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Health Disparities Among People Infected With Influenza, Rhode Island, 2013-2018

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Abstract

Objectives: Health disparities are associated with poor outcomes related to public health. The objective of this study was to assess health disparities associated with influenza infection based on median household income and educational attainment.

Methods: We geocoded people with documented confirmed influenza infection by home address to identify the US Census 2010 tract in which they lived during 4 influenza surveillance seasons (2013-2014, 2015-2016, 2016-2017, and 2017-2018) in Rhode Island. We dichotomized influenza as severe if the person with influenza infection was hospitalized (ie, inpatient) or as nonsevere if the person was not hospitalized (ie, outpatient). We examined 2 socioeconomic factors: median household income (defined as low, medium low, medium high, and high) and educational attainment (defined as a ratio among people who completed <high school, high school, some college, or ≥bachelor's degree). We calculated relative rates (RRs) to determine the associated level of risk for each socioeconomic factor.

Results: The incidence of influenza per 100 000 person-years was significantly higher in populations with low vs high median household income (620 vs 303; $P < .001$) and in populations with low vs high educational attainment (583 vs 323; $P < .001$). The RR of a severe infection in the quartile with the lowest educational attainment (0.57) was significantly higher than the RR in the other 3 quartiles of educational attainment (range, 0.36-0.39; $P = .01$). However, the RR of a severe infection was higher in the 3 quartiles of median household income (range, 0.38-0.40) than in the quartile with the lowest median household income (0.29).

Conclusions: People in Rhode Island with a lower socioeconomic status are at greater risk of an influenza infection than people with higher socioeconomic status. The reasons for these disparities require further investigation.

Keywords

influenza, health disparities, socioeconomic

More than 200 000 influenza-related hospitalizations and more than 50 000 influenza-related deaths occur in the United States annually.[1] Children aged <5 and adults aged >65 are more likely than people aged 5-65 to contract influenza and have severe complications and are at a higher risk for hospitalization and death.[2,3] During the 2017-2018 influenza season, Rhode Island had the highest percentage of influenza vaccination for children aged 6 months through 17 years (76%) compared with the national average (58%).[4] Moreover, Rhode Island had the highest influenza vaccination coverage in the nation for all people >6 months of age during the 2017-2018 influenza season (50% vs 47% national average).[4,5]

Despite high rates of compliance with influenza vaccination in Rhode Island, the incidence of influenza-related hospitalizations in Rhode Island is consistently higher than the national average.[6] For example, during the 2016-2017 influenza season, the rate of influenza-related hospitalizations in Rhode Island (115 per 100 000 population) was higher than the national average (65 per 100 000 population) and continued during the 2017-2018 influenza season (Rhode Island: 131 per 100 000 population; United States: 102 per 100 000 population).[6-8] Understanding drivers of the high

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rates of influenza-related hospitalization is of public health importance. Historically, individual factors (eg, vaccination status, race/ethnicity, chronic health conditions) have been used to examine predictors of influenza severity.[5] More recently, neighborhood and environmental characteristics (eg, household crowding, accessibility of preventive services) have been examined as factors in disparities in influenza-related hospitalizations.[9] Location-based measures provide data on both physical and social neighborhood characteristics, such as median household income level, educational attainment, and access to preventive and treatment resources. Some studies have reported a correlation between influenza-related hospitalizations and regions with low socioeconomic status.[9,10] Although a combination of individual and population-level characteristics may affect a person's risk of an influenza-related hospitalization,[11] gaps in knowledge persist. The objective of our study was to examine possible health disparities in influenza-related infections.

Methods

The Rhode Island Department of Health Center for Acute Infectious Disease Epidemiology conducted annual influenza surveillance from 2013 to 2018 (unpublished data, Rhode Island Department of Health). During each influenza surveillance season (October–May of 2013-2014, 2015-2016, 2016-2017, and 2017-2018), sentinel physicians and Rhode Island–based hospitals reported data on patients with laboratory-confirmed influenza, as well as influenza-related hospitalizations and deaths. Surveillance data included demographic characteristics, residential street address, hospital where medical care was sought, hospitalization (ie, management as an inpatient or outpatient), admission and discharge dates for patients who were hospitalized (ie, inpatients), influenza diagnostic test used, date the influenza test was performed, and influenza strain. We geocoded all cases by home address using ArcGIS version 10.6 (Esri) to identify the US Census 2010 tract in which the patients lived. The Rhode Island Department of Health Institutional Review Board determined that surveillance for hospitalizations attributed to laboratory-confirmed influenza was exempt.

We used a binary classification process similar to that used by another study, in which we dichotomized each case as either inpatient or outpatient.[12] We considered a patient's influenza infection to be severe if the patient was hospitalized (ie, inpatient) or nonsevere if the patient was not hospitalized (ie, outpatient).

We acquired population-level socioeconomic data from the US Census 2010 Summary File 1.[13] From Summary File 1, we assessed 2 types of area-based socioeconomic measures: median household income and educational attainment. We selected median household income and educational attainment for analysis because they have consistently demonstrated socioeconomic gradients across various health outcomes in previous studies and have the greatest potential for high external validity.[1,9] We stratified census tracts by median household income as follows: low ($13 099-$45 174), medium low ($45 182-$61 891), medium high ($62 079-$79 044), and high ($79 385-$170 625).

We used US Census 2010 definitions of educational attainment, namely, the highest level of education that a person had completed.[14] We defined educational attainment using 4 groups: <high school graduate, high school graduate, some college, and ≥bachelor's degree. We created a ratio to assess the proportion of people with a low level of education to people with a high level of education in each census tract. This ratio was equal to the population of a census tract with low educational attainment (ie, <high school graduate and high school graduate) divided by the population of that census tract with high educational attainment (ie, some college and ≥bachelor's degree). The resulting ratio assigned to each census tract was a single data point representing its level of educational attainment compared with other tracts, with high values representing low levels of educational attainment and low values representing high levels of educational attainment. We then stratified the tracts into 4 quartiles according to ratio of educational attainment: low, medium low, medium high, and high educational attainment.

$$Education\ Ratio = \frac{Low_1 + Low_2}{High_1 + High_2}$$

We based data analyses on methods used in previous studies and the Public Health Disparities Geocoding Project.[9,10,15] We used the US Census 2010 population data in the denominator for all incidence calculations. We defined incidence as cases per 100 000 person-years. We calculated relative rates (RRs) to determine the level of risk associated with median household income and median educational attainment during each influenza season (2013-2014, 2015-2016, 2016-2017, 2017-2018). We used the Pearson χ^2 test to assess for significant differences between the incidence of confirmed influenza infections, with $P < .05$ considered significant. We did not test for trend. We performed statistical analyses in SPSS version 25.0 (IBM Corp).

Results

The Rhode Island Department of Health collected data for 19 333 cases of influenza during 4 influenza seasons (2013-2014, 2015-2016, 2016-2017, and 2017-2018). Of the 19 333 influenza cases, we geocoded and included in our analysis 18 273 (94.5%). The incidence (cases per 100 000 person-years) of confirmed influenza infection among children aged <5 was 466 and among adults aged >65 was 585 (Table 1). The incidence per 100 000 person-years of confirmed influenza infection was significantly lower among children and adolescents aged 5-17 (379; $P < .001$) and adults aged 18-64 (384; $P < .001$) than among other

Table 1. Incidence of influenza-related hospitalizations in Rhode Island (n = 18 273), 2013-2018[a]

Characteristic	Population	No. (%) of cases	Incidence[b]	*P* value[c]
Individual characteristics[d]				
Age, y				<.001
<5	51 469	959 (5.2)	466	
5-17	198 611	3013 (16.5)	379	
18-64	637 017	9777 (53.5)	384	
≥65	160 472	4524 (24.8)	585	
Sex				.01
Male	509 118	8075 (44.2)	397	
Female	538 451	10 198 (55.8)	474	
Census tract–level variables[d]				
Median income[e]				<.001
Low	263 068	6519 (35.7)	620	
Medium low	243 560	4584 (25.1)	467	
Medium high	251 379	3680 (20.1)	366	
High	287 762	3490 (19.1)	303	
Educational attainment[f]				<.001
Low	265 426	6193 (33.9)	583	
Medium low	266 490	4877 (26.7)	458	
Medium high	265 583	3976 (21.8)	374	
High	250 070	3227 (17.7)	323	

[a]Data source: Rhode Island Department of Health.
[b]Annual incidence was calculated per 100 000 person-years during 4 influenza seasons (2013-2014, 2015-2016, 2016-2017, and 2017-2018).
[c]Using the Pearson χ^2 test for trend, with $P < .05$ considered significant.
[d]Individual- and population-level estimates were obtained from the Census 2010 summary file 1.[13]
[e]Household income levels were defined as low ($13 099-$45 174), medium low ($45 182-$61 891), medium high ($62 079-$79 044), and high ($79 385-$170 625).
[f]Educational attainment was defined as a comparison among people who completed <high school (low), high school (medium low), some college (medium high), or ≥bachelor's degree (high). We created a ratio to assess the proportion of people with a low level of education to people with a high level of education in each census tract. This ratio was equal to the population of a census tract with low educational attainment (ie, <high school graduate and high school graduate) divided by the population of that census tract with high educational attainment (ie, some college and ≥bachelor's degree). The resulting ratio assigned to each census tract is a single data point representing its level of educational attainment compared with other census tracts, with high values representing low levels of educational attainment and low values representing high levels of educational attainment. We then stratified the tracts into 4 quartiles according to ratio of educational attainment: low, medium low, medium high, and high educational attainment.

age groups. The incidence per 100 000 person-years of confirmed influenza infection was significantly higher among female patients than among male patients (474 vs 397; $P = .01$).

The incidence per 100 000 person-years of confirmed influenza infection was twice as high in populations with low median household income than in populations with high median household income (620 vs 303; $P < .001$; Table 1). The RRs of confirmed influenza infection between populations with low median household income and populations with high median household income ranged from 2.3 during the 2013-2014 influenza season to 1.9 during the 2017-2018 influenza season (Table 2).

The incidence per 100 000 persons-years of confirmed influenza infection was significantly higher in populations with low educational attainment (583) than in populations with high educational attainment (323; $P < .001$; Table 1). The RRs of confirmed influenza infection between populations with low educational attainment and high educational attainment ranged from 1.9 during the 2013-2014 influenza season to 1.7 during the 2016-2017 influenza season ($P < .001$; Table 2).

For median household income, we found the highest numbers of inpatient (n = 1456) and outpatient (n = 5063) cases of confirmed influenza infection in the lowest quartile of median household income, and as income level increased, the number of cases decreased (Figure 1). We found a similar trend for educational attainment (Figure 2): we found the highest number of inpatient (n = 1406) and outpatient (n = 4787) cases in the quartile with the lowest level of educational attainment, and as educational attainment increased, the number of cases decreased.

The RR of a severe influenza infection (ie, incidence rate ratio between the incidence of inpatient influenza cases and the incidence of outpatient influenza cases) in the population with the lowest educational attainment (0.57) was significantly higher than in the populations in the other 3 quartiles of educational attainment (range, 0.36-0.39; $P = .01$;

Table 2. Relative rates of influenza-related hospitalizations, by influenza season, Rhode Island, 2013-2018[a]

Influenza season	No. of cases in Rhode Island[b]	Incidence in Rhode Island[c]	Incidence in the United States[c]	Rhode Island	
				Median household income, relative rate[d] (*P* value[e])	Educational attainment, relative rate[d] (*P* value[e])
2013-2014	3479	83.0	35.1	2.3 (<.001)	1.9 (<.001)
2015-2016	3692	88.1	31.4	2.2 (<.001)	1.8 (<.001)
2016-2017	4650	111.0	62.0	2.0 (<.001)	1.7 (<.001)
2017-2018	6452	154.0	102.9	1.9 (<.001)	1.8 (<.001)

[a]Data source: Rhode Island Department of Health.
[b]Refers to the number of confirmed cases of influenza during each influenza season.
[c]Influenza-related hospitalization incidence rates in Rhode Island and the United States among all age groups per 100 000 person-years per influenza season. US incidence rates were obtained from the Influenza Hospitalization Surveillance Network.[16]
[d]Relative rates were calculated as the rate of high median household income ($79 385-$170 625) or education (≥bachelor's degree) compared with the rate of low median household income ($13 099-$45 174) or education (<high school graduate).
[e]*P* values (Pearson χ^2 test) were based on the comparison of figures in each category across all 4 influenza seasons, with a significance level of .05.

Table 3). However, the RR of a severe influenza infection was greater among cases in populations with medium-low, medium-high, and high median household income (range, 0.38-0.40) than among cases in the population with low median household income (0.29; $P = .002$).

Discussion

We analyzed geocoded data to determine whether socioeconomic status affected the incidence and/or severity of influenza infections among people in Rhode Island. We detected a distinct gradient with decreasing incidence among confirmed cases of influenza infection as median household income increased. The incidence of both inpatient and outpatient cases also decreased as median household income increased, indicating an inverse correlation between incidence of influenza and median household income level. The relationship across median household income levels was maintained at similar RRs during all 4 influenza seasons. US Census tract data stratified by educational attainment

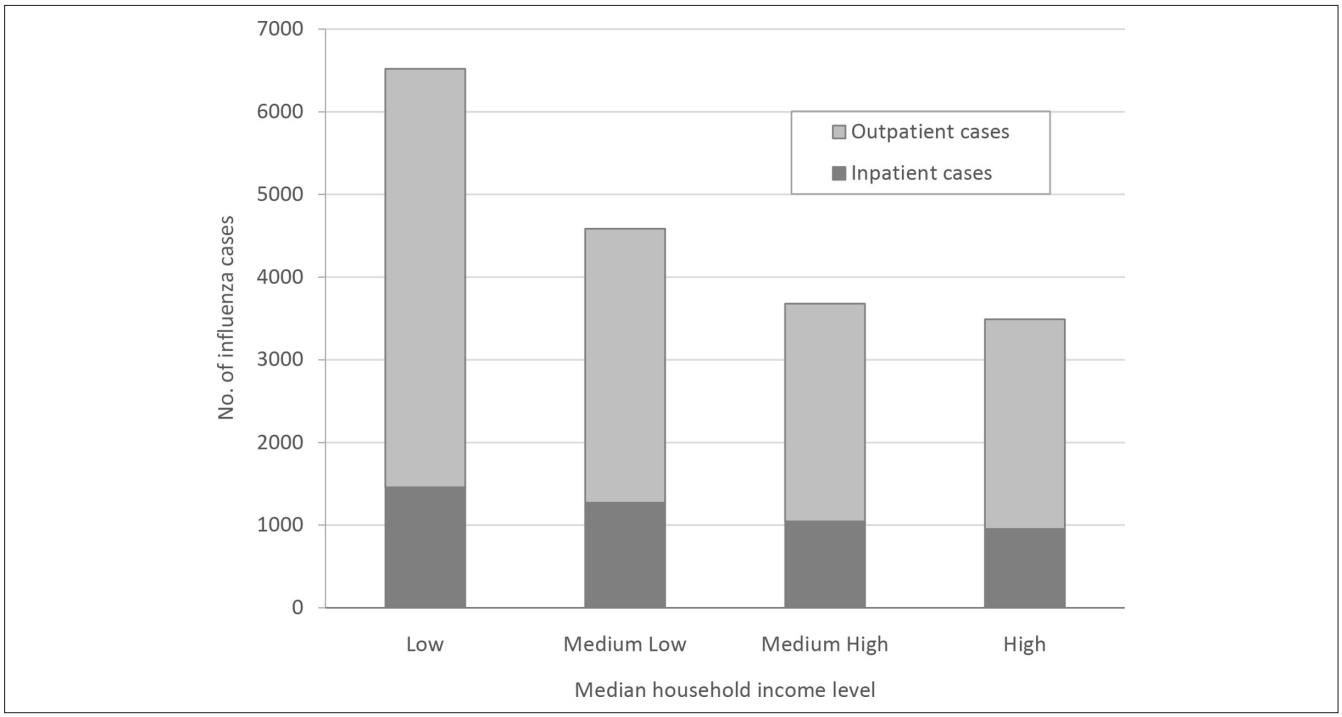

Figure 1. Number of inpatient and outpatient influenza cases, by median household income levels, Rhode Island, 2013-2018. Household income levels were defined as low ($13 099-$45 174), medium low ($45 182-$61 891), medium high ($62 079-$79 044), and high ($79 385-$170 625). Data source: Rhode Island Department of Health.

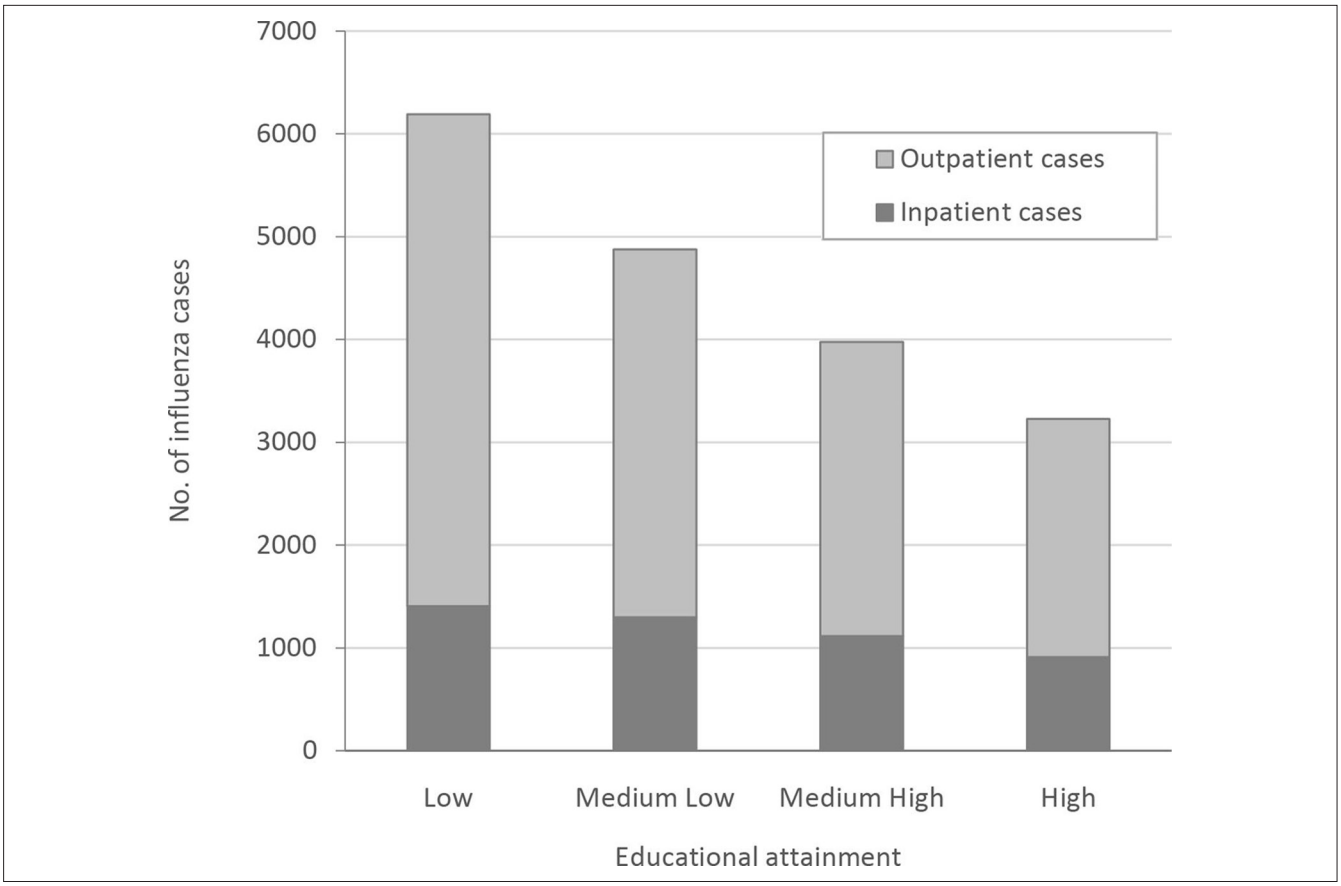

Figure 2. Number of inpatient and outpatient influenza cases, by educational attainment, Rhode Island, 2013-2018. Educational attainment was defined as a ratio among people who completed <high school (low), high school (medium low), some college (medium high), or ≥bachelor's degree (high). See the *Methods* section for a description of how levels of educational attainment were determined. Data source: Rhode Island Department of Health.

revealed that the incidence of confirmed inpatient and outpatient influenza cases decreased as educational attainment increased. This inverse correlation between the incidence of influenza and educational attainment was evident during all 4 influenza seasons, with similar RRs showing a trend toward higher incidence of influenza in regions of the state inhabited by people with lower educational attainment. Several factors may contribute to the disparity in areas with lower educational attainment compared with areas with higher educational attainment, such as lack of time allocated to get vaccinated, lack of access to primary care, domiciliary crowding, and possibly less awareness of the benefits of influenza vaccination. Although these factors may not completely explain the difference in incidence of influenza infection between regions of high and low socioeconomic status, they may serve as targets for increased influenza prevention efforts.

People in the low median household income quartile had a lower likelihood of influenza-related hospitalization (ie, our measurement of severity of influenza infection) than people in higher income quartiles. Although this result was unexpected, it may reflect a greater proportion of older adults in the higher socioeconomic groups, a bias toward greater likelihood of influenza-related hospitalization among people with higher socioeconomic status than among people with lower socioeconomic status, or other potential confounders such as health insurance status and race/ethnicity.[16]

Limitations

Our study had several limitations. First, the data set included only influenza cases that were reported to the Rhode Island Department of Health. As such, ascertainment bias may have occurred because some cases may not have been reported to a health care professional, and some health care professionals may have failed to report cases to the Rhode Island Department of Health. Unreported influenza cases were likely to have been less severe infections because such cases did not come to medical attention. Therefore, the data set may have included a greater proportion of more severe cases than the total amount of cases that existed in the community. Second, we did not have access to data from additional influenza seasons or data from other

Table 3. Influenza incidence rate ratios of inpatient cases vs outpatient cases in Rhode Island, 2013-2018[a]

Variable	Incidence of inpatient cases[b]	Incidence of outpatient cases[b]	Incidence rate ratio[c]
Median household income[d]			
Low	138	481	0.29
Medium low	130	338	0.38
Medium high	104	262	0.40
High	83	220	0.38
Education level[e]			
Low	132	232	0.57
Medium low	122	336	0.36
Medium high	105	270	0.39
High	91	232	0.39

[a]Data source: Rhode Island Department of Health.
[b]Influenza-related hospitalization incidence rates in Rhode Island among all age groups per 100 000 person-years across 4 influenza seasons (2013-2014, 2015-2016, 2016-2017, 2017-2018).
[c]The incidence rate ratio was calculated by comparing the incidence rate of inpatient cases with the incidence rate of outpatient cases for median household income and educational attainment among people in Rhode Island.
[d]Household income levels were defined as low ($13 099-$45 174), medium low ($45 182-$61 891), medium high ($62 079-$79 044), and high ($79 385-$170 625).
[e]Educational attainment was defined as a ratio among people who completed <high school (low), high school (medium low), some college (medium high), or ≥bachelor's degree (high). See the *Methods* section for a description of how levels of educational attainment were determined.

states, which could have provided a more robust foundation for our analysis. Third, data on vaccination status, health insurance status, and race/ethnicity were not available for this study. These data are important because another study showed a positive correlation between race/ethnicity and median household income, educational attainment, and likelihood of influenza infection.[15] Lastly, we were unable to derive additional statistical relationships through multivariate analysis because of a lack of information on various individual risk factors, such as vaccination status, health insurance status, and race/ethnicity.

Conclusion

In Rhode Island, people who live in areas with low socioeconomic status had an increased incidence of influenza-related hospitalizations, and people with low educational attainment were more likely than people with higher educational attainment to have an influenza-related hospitalization. However, a greater proportion of influenza cases among people with higher median household incomes (vs lower median household incomes) were hospitalized. A better understanding of these disparities may inform public health efforts in Rhode Island and other states to mitigate the risk of influenza infection. Our study provides a basis for a nationwide analysis to determine if the trends found in Rhode Island have broader reach. In addition, our findings may have relevance to the risk and outcomes of patients with other respiratory infections, including coronavirus disease 2019 (COVID-19) infection.

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