Effect of Race/Ethnicity and Socioeconomic Status on Pandemic H1N1-Related Outcomes in Massachusetts

Hilary Placzek, PhD, MPH, and Lawrence Madoff, MD

Objectives. We linked hospital discharge and American Community Survey and US Census data to investigate 2009 H1N1 influenza (H1N1)-related outcomes by racial/ethnic groups and socioeconomic status (SES).

Methods. We examined the population discharged from any acute care hospital in Massachusetts and calculated rates of intensive care unit (ICU) stay by racial/ethnic and SES groups between April 26 and September 30, 2009. We used logistic regression models to identify predictors of ICU stay.

Results. Of 4874 H1N1-related hospitalizations, 526 (11%) were admitted to the ICU. Those in less affluent SES groups had lower risk of ICU stay than the most affluent SES group. Compared with Whites, Hispanics had significantly lower risk of 2009 H1N1-related ICU stay (odds ratio = 0.52; 95% confidence interval = 0.32, 0.86). Only 13% of Whites admitted to the ICU were in the lowest SES group, compared with 63% of Hispanics and 43% of Blacks.

Conclusions. To our knowledge, this is the first statewide description of 2009 H1N1 influenza-related ICU stays according to racial/ethnic group and SES in the United States. Future work should investigate evidence related to social determinants of health among racial/ethnic groups to reduce disparities in relation to pandemic influenza. (*Am J Public Health.* 2014;104:e31–e38. doi:10.2105/AJPH.2013.301626)

Previously published analyses of statewide 2009 H1N1 epidemiological data suggest that there have been disproportionate numbers of hospitalized H1N1 cases among non-White racial/ethnic groups in Massachusetts. Compared with hospital discharges for seasonal influenza, discharges for influenza-like illness (ILI) during the H1N1 pandemic had higher proportions of non-Hispanic Blacks (10% and 18%, respectively) and Hispanics (14% and 23%).[1] The Centers for Disease Control and Prevention (CDC) also reported greater proportions of hospitalizations and deaths among Hispanics, Blacks, Asian/Pacific Islanders,[2] and American Indians/Alaska Natives[3] than among Whites nationwide. However, population-based rates of 2009 H1N1 influenza-related intensive care unit (ICU) admissions according to specific racial/ethnic groups have not been reported. One study assessed racial disparities with regard to exposure, susceptibility, and access to health care during the US 2009 H1N1 influenza pandemic,[4] and found significant race/ethnicity-related disparities in potential risk from 2009 H1N1 influenza. These disparities by racial/ethnic group may interact with existing health inequalities and contribute to increased mortality and morbidity in these subpopulations.

Quinn et al. also report that

> significant differences in access to health care and with greater perceived discrimination in health care place Blacks and Spanish-speaking Hispanics at greater risk of receiving later—and perhaps poorer—health care.[4(p291)]

Implications of this previous work are limited, however, because the authors of these studies, including Quinn et al., could not correlate their findings with actual incidence of 2009 H1N1 influenza infections or complications. Other work has reported disparities related to 2009 H1N1 influenza-related hospitalizations in the United States, but it used self-reported data[5] or surveillance data[6] to characterize 2009 H1N1 influenza-related hospitalizations. We address the limitations in previous, related literature by using a population-based, hospital discharge database that includes diagnosis codes for all patients discharged from all acute care centers during the first wave of the 2009 H1N1 influenza pandemic in Massachusetts.

It is difficult to determine whether socioeconomic status (SES) is significantly associated with outcomes from 2009 H1N1 influenza infection. Limitations in access to complete, timely, and population-based data contribute to this problem. Because of the lack of socioeconomic data in most US public health surveillance systems, it is not possible to compare SES across racial/ethnic groups and measure their contribution to racial/ethnic health disparities.[7] For instance, 70% of the 467 US public health objectives for the year 2010 lack socioeconomic targets because of an absence of baseline data.[8] However, Massachusetts has combined statewide surveillance data with zip codes from American Community Survey (ACS) and US Census data to provide measures of health outcomes and health care utilization.[9,10] The ACS, a division of the US Census Bureau, is an ongoing statistical survey that samples a percentage of the population every year; it is conducted to provide up-to-date information about the social and economic needs of American communities.[11] Currently in use at the state level in Massachusetts, this methodology provides area-based measures of demographic information for public health surveillance research and reporting.

In this study, we used a population-based hospital discharge database to report 2009 H1N1 influenza-related ICU admissions by race/ethnicity. We then employed methods previously described in the literature[7,12] to establish a measure of SES for each individual based on the zip code of his or her home address. We also report measures of association between ICU stay and race/ethnicity, adjusted for SES.

METHODS

We analyzed data from the Hospital Discharge Database (HDD), a population-based, patient-linked listing of all hospital discharges

in Massachusetts that includes up to 15 *International Classification of Diseases, Ninth Revision* (*ICD-9*)-coded discharge diagnoses for each patient.[13,14] The HDD contains discharge data for all inpatients discharged from all 76 acute care hospitals in Massachusetts, including sociodemographic, clinical, and charge data, with a total of 377 variables. Patients met the following inclusion criteria: they were (1) discharged from any acute care hospital in Massachusetts between April 26 and September 30, 2009; (2) assigned 1 or more diagnosis codes corresponding to a grouping of *ICD-9* codes[1] used to identify ILI; and (3) younger than 65 years. We categorized the following groups in the HDD as an indicator of race/ethnicity: (1) non-Hispanic Whites (n = 3144), (2) Hispanics (n = 704), (3) non-Hispanic Blacks (n = 578), and (4) "others" (n = 448), which included Asians (n = 172), American Indians/Alaska Natives (n = 8), other (n = 145), and unknown (n = 123).

American Community Survey Data as a Measure of Socioeconomic Status

Using the area-based socioeconomic measure of 5-digit zip code as an identifier, we linked ACS data obtained from the US Census Bureau to those in the HDD population. ACS 2006–2010 data provide 5-year estimates of a measure of SES through aggregate levels of affluence. ACS data have a complex system of weighting and methodology for the sampling strategy; the basic weighting area used for the group quarter weighting is the state. For the purposes of this analysis, weighting variables were not included.[15] SES measures are based on the percentage of people living below 100% of the federal poverty line in an area code. In 2010, the poverty line (which varies by household size and age composition) was equal to $22 113 for a family of 2 adults and 2 children.[16] In previous work, these indicators have been used to categorize SES[17–19] and to provide guidance for identifying connections between income and mortality.[7,20,21] We excluded 2% of those admitted with ILI between April 26 and September 30, 2009 (n = 89) because of missing zip code information.

On the basis of previous analyses,[7,21] we divided SES zip code data into the following 4 quartiles, defined by the percentage of the population living below the federal poverty line: (1) 0 to 5.9% (most affluent), (2) 6% to 11.9% (upper middle), (3) 12% to 18.9% (lower middle), and (4) 19% or above (least affluent), which corresponds to the federal definition of a poverty area.[22]

Influenza-Like Illness Selection Criteria and Study Outcome

Selection criteria correspond to a variation of a list of codes validated against virological results in a study evaluating code-based syndromic surveillance for ILI. These codes correlated highly with positive viral specimens in previous research.[23] Our previous work found that inclusion of the *ICD-9* code for "pneumonia, organism NOS" (486.0) led to misclassification of hospitalized ILI cases during the 2009 H1N1 influenza pandemic.[1] We therefore excluded it in this study. We have also included the *ICD-9* diagnosis code for novel influenza A (2009 H1N1 influenza, 488.1) introduced in June 2009. Nationwide US influenza data indicated that only 7% of 2009 H1N1 influenza-related hospitalizations occurred in those aged 65 years and older,[24] so we excluded that age group from the study population to minimize misclassification bias that could be introduced by noninfluenza cases within the ILI criteria. The outcome is ICU admission determined by ICU-related diagnosis codes.

Time Period Selection

We examined the population discharged from any acute care hospital in Massachusetts between April 26 and September 30, 2009. Confirmed-case laboratory specimen data from the Massachusetts State Laboratory indicated that between April 19 and October 1, 2009, 99% of influenza virus isolates were 2009 H1N1 influenza. In addition, 34% of all submitted specimens were positive for 2009 H1N1 influenza.[25] This time interval occurred before 2009 H1N1 influenza vaccine was released and therefore represents a unique time to study the impact of the virus prior to the availability of immunization. Prior to April 26, 2009, seasonal influenza activity was common in Massachusetts; April 26 marks the first date that 2009 H1N1 influenza was detected, and September 30 marks the beginning of the official influenza season.

Statistical Analysis

We conducted all analyses with SAS version 9.2 (SAS Institute, Cary, NC) and Stata version 11.2 (StataCorp LP, College Station, TX). The statistical analysis involved 3 steps. In step 1, we determined the population discharged from any hospital in Massachusetts between April 26 and September 30, 2009, and described characteristics by racial/ethnic groups. We calculated population-based rates using ACS data from the US Census Bureau. In step 2, we linked by 5-digit zip code the HDD study population to the ACS indicator "percentage of people living below 100% poverty." We then quantified each racial/ethnic group's socioeconomic gradient to examine whether racial/ethnic groups had different levels of SES. We compared characteristics of each group using the χ^2 test for categorical variables and analysis of variance for normally distributed continuous variables. In step 3, we examined the association between H1N1-related outcomes by racial/ethnic groups adjusted for SES.

We used 4 models to conduct the analysis. Model A refers to the null model investigating the association between ICU stay and racial/ethnic group. Model B adds the measure of SES to adjust for SES gradient. Model C investigates the association between ICU stay and SES group. Model D is the full multivariable model investigating the association between ICU stay and race/ethnicity, adjusted for (1) SES; (2) patient-level effects such as age, gender, and admission type; and (3) interactions between race and gender.

We applied model D to the full study population to determine predictors of 2009 H1N1 influenza-related ICU stay. To address selection bias and confounding within racial/ethnic strata, we stratified the full study population by racial/ethnic group. We used a logistic regression model to provide estimates. We used the XTLOGIT command in Stata with the "or" option to display estimated odds ratio values. Because the data source is a population-based hospital discharge data set and all discharges from all Massachusetts acute care hospitals are included in the model, we conducted a sensitivity analysis among all Massachusetts facilities to explore the level of correlation within a facility. We discovered that there was a low intraclass correlation

coefficient within facilities, which we suspected was a result of the large catchment area of many of the facilities, leading to a very heterogeneous patient population. Because of the large sample size in this study, we would need a large intraclass correlation coefficient to produce any meaningful impact on the level of association. We did not see any meaningful difference between the analysis described in the results and those found in the sensitivity analysis.

RESULTS

A total of 4874 individuals met inclusion criteria during the study period. Specific characteristics of the study population stratified by racial/ethnic group are shown in Table 1. Among the 4 groups, Hispanics and "other races" were the youngest (mean age = 21 years) and non-Hispanic Whites were the oldest (mean age = 35 years). Using ACS data in the denominator to determine population-based rates of ILI, we found that Hispanic and non-Hispanic Black populations had the highest rates of ILI (13 and 15 cases per 10 000 population, respectively). Hispanic and non-Hispanic Black populations had higher proportions of individuals younger than 18 years (18 and 19 per 10 000, respectively) than non-Hispanic Whites (8 per 10 000). These population-based rates by race are consistent with previously published findings.[1–3]

Among the hospitalized cohort, 526 individuals were admitted to the ICU (Table 2). Rates of those younger than 18 years admitted to the ICU were twice as high among Hispanics and non-Hispanic Blacks (2 per 10 000) as among non-Hispanic Whites (1 per 10 000). Within the hospitalized cohort, we found higher death rates, higher rates of admission through the emergency department, and longer lengths of stay among those in the ICU (Table 3). Hispanics admitted to the ICU had the highest length of stay (10.2 days); nearly two thirds (62%) were younger than 18 years, 57% were female, and nearly two thirds (63%) were from the lowest SES gradient, which was the highest percentage of all racial/ethnic groups (Table 3).

Statewide, there were differences in SES by racial/ethnic group as indicated by the percentage of people living below the poverty line (Table 1). According to ACS estimates, 30% of non-Hispanic Blacks and 19.8% of Hispanics reported living below the poverty line within the past 12 months, compared with 7.7% of non-Hispanic Whites. Of non-Hispanic Whites admitted to the ICU (Table 3), only 13% were in the lowest SES group, compared with 63% Hispanics and 43% non-Hispanic Blacks. These comparisons indicate that large differences exist with respect to SES gradients among racial/ethnic groups.

Hispanics had lower risk of ICU stay than non-Hispanic Whites (odds ratio [OR] = 0.52; 95% confidence interval [CI] = 0.32, 0.86; Table 4). Other statistically significant results showed that those in the upper middle SES and lowest SES groups had lower risk of ICU stay compared with the highest SES group (OR = 0.62 [95% CI = 0.47, 0.80] and 0.72 [95% CI = 0.54, 0.96], respectively). Compared with men, women had decreased risk of ICU stay (OR = 0.78; 95% CI = 0.62, 0.98), and those with admission through the outpatient department also had lower risk of ICU stay (OR = 0.53; 95% CI = 0.34, 0.83). Results from a race–gender interaction term indicated that Hispanic women had significantly increased risk of ICU stay (OR = 1.88; 95% CI = 1.00, 3.52).

We found different predictors of 2009 H1N1 influenza-related ICU stay by racial/ethnic group (Table 4). Among non-Hispanic Whites, risk of ICU stay was decreased for lower SES groups compared with the most affluent group, and lower for females than for

TABLE 1—Characteristics of the Study Population, by Race/Ethnicity: Massachusetts, 2009

Independent Variable	Non-Hispanic White (n = 3144)	Hispanic (n = 704)	Non-Hispanic Black (n = 578)	Other (n = 448)	*P*
Gender, no. (per 10 000)					
Male	1584 (7)	358 (13)	294 (15)	230 (7)	
Female	1562 (7)	345 (13)	284 (15)	217 (6)	
Age, mean ±SD	35 ±22.1	21 ±21.5	26 ±21.2	21 ±22.0	
Age, y, no. (per 10 000)					
< 18	844 (8)	365 (18)	241 (19)	251 (13)	< .001
18–44	866 (5)	198 (8)	182 (11)	98 (3)	< .001
45–64	1360 (9)	133 (14)	152 (17)	93 (6)	< .001
Deaths, no. (per 10 000)	19 (0.05)	4 (0.07)	1 (0.03)	4 (0.09)	
ICU admissions, no. (per 10 000)	345 (0.8)	53 (1)	69 (2)	59 (1)	< .05
Admitted to ICU through ED, no. (per 10 000)	1556 (4)	250 (4)	299 (8)	170 (3)	< .001
Admitted to ICU through OP, no. (per 10 000)	302 (0.7)	46 (0.8)	27 (0.7)	26 (0.4)	< .001
Total ILI hospitalizations by racial/ethnic group, per 10 000[a]	7	13	15	7	
Income in past 12 mo below poverty level, %	7.7	19.8	30.0	14.6	< .05

Note. ED = emergency department; ICU = intensive care unit; OP = outpatient department. The total study population was 4874. The total Massachusetts population was as follows: non-Hispanic White, 4 463 953; Hispanic, 558 676; non-Hispanic Black, 388 755; other, 678 112. The χ^2 test was used for categorical variables; the *t* test and analysis of variance was used for continuous variables. Population-based rates correspond to total number of H1N1 hospitalizations within subgroup per 10 000 people, calculated using American Community Survey (ACS) 5-year estimates (for 2006–2010). To calculate the proportions, we used data from the Hospital Discharge Database for the numerator and ACS data for the denominator.
[a]Total H1N1 discharges of each racial/ethnic group divided by total population for each racial/ethnic group, calculated using ACS 5-year estimates (for 2006–2010).

TABLE 2—Rates of 2009 H1N1 Influenza-Related Hospital Discharges, by Racial/Ethnic Group and Stay in Intensive Care Unit (ICU): Massachusetts, 2009

	Stay in ICU, No. (per 10 000) or Mean ±SD					No Stay in ICU, No. (per 10 000) or Mean ±SD				
Independent Variable	Non-Hispanic White (n = 345)	Hispanic (n = 53)	Non-Hispanic Black (n = 69)	Other (n = 59)	*P*	Non-Hispanic White (n = 2801)	Hispanic (n = 650)	Non-Hispanic Black (n = 509)	Other (n = 388)	*P*
Gender										
Male	196 (1)	23 (1)	43 (2)	34 (1)	.43	1388 (6)	335 (12)	251 (13)	196 (6)	.12
Female	149 (1)	30 (1)	26 (1)	25 (1)	.57	1413 (6)	315 (12)	258 (13)	192 (5)	< .05
Age	38 ±22	20 ±21	26 ±21	24 ±23	< .05	35 ±22	22 ±22	26 ±21	21 ±22	< .001
Age group, y										
< 18	79 (1)	32 (2)	29 (2)	31 (2)	.46	765 (7)	333 (16)	212 (17)	220 (11)	< .05
18–44	93 (1)	10 (0.4)	21 (1)	12 (0.4)	.19	773 (4)	188 (7)	161 (10)	86 (3)	< .05
45–64	159 (1)	10 (1)	19 (2)	15 (1)	.51	1201 (8)	123 (13)	133 (15)	78 (5)	< .05
Deaths	13 (0.03)	3 (0.05)	1 (0)	3 (0.07)	< .05	6 (0.02)	1 (0.02)	1 (0.03)	1 (0.01)	.09
Admitted through ED	186 (0.4)	22 (0.4)	41 (1)	23 (0.4)	.37	1370 (3)	228 (4)	258 (7)	147 (2)	< .05
Admitted through OP	20 (0.04)	1 (0.02)	2 (0.05)	1 (0.02)	.41	282 (0.6)	45 (0.8)	25 (0.7)	25 (0.4)	< .05

Note. ED = emergency department; OP = outpatient department. The total study population was 4874. The total Massachusetts population was as follows: non-Hispanic White, 4 463 953; Hispanic, 558 676; non-Hispanic Black, 388 755; other, 678 112. The χ^2 test was used for categorical variables; the *t* test and analysis of variance was used for continuous variables. Population-based rates correspond to total number of H1N1 hospitalizations within subgroup per 10 000 people, calculated using American Community Survey (ACS) 5-year estimates (for 2006–2010).

males (OR = 0.77; 95% CI = 0.61, 0.97). Non-Hispanic Black females had lower odds of ICU stay (OR = 0.59; 95% CI = 0.35, 1.00). Among the "other" racial/ethnic group, SES was significantly associated with lower risk of ICU stay (OR = 0.22 [95% CI = 0.09, 0.55], 0.46 [95% CI = 0.22, 0.94], and 0.28 [95% CI = 0.13, 0.63] for upper middle, lower middle, and lowest SES group, respectively).

TABLE 3—Description of Study Population by Racial/Ethnic Group and Stay in Intensive Care Unit (ICU) Among All Hospitals: Massachusetts, 2009

	Stay in ICU, No. (%) or Mean ±SD				No Stay in ICU, No. (%) or Mean ±SD			
	Non-Hispanic White (n = 337)	Hispanic (n = 57)	Non-Hispanic Black (n = 68)	Other (n = 65)	Non-Hispanic White (n = 2807)	Hispanic (n = 647)	Non-Hispanic Black (n = 510)	Other (n = 383)
Gender								
Male	196 (57)	23 (43)	43 (62)	34 (58)	1388 (50)	335 (52)	251 (49)	196 (51)
Female	149 (43)	30 (57)	26 (38)	25 (42)	1413 (50)	315 (48)	258 (51)	192 (49)
Age group, y								
< 18	79 (24)	32 (62)	29 (42)	31 (53)	765 (28)	333 (52)	212 (42)	220 (58)
18–44	93 (28)	10 (19)	21 (30)	12 (21)	773 (28)	188 (29)	161 (32)	86 (22)
45–64	159 (48)	10 (19)	19 (28)	15 (26)	1201 (44)	123 (19)	133 (26)	78 (20)
Age	38 ±22	20 ±21	26 ±21	24 ±23	35 ±22	22 ±22	26 ±21	21 ±22
% of population below poverty level								
0–5.9	130 (38)	2(4)	8 (12)	24 (42)	921 (34)	22 (3)	39 (8)	75 (20)
6.0–11.9	100 (29)	1(2)	9 (13)	7 (12)	934 (34)	59 (9)	57 (11)	93 (25)
12.0–18.9	68 (20)	16 (31)	22 (32)	16 (28)	563 (20)	170 (27)	159 (32)	102 (27)
≥ 19	43 (13)	32 (63)	29 (43)	10 (18)	323 (12)	390 (61)	249 (49)	107 (28)
Deaths	13 (4)	3 (5)	0 (0)	3 (5)	6 (0)	1 (0)	1 (0)	1 (0)
Admitted through ED	186 (54)	22 (42)	41 (59)	23 (39)	1370 (49)	228 (35)	258 (51)	147 (38)
Admitted through OP	20 (6)	1 (2)	2 (3)	1 (2)	282 (10)	45 (7)	25 (5)	25 (6)
Length of stay, d	6.8 ±9	10.2 ±12	5.6 ±6	5.2 ±6	3.2 ±3	3.0 ±3	2.8 ±3	2.7 ±3

Note. ED = emergency department; OP = outpatient department. The total study population was 4874. We calculated the proportions using Hospital Discharge Database data for 2009.

TABLE 4—Risk of H1N1-Related Stay in Intensive Care Unit (ICU), Stratified by Racial/Ethnic Group: Massachusetts, 2009

	Model, OR (95% CI)				Racial/Ethnic Group, OR (95% CI)			
Independent Variable	A	B	C	D (Full)	Non-Hispanic White	Hispanic	Non-Hispanic Black	Other
Racial/ethnic group								
Non-Hispanic White	1.00	1.00		1.00				
Hispanic	0.66* (0.49, 0.90)	0.68* (0.49, 0.95)		0.52* (0.32, 0.86)				
non-Hispanic Black	1.10 (0.84, 1.45)	1.14 (0.85, 1.53)		1.32 (0.90, 1.93)				
Other	1.23 (0.92, 1.66)	1.24* (0.91, 1.68)		1.29 (0.85, 1.96)				
% of population below poverty level								
0–5.9 (Ref)		1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.0–11.9		0.66** (0.52, 0.85)	0.66** (0.51, 0.85)	0.62** (0.47, 0.80)	0.69* (0.52, 0.93)	0.16 (0.01, 1.85)	0.74 (0.26, 2.12)	0.22** (0.09, 0.55)
12.0–18.9		0.81 (0.63, 1.05)	0.79 (0.62, 1.02)	0.79 (0.61, 1.02)	0.85 (0.62, 1.16)	0.80 (0.17, 3.85)	0.62 (0.25, 1.53)	0.46* (0.22, 0.94)
≥ 19		0.75* (0.56, 0.99)	0.69* (0.53, 0.89)	0.72* (0.54, 0.96)	0.89 (0.61, 1.29)	0.75 (0.16, 3.43)	0.54 (0.23, 1.29)	0.28* (0.13, 0.63)
Gender								
Male (Ref)				1.00	1.00	1.00	1.00	1.00
Female				0.78* (0.62, 0.98)	0.77* (0.61, 0.97)	1.68 (0.92, 3.07)	0.59* (0.35, 1.00)	0.87 (0.48, 1.56)
Age group, y								
< 18 (Ref)				1.00	1.00	1.00	1.00	1.00
18–44				1.03 (0.80, 1.33)	1.17 (0.85, 1.62)	0.53 (0.24, 1.15)	0.98 (0.52, 1.83)	1.10 (0.51, 2.39)
45–64				1.17 (0.93, 1.49)	1.30 (0.97, 1.75)	0.67 (0.29, 1.58)	0.93 (0.47, 1.83)	1.53 (0.72, 3.27)
Admission through ED				1.11 (0.92, 1.36)	1.10 (0.86, 1.40)	1.32 (0.70, 2.53)	1.40 (0.80, 2.46)	0.94 (0.49, 1.80)
Admission through OP				0.53* (0.34, 0.83)	0.62* (0.38, 1.00)	. . .[a]	0.70 (0.15, 3.22)	0.22 (0.03, 1.71)
Race × gender interaction								
Non-Hispanic White × female (Ref)				1.00				
Hispanic × female				1.88* (1.00, 3.52)				
Non-Hispanic Black × female				0.76 (0.43, 1.34)				
Other race × female				1.05 (0.57, 1.93)				

Note. OR = odds ratio; CI = confidence interval; ED = emergency department; OP = outpatient department. The dependent variable is influenza-like-illness-related stay in the intensive care unit. Model A refers to the null model investigating the association between ICU stay and racial/ethnic group. Model B adds the measure of socioeconomic status (SES) to adjust for SES gradient. Model C investigates the association between ICU stay and SES group. Model D refers to the full multivariable model investigating the association between ICU stay and race/ethnicity, adjusted for SES and patient-level effects such as age, gender, and admission type, and interactions between race and gender. To address selection bias and confounding within racial/ethnic strata, we stratified Model D by racial/ethnic group.

[a]Omitted because of collinearity.

*$P < .05$; **$P < .001$.

DISCUSSION

Regression results indicate that, among racial/ethnic groups in Massachusetts in 2009, there were statistically significant differences in H1N1 influenza-related ICU stay as well as different predictors of ICU stay. In the full multivariable model, Hispanics had significantly lower odds of ICU stay than non-Hispanics Whites, and women had lower risk than men. These results provide data to better understand the relationship between race/ethnic groups, SES, and severity of influenza (indicated by ICU admission). Results from this assessment provide vital information about the population burden of disease among race/ethnic groups and SES strata.

There are theories explaining how different levels of disease exposure, health care access, treatment, and (ultimately) health outcomes are affected by social determinants. These theories may help explain why specific racial/ethnic groups may require hospitalization from pandemic influenza or have more severe ILI-related complications. One of these theories applies the contribution of different determinants of health—combining measures of SES and geographic location as we have done in this study.[26] The mechanisms contributing to health inequalities among different SES groups are a complex interplay among the following factors: (1) composition—people in poorer areas have worse health because poor individuals have poor health; (2) context—people in poorer areas have worse health because a concentration of poverty creates or worsens harmful social interactions; and (3) geographic location—the location of public facilities, such as supermarkets or health clinics, and environmental pollution contribute to worse health.[26,27] We found that, among those hospitalized, there were disproportionately larger numbers of Hispanics and non-Hispanic Blacks from poorer areas, and people in poorer areas had lower risk of ILI-related ICU stay. This may not necessarily reflect the actual incidence of disease among these geographic areas; it may be a function of how we have reported data from an administrative hospital discharge data source. During the H1N1 pandemic in 2009, there was an inherent bias in who was diagnosed and tested for H1N1 related to specific demographic groups, leading to certain groups being overrepresented in surveillance and reporting data.[28] This bias could have affected our findings. Because we do not have information on every individual who may have been sick and did not have an encounter with a hospital, it is difficult to postulate about the actual incidence and risk in the entire Massachusetts population.

We also found that those in lower SES groups had decreased risk of ILI-related ICU stay (Table 4). This could be because more affluent groups have increased perception of risk from influenza or better health-seeking behavior, and increased exposure to the health care system. Conversely, lower SES groups may have less access to quality health care, or there could be other factors affecting their exposure to and utilization of the health care system, such as distrust of health care professionals and medical centers or cultural or language barriers.

Overall, we found that women were at lower risk for ILI-related ICU stay than men in the full multivariable model (OR = 0.78; 95% CI = 0.62, 0.98). Behavioral reasons could support this finding. One study investigating the dynamics of risk perceptions and precautionary behavior in response to the H1N1 pandemic found that women had a higher perception of the risks of influenza infection, greater willingness to take medications, and increased engagement in information-seeking activities compared with men.[29] This difference in risk perception could affect the severity of disease if women were more likely to engage in preventive health measures. There might also have been biological factors present, which would support this finding. A person's gender affects the seriousness of influenza in terms of susceptibility, course of illness, and treatment. Men may have been more sick and required in-hospital ICU stay. Alternatively, women may have required less time to recover, refused ICU admission, or not required an ICU stay while in hospital. Admission to an ICU is based in part on subjective criteria and may be subject to numerous biases. We were not able to discriminate among these scenarios since we did not have access to medical chart data to define the course of each individual's illness or the rationales behind health care decisions. However, there are clear differences among gender groups that could be attributable to both behavioral and biological factors, and these should be explored in future work.

Contrary to the overall results indicating that women were at decreased risk, we found that Hispanic women were at increased risk for ILI-related ICU stay. Results from a race–gender interaction term indicated that Hispanic women had significantly increased risk of ICU compared with the rest of the population. The literature has shown that pregnant women were considered to be at high risk for 2009 H1N1 influenza-related complications.[30] We identified those with *ICD-9* codes corresponding to pregnancy conditions or complications (codes 630.0–679.9; n = 109). Thirty-one pregnancies occurred among Hispanic women (9% of the total Hispanic female population), 52 among non-Hispanic White women (3%), and 14 among non-Hispanic Black women (5%). The disproportionately high number of pregnant Hispanic women may partially explain the increased risk of 2009 H1N1 influenza-related ICU stays among Hispanic women. Since the total number of pregnant women was so low, there could be additional gender-related issues present among Hispanic women causing 2009 H1N1 influenza-related ICU stay.

Health care access could explain why specific racial/ethnic groups had different rates of 2009 H1N1 influenza-related hospitalizations and ICU admissions. Massachusetts enacted comprehensive health care reform in April 2006 that requires all state residents to carry a minimum level of health insurance, subject to penalties for noncompliance starting in 2008.[31] This health care reform, which included a health insurance mandate, has been associated with significant increases in insurance coverage and access.[32] Coverage reports from 2011 indicate over 99% health insurance coverage within Massachusetts, although some groups are still difficult to reach—especially subpopulations where English is not the primary language. Unfortunately, we could not establish a measure of access to health care in this study since this was a retrospective analysis of administrative data.

Other studies have shown that primary language spoken influences access to care and receipt of preventive services among US Hispanics.[33] Disparities among exposure, susceptibility, and access to health care, most notably among Spanish-speaking Hispanics, may exacerbate existing health inequalities and could

influence access to health care in these populations during pandemic influenza outbreaks.[4] Primary language spoken, cultural barriers, and racial discrimination could still be considerable barriers to adequate health care among Hispanics, especially during pandemic influenza settings. We were not able to identify primary language spoken among the Hispanic population, but future assessments might address how language influences influenza-related outcomes.

Finally, we did not find statistical associations within age groups in this analysis. Epidemiological findings indicated that younger individuals—especially among non-White minority groups—were at greater risk for 2009 H1N1 influenza-related complications.[1] Age-related factors were not the focus of this analysis, but we did control for age in our full multivariable model.

This study demonstrates the feasibility of establishing a measure of socioeconomic affluence with a population-based hospital administrative database. The ability to establish an SES measure allows for the monitoring of US socioeconomic inequalities regarding influenza-related outcomes. The SES results are probably not due to misclassification from incorrect or unidentified 5-digit zip code; we found that 98% of records contained zip code information whose accuracy is verified annually by the Massachusetts Department of Public Health (Sylvia Hobbs, Massachusetts Department of Public Health, written communication, 2011). The methods we have outlined, however, should not be used to interpret zip code–level information as a proxy for individual-level information. These methods, also discussed in other prior analyses,[12] are based on individuals categorized in relation to the socioeconomic situation within their immediate residential area. Therefore, using zip code as an indicator for SES captures a mix of individual-level as well as area-based socioeconomic effects.

Limitations

In previous research, census tract–level data for SES indicators consistently detected expected socioeconomic gradients in health across a wide range of health outcomes.[7,21] We could not explore census tract–level data, however, because we received study approval using only fully de-identified data. Future analyses linking census tract–level measures of SES and influenza-related discharges may establish measures of association with more granularity and significance.

Conclusions

To our knowledge, this is the first statewide, population-based description of 2009 H1N1 influenza-related ICU stays according to racial/ethnic groups and SES in the United States. Our main results indicate that large differences exist with respect to H1N1-related outcomes among racial/ethnic groups and SES gradients. Results from a multivariable model indicate that lower SES groups had lower risk for ICU stay compared with the most affluent groups. Women were also shown to be at lower risk for 2009 H1N1-related ICU stay than men, and Hispanics had significantly lower risk of 2009 H1N1-related ICU stay compared with Whites. We recommend that further work should determine specific risk factors and preventive measures among these demographics.

These results highlight the feasibility and importance of monitoring racial/ethnic differences with regard to pandemic influenza susceptibility and severity, especially in relation to US socioeconomic inequalities. Through our efforts to report epidemiological findings related to H1N1-related outcomes, we revisited the overall aim of public health in the setting of influenza outbreaks. To do this, we used data from disease surveillance and laboratory testing to improve public messaging as well as vaccine and antiviral allocation to high risk groups. Our results provide data for more reasonable estimates of disease by racial/ethnic and SES groups, and we describe methods that can be used in future assessments to report pandemic-related outcomes. The implications of our findings lead to the conclusion that high-risk groups, such as Hispanic women, would benefit from improved surveillance and resource allocation. Future work should investigate social determinants of health—such as environmental factors, SES, education, and income—among racial/ethnic groups to guide resource allocation and reduce disparities in relation to pandemic influenza preparedness. As electronic health record systems improve and become more widely used, we expect that hospital data will become available to public health officials in real time, facilitating the application of these types of methods during an outbreak. ■

About the Authors

Hilary Placzek is with the Department of Clinical and Population Health Research, University of Massachusetts Medical School, Worcester, and HealthCore, Inc, Andover. Lawrence Madoff is with the Division of Infectious Diseases and Immunology, University of Massachusetts Medical School, Worcester, and the Division of Epidemiology and Immunization, Massachusetts Department of Public Health, Jamaica Plain.

Correspondence should be sent to Hilary Placzek, PhD, MPH, 300 Brickstone Square, 8th Fl, Suite 801A, Andover, MA 01810-1437 (e-mail: hilary.placzek@umassmed.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted August 14, 2013.

Contributors

H. Placzek participated in the design of the study, performed the statistical analysis, and drafted the article. L. Madoff participated in the study design and coordination and helped to draft the article. Both authors read and approved the final article.

Acknowledgments

We especially acknowledge Bruce Barton, PhD (University of Massachusetts Medical School [UMMS]), for his methodological consultation. We also acknowledge the following individuals for their contribution to this article: Bruce Cohen, PhD (Massachusetts Department of Public Health [MDPH]), James West, PhD (MDPH), Alan Rothman, MD (University of Rhode Island), and Richard Ellison, MD (UMMS). We acknowledge the support of the Division of Epidemiology and Immunization at the Massachusetts Department of Public Health, and the Clinical and Population Health Research Department at the University of Massachusetts Medical School.

Human Participant Protection

This project involved retrospective analysis of a statewide administrative hospital database. Institutional review board approval was granted by both the University of Massachusetts Medical School and the Massachusetts Department of Public Health.

References

1. Placzek H, Madoff L. Identification of influenza cases during the H1N1 pandemic in Massachusetts using population-based hospital discharge data. *PLoS Curr.* 2011;3:RRN1256.

2. Centers for Disease Control and Prevention. 2009 pandemic influenza A (H1N1) virus infections—Chicago, Illinois, April–July 2009. *MMWR Morb Mortal Wkly Rep.* 2009;58(33):913–918.

3. Centers for Disease Control and Prevention. Deaths related to 2009 pandemic influenza A (H1N1) among American Indian/Alaska natives—12 states, 2009. *MMWR Morb Mortal Wkly Rep.* 2009;58(48):1341–1344.

4. Quinn SC, Kumar S, Freimuth VS, Musa D, Casteneda-Angarita N, Kidwell K. Racial disparities in exposure, susceptibility, and access to health care in the US

H1N1 influenza pandemic. *Am J Public Health.* 2011; 101(2):285–293.

5. Dee DL, Bensyl DM, Gindler J, et al. Racial and ethnic disparities in hospitalizations and deaths associated with 2009 pandemic influenza A (H1N1) virus infections in the United States. *Ann Epidemiol.* 2011; 21(8):623–630.

6. Thompson DL, Jungk J, Hancock E, et al. Risk factors for 2009 pandemic influenza A (H1N1)-related hospitalization and death among racial/ethnic groups in New Mexico. *Am J Public Health.* 2011;101(9):1776–1784.

7. Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Race/ethnicity, gender, and monitoring socioeconomic gradients in health: a comparison of area-based socioeconomic measures—The Public Health Disparities Geocoding Project. *Am J Public Health.* 2003;93(10):1655–1671.

8. *Healthy People 2010.* Conference ed. Washington, DC: US Dept of Health and Human Services; 2013. Available at: http://www.health.gov/healthypeople. Accessed August 17, 2011.

9. Massachusetts Dept of Public Health, Bureau of Health Information, Statistics, Research, and Evaluation. Massachusetts Deaths 2008. Available at: http://www.mass.gov/Eeohhs2/docs/dph/research_epi/death_report_08.pdf. Accessed November 14, 2011.

10. Zhang Y, Cohen B, Macaluso M, Zhang Z, Durant T, Nannini A. Probabilistic linkage of assisted reproductive technology information with vital records, Massachusetts 1997–2000. *Matern Child Health J.* 2012;16(8):1703–1708.

11. US Census Bureau. American Community Survey. 2013. Available at: http://www.census.gov/acs/www. Accessed October 26, 2012.

12. Krieger N, Chen JT, Waterman PD, Rehkopf DH, Subramanian SV. Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: The Public Health Disparities Geocoding Project. *Am J Public Health.* 2005;95(2):312–323.

13. Commonwealth of Massachusetts, Center for Health Information and Analysis. Acute hospital case mix databases. 2010. Available at: http://www.mass.gov/chia/researcher/hcf-data-resources/case-mix. Accessed September 21, 2013.

14. *International Classification of Diseases, Ninth Revision.* Hyattsville, MD: National Center for Health Statistics; 1980. DHHS publication PHS 80–1260.

15. US Census Bureau. American Community Survey (ACS) design and methodology. Chapter 11: weighting and estimation. Revised December 2010. Available at: http://www.census.gov/acs/www/Downloads/survey_methodology/Chapter_11_RevisedDec2010.pdf. Accessed October 26, 2012.

16. US Census Bureau. Poverty thresholds in the United States. 2013. Available at: https://www.census.gov/hhes/www/poverty/data/threshld/index.html. Accessed October 26, 2012.

17. Powell LM, Slater S, Chaloupka FJ, Harper D. Availability of physical activity-related facilities and neighborhood demographic and socioeconomic characteristics: a national study. *Am J Public Health.* 2006;96 (9):1676–1680.

18. Merkin SS, Stevenson L, Powe N. Geographic socioeconomic status, race, and advanced-stage breast cancer in New York City. *Am J Public Health.* 2002;92 (1):64–70.

19. Pappas G, Hadden WC, Kozak LJ, Fisher GF. Potentially avoidable hospitalizations: inequalities in rates between US socioeconomic groups. *Am J Public Health.* 1997;87(5):811–816.

20. Rehkopf DH, Berkman LF, Coull B, Krieger N. The non-linear risk of mortality by income level in a healthy population: US National Health and Nutrition Examination Survey mortality follow-up cohort, 1988–2001. *BMC Public Health.* 2008;8:383.

21. Krieger N, Chen JT, Waterman PD, Soobader MJ, Subramanian SV, Carson R. Geocoding and monitoring of US socioeconomic inequalities in mortality and cancer incidence: does the choice of area-based measure and geographic level matter? The public health disparities geocoding project. *Am J Epidemiol.* 2002;156(5):471–482.

22. US Census Bureau. Poverty areas. Available at: http://www.census.gov/population/socdemo/statbriefs/povarea.html. Accessed October 26, 2012.

23. Marsden-Haug N, Foster V, Gould P, Elbert E, Wang H, Pavlin J. Code-based syndromic surveillance for influenzalike illness by International Classification of Diseases, Ninth Revision. *Emerg Infect Dis.* 2007;13 (2):207–216.

24. Centers for Disease Control and Prevention. CDC estimates of 2009 H1N1 influenza cases, hospitalizations and deaths in the United States, April 2009–January 16, 2010. Available at: http://www.cdc.gov/h1n1flu/estimates_2009_h1n1.htm. Accessed October 26, 2012.

25. Massachusetts Dept of Public Health. Weekly flu report, October 1, 2009. Available at: http://publichealth.blog.state.ma.us/h1n1-swine-flu/page/10. Accessed October 26, 2012.

26. O'Campo P. Invited commentary: advancing theory and methods for multilevel models of residential neighborhoods and health. *Am J Epidemiol.* 2003;157(1): 9–13.

27. Macintyre S, Ellaway A, Cummins S. Place effects on health: how can we conceptualise, operationalise and measure them? *Soc Sci Med.* 2002;55(1):125–139.

28. Stoto MA. The effectiveness of US public health surveillance systems for situational awareness during the 2009 H1N1 pandemic: a retrospective analysis. *PLoS One.* 2012;7(8):e40984.

29. Ibuka Y, Chapman GB, Meyers LA, Li M, Galvani AP. The dynamics of risk perceptions and precautionary behavior in response to 2009 (H1N1) pandemic influenza. *BMC Infect Dis.* 2010;10:296.

30. Girard MP, Tam JS, Assossou OM, Kieny MP. The 2009 A (H1N1) influenza virus pandemic: a review. *Vaccine.* 2010;28(31):4895–4902.

31. 188th General Court of the Commonwealth of Massachusetts. An act providing access to affordable, quality, accountable health care. 2006. Available at: http://www.mass.gov/legis/laws/seslaw06/sl060058.htm. Accessed October 26, 2012.

32. Pande AH, Ross-Degnan D, Zaslavsky AM, Salomon JA. Effects of healthcare reforms on coverage, access, and disparities: quasi-experimental analysis of evidence from Massachusetts. *Am J Prev Med.* 2011;41(1):1–8.

33. DuBard CA, Gizlice Z. Language spoken and differences in health status, access to care, and receipt of preventive services among US Hispanics. *Am J Public Health.* 2008;98(11):2021–2028.