Risk Factors for 2009 Pandemic Influenza A (H1N1)–Related Hospitalization and Death Among Racial/Ethnic Groups in New Mexico

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Objectives. We assessed risk factors for 2009 pandemic influenza A (H1N1)–related hospitalization, mechanical ventilation, and death among New Mexico residents.

Methods. We calculated population rate ratios using Poisson regression to analyze risk factors for H1N1-related hospitalization. We performed a cross-sectional analysis of hospitalizations during September 14, 2009 through January 13, 2010, using logistic regression to assess risk factors for mechanical ventilation and death among those hospitalized.

Results. During the study period, 926 laboratory-confirmed H1N1-related hospitalizations were identified. H1N1-related hospitalization was significantly higher among American Indians (risk ratio [RR]=2.6; 95% confidence interval [CI]=2.2, 3.2), Blacks (RR=1.7; 95% CI=1.2, 2.4), and Hispanics (RR=1.8; 95% CI=1.5, 2.0) than it was among non-Hispanic Whites, and also was higher among persons of younger age and lower household income. Mechanical ventilation was significantly associated with age 25 years and older, obesity, and lack of or delayed antiviral treatment. Death was significantly associated with male gender, cancer during the previous 12 months, and liver disorder.

Conclusions. This analysis supports recent national efforts to include American Indian/Alaska Native race as a group at high risk for complications of influenza with respect to vaccination and antiviral treatment recommendations. (*Am J Public Health.* 2011;101:1776–1784. doi:10.2105/AJPH.2011.300223)

Rates of 2009 pandemic influenza A (H1N1)–related hospitalization and death in Arizona and New Mexico have been reported to be higher among American Indians/Alaska Natives (AIANs) than among non-AIAN populations.[1] An investigation in 12 states, comprising 50% of the country's AIAN population, reported that death rates among AIANs were 4 times higher than among non-AIANs.[1] Other studies have reported similar patterns of higher pandemic H1N1–related hospitalization and death among other indigenous populations compared with nonindigenous populations.[2–4] Health outcome differences by race/ethnicity are not fully understood but might be explained by the prevalence of underlying chronic medical conditions, access to medical care, and socioeconomic status (SES).[5,6]

The New Mexico Department of Health (NMDOH) began conducting statewide active surveillance of pandemic H1N1–related hospitalizations and deaths in September 2009. Statewide surveillance in New Mexico includes data primarily from 3 major racial/ethnic groups: American Indians (AIs), Hispanic Whites, and non-Hispanic Whites. In New Mexico, varied socioeconomic, cultural, and geographic factors exist that might influence access to medical care and health outcomes identified through surveillance. Given that most individuals with H1N1 illness are not hospitalized, the true denominator of H1N1 disease is difficult to determine; we therefore focused on severe illness. Specifically, we conducted this analysis to assess risk factors, including race/ethnicity, for increased pandemic H1N1–related hospitalization, mechanical ventilation, and death among New Mexico residents.

METHODS

We estimated associations between race/ethnicity, gender, age group, county median household income, and population-based rates of pandemic H1N1–related hospitalization using Poisson regression. We performed a cross-sectional analysis using logistic regression to assess risk factors for mechanical ventilation and death among those hospitalized. This analysis included race/ethnicity, gender, age group, county median household income, and variables related to obesity, high-risk medical conditions, antiviral treatment, distance to medical care, and rural–urban residence location. Hospitalizations among New Mexico residents during the period September 14, 2009 to January 13, 2010 were included. The surveillance time frame was chosen to correspond with the beginning of active surveillance at NMDOH and to continue for 4 months to allow for efficient calculation of annualized results while capturing the fall 2009 peak of H1N1 hospitalizations in New Mexico.

Case Definitions

Before October 12, 2009, a confirmed H1N1-related hospitalization was defined as illness in a New Mexico resident who had been admitted to a hospital with a positive influenza test by real-time polymerase chain reaction or culture. On October 12, 2009, this definition was expanded by NMDOH to include any positive influenza test, including rapid test through enzyme immunoassay, direct or indirect fluorescent antibody, culture, or real-time polymerase chain reaction. Case definition changes were made to comprehensively identify H1N1 disease in New Mexico because Centers for Disease Control and Prevention (CDC) data indicated that, as of October 3,

2009, 99% of circulating influenza viruses in the United States were H1N1.[7,8]

Data Collection

NMDOH communicated weekly with hospitals as part of the active surveillance process. Hospitals provided weekly reports to NMDOH of all laboratory-confirmed influenza hospitalizations. NMDOH collected data on influenza-related deaths from hospitals, the NMDOH Bureau of Vital Records and Health Statistics, and the statewide Office of the Medical Investigator. To collect data, NMDOH used a standardized medical record abstraction form, completed by hospital infection preventionists or NMDOH staff, which included information regarding demographics, underlying medical conditions, clinical characteristics, vaccination history, and antiviral treatment. To obtain accurate estimates of body mass index (BMI; defined as weight in kg divided by height in m^2) and obesity, NMDOH staff rereviewed all cases for the surveillance period and contacted infection preventionists for height and weight information. This process included recording whether or not the medical record text indicated obese, morbidly obese, or normal or healthy weight for height–body habitus, even if the record did not include BMI, height, or weight specifically. For deaths, autopsy records were reviewed by NMDOH staff if available.

Data Analysis

We chose independent variables on the basis of knowledge and hypotheses of characteristics and factors that could influence risk of outcomes of interest. We estimated associations with the primary outcome measure, population-based incidence rates of H1N1-related hospitalization, using Poisson regression. We calculated unadjusted and adjusted rate ratios and 95% confidence intervals. Because of the population-based method used, independent variables were also those for which standardized population based data were available, including race/ethnicity, gender, age group, and county median household income.

We analyzed age by age group rather than as a continuous variable to provide more readily usable comparisons with other literature. We used county median household income estimates for 2008 from the US Census Bureau's Small Area Income and Poverty Estimates program[9] as a proxy for SES. Median household income estimates ranged from $27 580 to $102 602. We grouped the 33 New Mexico counties into the following quartiles by median household income: less than $30 366, $30 366 to $36 238, $36 239 to $42 101, and $42 102 or higher. We assigned patients a median household income category that was based on their county of residence. Population denominators for the Poisson regression model were based on 2008 estimates as generated by the University of New Mexico Bureau of Business and Economic Research (BBER). We used BBER data because it is believed that US Census Bureau population estimates represent an undercount for New Mexico. The BBER evaluates population data and uses a housing unit–based methodology, validated by building permits and birth and death records, resulting in a more accurate population estimate for New Mexico. We calculated age-standardized rates for each racial/ethnic group by using direct standardization to the 2000 US Census standard population.[10]

We assessed risk factors for mechanical ventilation and death among hospitalized H1N1-infected patients by cross-sectional analysis using univariate and multivariate logistic regression. We calculated odds ratios and 95% confidence intervals. Independent variables in this analysis included race/ethnicity, gender, age group, county median household income, obesity, high-risk medical conditions, pregnancy status, antiviral treatment, distance to medical care, and rural or urban residence. Variables statistically significant at $P \leq .1$ on univariate analysis were included in the multivariate analysis.

High-risk medical conditions were those defined by the CDC for influenza complications, which included asthma, chronic lung disease, chronic cardiovascular disease, diabetes, other chronic metabolic disease, renal disease, cognitive or neurological disease, hepatic disease, and immunosuppression.[11] Because cancer within the past 12 months was hypothesized to be important as a separate risk category for immunosuppression, NMDOH collected this variable in a separate category during the surveillance period. Straight-line distances from a patient's residence zip code to the zip code of the initial admitting hospital, which we used to provide a measure of distance to medical care, were divided into quartiles for analytic purposes.

To assign a measure of rurality, we used the rural–urban commuting area codes for the year 2000, which are based on zip code.[12] We classified patients as having an urban, large rural, small rural, or isolated home residence on the basis of their home address (or post office box) zip code. As in the Poisson regression analysis, we modeled SES using quartiles of median household income based on county of residence.

We calculated BMI for all nonpregnant patients aged 2 years or older whose height and weight were documented. For patients between 2 and 20 years of age, we compared calculated BMI values with BMI-for-age percentiles from the 2000 CDC US Growth Charts.[13] We classified as obese patients whose BMI-for-age values were equal to or greater than the 95th percentile and patients older than 20 years whose calculated BMI was 30 or above. When height or weight information was unavailable, we classified patients as obese or not obese on the basis of narrative documentation, or lack thereof, in the medical record. We conducted all analyses with SAS version 9.1 or 9.2 (SAS Institute, Cary, NC).

RESULTS

During the surveillance period, a total of 926 laboratory-confirmed pandemic H1N1–related hospitalizations were identified among New Mexico residents (Table 1). The overall incidence rate of H1N1-related hospitalizations was 11.1 per 100 000 person-months (95% confidence interval [CI]=10.4, 11.9). By race/ethnicity, the age-standardized incidence rates per 100 000 person-months were as follows: AI, 19.2 (95% CI=16.2, 22.3); Asian/Pacific Islander, 8.4 (95% CI=3.4, 13.4); Black, 13.9 (95% CI=7.9, 19.9); Hispanic, 12.8 (95% CI=11.6, 14.1); and non-Hispanic White, 7.3 (95% CI=6.3, 8.3).

Of hospitalized patients, 62% had 1 or more medical condition placing them at high risk for influenza complications (Table 1). The 3 most commonly reported high-risk medical conditions among H1N1-related hospitalized patients

TABLE 1—Descriptive Characteristics of 2009 Pandemic Influenza A (H1N1)–Related Hospitalizations and Deaths: New Mexico, September 14, 2009–January 13, 2010

Characteristic	Hospitalized Patients, No. (%) (n = 926)	Mechanically Ventilated Patients, No. (%) (n = 106)	Deaths, No. (%) (n = 35)
Age group, y			
≤4	191 (21)	2 (2)	1 (3)
5–24	254 (27)	17 (16)	5 (14)
25–49	224 (24)	46 (43)	11 (31)
50–64	156 (17)	27 (25)	9 (26)
≥65	101 (11)	14 (13)	9 (26)
Gender			
Female	472 (51)	52 (49)	12 (34)
Male	454 (49)	54 (51)	23 (66)
Race/ethnicity			
American Indian	170 (18)	28 (26)	6 (17)
Asian/Pacific Islander	11 (1)	0 (0)	0 (0)
Black	27 (3)	1 (1)	0 (0)
Hispanic	448 (48)	46 (43)	14 (40)
Non-Hispanic White	234 (25)	29 (27)	15 (43)
Unknown	36 (4)	2 (2)	0 (0)
County median household annual income quartile, $			
≤30 365	33 (4)	2 (2)	0 (0)
30 366–36 238	123 (13)	16 (15)	5 (14)
36 239–42 102	285 (31)	17 (16)	8 (23)
≥42 103	485 (52)	71 (67)	22 (63)
Rurality of residence[a]			
Urban	501 (54)	50 (57)	23 (66)
Large rural	264 (29)	27 (25)	8 (23)
Small rural	86 (9)	8 (8)	1 (3)
Isolated	71 (8)	10 (9)	2 (6)
Unable to classify	4 (1)	1 (1)	1 (3)
Pregnant	50 (5)	1 (1)	0 (0)
Obese			
BMI only	229/497 (56)	40/71 (56)	8/23 (35)
BMI and medical record text	273/744 (37)	51/102 (50)	12/34 (35)
High-risk medical condition			
Any high-risk medical condition	576 (62)	74 (70)	27 (77)
Asthma	254 (27)	22 (21)	6 (17)
Other chronic lung disease	149 (16)	26 (24)	8 (23)
Chronic cardiovascular disease	141 (15)	24 (22)	12 (34)
Diabetes	152 (16)	24 (23)	10 (29)
Other chronic metabolic disease	68 (7)	10 (9)	3 (9)
Cancer occurrence during previous 12 mo	25 (3)	7 (7)	6 (17)
Renal disease	63 (7)	11 (10)	4 (11)
Neurological disease	103 (11)	19 (18)	7 (20)
Immunosuppression	83 (9)	18 (17)	4 (11)
Liver disorder	32 (3)	5 (5)	7 (20)

Continued

were asthma (27%), diabetes (16%), and other chronic lung disease (16%). Presence of at least 1 high-risk medical condition by racial/ethnic group was as follows: 54% among AIs, 63% among Hispanics, 65% among non-Hispanic Whites, 73% among Asians/Pacific Islanders, and 78% among Blacks.

The mean time from illness onset to seeking medical care was 2.1 days (95% CI=2.0, 2.3). Of hospitalized patients, 74% received neuraminidase antiviral treatment. Among those treated with a neuraminidase antiviral, the mean time from seeking medical care to treatment was 1.3 days (95% CI=1.2, 1.5) and the mean time from illness onset to treatment was 3.2 days (95% CI=3.0, 3.5). No statistically significant differences existed by racial/ethnic group for these measures.

Among the 761 nonpregnant patients aged 2 years or older, 497 had BMI data available and 229 (46%) were classified as obese. Of the 264 patients without BMI data, medical records were available for 247; of these, 44 patients (18%) were classified as obese on the basis of narrative documentation. Availability of BMI data and medical records did not differ significantly by racial/ethnic group. When both BMI data and narrative documentation were considered, 273 of 744 patients (37%) were classified as obese. Compared with non-Hispanic Whites, AIs and Hispanics had significantly higher odds of obesity under both classification schemes: BMI only (for AIs, odds ratio [OR]=2.2; 95% CI=1.3, 3.7; for Hispanics, OR=1.9, 95% CI=1.2, 2.9) and BMI plus narrative (for AIs, OR=2.5; 95% CI=1.6, 4.0; for Hispanics, OR=1.7; 95% CI=1.1, 2.5).

Risk Factors for H1N1-Related Hospitalization

Poisson regression analysis indicated that risk for pandemic H1N1-related hospitalization differed by race/ethnicity, age group, and county median household income, but not by gender (Table 2). On multivariate Poisson regression, the rate of H1N1-related hospitalization was significantly higher among AIs, Blacks, and Hispanics than it was among non-Hispanic Whites. Children aged 4 years or younger and those aged 5 to 24 years were significantly more likely to be hospitalized for H1N1 illness than were persons aged 65 years or older, but persons aged 25 to 49 years had a significantly lower rate of

TABLE 1—*Continued*

Treatment with neuraminidase antiviral			
Not treated	232 (25)	18 (17)	9 (26)
Treated ≤2 d from illness onset	329 (36)	20 (19)	5 (14)
Treated ≥3 d from illness onset	340 (37)	64 (60)	18 (51)
Distance from residence zip code to hospital zip code, miles[b]			
0	252 (27)	26 (24)	12 (34)
>0 to <6.35	193 (21)	18 (17)	4 (11)
6.35 to <13.3	220 (24)	25 (24)	11 (31)
≥13.3	225 (24)	31 (29)	6 (17)
Unable to classify	36 (4)	6 (6)	2 (6)

Note. BMI = body mass index.
[a]The rural–urban commuting area codes for 2000, based on zip code, were used to assign a measure of rurality.[11]
[b]"0 miles" indicates that residence was in the same zip code as the hospital. For residences that were not in same zip code as the hospital, straight-line distances were derived by a SAS (SAS Institute, Cary, NC) function that calculated distance based on the centroid for the zip codes.

hospitalization. Compared with residents of counties in the quartile with the highest median household annual income, residents of counties in the third quartile and lowest quartile had an elevated rate of hospitalization.

Risk Factors for Mechanical Ventilation

We assessed risk factors for mechanical ventilation using logistic regression analysis (Table 3). When racial/ethnic group was represented as 5 categories in univariate analysis with non-Hispanic Whites as the referent group, only AIs had elevated odds of mechanical ventilation (OR=1.4; 95% CI=0.8, 2.4). Because of the similar odds of mechanical ventilation among Hispanics (OR=0.8; 95% CI=0.5, 1.3) and non-Hispanic Whites and the limited number of Black (n=1) and Asian/Pacific Islander (n=0) patients receiving mechanical ventilation treatment, AIs were compared with other racial/ethnic groups in subsequent analyses. Compared with all other racial/ethnic groups, AIs had elevated odds of mechanical ventilation (OR=1.7; 95% CI=1.0, 2.7).

Given the substantial number of records missing obesity classification even after BMI and medical record text were combined, we considered 2 multivariate logistic regression models, 1 that included obesity as a covariate (model 1) and 1 that did not (model 2) (Table 4). Model 1 included those who were missing height or weight data but whose obesity classification was documented by medical records. The only covariates significantly associated with mechanical ventilation in both models were age group 25 to 49 years, age group 50 to 64 years, and treatment with a neuraminidase antiviral 3 days or more after illness onset. In model 1, age group 65 years or older (OR=3.0; 95% CI=1.1, 8.3), obesity (OR=2.1; 95% CI=1.2, 3.8), and not receiving neuraminidase antiviral treatment (OR=2.8; 95% CI=1.1, 7.3) were also significantly associated with mechanical ventilation. Model 1 also provided evidence of a positive association between odds of mechanical ventilation and being AI (OR=1.9; 95% CI=0.9, 3.8), having other chronic lung disease (OR=1.7; 95% 0.9, 3.3), or having an immunosuppressive condition (OR=2.0; 95% CI=0.9, 4.4); however, these associations did not reach statistical significance. In model 2, associations trended in the same direction as in model 1, with 2 additional associations reaching statistical significance: age group birth to 4 years (OR=0.2; 95% CI=0.04, 0.9) and AI race (OR=2.1; 95% CI=1.1, 4.1).

TABLE 2—Characteristics of 2009 Pandemic Influenza A (H1N1)–Related Hospitalization: New Mexico, September 14, 2009–January 13, 2010

Risk Factor	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Age group, y		
Birth–4	4.1 (3.2, 5.2)	3.3 (2.6, 4.3)
5–24	2.3 (1.8, 2.8)	1.9 (1.5, 2.4)
25–49	0.8 (0.7, 1.1)	0.8 (0.6, 0.96)
50–64	1.1 (0.8, 1.4)	1.0 (0.8, 1.4)
≥65 (Ref)	1.0	1.0
Gender		
Male	1.0 (0.9, 1.1)	1.0 (0.9, 1.1)
Female (Ref)	1.0	1.0
Race/ethnicity		
American Indians	2.9 (2.4, 3.4)	2.6 (2.2, 3.2)
Asian/Pacific Islanders	1.1 (0.7, 2.0)	1.1 (0.6, 1.9)
Blacks	2.0 (1.4, 2.8)	1.7 (1.2, 2.4)
Hispanics	2.1 (1.8, 2.4)	1.8 (1.5, 2.0)
Non-Hispanic Whites (Ref)	1.0	1.0
County median household annual income quartile, $		
≤30 365	1.5 (1.1, 2.0)	1.6 (1.2, 2.1)
30 366–36 238	1.3 (1.1, 1.6)	1.0 (0.9, 1.3)
36 239–42 102	1.8 (1.6, 2.0)	1.7 (1.5, 1.9)
≥42 103 (Ref)	1.0	1.0

Note. CI = confidence interval; RR = risk ratio.

Risk Factors for Death

Univariate logistic regression analysis indicated that the following characteristics were significantly correlated with death: age group 65 years or older (OR=4.9; 95% CI=1.6,

TABLE 3—Unadjusted Characteristics of Increased Severity of 2009 Pandemic Influenza A (H1N1) Illness Among Hospitalized Patients: New Mexico, September 14, 2009–January 13, 2010

Risk Factor	Mechanical Ventilation, OR (95% CI)	Death, OR (95% CI)
Age group, y		
Birth–4	0.1 (0.03, 0.6)	0.3 (0.03, 2.3)
5–24 (Ref)	1.0	1.0
25–49	3.6 (2.0, 6.5)	2.6 (0.9, 7.5)
50–64	2.9 (1.5, 5.5)	3.0 (1.0, 9.3)
≥65	2.2 (1.1, 4.7)	4.9 (1.6, 14.9)
Gender		
Male	1.1 (0.7, 1.6)	2.0 (1.01, 4.2)
Female (Ref)	1.0	1.0
Race/ethnicity		
American Indian	1.7 (1.0, 2.7)	0.9 (0.4, 2.1)
All other groups (Ref)	1.0	1.0
County median household annual income quartile, $		
≤30 365	0.4 (0.1, 1.7)	. . .
30 366–36 238	0.9 (0.5, 1.6)	0.9 (0.3, 2.4)
36 239–42 102	0.4 (0.2, 0.6)	0.6 (0.3, 1.4)
≥42 103 (Ref)	1.0	1.0
Rurality of residence[a]		
Large rural	0.8 (0.5, 1.3)	0.6 (0.3, 1.5)
Small rural	0.7 (0.3, 1.6)	0.2 (0.03, 1.8)
Isolated	1.2 (0.6, 2.5)	0.6 (0.1, 2.6)
Urban (Ref)	1.0	1.0
Pregnancy status[b]		
Pregnant	0.1 (0.01, 0.7)	. . .
Not pregnant (Ref)	1.0	1.0
Obesity status		
Obese (by BMI only)	1.6 (0.9, 2.6)	0.6 (0.2, 1.4)
Obese (by BMI and medical record text)	1.9 (1.2, 2.9)	0.9 (0.5, 1.9)
Not obese (Ref)	1.0	1.0
High-risk medical condition		
Any high-risk medical condition	1.5 (0.9, 2.3)	2.1 (0.9, 4.7)
Asthma	0.7 (0.4, 1.1)	0.5 (0.2, 1.3)
Other chronic lung disease	1.8 (1.1, 3.0)	1.6 (0.7, 3.6)
Chronic cardiovascular disease	1.7 (1.1, 2.8)	3.0 (1.5, 6.1)
Diabetes	1.5 (0.9, 2.5)	2.0 (1.0, 4.3)
Other chronic metabolic disease	1.4 (0.7, 2.8)	1.2 (0.3, 3.8)
Cancer occurrence during previous 12 mo	3.3 (1.3, 8.0)	9.2 (3.4, 24.8)
Renal disease	1.7 (0.9, 3.4)	1.8 (0.6, 5.1)
Neurological disease	1.9 (1.1, 3.3)	2.0 (0.8, 4.7)
Immunosuppression	2.4 (1.4, 4.3)	1.3 (0.4, 3.8)
Liver disorder	1.4 (0.5, 3.8)	8.2 (3.3, 20.7)
No high-risk medical condition (Ref)	1.0	1.0
Treatment with neuraminidase antiviral		

Continued

14.9), male gender (OR=2.0; 95% CI=1.01, 4.2), experiencing cardiovascular disease (OR=3.0; 95% CI=1.5, 6.1), occurrence of cancer during the previous 12 months (OR=9.2; 95% CI=3.4, 24.8), having a liver disorder (OR=8.2; 95% CI=3.3, 20.7), or treatment with a neuraminidase antiviral 3 or more days after illness onset (OR=3.6; 95% CI=1.3, 9.9). After adjustment with multivariate logistic regression analysis, only male gender (OR=2.2; 95% CI=1.003, 4.9), cancer during the previous 12 months (OR=6.1; 95% CI=1.6, 23.0), or having a liver disorder (OR=7.3; 95% CI=2.5, 21.0) remained significant. Race/ethnicity was not associated with death.

DISCUSSION

In this analysis, Poisson regression results revealed that the rate of pandemic H1N1–related hospitalization in New Mexico was significantly higher for AIs than for non-Hispanic Whites. Higher rates of disease severity among AIANs have been noted previously in the literature, although the reasons for these differences have not been clearly elucidated.[1,14,15] Rate ratios of hospitalization were also higher for Hispanics and Blacks than they were for non-Hispanic Whites, although lower than they were for AIs. Race/ethnicity was significantly associated with mechanical ventilation only when obesity was not included in the model. In-hospital death was not associated with race/ethnicity. Previous studies have surmised that AIANs might have higher rates of influenza-related hospitalization and death as a result of higher baseline rates of underlying chronic medical conditions (e.g., diabetes), which can contribute to more severe disease.[1,4,15] Among hospitalized persons in New Mexico, AIs had lower overall presence of chronic medical conditions than did other racial/ethnic groups. This was an unexpected finding, and the reason was unclear.

We also evaluated mean times between illness onset, seeking care, and receiving antivirals. We identified no statistically significant differences between racial/ethnic groups. Overall proportions of antiviral use among those hospitalized in New Mexico were similar to antiviral use among hospitalized US[16] and California cohorts.[17] Among the New Mexico

TABLE 3—*Continued*

Not treated	1.3 (0.7, 2.5)	2.6 (0.9, 7.9)
Treated ≥3 d from illness onset	3.6 (2.1, 6.1)	3.6 (1.3, 9.9)
Treated ≤2 d from illness onset (Ref)	1.0	1.0
1-d increase in time interval from illness onset to seeking medical care	1.1 (1.02, 1.2)	1.1 (0.9, 1.2)
Distance from residence zip code to hospital zip code, miles[c]		
>0 to <6.35	1.0 (0.5, 1.9)	0.4 (0.1, 1.4)
≥6.35 to <13.3	1.1 (0.6, 2.0)	1.1 (0.5, 2.4)
≥13.3	1.3 (0.7, 2.3)	0.5 (0.2, 1.5)
0 (Ref)	1.0	1.0

BMI = body mass index; CI = confidence interval; OR = odds ratio. Ellipses indicate that an estimate was not calculated because no events occurred among exposure group.
[a]The Rural Urban Commuting Area codes for 2000, based on zip code, were used to assign a measure of rurality.[11]
[b]Females aged 11–50 years.
[c]"0 miles" indicates that residence was in the same zip code as the hospital. For residences that were not in same zip code as the hospital, straight-line distances were derived by a SAS (SAS Institute, Cary, NC) function that calculated distance based on the centroid for the zip codes.

cohort, antiviral timing was independently associated with mechanical ventilation and death. In Canada, receipt of antivirals 3 or more days after illness onset was found to be a predictor of disease severity, as defined by admission into an intensive care unit.[15]

Extremes of age have commonly been cited as risk factors for complications from influenza.[11,17–19] In this study, age was significantly associated with hospitalization and mechanical ventilation. Younger age groups were associated with hospitalization, whereas older age groups were associated with mechanical ventilation. These findings are similar to those of other studies of pandemic H1N1 risk based on age.[17–19] Young children might be most vulnerable to acquiring infection on the basis of hygiene habits, lower immunity to infection because of a lack of previous exposure to the virus or similar viruses,[20] longer duration of virus shedding,[21] increased transmission,[22] and increased exposure in child care and social settings. Older persons might be more likely to become the most severely ill because of the presence and longer duration of underlying medical conditions.[23] These findings differ from patterns of transmission for seasonal influenza in that this pandemic disproportionately affected adolescents and younger adults.

In addition to age, the presence of high-risk underlying medical conditions has been reported to play a critical role in the severity and outcome of influenza disease.[15–19,24] In New Mexico, hospitalized persons and those who died during hospitalization had high-risk medical conditions in proportions similar to those found in other studies; these conditions included the presence of any high-risk medical condition and of specific risk factors (e.g., diabetes, cardiovascular disease, and asthma).[1,16,17] This analysis did not identify any high-risk factors or conditions, apart from age group, as being independently associated with mechanical ventilation. The need for mechanical ventilation is probably multifactorial and complex. For example, it might be related to living conditions such as exposure to wood smoke, smoking history, secondary smoke exposure, or history of need for mechanical ventilation with prior respiratory illnesses. Of the high-risk medical conditions, only cancer during the previous 12 months and liver disease were independently associated with death. The strong associations seen with cancer in the last 12 months and liver disease, conditions that possibly represent more compromised health status, suggest that more severe chronic disease is an important determinate of outcome among H1N1 patients.

When we used both BMI and medical record text for classification, obesity was independently associated with mechanical ventilation. However, obesity was not significantly associated with mechanical ventilation when determined by BMI alone. In light of the association detected with a more sensitive obesity classification method, this result could reflect a lack of statistical power given the large number of patients without BMI data available. Obesity was not associated with death by either classification. A US cohort study identified morbid obesity as being associated with H1N1-related hospitalization and identified obesity and morbid obesity as being associated with death among persons aged 20 years and older.[24] Although our study did not directly evaluate obesity as a risk factor for hospitalization, 51% of hospitalized New Mexico patients aged 18 years or older were categorized as obese on the basis of BMI alone, which is nearly twice the 26% prevalence of obesity reported among New Mexico adults by the 2008 Behavioral Risk Factor Surveillance System.[25] The percentage of hospitalized patients aged 18 years or older categorized as obese or morbidly obese was similar to that in other studies.[16,17]

Limitations and Strengths

Limitations of this analysis include the fact that data were collected for surveillance purposes and therefore were not as extensive as data collected for a specific study objective. Underreporting and undertesting might have limited our ability to identify cases. We only approximated SES using median household income by county of residence. This approximation limited our ability to measure associations between influenza-related hospitalization and death and important socioeconomic elements (e.g., education level, specific household income, and health insurance coverage).

Although we attempted to measure geographic access to medical care by straight-line distance, this measure might be influenced by other factors such as driving distance and time.[26,27] Racial/ethnic misclassification was possible as study investigators were unable to verify the methods used in each facility for obtaining racial/ethnic information. In addition, absence of documented underlying comorbidities, including obesity, was recorded as an absence of the condition. There was the potential for misclassification of these conditions. Lack of complete BMI data and overall limited number of deaths might have reduced the power to detect racial/ethnic differences for the outcomes of mechanical ventilation and death. It is also possible that racial/ethnic differences do not exist for these outcomes.

TABLE 4—Adjusted Characteristics of Increased Severity of 2009 Pandemic Influenza A (H1N1) Illness Among Hospitalized Patients: New Mexico, September 14, 2009–January 13, 2010

	Mechanical Ventilation, OR (95% CI)		
Risk Factor	Model 1 (n = 596)	Model 2 (n = 733)	Death, OR (95% CI)
Age group, y			
Birth–4	0.7 (0.2, 3.7)	0.2 (0.04, 0.9)	0.3 (0.03, 2.2)
5–24 (Ref)	1.0	1.0	1.0
25–49	2.9 (1.3, 6.6)	2.6 (1.2, 5.5)	1.5 (0.5, 4.9)
50–64	3.1 (1.3, 7.6)	2.5 (1.1, 5.9)	1.5 (0.4, 5.3)
≥65	3.0 (1.1, 8.3)	2.0 (0.8, 5.3)	2.6 (0.7, 9.5)
Gender (model 1)[a]			
Male	1.1 (0.6, 1.8)	. . .[a]	2.2 (1.003, 4.9)
Female	1.0	. . .[a]	1.0
Gender (model 2)[a]			
Male	. . .[a]	0.9 (0.5, 1.5)	. . .[a]
Female, pregnant	. . .[a]	0.3 (0.03, 2.3)	. . .[a]
Female, nonpregnant	. . .[a]	1.0	. . .[a]
Race/ethnicity			
American Indian	1.9 (0.9, 3.8)	2.1 (1.1, 4.1)	1.0 (0.4, 2.6)
All other groups (Ref)	1.0	1.0	1.0
Median household annual income quartile, $			
≤30 365	1.2 (0.2, 6.3)	1.0 (0.2, 4.6)	. . .[b]
30 366–36 238	0.6 (0.3, 1.2)	0.6 (0.3, 1.4)	. . .[b]
36 239–42 102	0.6 (0.3, 1.4)	0.6 (0.3, 1.1)	. . .[b]
≥42 103 (Ref)	1.0	1.0	1.0
Obesity status			
Obese (by BMI and medical record text)	2.1 (1.2, 3.8)	. . .[c]	. . .[b]
Not obese (Ref)	1.0	1.0	1.0
High-risk medical condition			
Asthma	0.6 (0.3, 1.1)	0.7 (0.4, 1.2)	. . .[b]
Other chronic lung disease	1.7 (0.9, 3.3)	1.9 (0.9, 3.6)	. . .[b]
Chronic cardiovascular disease	1.0 (0.5, 1.9)	1.2 (0.6, 2.4)	1.2 (0.5, 3.0)
Diabetes	0.8 (0.4, 1.5)	0.8 (0.4, 1.5)	1.2 (0.5, 2.9)
Cancer occurrence during previous 12 mo	0.8 (0.2, 3.6)	1.2 (0.3, 4.5)	6.1 (1.6, 23.0)
Neurological disease	1.5 (0.7, 3.2)	1.3 (0.6, 2.9)	. . .[b]
Immunosuppression	2.0 (0.9, 4.4)	1.5 (0.7, 3.2)	. . .[b]
Liver disorder	. . .[b]	. . .[b]	7.3 (2.5, 21.0)
No high-risk medical condition (Ref)	1.0	1.0	1.0
Neuraminidase treatment			
Not treated	2.8 (1.1, 7.3)	1.8 (0.8, 4.3)	2.1 (0.7, 6.7)
Treated ≥3 d from illness onset	7.0 (3.0, 16.0)	4.6 (2.1, 9.6)	2.7 (0.9, 7.6)
Treated ≤2 d from onset (Ref)	1.0	1.0	1.0
1-d increase in time interval from illness onset to seeking medical care	1.0 (0.9, 1.1)	1.0 (0.9, 1.1)	. . .[b]

Note. BMI = body mass index; CI = confidence interval; OR = odds ratio.

[a]Given the substantial number of records missing obesity classification even after BMI and medical record text were combined, we considered 2 multivariate logistic regression models, 1 that included obesity as a covariate (model 1) and 1 that did not (model 2). Gender is represented as 3 categories in mechanical ventilation model 2 because pregnancy variable reached statistical significance level for inclusion in multivariate model. Gender is represented as 2 categories in (1) mechanical ventilation model 1 because inclusion of obesity variable resulted in exclusion of all pregnant women and in (2) death model because no deaths occurred among pregnant women.

[b]Variable did not reach statistical significance level ($P = .1$) for inclusion in multivariate model.

[c]Excluded to investigate other risk factors among larger proportion of study population.

Lack of a standardized population-based data source for obesity for all individuals aged 2 years and older precluded the ability to control for obesity in the H1N1-related hospitalization analysis. Controlling for obesity might have reduced the racial/ethnic differences that were found for H1N1-related hospitalization. Finally, differences by race/ethnicity in H1N1-related hospitalizations might be a partial proxy for another factor, such as poverty, which is a well-established risk factor for adverse health outcomes.[28–31]

The strengths of this analysis include our ability to use population-based surveillance data, which allowed the results to be more generalizable. Statewide participation in the surveillance effort and regular follow-up by NMDOH ensured more comprehensive data collection. Furthermore, external validity is supported by the inclusion of all age groups and racial/ethnic groups. External validity is also strengthened by our findings of higher hospitalization rates for AIs than for non-Hispanic Whites and of proportions of high-risk factors and antiviral use similar to those reported in other studies.

Conclusions

Although AI race was independently associated with pandemic H1N1–related hospitalization, mechanical ventilation and in-hospital death were not significantly associated with race/ethnicity. This analysis supports recent national efforts to include AIAN race as a group at high risk for complications of influenza with respect to vaccination and antiviral treatment recommendations.[32,33] Future studies should include more thorough evaluation of underlying medical conditions (including obesity), access to medical care (including geographic proximity), and socioeconomic factors at an individual level, which could yield key information regarding risk factors for severe H1N1 outcomes. In addition, future studies might compare characteristics and risk factors for severe H1N1 illness outcomes between states or regions within the United States, particularly among racial/ethnic groups. ■

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Human Participant Protection

This work was not considered to be human participation research and was conducted with information obtained in the course of public health practice and surveillance for a notifiable condition.

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