Influenza Hospitalizations Among American Indian/Alaska Native People and in the United States General Population

Prabhu P. Gounder,[1] **Laura S. Callinan,**[2,a] **Robert C. Holman,**[2] **Po-Yung Cheng,**[3] **Michael G. Bruce,**[1] **John T. Redd,**[4] **Claudia A. Steiner,**[5] **Joseph Bresee,**[3] **and Thomas W. Hennessy**[1]

[1]Arctic Investigations Program, Division of Preparedness and Emerging Infections, National Center for Zoonotic and Emerging Infectious Diseases, Centers for Disease Control and Prevention, Anchorage, Alaska; [2]Division of High-Consequence Pathogens and Pathology, National Center for Zoonotic and Emerging Infectious Diseases; [3]Influenza Division, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia; [4]Indian Health Service, Santa Fe, New Mexico; [5]Healthcare Cost and Utilization Project, Center for Delivery, Organizations, and Markets, Agency for Healthcare Research and Quality, US Department of Health and Human Services, Rockville, Maryland

Background. Historically, American Indian/Alaska Native (AI/AN) people have experienced a disproportionate burden of infectious disease morbidity compared with the general US population. We evaluated whether a disparity in influenza hospitalizations exists between AI/AN people and the general US population.

Methods. We used Indian Health Service hospital discharge data (2001–2011) for AI/AN people and 13 State Inpatient Databases (2001–2008) to provide a comparison to the US population. Hospitalization rates were calculated by respiratory year (July–June). Influenza-specific hospitalizations were defined as discharges with any influenza diagnoses. Influenza-associated hospitalizations were calculated using negative binomial regression models that incorporated hospitalization and influenza laboratory surveillance data.

Results. The mean influenza-specific hospitalization rate/100 000 persons/year during the 2001–2002 to 2007–2008 respiratory years was 18.6 for AI/AN people and 15.6 for the comparison US population. The age-adjusted influenza-associated hospitalization rate for AI/AN people (98.2; 95% confidence interval [CI], 51.6–317.8) was similar to the comparison US population (58.2; CI, 34.7–172.2). By age, influenza-associated hospitalization rates were significantly higher among AI/AN infants (<1 year) (1070.7; CI, 640.7–2969.5) than the comparison US infant population (210.2; CI, 153.5–478.5).

Conclusions. American Indian/Alaska Native people had higher influenza-specific hospitalization rates than the comparison US population; a significant influenza-associated hospitalization rate disparity was detected only among AI/AN infants because of the wide CIs inherent to the model. Taken together, the influenza-specific and influenza-associated hospitalization rates suggest that AI/AN people might suffer disproportionately from influenza illness compared with the general US population.

Keywords. American Indian; epidemiology; healthcare disparities; influenza.

American Indian/Alaska Native (AI/AN) people have historically suffered from a higher burden of infectious disease morbidity and mortality compared with the

general US population [1–3]. The AI/AN age-adjusted death rate for pneumonia and influenza, the leading infectious disease cause of death in the United States, is 1.5 times higher than the rate among all US races [4, 5]. The rate of hospitalizations with pneumonia were reported to be higher for AI/AN children during 2006–2008 and for older AI/AN adults during 2000–2002, specifically for the Alaska and Southwest regions, than the corresponding rate for the general US population [6, 7]. Reasons put forth for this disparity include living conditions that facilitate transmission of infectious agents (eg, household crowding, inadequate water, and sanitation), poverty, and high prevalence of

underlying diseases (eg, diabetes, obesity, and cardiovascular disease) associated with more severe infections [8–11]. Within AI/AN communities, certain groups, such as the elderly, might be especially susceptible to infections [12].

Seasonal influenza-associated mortality in the United States is variable and ranged from 3000–49 000 deaths during 1976 through 2007 [13]. However, the proportion of these deaths occurring among AI/AN people is unknown, and death certificate data are likely to underestimate the true AI/AN mortality rate because of misclassification of race [14]. Because influenza is associated with a large number of hospitalizations, assessing influenza hospitalization rates can provide a better understanding of the health burden associated with severe influenza infection in this population [15].

Determining the number of influenza-related hospitalizations by using administrative data (eg, insurance claims, hospital discharge records) is difficult; limitations include clinicians not recognizing influenza, insensitivity of diagnostic tests, discordance between administrative documentation and clinical outcomes, and hospitalization for secondary complications after influenza infection resolution [16–20]. Therefore, we used previously described statistical models to estimate the influenza-associated hospitalization rate among AI/AN people [21]. To evaluate influenza hospitalization rate disparities, we compared hospitalization rates for AI/AN people with that for the overall US population.

Methods

We analyzed hospital discharge data for AI/AN persons using the Indian Health Service (IHS) National Data Warehouse (NDW) Direct and Contract Health Care Inpatient data for 2001–2011 [22]. The data are reported from IHS-operated and tribally operated hospitals and community hospitals contracted to provide healthcare by IHS or local tribes [23]. Approximately 57% of self-identified AI/AN persons live in geographic areas serviced by IHS/tribal direct or contract healthcare facilities, although they may or may not use those services [4]. For that reason, the IHS user populations—defined as AI/AN persons that were enrolled with IHS and received healthcare at an IHS/tribal direct or contract healthcare facility during the previous 3 years—adjusted proportionately to respiratory years served as the denominators for the AI/AN population [21]. The IHS administers healthcare services through 12 regional Area Offices [4]. The California and Portland Areas were excluded from analysis because no IHS or tribally operated hospitals exist in that region. Furthermore, services provided by contract hospitals in the California Area are not reported by inpatient diagnoses, and limited contract services are provided in the Portland Area.

For the general US population, hospitalization data were obtained from the State Inpatient Databases (SIDs). The SIDs are among a group of databases managed by the Healthcare Cost and Utilization Project (HCUP) in the Agency for Healthcare Research and Quality, a Federal-State-Industry partnership [24]. The SIDs contain all encounter-level hospital discharge records from participating hospitals in up to 46 states, including hospitals providing contract healthcare for IHS. Data from IHS/tribal hospitals are not included in the SIDs. For the present study, SIDs data were available from 2001 to 2008 for 13 states (Arizona, California, Colorado, Iowa, Illinois, Kansas, Massachusetts, Maryland, New Jersey, Oregon, South Carolina, Washington, and Wisconsin), representing 40% of the US population; these data had been compiled through a collaboration with HCUP for a previous study estimating influenza hospitalizations in the United States [21]. We will refer to these data as the comparison US population. Annual overall and age-specific 2001–2008 population estimates for these states were obtained from the US Census Bureau and were adjusted to respiratory years [25].

National influenza viral data for 2001–2008 were collected by World Health Organization Collaborating Laboratories and National Respiratory and Enteric Virus Surveillance System laboratories participating in influenza surveillance throughout the United States [26, 27]. In the present study, we used previously reported weekly number of influenza tests performed (viral culture, real-time polymerase chain reaction, and antigen detection) and the proportion of positive tests by type or subtype [21]. The surveillance data indicate that influenza virus predominantly circulates in the winter months and across calendar years. Therefore, as done in previous influenza studies, we defined each respiratory year as starting in July and ending in June of the following year to encompass the entire influenza season [13, 21].

Annual influenza-specific hospitalization rates were calculated by respiratory year for the AI/AN population by using data from the IHS NDW during 2001–2011 and for the comparison US population by using data from the HCUP SID for the 13 states during 2001–2008. The unit of analysis in the present study is a hospitalization, so repeated hospitalizations by the same individual would be counted as separate hospitalizations. We determined influenza-specific hospitalization rates by calculating the number of hospital discharge records with an *International Disease Classification, Ninth Revision, Clinical Modification* (ICD-9-CM) code for influenza (codes 487–488) listed as any of the diagnoses per 100 000 persons for the respective populations [28]. We analyzed data by 5 age categories: infants (<1 year), 1–4, 5–49, 50–64, and ≥65 years.

To estimate the excess hospitalizations associated with influenza that were not identified by the ICD-9-CM-coded data, we used negative binomial regression models as described by Zhou et al [21]. After excluding the influenza-specific hospitalizations, we fit age-specific negative binomial regression models to the weekly number of hospitalizations with a primary

(ie, first-listed) respiratory and circulatory diagnosis (ICD-9-CM codes 390–519) in the IHS NDW and in the 13 states in HCUP SID. The model also excluded hospitalizations with first-listed discharge codes for respiratory syncytial virus (RSV) bronchiolitis or RSV pneumonia (ICD-9-CM codes 466.11, and 480.1, respectively) to minimize confounding by RSV, which circulates during the same time of the year as influenza. The models included covariates for the proportion of respiratory specimens testing positive for influenza A subtypes H1N1 and H3N2 and influenza B. To estimate excess hospitalizations associated with influenza, we took the difference between hospitalizations predicted by using a full model that incorporated all viral terms and the expected baseline, where the baseline represented a model in which a viral covariate was set to 0. The full model included terms for time trends and seasonal variation and can be written as follows:

$$Y_{age}(i) = \alpha \exp \left\{ \beta_0 + \beta_1[t_i] + \beta_2[t_i^2] + \beta_3[t_i^3] + \beta_4\left[\sin\left(\frac{2t_i\pi}{52.15}\right)\right] \right.$$
$$+ \beta_5\left[\cos\left(\frac{2t_i\pi}{52.15}\right)\right] + \beta_6[A(H1N1)] + \beta_7[A(H3N2)]$$
$$\left. + \beta_8[B] \right\}$$

where $Y_{age}(i)$ represented the number of hospitalizations during a particular week i in each age group, α was the offset term and was equal to the log of the population size in each age group, and β_6 through β_8 represented coefficients associated with the standardized specimens testing positive during a given week. Secular time trends were represented by linear, quadratic, and cubic polynomial terms. The circulating influenza type and subtypes were assumed to be independent within and between respiratory years. The total number of influenza-associated hospitalizations for a respiratory year was the sum of the respiratory year influenza-specific hospitalizations (ie, hospitalizations with any-listed ICD-9-CM code for influenza) and the modeled estimate of excess hospitalizations associated with influenza. The 95% confidence intervals (CIs) were calculated from the model variance for the predicted values from the regression models; we assumed there was no uncertainty in the sum of the influenza-specific hospitalizations. The 95% CIs were used to assess for significant rate differences between groups [21]. Overall estimated influenza-associated age-adjusted hospitalization rates were calculated by direct standardization with the age-specific US 2000 intercensal census population [29]. To estimate the proportion of influenza-associated hospitalizations captured by ICD-9-CM-coded data alone, we divided the influenza-specific hospitalization rate by the influenza-associated hospitalization rate.

In the present study, we will refer to (1) influenza hospitalization rates calculated by using ICD-9-CM-coded data as influenza-specific rates (codes 487–488) and (2) rates estimated by incorporating the negative binomial regression models as influenza-associated rates. All hospitalization rates will be presented in terms of hospitalizations per 100 000 persons per year.

RESULTS

The mean annual influenza-specific hospitalization rate among AI/AN people during the 2001–2002 through 2007–2008 respiratory years was 18.6/100 000/year (range, 8.3–25.4) (Table 1). The mean annual influenza-specific hospitalization rate in the comparison US population was 15.6 (range, 5.2–28.8) (Table 2). For both AI/AN people and the US population, infants had the highest mean influenza-specific hospitalization rate followed by adults aged ≥65 years. For primary respiratory and circulatory-coded hospitalizations, adults aged ≥65 years had the highest mean rates followed by infants for the US population, whereas among the AI/AN population, infants had the highest mean rate followed by adults aged ≥65 years (Tables 1 and 2). Among all ages, the mean primary respiratory and circulatory-coded hospitalization rate was lower for AI/AN people (mean, 1310.2; range, 1248.4–1380.4) compared with the US population (mean, 2689.1; range, 2436.2–2872.1).

The point estimate for the mean age-adjusted influenza-associated hospitalization rate estimated by using the regression models for AI/AN people was 98.2 (95% CI, 51.6–317.8), compared with the US population (mean, 58.2; 95% CI, 34.7–172.2); the difference was not statistically significant (Table 3). By age group, the difference in mean influenza-associated hospitalization rate was significant only among infants; AI/AN infants had a hospitalization rate (mean, 1070.7; 95% CI, 640.7–2969.5) 5 times the US infant population rate (mean, 210.2; 95% CI, 153.5–478.5). The highest point estimate for the mean age-adjusted influenza-associated hospitalization rate during 2001–2008 occurred in the 2003–2004 respiratory year for both the AI/AN (mean, 126.7) and US populations (mean, 82.4). Compared with the influenza-associated hospitalizations estimated by using the regression models, ICD-9-CM influenza-coded data generally captured a smaller proportion of the hospitalizations among AI/AN people compared with the US population, especially among children aged <5 years (Table 4).

DISCUSSION

The overall influenza-specific hospitalization rate among AI/AN people and influenza-associated hospitalization rate among AI/AN infants were higher than the comparison US population. Taken together, our data indicate a trend toward AI/AN people experiencing a disproportionate burden of hospitalizations from influenza illness compared with the general US population. Although the AI/AN population had grown twice as fast as the US general population in the previous decade [30], to our knowledge, the burden of influenza hospitalizations

Table 1.   Influenza-Specific Diagnosis and ICD9-CM-Coded Respiratory and Circulatory Diagnosis Hospitalization Rates Among American Indian and Alaska Native Persons, IHS, 2001–2011*

Year[a]	Influenza (Any-Listed) by Age Group, y[b]						Respiratory and Circulatory (Primary) by Age Group, y[c]					
	<1	1–4	5–49	50–64	≥65	All Ages	<1	1–4	5–49	50–64	≥65	All Ages
2001-2002	218.8	33.1	4.6	12.8	36.6	13.1	10506.5	1680.3	440.7	3015.3	7292.5	1373.1
2002-2003	126.0	16.2	3.9	13.8	12.3	8.3	9614.2	1568.4	431.9	2911.8	7013.7	1328.8
2003-2004	377.5	52.6	10.6	28.6	72.6	25.4	9945.3	1743.5	441.3	2942.2	7149.8	1380.4
2004-2005	181.4	30.0	5.6	21.3	79.8	16.8	8127.9	1577.3	427.2	2775.8	6700.7	1301.2
2005-2006	389.8	50.4	6.1	18.2	66.0	21.0	8004.4	1607.4	418.3	2606.1	6531.2	1284.0
2006-2007	614.3	63.3	4.7	8.0	30.8	21.2	6762.1	1461.2	410.6	2476.3	6507.6	1248.4
2007-2008	530.7	53.4	6.7	21.7	61.7	24.2	8263.9	1488.7	420.3	2351.7	6143.4	1255.6
Mean[d]	*348.4*	*42.7*	*6.0*	*17.8*	*51.4*	*18.6*	*8746.3*	*1589.5*	*427.2*	*2725.6*	*6762.7*	*1310.2*
2008-2009	455.3	57.1	5.8	7.9	23.2	18.2	6922.2	1288.9	367.0	2121.8	5311.3	1103.8
2009-2010	917.4	132.9	51.2	87.0	88.2	77.0	9141.0	1594.4	433.0	2199.2	5424.8	1231.0
2010-2011	476.7	56.2	9.2	25.2	87.8	26.8	6832.6	1221.0	336.5	1943.7	5160.3	1057.9

Abbreviations: ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*; IHS, Indian Health Service.

[a] Respiratory year is July through June.

[b] ICD-9-CM codes 487 and 488 listed among any of the discharge diagnoses.

[c] ICD-9-CM codes 390–519 as a first-listed (primary) discharge diagnosis.

[d] Mean for respiratory years period of 2001–2002 through 2007–2008 to correspond with period of data available for the State Inpatient Database data.

* Source: Indian Health Service. Direct/Contract Health Service inpatient data, fiscal years 2001–2011. Albuquerque, NM: Indian Health Service, 2012. Data are rates of discharges per 100 000 persons calculated by using IHS user population for each respiratory year as the denominator. The unit of analysis is a hospitalization, so multiple hospitalizations for the same individual would be counted as separate hospitalizations.

among this rapidly growing population has not been evaluated nationally. By understanding the impact of influenza infections on AI/AN people, a population considered vulnerable because of certain socioeconomic and environmental risk factors, policymakers should be informed regarding seasonal epidemic and pandemic influenza preparedness and response [12].

The mean influenza-specific hospitalization rate for all ages during the 2001–2002 to 2007–2008 respiratory years was higher among AI/AN people (18.6) than the comparison US population (15.6) during 2001–2008. However, the mean age-adjusted influenza-associated hospitalization rates were similar between the 2 populations because the 95% CIs for the

Table 2.   Influenza-Specific Diagnosis and ICD9-CM-Coded Respiratory and Circulatory Diagnosis Hospitalization Rates for the Comparison US Population, Using 13 State Inpatient Databases, 2001–2008*

Year[a]	Influenza (Any-Listed) by Age Group, y[b]						Respiratory and Circulatory (Primary) by Age Group, y[c]					
	<1	1–4	5–49	50–64	≥65	All Ages	<1	1–4	5–49	50–64	≥65	All Ages
2001-2002	79.5	22.9	3.7	6.5	26.4	8.9	4718.9	1266.7	631.8	3778.6	14284.4	2807.8
2002-2003	55.9	14.3	2.8	3.6	10.0	5.2	4553.2	1261.1	644.2	3715.6	13825.0	2760.0
2003-2004	278.7	83.8	9.3	18.7	95.1	28.8	4685.8	1336.0	669.3	3789.9	14364.5	2872.1
2004-2005	106.5	25.2	5.9	16.4	87.9	19.8	4093.0	1194.2	653.6	3693.0	13957.9	2800.3
2005-2006	135.8	27.0	5.1	10.6	55.6	15.0	3961.7	1152.3	625.1	3432.8	12880.4	2627.2
2006-2007	100.8	22.6	3.9	6.2	21.5	8.8	3623.1	990.2	534.2	3199.5	12005.9	2436.2
2007-2008	167.6	34.8	8.1	18.4	84.3	22.9	3839.2	1100.9	555.3	3251.2	12194.6	2519.8
Mean	*132.1*	*32.9*	*5.5*	*11.5*	*54.4*	*15.6*	*4210.7*	*1185.9*	*616.2*	*3551.5*	*13359.0*	*2689.1*

Abbreviations: ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

[a] Respiratory year is July through June.

[b] ICD-9-CM codes 487 and 488 listed among any of the discharge diagnoses.

[c] ICD-9-CM codes 390–519 as a first-listed (primary) discharge diagnosis.

* Source: Healthcare Cost and Utilization Project. Overview of the State Inpatient Databases. Available at: http://www.hcup-us.ahrq.gov/sidoverview.jsp. Accessed 1 April 2013. Data are rates of discharges per 100 000 persons calculated by using US Census Bureau population estimates for each influenza season as the denominator; the unit of analysis is a hospitalization, so repeated hospitalizations by the same individual would be counted as separate hospitalizations.

Table 3. Influenza-Associated Hospitalization Rates for the American Indian and Alaska Native Persons and Comparison US Populations, IHS, and 13 State Inpatient Databases, 2001–2008*

Year[a]	Aged <1 y		Aged 1–4 y		Aged 5–49 y		Aged 50–64 y		Aged ≥65 y		All Ages[b]	
	AI/AN	US	AI/AN	US	AI/AN	US	AI/AN	US	AI/AN	US	AI/AN	US
2001-2002	913.4	155.4	170.6	28.3	20.4	14.2	126.1	61.0	356.2	284.3	98.3	57.5
2002-2003	1413.4	173.4	265.6	15.1	19.3	15.3	115.5	47.4	215.4	177.0	90.5	42.4
2003-2004	997.8	356.7	206.2	92.0	29.8	18.9	146.9	75.8	484.5	392.0	126.7	82.4
2004-2005	601.3	162.1	137.0	30.3	22.9	20.1	140.9	79.4	403.0	375.0	101.9	75.6
2005-2006	774.6	184.3	149.1	30.6	18.1	13.2	95.9	49.9	290.8	239.6	81.1	50.1
2006-2007	1510.5	190.5	276.7	23.3	14.8	8.9	61.0	26.0	168.1	102.8	75.4	26.4
2007-2008	1283.8	248.7	230.6	38.2	26.2	21.7	138.8	76.4	366.5	336.7	113.6	73.0
Minimum	601.3	155.4	137.0	15.1	14.8	8.9	61.0	26.0	168.1	102.8	75.4	26.4
Maximum	1510.5	356.7	276.7	92.0	29.8	21.7	146.9	79.4	484.5	392.0	126.7	82.4
Mean	**1070.7**	**210.2**	205.1	36.8	21.6	16.1	117.9	59.4	326.3	272.5	98.2	58.2
95% CI	**640.7–2969.5**	**153.5–478.5**	112.9–627.9	32.9–187.2	10.8–72.8	9.3–49.0	52.8–432.9	30.9–196.4	175.3–1049.8	160.9–755.0	51.6–317.8	34.7–172.2

Abbreviations: AI/AN, American Indian/Alaska Native; CI, confidence interval; IHS, Indian Health Service.

[a] Respiratory year is July through June.

[b] Standardized with 2000 intercensal census population for each age group.

* Source: Indian Health Service. Direct/Contract Health Service inpatient data, fiscal years 2001–2011. Albuquerque, NM: Indian Health Service, 2012. Healthcare Cost and Utilization Project. Overview of the State Inpatient Databases. Available at: http://www.hcup-us.ahrq.gov/sidoverview.jsp. Accessed 1 April 2013. Data are rates of discharges per 100 000 persons of corresponding group. Statistically significant differences in mean influenza-associated hospitalization rates between AI/AN persons and comparison US populations are indicated in bold.

Table 4. Any-Listed ICD-9-CM-Coded Influenza Hospitalizations as a Proportion of the Influenza Hospitalizations Estimated by the Model for the American Indian and Alaska Native and Comparison US Populations, IHS, and 13 State Inpatient Databases, 2001–2008*

Year[a]	Aged <1 y		Aged 1–4 y		Aged 5–49 y		Aged 50–64 y		Aged ≥65 y	
	AI/AN	US	AI/AN	US	AI/AN	US	AI/AN	US	AI/AN	US
2001-2002	24%	51%	19%	81%	23%	26%	10%	11%	10%	9%
2002-2003	9%	32%	6%	95%	20%	18%	12%	8%	6%	6%
2003-2004	38%	78%	26%	91%	36%	49%	19%	25%	15%	24%
2004-2005	30%	66%	22%	83%	24%	29%	15%	21%	20%	23%
2005-2006	50%	74%	34%	88%	34%	39%	19%	21%	23%	23%
2006-2007	41%	53%	23%	97%	32%	44%	13%	24%	18%	21%
2007-2008	41%	67%	23%	91%	26%	37%	16%	24%	17%	25%

Abbreviation: AI/AN, American Indian/Alaska Native; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*; IHS, Indian Health Service.

[a] Respiratory year is July through June.

* Sources: Indian Health Service. Direct/Contract Health Service inpatient data, fiscal years 2001–2011. Albuquerque, NM: Indian Health Service, 2012. Healthcare Cost and Utilization Project. Overview of the State Inpatient Databases. Available at: http://www.hcup-us.ahrq.gov/sidoverview.jsp. Accessed 1 April 2013.

influenza-associated hospitalization rates were wide and over-lapped for all age groups except infants. The wide 95% CIs for the estimated influenza-associated hospitalization rates are a result of the modeling approach, in which the annual 95% CI was determined by summing the weekly 95% CIs, rather than a small sample size (>14 000 hospitalizations/year in NDW and >2 600 000 hospitalizations/year in SID). Because the wide CIs are inherent to the model, clinically significant differences in influenza-associated hospitalizations between populations might be masked. The estimates for influenza-specific hospitalizations are more precise (because the SID and NDW consist of ∼100% of discharges) and specific [23, 24], but ICD-9-CM coded data alone substantially underestimates the number of hospitalizations resulting from influenza illness. Because of the trade-offs involved in estimating the number of influenza hospitalizations by ICD-9-CM-coded data versus modeling, assessing for disparities between populations requires consideration of results from both approaches together.

Despite the wide 95% CIs, the trend in the point estimates for the influenza-associated hospitalization rates that we observed among AI/AN people compared with the comparison US population along with previous studies suggest there may still be a true underlying disparity that we were unable to identify statistically. The influenza-specific hospitalization rate determined by ICD-9-CM-coded data alone is consistently higher among AI/AN people compared with the comparison US population and corroborates the trend identified by the modeling. Moreover, our results are consistent with studies showing a disparity in health outcomes associated with other infectious diseases among AI/AN people [1, 2]. During 2009, AI/AN mortality rate associated with pandemic influenza A H1N1 virus (pH1N1) infection was 4 times higher than other racial groups [31]. The social and environmental factors thought to increase AI/AN people's risk for other infectious diseases (eg, higher household crowding and inadequate access to water and sanitation) could predispose to influenza infection as well [9]. In addition, AI/AN people are more likely than other racial groups to have an underlying medical condition that increases the risk of experiencing influenza infection [11]. However, only 41% of AI/AN adults aged 18–64 years with high-risk comorbid conditions had received an influenza vaccine during the 2010–2011 season compared with 48% of non-Hispanic white adults [32]. The combination of low vaccine coverage coupled with higher rates of comorbid conditions among AI/AN people highlights the missed opportunities in this populations for prevention of influenza and serious complications [33]. Continued analysis of hospital discharge data, along with results from new methods of maintaining surveillance for influenza-like illness in AI/AN populations [34], will allow ongoing comparison of the burden of influenza in AI/AN people and the overall US population and ensure that public health responses can be targeted for maximal effect.

Our results indicate that influenza-specific hospitalization rates represent a smaller proportion of all influenza-associated hospitalizations among AI/AN people than in the comparison US population. The reasons for this observation are unclear. One contributing reason could be that the IHS inpatient data do not include persons in the IHS user population who used private health insurance for hospitalizations at non-IHS or non-contract facilities [23]. In addition, AI/AN people might be less likely to seek care for influenza illness compared with the general US population. During the pH1N1 season in 2009–2010, AI/AN people were twice as likely to report influenza-like illness symptoms compared with non-Hispanic whites, but they sought care for influenza-like illness at the same rate as non-Hispanic whites [35]. The lower age-adjusted, primary respiratory and circulatory coded hospitalization rates observed in our analysis among AI/AN people than in the comparison US

population support the possibility of differential healthcare-seeking behavior or differential physical access to healthcare. Therefore, it is important that policymakers and researchers using administrative data understand that influenza ICD-9-CM-coded data likely underestimate the true disparity in influenza-associated hospitalization rates between the AI/AN and the general US populations.

During 2001–2008, the respiratory year-to-year trend in influenza-associated hospitalization rates for all ages among AI/AN people mirrored the modeled hospitalization rates among the comparison US population. These year-to-year trends reflect factors independent of the underlying population such as the predominant circulating influenza type and subtype. For example, influenza A H3N2 viruses are associated with more severe disease, especially among the elderly, and predominated during the 2003–2004, 2004–2005, and 2007–2008 respiratory years [21, 36, 37]. Correspondingly, we identified high influenza-associated hospitalization rates among both the AI/AN and comparison US populations during those 3 respiratory years.

Among the AI/AN population, the highest influenza-specific hospitalization rate occurred during 2009–2010 when pH1N1 virus predominated [26]. Although we did not calculate pH1N1-associated hospitalization rates for the US population for 2009–2010, previously reported national pH1N1-associated hospitalization rates of 4.5/100 000 among all persons and 13.0/100 000 among children aged 0–4 years were substantially lower than our influenza-specific and influenza-associated hospitalization estimates for the AI/AN population [38]. This disparity would have been expected by extrapolating from the disparity observed in our study in previous respiratory years and is consistent with other studies that have demonstrated AI/AN people suffered disproportionate mortality from 2009 pH1N1 [31].

Our study had certain limitations that could differentially bias the modeled estimates of the hospitalization rates between the 2 populations and impact the magnitude of the disparity we detected. First, the seasonal onset, duration, and severity of influenza activity—which the model incorporated by using weekly laboratory viral data on the proportion of respiratory specimen positive for influenza—is not uniform across the country [39]. However, those viral data were not available specifically from IHS facilities, so we used the same national viral surveillance data to model hospitalization rates for the AI/AN and US populations. Second, we cannot exclude differential recognition of and coding for influenza in the medical records between the IHS and SID data. In addition, our model did not fully account for confounding by RSV. As a result, our estimates for influenza hospitalizations are slightly higher than previously reported [21]. However, confounding by RSV should not substantially impact our interpretation of the relative disparity in influenza-associated hospitalization rates observed between the AI/AN and US populations because the same viral data were used to model hospitalization rates for both populations. Lastly,

the AI/AN people within the IHS/tribal healthcare system and the 13 states in the SID may not represent the entire national AI/AN or US population.

The results of this study demonstrate that AI/AN people suffer from a disproportionate burden of hospitalizations associated with influenza illness. Several actions are likely to assist greatly in reducing this disparity: addressing the underlying social and environmental risk factors that predispose AI/AN people to infections, increasing influenza vaccine coverage in this high-risk population, and ensuring appropriate use of antiviral medications. These are important actions that can be considered in seasonal and pandemic influenza preparedness policy decisions that address the vulnerability of AI/AN people.

Notes

References

1. Holman RC, Curns AT, Kaufman SF, et al. Trends in infectious disease hospitalizations among American Indians and Alaska Natives. Am J Public Health 2001; 91:425–31.
2. Holman RC, Folkema AM, Singleton RJ, et al. Disparities in infectious disease hospitalizations for American Indian/ Alaska Native people. Public Health Rep 2011; 126:508–21.
3. Holman RC, Curns AT, Cheek JE, et al. Infectious disease hospitalizations among American Indian and Alaska native infants. Pediatrics 2003; 111:E176–82.
4. Indian Health Service. Trends in Indian Health 2002–2003. Available at: http://www.ihs.gov/ihs_stats/files/Trends%20Cover%20Page%20&%20Front%20Text.pdf. Accessed 13 March 2013.
5. Heron M. Deaths: Leading Causes for 2009. National vital statistics reports. Vol. 61. Hyattsville, MD: National Center for Health Statistics, 2012.
6. Singleton RJ, Holman RC, Folkema AM, et al. Trends in lower respiratory tract infection hospitalizations among American Indian/Alaska Native children and the general US child population. J Pediatr 2012; 161:296–302 e2.
7. Holman RC, Yorita KL, Singleton RJ, et al. Increasing rate of pneumonia hospitalizations among older American Indian and Alaska Native adults. J Health Dispar Res Pract 2008; 2:35–48.
8. Wenger JD, Zulz T, Bruden D, et al. Invasive pneumococcal disease in Alaskan children: impact of the seven-valent pneumococcal conjugate vaccine and the role of water supply. Pediatr Infect Dis J 2010; 29:251–6.
9. Hennessy TW, Ritter T, Holman RC, et al. The relationship between in-home water service and the risk of respiratory tract, skin, and

gastrointestinal tract infections among rural Alaska natives. Am J Public Health **2008**; 98:2072–8.

10. Castor ML, Smyser MS, Taualii MM, et al. A nationwide population-based study identifying health disparities between American Indians/Alaska Natives and the general populations living in select urban counties. Am J Public Health **2006**; 96:1478–84.

11. Jernigan VB, Duran B, Ahn D, et al. Changing patterns in health behaviors and risk factors related to cardiovascular disease among American Indians and Alaska Natives. Am J Public Health **2010**; 100:677–83.

12. Groom AV, Jim C, Laroque M, et al. Pandemic influenza preparedness and vulnerable populations in tribal communities. Am J Public Health **2009**; 99(Suppl 2):S271–8.

13. Centers for Disease Control and Prevention (CDC). Updated estimates of mortality associated with seasonal influenza through the 2006–2007 influenza season. MMWR Morb Mortal Wkly Rep **2010**; 59:1057–62.

14. Arias E, National Center for Health Statistics (U.S.). The validity of race and Hispanic origin reporting on death certificates in the United States: data evaluation and methods research. Hyattsville, MD: U.S. Department of Health and Human Services/Centers for Disease Control and Prevention/National Center for Health Statistics, 2008 Vital and Health Statistics Series 2).

15. Thompson WW, Shay DK, Weintraub E, et al. Influenza-associated hospitalizations in the United States. JAMA **2004**; 292:1333–40.

16. Grijalva CG, Craig AS, Dupont WD, et al. Estimating influenza hospitalizations among children. Emerg Infect Dis **2006**; 12:103–9.

17. Thompson WW, Shay DK, Weintraub E, et al. Mortality associated with influenza and respiratory syncytial virus in the United States. JAMA **2003**; 289:179–86.

18. Jollis JG, Ancukiewicz M, DeLong ER, et al. Discordance of databases designed for claims payment versus clinical information systems. Implications for outcomes research. Ann Intern Med **1993**; 119:844–50.

19. Poehling KA, Edwards KM, Weinberg GA, et al. The underrecognized burden of influenza in young children. N Engl J Med **2006**; 355:31–40.

20. Suryaprasad A, Redd JT, Cheek J, et al. Effect of rapid influenza diagnostic testing on antiviral treatment decisions for patients with influenza-like illness in the Southwestern United States, May–December, 2009. Public Health Rep. In press.

21. Zhou H, Thompson WW, Viboud CG, et al. Hospitalizations associated with influenza and respiratory syncytial virus in the United States, 1993–2008. Clin Infect Dis **2012**; 54:1427–36.

22. Indian Health Service. National Data Warehouse. Available at: http://www.ihs.gov/NDW/. Accessed 1 April 2013.

23. Indian Health Service. Direct/Contract Health Service inpatient data, fiscal years 2001–2011. Albuquerque, NM: Department of Health and Human Services, **2012**.

24. Healthcare Cost and Utilization Project. Overview of the State Inpatient Databases. Available at: http://www.hcup-us.ahrq.gov/sidoverview.jsp. Accessed 1 April 2013.

25. US Bureau of the Census. State single year of age and sex population estimates. Available at: http://www.census.gov/popest/estimates.html. Accessed 12 December 2010.

26. Centers for Disease Control and Prevention. United States Surveillance Data: 1997–1998 through 2009–2010 Seasons. Available at: http://www.cdc.gov/flu/weekly/ussurvdata.htm. Accessed 2 April 2013.

27. Centers for Disease Control and Prevention. The National Respiratory and Enteric Virus Surveillance System (NREVSS). Available at: http://www.cdc.gov/surveillance/nrevss/rsv/reports.html. Accessed 2 April 2013.

28. International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Available at: http://www.cdc.gov/nchs/icd/icd9cm.htm. Accessed 10 October 2012.

29. National Center for Health Statistics (U.S.). Intercensal estimates of the resident population of the United States for July 1, 2000-July 1, 2009, by year, county, single-year of age (0, 1, 2, .., 85 years and over), bridged race, Hispanic origin, and sex. Prepared under a collaborative arrangement with the U.S. Census Bureau. Available at: http://www.cdc.gov/nchs/nvss/bridged_race.htm. Accessed 10 April 2013.

30. The American Indian and Alaska Native Population: 2010. Prepared by the U.S. Census Bureau, **2012**.

31. Centers for Disease Control and Prevention (CDC). Deaths related to 2009 pandemic influenza A (H1N1) among American Indian/Alaska Natives—12 States, 2009. MMWR Morb Mortal Wkly Rep **2009**; 58:1341–4.

32. Centers for Disease Control and Prevention. Final state-level influenza vaccination coverage estimates for the 2010–11 season–United States, National Immunization Survey and Behavioral Risk Factor Surveillance System, August 2010 through May 2011. Available at: http://www.cdc.gov/flu/professionals/vaccination/coverage_1011estimates.htm#Table2. Accessed 5 April 2013.

33. Kostova D, Reed C, Finelli L, et al. Influenza illness and hospitalizations averted by influenza vaccination in the United States, 2005–2011. PLoS One **2013**; 8:e66312.

34. Keck JW, Redd JT, Cheek JE, et al. Influenza surveillance using electronic health records in the American Indian and Alaska Native population. J Am Med Inform Assoc **2014**; 21:132–8.

35. 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**; 21:623–30.

36. Brammer TL, Murray EL, Fukuda K, et al. Surveillance for influenza–United States, 1997–98, 1998–99, and 1999–00 seasons. MMWR Surveill Summ **2002**; 51:1–10.

37. Centers for Disease Control and Prevention (CDC). Update: Influenza Activity—United States, 2003–04 Season. MMWR Morb Mortal Wkly Rep **2004**; 53:284–7.

38. Reed C, Angulo FJ, Swerdlow DL, et al. Estimates of the prevalence of pandemic (H1N1) 2009, United States, April-July 2009. Emerg Infect Dis **2009**; 15:2004–7.

39. Centers for Disease Control and Prevention. FluView: Influenza-Like Illness Activity Level Indicator Determined by Data Reported to ILINet. Available at: http://gis.cdc.gov/grasp/fluview/main.html. Accessed 11 April 2013.