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Authors
Dickinson, Drew T
He, Jiayi
Gussin, Gabrielle
et al.

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Quantifying influenza exposure within California hospitals and nursing homes using administrative data

Drew T. Dickinson MPH [a,b,*], Jiayi He MS [b], Gabrielle Gussin MS [b], Stefan Gravenstein MD, MPH [c], Louise-Marie Dembry MD, MS, MBA [a,d], Susan S. Huang MD, MPH [b,e]

[a] Department of Epidemiology of Microbial Diseases, Yale School of Public Health, New Haven, CT
[b] Division of Infectious Diseases, University of California Irvine School of Medicine, Irvine, CA
[c] Departments of Medicine and Health Services, Policy, and Practice, Center for Gerontology & Healthcare Research, Brown University and Providence Veterans Administration Medical Center, Providence, RI
[d] Department of Medicine, VA Connecticut Health Care System, West Haven, CT
[e] Health Policy Research Institute, University of California Irvine School of Medicine, Irvine, CA

Abstract
Influenza acquisition occurs in hospitals and nursing homes (NHs), highlighting the need for infection prevention. We used administrative data to quantify influenza exposure and facility-onset influenza rates for California hospitals and NHs during the 2015-2016 influenza season. Higher facility-onset influenza rates were identified in NHs compared with hospitals, despite fewer influenza exposure-days in NHs. Validation of administrative data are needed.

At least 15% of influenza cases are acquired within health care facilities.[1] Individuals within health care facilities may be at particularly high risk of contracting influenza owing to proximity to other ill patients, shared health care personnel, and compromised health. Outbreaks of influenza in nursing homes (NHs) have been widely reported in the United States, whereas cases of nosocomial influenza within hospitals have been described as singular events with little clustering.[2,3] The comorbidities and increased age of NH residents increases this population's risk of acquiring influenza, even with high vaccination coverage.[4]

Hospitals and NHs have a duty to protect patients from influenza. Estimating and comparing influenza exposure and rates between these facility types, while controlling for age and comorbidities, may help inform whether different infection prevention measures are needed to contain the spread.

METHODS

We conducted a comparative study of 2 retrospective cohorts: adult patients in California general acute care hospitals and adult NH residents in California. The study period included the 5-month 2015-2016 influenza season, defined as the peak influenza month plus the 2 preceding and subsequent months. For each facility, influenza cases were identified according to ICD-10 codes from the mandatory California hospitalization dataset and the Centers for Medicare and Medicaid Services Minimum Data Set for NHs.[5,6]

Influenza exposure to patients in health care facilities was calculated by summing all inpatient-days for patients with influenza diagnoses. Given the severity of illness in hospitalized patients and common immunocompromised states, we assumed hospitalized patients with influenza were infectious for the entirety of their hospital stay.[7] Owing to prolonged NH stays, we assumed NH residents were infectious for a maximum of 10 days or until discharge, which-ever was shorter. Individuals residing in both hospitals and NHs, whose influenza was not present on admission, were assumed to be infectious starting at the midpoint of their stay. Influenza exposure-days per average daily census were calculated, normalizing across variously sized facilities.

To calculate facility-onset influenza rates, numbers of hospital-onset influenza (HOI) cases were summed among those with influenza diagnoses that were not present upon admission and those who had hospital lengths of stay longer than 2 days. These cases were divided by patient-days among all hospitalized patients, starting from the third hospital day onward. Owing to reduced fidelity of NH coding practices after the first 14 days of stay, NH-onset influenza (NHOI) cases were summed among recently admitted residents whose influenza acquisition occurred between day 3 and 14 of stay. This included those transferred to a hospital where influenza was diagnosed upon admission. Influenza acquisition was assumed to be the date of transfer. Those diagnosed with influenza in a NH were assumed to acquire influenza at the midpoint of the admission date and the assessment date associated with an influenza diagnosis. NHOI rates were calculated as cases divided by NH resident-days occurring between the third and fourteenth day of stay.

Mean exposure-days per average daily census and mean facility-onset influenza rates across hospital and NH subgroups were com-pared using a 2-sided Wilcoxon 2-sample test. Adjusted comparisons to assess the effect of facility type (NH vs hospital) on facility-onset influenza rate were performed using a negative binomial multivariable regression model controlling for influenza exposure-days per average daily census and facility characteristics (number of annual admissions, mean daily census during influenza season, facility mean length of stay, mean facility age, percentage of male patients/residents, percentage of white patients/residents, percentage of patients/residents with Medicare, percentage of patients/residents with Medicaid, and mean facility Elixhauser score).[8] All analyses were con-ducted using SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

We evaluated influenza cases from December 2015 to April 2016 in 343 hospitals and 1,048 NHs (Supplementary Fig S1). Facility characteristics are shown in Table 1.

In hospitals, 8,583 patients contributed 55,970 hospital-days of influenza exposure. In NHs, 413 patients contributed 3,451 NH-days of influenza exposure (median of 5; interquartile range [IQR], 3-7) infectious days per hospitalized influenza patient and median of 10 (IQR, 7-10) infectious days per NH resident with influenza). This translated to a mean of 1.0 (SD, 0.9) influenza hospital exposure-days per average daily census versus a mean of 0.02 (SD, 0.06) influenza NH exposure-days per average daily census during influenza season ($P < .001$).

Despite greater exposure, hospitals had a lower facility-onset influenza rate. There were 180 HOI cases and 468 NHOI cases, resulting in a mean HOI rate of 0.04 (SD, 0.08) cases per 1,000 patient-days and a mean NHOI rate of 0.10 (SD, 0.21) cases per 1,000 recently admitted resident-days ($P =.011$). In bivariate analysis, NHs had 2.6 (95% CI, 2.2-3.3) times the rate of facility-onset influenza compared with hospital (Table 2). In adjusted analysis, NHs had 10.8 (95% CI, 6.2-18.9) times the rate of facility-onset influenza compared with hospitals (Table 2).

DISCUSSION

We calculated nearly 60,000 days of influenza exposure to other patients in California hospitals and NHs during an influenza season. Despite lower influenza exposure, NHs had 11-fold the rate of facility-onset influenza during a resident's first 2 weeks of stay compared with hospitals. It is also important to note that the reported risks of influenza are likely underestimated owing to imperfect testing in both settings.

Our results have important infection prevention implications. The greater NHOI rate may be attributed to differences in NH infection control programs compared with hospitals. Recently mandated NH infection control programs have likely not reached their full potential in staffing, scope, or practice.9 We did not have access to staff vaccination rates. Vaccination rates for health care personnel in hospitals are higher than for those in nursing homes on a national level, and such a difference could help explain our findings.[10]

Our study has several limitations. First, administrative data need validation for this purpose. The number of diagnostic codes available in NH administrative datasets is reduced compared to hospitals (10 for NHs vs 24 for hospitals), which may cause differential underestimation of influenza cases in NHs. Second, we could not account for differing indications to test for and diagnose influenza between facilities, leading to possible ascertainment bias.

In conclusion, we calculated a nearly 11-fold higher identification of influenza in NHs compared with hospitals when accounting for influenza exposure and other facility characteristics. Formalized infection prevention programs in NHs may have future positive impact.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2019.10.018.

Table 1
Characteristics of hospitals and NHs

Variable	Hospitals Median (IQR)	NHs Median (IQR)
N	343	1,048
Total annual admissions	6,316 (2,287-11,239)	384 (223-605)
Average daily census during influenza season	114 (46-201)	224 (146-293)
Mean length of stay (d)	6 (5-7)	117 (65-214)
Mean age (y)	59 (55-63)	76 (72-80)
% Male	42 (38-48)	42 (36-50)
% White	76 (56-89)	57 (39-78)
% Medicare	48 (39-55)	40 (22-56)
% Medicaid	24 (12-36)	35 (18-52)
Mean Elixhauser comorbidity score	3 (3-3)	1 (1-1)

IQR, interquartile range; NHs, nursing homes.

Table 2
Facility-level characteristics associated with facility-onset influenza in bivariate and multivariable negative binomial regression

	Bivariate		Multivariable*	
Variable	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Facility-type (NH vs hospital)	2.6 (2.1-3.3)	<.001	10.8 (6.2-18.9)	<.001
Influenza exposure-days per average daily census	0.9 (0.8-1.0)	.16	2.3 (1.9-2.9)	<.001
Facility mean age in years†	1.6 (1.4-1.7)	<.001	1.0 (0.8-1.3)	.89
Facility % white race†	1.02 (0.97-1.06)	.50	1.00 (0.96-1.05)	.88
Facility % male†	0.8 (0.7-0.9)	<.001	0.9 (0.8-1.0)	.05
Facility mean length of stay in days†	1.00 (0.99-1.01)	.48	0.97 (0.95-0.98)	<.001

CI, confidence interval; NH, nursing home; OR, odds ratio.
*Adjusted analysis controlled for the facility characteristics of mean facility age, per-cent white patients/residents, percent male patients/residents, mean facility length of stay, and influenza exposure-days per occupied bed. The proportion of Medicare and Medicaid patients/residents in the facility was collinear with mean facility age. Annual admissions and mean facility Elixhauser score were collinear with facility type. Aver-age daily census during the influenza season was collinear with influenza exposure-days per average daily census.
Odds ratios for age, race, sex, and length of stay are scaled per 10-unit increase.

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*Address correspondence to Drew T. Dickinson, MPH, 513 Parnassus Ave, San Fran-cisco, CA 94143.

E-mail address: drew.dickinson@ucsf.edu (D.T. Dickinson).

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