomes and census tract SES allows for public health interventions to more effectively target vulnerable populations. Furthermore, routine use of these methods may help elucidate previously unrecognized disparities in public health surveillance data.

*Limitations*

There are three important limitations to the results of this study. First, by applying population level SES data to individuals the study can only determine how census tract, or neighborhood level, SES affects individual health outcomes, not how each individual's SES affects their individual health. Second, this study does not analyze influenza incidence, but rather the incidence of laboratory confirmed influenza. In addition, in this study there is no way to know if the people with influenza infection are getting tested at different rates according to their SES. Finally, surveillance methods across the state vary from a combination of active and passive, to just passive. This means that during surveillance certain areas are likely to catch a smaller percent of actual cases than is the case where active surveillance is being conducted. This surveillance bias could skew results, but because the analyses are done for the entire state, the effects are likely minimized.

*Recommendations for Public Health Intervention and Future Research*

The results indicate that there is an increased incidence of laboratory-confirmed influenza among people living in a neighborhood where an increased number of people face a language barrier to health care. This implies that inability to speak English "very well" has a direct effect on health, whether that be because persons in these neighborhoods are not reached by public health campaigns aimed to limit the spread of influenza or because they may be generally poor and thus must go to an emergency room for health care where testing for influenza may be more routine than at a doctor's office. Given that the population of Connecticut is primarily non-Hispanic White in composition, the former seems probable, although it could be a combination of both.[28] Research on reaching isolated communities, whether they be isolated through language barriers, poverty, or even just living in an urban neighborhood, has begun to center on the use of Community Health Workers to reach vulnerable populations.[29] In fact, in 2011 the Connecticut Public Health Association (CPHA) began to explore supporting community health workers. In addition to targeting public health informational campaigns, which can reduce the language barrier, Community Health workers could provide health care services and information to neighborhoods that public health interventions have traditionally been unable to reach.[47] This could effect a significant decrease in disease incidence across the board.

Additional research is needed to further explore the relationship between residential crowding and influenza incidence. This study confirms that crowding may be a significant factor in the spread of a pandemic influenza strain. If this is the case, the knowledge of this interaction would allow public health professionals to appropriately assign resources to communities in a way that best limits the spread of a pandemic. Overall, more research into the effect of neighborhood level SES on individual influenza-related health outcomes within and beyond Connecticut is merited.

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Appendices

## Appendix A – Tables

**TABLE 1: Race/Ethnicity, Age and Gender of Influenza Cases in Connecticut Compared to the General Population of Connecticut (2006-2012)**

| | Population (n=3,574,097) | All Laboratory-Confirmed Cases (n=28,121) | | Non-Hospitalized (n= 26,060) | | Hospitalizations, non-Death (n= 2,005)**** | | Deaths (n=56)**** | |
|---|---|---|---|---|---|---|---|---|---|
| | No. (%) | No. Cases* (%) | p | No. Cases* (%) | p | No. Cases* (%) | p | No. Cases* (%) | p |
| Race** | | | | | | | | | |
| non-Hispanic White | 2,546,262 (71.2) | 8,083 (61.8) | <.0001 | 6,950 (62.4) | <.0001 | 1097 (58.1) | <.0001 | 36 (67.9) | 0.461 |
| non-Hispanic Black | 335,119 (9.4) | 2,009 (15.4) | <.0001 | 1,653 (14.8) | <.0001 | 348 (18.4) | <.0001 | 8 (15.1) | 0.168 |
| Hispanic | 479,087 (13.4) | 2,468 (18.9) | <.0001 | 2,074 (18.6) | <.0001 | 387 (20.5) | <.0001 | 7 (13.2) | 0.928 |
| Age | | | | | | | | | |
| Under 18 | 817,015 (22.9) | 13,411 (47.7) | <.0001 | 13,079 (50.2) | <.0001 | 330 (16.5) | <.0001 | 2 (3.6) | 0.001 |
| 18-64 | 2,250,523 (63.0) | 11,799 (42.0) | <.0001 | 10,789 (41.4) | <.0001 | 980 (48.9) | <.0001 | 30 (53.6) | 0.145 |
| 65 plus | 506,559 (14.2) | 2,911 (10.4) | <.0001 | 2,192 (8.4) | <.0001 | 695 (34.7) | <.0001 | 24 (42.9) | <.0001 |
| Gender*** | | | | | | | | | |
| Male | 1,739,614 (48.7) | 12,979 (46.8) | <.0001 | 12,093 (47.1) | <.0001 | 860 (43.1) | <.0001 | 26 (46.4) | 0.737 |
| Female | 1,834,483 (51.3) | 14,741 (53.2) | <.0001 | 13,577 (52.9) | <.0001 | 1,134 (56.9) | <.0001 | 30 (53.6) | 0.737 |

Note: p values determined through Chi Squared test

* Percents do not sum to 100 because cases among other race/ethnicities were reported but are not shown. For the population, percents for other race/ethnicities is also not shown. Percents for age and gender may not add to 100 due to rounding.

**46.5% (13,081 out of 28,121) of cases had an identified race or ethnicity

*** 98.6% (27,720 out of 28,212) of cases had an identified gender

****Hospitalization and Death Cases were only reported for the following seasons: 2009-2010, 2010-2011 and 2011-2012.

**TABLE 2A: Laboratory-Confirmed Influenza Incidence in Connecticut by Race/Ethnicity, Age and Gender (2006-2012)**

| | All Laboratory-Confirmed Cases (n=28,121) | | | Non-Hospitalized (n= 26,060) | | | Hospitalizations, non-Death (n= 2,005)**** | | | Deaths (n=56)**** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Case Count | Incidence | Relative Rate | Case Count | Incidence | Relative Rate | Case Count | Incidence | Relative Rate | Case Count | Incidence | Relative Rate |
| Race* | | | | | | | | | | | | |
| non-Hispanic White | 8,083 | 52.9 | Ref | 6,950 | 45.5 | Ref | 1,097 | 14.4 | Ref | 36 | 0.5 | Ref |
| non-Hispanic Black | 2,009 | 99.9 | 1.9 | 1,653 | 82.2 | 1.8 | 348 | 34.6 | 2.4 | 8 | 0.8 | 1.7 |
| Hispanic | 2,468 | 85.9 | 1.6 | 2,074 | 72.2 | 1.6 | 387 | 26.9 | 1.9 | 7 | 0.5 | 1.0 |
| Age** | | | | | | | | | | | | |
| Under 18 | 13,411 | 273.6 | 3.1 | 13,079 | 266.8 | 3.3 | 330 | 13.5 | 0.9 | 2 | 0.1 | 0.2 |
| 18-64 | 11,799 | 87.4 | Ref | 10,789 | 79.9 | Ref | 980 | 14.5 | Ref | 30 | 0.4 | Ref |
| 65 plus | 2,911 | 95.8 | 1.1 | 2,192 | 72.1 | 0.9 | 695 | 45.7 | 3.2 | 24 | 1.6 | 3.6 |
| Gender*** | | | | | | | | | | | | |
| Male | 12,979 | 124.3 | Ref | 12,093 | 115.9 | Ref | 860 | 16.5 | Ref | 26 | 0.5 | Ref |
| Female | 14,741 | 133.9 | 1.1 | 13,577 | 123.3 | 1.1 | 1,134 | 20.6 | 1.3 | 30 | 0.5 | 1.1 |

Note: Incidence refers to the average seasonal incidence per 100,000 people. For all cases and non-hospitalized cases, data were available for six seasons, while for hospilatizations and deaths only three seasons.

*Race was identified for 46.5% (13,081 out of 28,121) of all cases, 42.7% (11,139 out of 26,060) of non-hospitalized cases, 94.2% (1,889 out of 2,005) of hospitalized cases, and 94.6% (53 out of 56) of death cases.

** All cases reported age.

*** Gender was identified for 98.6% (27,720 out of 28,212) of all cases, 98.5% (25,670 out of 26,060) of Non-Hospitalized cases, 99.5% (1,994 out of 2,005) of Hospitalization cases, and 100% of Death cases.

****Hospitalization and Death Cases were only reported for three seasons (2009-2010, 2010-2011, 2011-2012)

Table 2B: Incidence of Laboratory-Confirmed Influenza by Area-Based SES Measures, Connecticut (2006-2012)

| | All Laboratory-Confirmed Cases (n=28,121) | | Non-Hospitalized (n= 26,060) | | Hospitalizations, non-Death (n= 2,005) | | Deaths (n=56) | |
|---|---|---|---|---|---|---|---|---|
| Percent of Census Tract* | Relative Rate | p | Relative Rate | p | Relative Rate | p | Relative Rate | p |
| Crowding | 1.4 | <.0001 | 1.3 | <.0001 | 2.5 | <.0001 | 1.2 | 0.228 |
| Poverty | 1.4 | <.0001 | 1.3 | <.0001 | 3.1 | <.0001 | 1.0 | 0.032 |
| Unemployment | 1.4 | <.0001 | 1.4 | <.0001 | 2.5 | <.0001 | 1.3 | 0.056 |
| Language Barrier | 1.5 | <.0001 | 1.4 | <.0001 | 2.8 | <.0001 | 1.1 | 0.595 |
| Urban Area | 1.7 | <.0001 | 1.6 | <.0001 | 4.1 | <.0001 | ***2.2 | 0.070 |
| Children | 1.6 | <.0001 | 1.6 | <.0001 | 1.1 | 0.717 | 0.8 | 0.908 |
| Age 65+ | 0.8 | <.0001 | 0.9 | <.0001 | 0.7 | <.0001 | 2.3 | 0.467 |

Note: Relative Rate values compare the incidence of each outcome at the highest and lowest percent levels of each census tract measure. p values determined through Chi Squared test for trend based on the gradient of all levels of each measure.

*Hospitalization and death cases were only available for three seasons: 2009-2010, 2010-2011 and 2011-2012.

** The U.S. Census defines crowding as housing units with greater than one person per room, which is determined by dividing the total number of people by the total number of rooms in each occupied housing unit.

The U.S. Census defines poverty as the % of unrelated individuals and people in families whose income fell below the poverty threshold.

The U.S. Census defines the % of all civilians aged 16 years and over who were not at work and/or did not have a job during the week of their interview, and who were actively seeking work within four weeks time and able to start a job.

Language Barrier refers to the U.S Census measure of ability to speak English "very well" among Spanish speaking households. The U.S. Census defines ability to speak English less than “very well” when survey respondents 5 years and over answer “well,” “not well,” or “not at all” to the question of how they would rate their own English speaking ability.

The U.S. Census defines urban as an urban area, in which there are 50,000 or more people residing, or as an urban cluster, in which between 2,500 and 50,000 people are residing.

The U.S. Census defines age as the number of complete years that have elapsed since a person’s birth date at the time of the interview. Children are people less than 18 years old.

*** .5 added to all mean annual incidence values for the calculation of relative rate values for the percent of the census tract which is urban compared to incidence of deaths due to influenza because the reference category has an incidence of zero.

**Table 2C: Laboratory-Confirmed Influenza incidence by percent of census tract poverty and crowding, Connecticut (2006-2012)**

| | All Laboratory-Confirmed Cases (n=28,121) | | | | Non-Hospitalized (n= 26,060) | | | | Hospitalizations, non-Death (n= 2,005)* | | | | Deaths (n=56)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Case Count | Incidence | Relative Rate | p | Case Count | Incidence | Relative Rate | p | Case Count | Incidence | Relative Rate | p | Case Count | Incidence | Relative Rate | p |
| Poverty (%)** | | | | | | | | | | | | | | | | |
| <5 | 12,315 | 123.6 | Ref | <.0001 | 11,688 | 117.4 | Ref | <.0001 | 607 | 11.9 | Ref | <.0001 | 20 | 0.5 | Ref | 0.032 |
| 5 to 10 | 5,340 | 110.3 | 0.9 | | 4,930 | 101.9 | 0.9 | | 402 | 16.5 | 1.4 | | 8 | 0.4 | 0.8 | |
| 10 to 20 | 5,518 | 138.0 | 1.1 | | 5,033 | 126.2 | 1.1 | | 466 | 22.7 | 1.9 | | 19 | 0.9 | 2.0 | |
| >20 | 4,948 | 173.2 | 1.4 | | 4,409 | 154.5 | 1.3 | | 530 | 36.9 | 3.1 | | 9 | 0.4 | 1.0 | |
| Crowding (%)** | | | | | | | | | | | | | | | | |
| <1 | 13,443 | 120.3 | Ref | <.0001 | 12,661 | 113.3 | Ref | <.0001 | 758 | 13.5 | Ref | <.0001 | 24 | 0.5 | Ref | 0.228 |
| 1 to 2.9 | 7,528 | 125.2 | 1.0 | | 6,947 | 115.4 | 1.0 | | 562 | 18.8 | 1.4 | | 19 | 0.6 | 1.4 | |
| 2.9 to 4.9 | 2,722 | 159.4 | 1.3 | | 2,482 | 144.8 | 1.3 | | 237 | 28.8 | 2.1 | | 3 | 0.4 | 0.9 | |
| >4.9 | 4,428 | 167.1 | 1.4 | | 3,970 | 150.2 | 1.3 | | 448 | 33.2 | 2.5 | | 10 | 0.5 | 1.2 | |

Note: Incidence refers to the average seasonal incidence per 100,000 people. p values determined through Chi Squared test for trend.

*Hospitalization and death cases were only available for three seasons.

** The U.S. Census defines crowding as more than one occupant per room in a residence.

The U.S. Census defines poverty as the percent of the population living below the Federal Poverty Line.

**Table 3A: Laboratory-Confirmed Influenza incidence by season in Connecticut (2006-2012)**

| All Laboratory-Confirmed Cases | 2006-2007 | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 |
|---|---|---|---|---|---|---|
| Total | 54.95 | 144.20 | 107.47 | 321.09 | 130.44 | 26.38 |
| Race* | | | | | | |
| non-Hispanic White | 23.96 | 71.28 | 60.95 | 94.02 | 54.00 | 12.25 |
| non-Hispanic Black | 51.62 | 129.80 | 88.92 | 207.09 | 91.01 | 29.54 |
| Hispanic | 34.44 | 100.19 | 84.95 | 186.60 | 88.08 | 19.41 |
| Age | | | | | | |
| Under 18 | 102.32 | 222.76 | 254.10 | 855.19 | 175.27 | 28.76 |
| 18-64 | 37.01 | 107.93 | 69.10 | 188.84 | 97.76 | 21.46 |
| 65 plus | 58.24 | 178.66 | 41.46 | 47.18 | 203.33 | 44.42 |
| Gender** | | | | | | |
| Male | 54.72 | 134.23 | 104.45 | 306.45 | 117.67 | 26.10 |
| Female | 55.17 | 153.67 | 110.33 | 318.45 | 138.08 | 25.89 |
| **Non-Hospitalized** | 2006-2007 | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 |
| Total | 54.95 | 144.20 | 107.47 | 295.29 | 105.29 | 19.78 |
| Race* | | | | | | |
| non-Hispanic White | 23.96 | 71.28 | 59.77 | 76.15 | 32.60 | 7.11 |
| non-Hispanic Black | 51.62 | 129.80 | 88.92 | 154.57 | 51.03 | 16.11 |
| Hispanic | 34.44 | 100.19 | 84.95 | 135.47 | 61.78 | 14.82 |
| Age | | | | | | |
| Under 18 | 102.32 | 222.76 | 254.10 | 824.71 | 166.58 | 27.42 |
| 18-64 | 37.01 | 107.93 | 69.10 | 163.87 | 82.43 | 17.02 |
| 65 plus | 58.24 | 178.66 | 41.46 | 25.27 | 107.98 | 19.74 |
| Gender** | | | | | | |
| Male | 54.72 | 134.23 | 104.45 | 283.86 | 95.37 | 20.18 |
| Female | 55.17 | 153.67 | 110.33 | 289.73 | 110.55 | 18.81 |
| **Hospitalizations, non-Death** | 2006-2007 | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 |
| Total | -- | -- | -- | 24.87 | 24.54 | 6.58 |
| Race* | | | | | | |
| non-Hispanic White | -- | -- | -- | 17.01 | 20.85 | 5.14 |
| non-Hispanic Black | -- | -- | -- | 51.03 | 39.09 | 13.43 |
| Hispanic | -- | -- | -- | 50.10 | 25.88 | 4.59 |
| Age | | | | | | |
| Under 18 | -- | -- | -- | 30.35 | 8.57 | 1.35 |
| 18-64 | -- | -- | -- | 23.95 | 15.02 | 4.44 |
| 65 plus | -- | -- | -- | 20.14 | 92.59 | 8.16 |
| Gender** | | | | | | |
| Male | -- | -- | -- | 21.79 | 21.67 | 5.86 |
| Female | -- | -- | -- | 27.69 | 26.93 | 7.09 |
| **Deaths** | 2006-2007 | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 |
| Total | -- | -- | -- | 0.92 | 0.62 | 0.03 |
| Race* | | | | | | |
| non-Hispanic White | -- | -- | -- | 0.86 | 0.55 | 0.00 |
| non-Hispanic Black | -- | -- | -- | 1.49 | 0.90 | 0.00 |
| Hispanic | -- | -- | -- | 1.04 | 0.42 | 0.00 |
| Age | | | | | | |
| Under 18 | -- | -- | -- | 0.12 | 0.12 | 0.00 |
| 18-64 | -- | -- | -- | 1.02 | 0.31 | 0.00 |
| 65 plus | -- | -- | -- | 1.78 | 2.76 | 0.20 |
| Gender** | | | | | | |
| Male | -- | -- | -- | 0.80 | 0.63 | 0.06 |
| Female | -- | -- | -- | 1.04 | 0.60 | 0.00 |

Note: This table provides incidence per 100,000 people. 81 cases are excluded from this analysis because of missing dates. Each season begins on May 1 and ends on April 30. Hospitalization and death cases were not available for the first three seasons.

*Race was identified for 46.5% (13,081 out of 28,121) of all cases, 42.7% (11,139 out of 26,060) of Non-Hospitalized cases, 94.2% (1,889 out of 2,005) of Hospitalization cases, and 94.6% (53 out of 56) of Death cases.

** Gender was identified for 98.6% (27,720 out of 28,212) of all cases, 98.5% (25,670 out of 26.060) of Non-Hospitalized cases, 99.5% (1,994 out of 2,005) of Hospitalization cases, and 100% of Death cases.

**Table 3B: Laboratory-Confirmed Influenza Incidence According to Census Tract Poverty by Season in Connecticut (2006-2012)**

| | All Laboratory-Confirmed Cases (n=28,121) | | | Non-Hospitalized (n= 26,060) | | | Hospitalizations, non-Death (n= 2,005) | | | Deaths (n=56) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High vs. Low Poverty, | | | High vs. Low Poverty, | | | High vs. Low Poverty, | | | High vs. Low Poverty, | |
| Season | Cases | Relative Rate | p | Cases | Relative Rate | p | Cases | Relative Rate | p | Cases | Relative Rate | p |
| 2006-2007 | 1964 | 1.66 | <.0001 | 1964 | 1.66 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2007-2008 | 5154 | 1.45 | <.0001 | 5154 | 1.45 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2008-2009 | 3841 | 1.37 | <.0001 | 3841 | 1.37 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2009-2010 | 11476 | 1.27 | <.0001 | 10554 | 1.15 | 0.071 | 889 | 3.81 | <.0001 | 33 | 1.33 | 0.041 |
| 2010-2011 | 4662 | 1.55 | <.0001 | 3763 | 1.42 | <.0001 | 877 | 2.33 | <.0001 | 22 | 0.61 | 0.604 |
| 2011-2012 | 943 | 1.79 | <.0001 | 707 | 1.41 | 0.000 | 235 | 3.86 | <.0001 | 1 | *** | -- |

**Table 3C: Laboratory-Confirmed Influenza Incidence According to Census Tract Crowding by Season in Connecticut (2006-2012)**

| | All Laboratory-Confirmed Cases (n=28,121) | | | Non-Hospitalized (n= 26,060) | | | Hospitalizations, non-Death (n= 2,005) | | | Deaths (n=56) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High vs. Low Crowding, | | | High vs. Low Crowding, | | | High vs. Low Crowding, | | | High vs. Low Crowding, | |
| Season | Cases | Relative Rate | p | Cases | Relative Rate | p | Cases | Relative Rate | p | Cases | Relative Rate | p |
| 2006-2007 | 1964 | 1.46 | <.0001 | 1964 | 1.46 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2007-2008 | 5154 | 1.41 | <.0001 | 5154 | 1.41 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2008-2009 | 3841 | 1.19 | <.0001 | 3841 | 1.19 | <.0001 | -- | -- | -- | -- | -- | -- |
| 2009-2010 | 11476 | 1.32 | <.0001 | 10554 | 1.22 | <.0001 | 889 | 3.02 | <.0001 | 33 | 1.37 | 0.246 |
| 2010-2011 | 23562 | 1.65 | <.0001 | 3763 | 1.57 | <.0001 | 877 | 2.09 | <.0001 | 22 | 1.12 | 0.570 |
| 2011-2012 | 943 | 1.53 | <.0001 | 707 | 1.42 | 0.001 | 235 | 1.95 | <.0001 | 1 | *** | -- |

Note: Each season begins May 1 and ends April 30. Hospitalization and death case counts were not available for the first three seasons. 81 cases are excluded from this analysis because of missing date
High vs. Low Poverty Relative Rate is calculated by dividing the respective incidence in highest-poverty tracts (poverty > 20 %) by that in the lowest-poverty tracts (poverty < 5 %) for each influenza seaso
High vs. Low Crowding Relative Rate is calculated by by dividing the influenza-associated hospitalization incidence in highest-crowding tracts (>5%) by that in the lowest-crowding tracts (crowding < 1%).
The p values (chi square for trend) are based on the gradient of all four poverty or crowding levels for each season.
The Census defines crowding as more than one occupant per room in a residence. The Census defines poverty as the percent of the population living below the Federal Poverty Line.
***Relative Rate could not be determined

**Table 4: Laboratory-Confirmed Influenza Incidence Correlation with Area-Based U.S. Census Measures, Connecticut (2006-2012)**

**Connecticut (State-Wide)**

| Characteristic** | a. All Laboratory-Confirmed Cases (n=28,121) | | b. Non-Hospitalized (n=26,060) | | c. Hospitalizations, non-Death (n=2,005) | | d. Deaths (n=56) | |
|---|---|---|---|---|---|---|---|---|
| | R | p | R | p | R | p | R | p |
| Poverty | 0.19 | <.0001 | 0.15 | <.0001 | 0.39 | <.0001 | -0.01 | 0.8569 |
| Crowding | 0.17 | <.0001 | 0.14 | <.0001 | 0.30 | <.0001 | 0.00 | 0.9113 |
| Unemployed | 0.26 | <.0001 | 0.22 | <.0001 | 0.40 | <.0001 | 0.02 | 0.5985 |
| Language Barrier | 0.16 | <.0001 | 0.14 | <.0001 | 0.27 | <.0001 | -0.02 | 0.4882 |
| Urban Area | 0.22 | <.0001 | 0.20 | <.0001 | 0.25 | <.0001 | 0.07 | 0.0588 |
| Children | 0.28 | <.0001 | 0.28 | <.0001 | 0.08 | 0.0225 | -0.01 | 0.7894 |
| Elderly | -0.06 | 0.0864 | -0.06 | 0.1123 | -0.06 | 0.075 | 0.07 | 0.0322 |

**New Haven County, CT**

| Characteristic** | a. All Laboratory-Confirmed Cases (n=28,121) | | b. Non-Hospitalized (n=26,060) | | c. Hospitalizations, non-Death (n=2,005) | | d. Deaths (n=56) | |
|---|---|---|---|---|---|---|---|---|
| | R | p | R | p | R | p | R | p |
| Poverty | 0.41 | <.0001 | 0.40 | <.0001 | 0.38 | <.0001 | -0.02 | 0.8123 |
| Crowding | 0.50 | <.0001 | 0.49 | <.0001 | 0.42 | <.0001 | 0.01 | 0.8626 |
| Unemployed | 0.51 | <.0001 | 0.50 | <.0001 | 0.45 | <.0001 | 0.04 | 0.6257 |
| Language Barrier | 0.36 | <.0001 | 0.34 | <.0001 | 0.36 | <.0001 | -0.01 | 0.8588 |
| Urban Area | 0.30 | <.0001 | 0.30 | <.0001 | 0.21 | <.0001 | 0.07 | 0.3107 |
| Children | 0.31 | <.0001 | 0.34 | <.0001 | 0.12 | 0.0997 | 0.02 | 0.7354 |
| Elderly | -0.16 | 0.0232 | -0.17 | 0.0194 | -0.10 | 0.176 | 0.03 | 0.6554 |

Note: R-values represent the degree of correlation between each characteristic and the incidence category. P values indicate how significant the correlation is.

** The U.S. Census defines crowding as housing units with greater than one person per room, which is determined by dividing the total number of people by the total number of roomsin each occupied housing unit.

The U.S. Census defines poverty as the % of unrelated individuals and people in families whose incomes fell below the poverty threshold.

The U.S. Census defines the% of all civilians aged 16 years and over who were not at work and/or not have a job during the week of their interview, and who were actively seeking work within four weeks time and able to start a job.

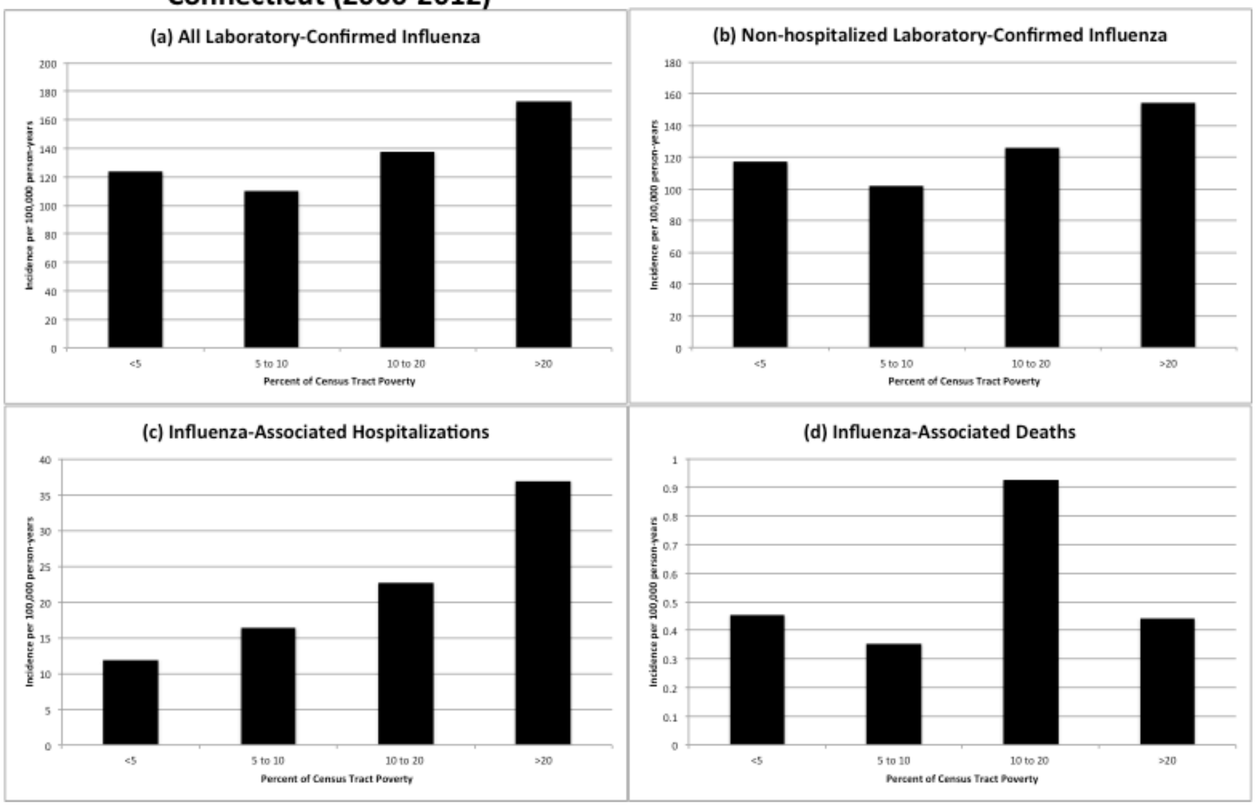
Language Barrier refers to the U.S Census measure of ability to speak English "very well" among Spanish speaking households. The U.S. Census defines ability to speak English less than "very well" when survey respondents 5 years and over answer "well," "not well," or "not at all" to the question of how they would rate their own English speaking ability.

The U.S. Census defines urban as an urban area, in which there are 50,000 or more people residing, or as an urban cluster, in which between 2,500 and 50,000 people are residing.

The U.S. Census defines age as the number of complete years that have elapsed since a person's birth date at the time of the interview. Children are people less than 18 years old.

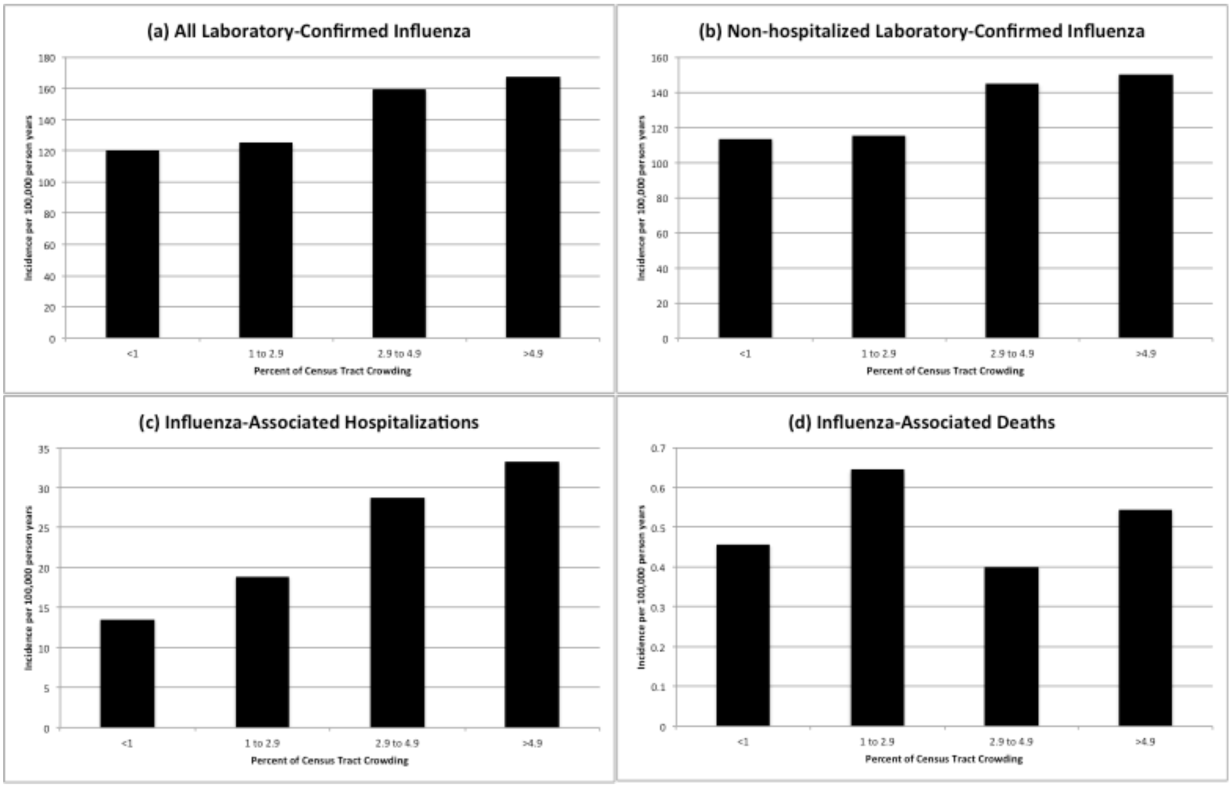
## Appendix B – Figures

**FIGURE 1: Laboratory-Confirmed Influenza Incidence by Percent of Census Tract Poverty, Connecticut (2006-2012)**



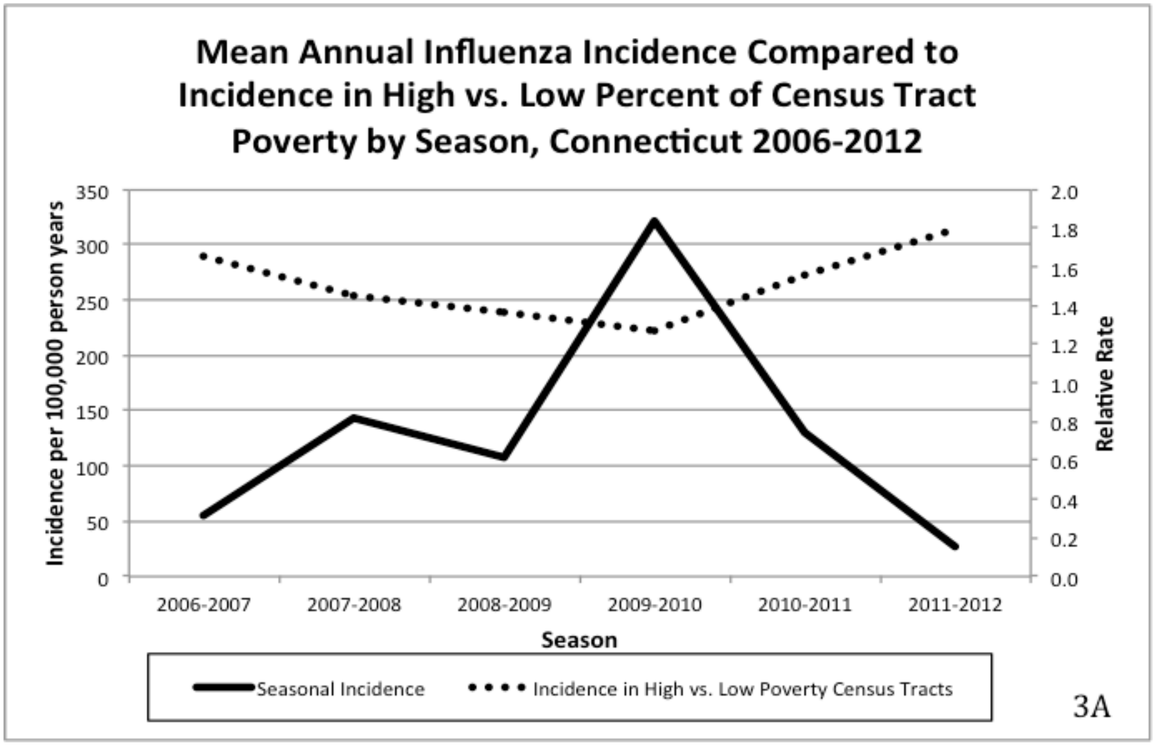

Note: Chi square test for trend indicates a significant relationship ($p<.0001$) between percent of census tract poverty and all laboratory-confirmed influenza, non-hospitalized laboratory-confirmed influenza, and influenza-associated hospitalization cases. For influenza-associated deaths the relationship is also significant ($p = 0.0324$).
Hospitalization and death mean annual incidences only reflect 3 seasons of data (2009-2010, 2010-2011, and 2011-2012).
The U.S. Census defines poverty as the percent of unrelated individuals and people in families whose incomes fell below the poverty threshold.

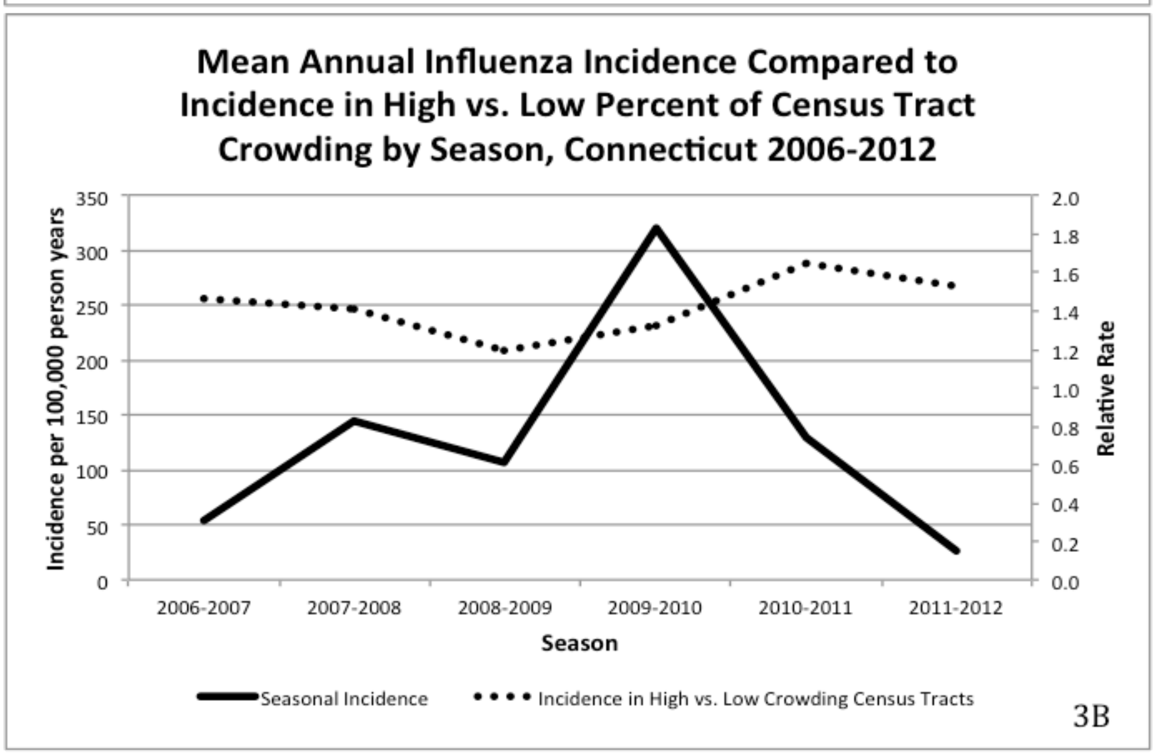
**FIGURE 2: Laboratory-Confirmed Influenza Incidence by Percent of Census Tract Crowding, Connecticut (2006-2012)**




Note: Chi square test for trend indicates a significant relationship ($p<.0001$) between percent of census tract crowding and all laboratory-confirmed influenza , non-hospitalized laboratory-confirmed influenza, and influenza-associated hospitalization cases. For influenza-associated deaths the relationship is not significant ($p = 0.2278$). Hospitalization and Death mean annual incidence rates only reflect 3 seasons of data (2009-2010, 2010-2011, and 2011-2012).
The U.S. Census defines crowding as more than one occupants per room in a residence.

**Figure 3: All Laboratory-Confirmed Influenza Incidence Compared to Incidence in High vs. Low Census Tract Poverty and Crowding by Season, Connecticut 2006-2012**




Note: Each season begins on May 1 and ends on April 30.
Relative rate values compare the incidence in highest vs. lowest percent levels of census tract poverty and crowding, respectively.