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Major Article

Association of increased influenza vaccination in health care workers with a reduction in nosocomial influenza infections in cancer patients

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Key Words:
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Background: Vaccination of health care workers (HCWs) remains a key strategy to reduce the burden of influenza infections in cancer patients.

Methods: In this 8-year study, we evaluated the effect of a multifaceted approach, including a mandatory influenza vaccination program, on HCW vaccination rates and its effect on nosocomial influenza infections in cancer patients.

Results: The influenza vaccination rate of all employees significantly increased from 56% (8,762/15,693) in 2006-2007 to 94% (17,927/19,114) in 2013-2014 ($P < .0001$). The 2009 mandatory participation program increased HCW vaccination rates in the targeted groups ($P < .0001$), and the addition of an institutional policy in 2012 requiring influenza vaccination or surgical mask use with each patient contact further increased vaccination rates by 10%-18% for all groups in 1 year. The proportion of nosocomial influenza infections significantly decreased ($P = .045$) during the study period and was significantly associated with increased HCW vaccination rates in the nursing staff ($P = .043$) and in personnel working in high-risk areas ($P = .0497$).

Conclusions: Multifaceted influenza vaccination programs supported by institutional policy effectively increased HCW vaccination rates. Increased HCW vaccination rates were associated with a reduction in the proportion of nosocomial influenza infections in immunocompromised cancer patients.

All cancer patients, particularly those with hematologic malignancies or recipients of hematopoietic cell transplant, are susceptible to community respiratory viruses, such as influenza. These patient populations have significant mortality rates (range, 15%-28%) after the influenza infection progresses to a lower respiratory tract infection or after respiratory superinfections develop.[1,2] Antiviral therapy is available for influenza infections, but prevention remains the cornerstone to protect these susceptible immunocompromised patients.[3] Influenza vaccination in health care workers (HCWs) is viewed as a core patient and HCW safety practice to reduce the risk of infection and prevent nosocomial transmission of influenza to patients and has been associated with reduced patient mortality.[4]

The University of Texas MD Anderson Cancer Center is a 656-bed National Cancer Institute–designated comprehensive cancer center with >19,000 employees. In 2006, Employee Health (EH) at our institution conducted a detailed analysis of employee influenza vaccination rates to determine the vaccination status of employees working in patient care areas. We found vaccination rates of 47% in HCWs caring for our immunocompromised or high-risk patients and 41% for HCWs in the inpatient nursing units; both of these rates were markedly lower than the overall employee vaccination rate (56%). Subsequently, interventions, including a mandatory influenza vaccination program, were implemented to increase the vaccination rate among our employees. These interventions particularly targeted HCWs, including nurses caring for high-risk patients and the nursing staff in general because the latter group had the most frequent and prolonged contact with our immunocompromised patient population. We evaluated the outcomes of these strategies to increase influenza vaccination rates in HCWs and assessed the effect of these strategies on nosocomial influenza infections in our patients with cancer.

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PATIENTS AND METHODS

Employee influenza vaccination program

In 2006, our baseline year, the employee influenza vaccination program consisted of large, on-site influenza vaccination clinics that were distributed throughout >20 geographically dispersed patient care areas and research and administration buildings and were supplemented by 1 week of roaming vaccination services via mobile carts to patient care areas. Records of employee influenza vaccination were collected using paper sign-in sheets. In 2007, EH initiated strategies to increase influenza vaccination rates in HCWs who had direct contact with our high-risk immunocompromised patients (eg, hematopoietic stem cell transplant recipients, patients with hematologic malignancies) and in all clinical nursing staff in the inpatient nursing units. Efforts centered on expanding access, education, and communication for influenza vaccination among HCWs.

To increase access, we implemented several strategies. All influenza vaccination clinics were relocated to the main hospital complex. Roaming service hours were increased from 30 to >100 hours, enhancing easy access to vaccinations in busy patient care areas. We also increased the number of on-site clinics and the scheduled clinic hours to >100 hours to improve access to vaccination opportunities during all work shifts.

We expanded our education and communication campaign by prominently advertising the expanded clinic schedule and centralized, hospital-based locations and distributing various educational materials on the safety and efficacy of influenza vaccination. We communicated with HCWs via all-employee e-mails, our institutional Web site, employee bulletin boards, and presentations at institutional meetings. Additionally, EH partnered with the infection control team to provide on-site vaccinations following their respiratory virus season in-services to inpatient areas as part of their preventive strategies to reduce nosocomial transmission. A mechanism for efficient on-site data entry of influenza vaccinations into an electronic medical record was developed, facilitating queries of vaccination rates and the ability to provide weekly updates of vaccination rates to supervisors and senior management.

Furthermore, in 2009, we piloted the mandatory participation influenza prevention program, which targeted HCWs in high-risk areas and in the nursing staff as subsequently defined. Program compliance was defined as one of the following: receiving an influenza vaccination from EH, providing documentation of vaccination by an outside provider, or signing a waiver-declination form. The waiver-declination form allowed for medical and personal belief exemptions and informed HCWs of the risk to our immunocompromised patients and to themselves posed by their declining vaccination. Weekly compliance updates were sent to managers and supervisors, and a final noncompliance list was sent to our executive leaders. In 2010, the program expanded to include all clinical operations employees; Patient care facilities employees with direct patient contact were added in 2011. In 2011, a compliance sticker was placed on institutional identification badges as visual confirmation of influenza vaccination.

In 2011, a new state law in Texas required health care facilities to implement a vaccine-preventable diseases policy. This legislative directive enabled us to develop and implement an institutional policy in 2012 for a mandatory vaccination program requiring all HCWs, including employees, contractors, trainees, and volunteers, either to receive influenza vaccination or to wear a surgical mask when caring for patients during the respiratory virus season. Compliance with mask use for unvaccinated HCWs was the responsibility of supervisors in each clinical area and was documented in a vaccine-preventable diseases policy compliance-monitoring database. Failure to comply with this policy could result in disciplinary action, including termination.

HCW groups

HCWs in high-risk areas included all employees working in the departments of stem cell transplantation and cellular therapy, leukemia, lymphoma and myeloma, infectious diseases, and pulmonary medicine and in the division of pediatrics, the division of anesthesiology and critical care, and emergency center areas.

Nursing staff included all inpatient nurses and affiliated nursing staff.

The clinical operations group, of which the high-risk areas and the nursing staff are subgroups, included all employees reporting to the physician-in-chief, providing direct patient care, providing hospital ancillary services, or providing administrative support. These employees are located in the main hospital complex and have a high likelihood of patient contact or have consistent interaction with HCWs who provide direct patient care.

The patient care facilities group consisted of housekeeping employees with direct patient contact; these employees are responsible for cleaning inpatient rooms and surroundings or outpatient clinic facilities.

Influenza surveillance

All year round, screening for respiratory viruses via nasal washes was performed on all patients, in both the inpatient and outpatient settings, who had at least 2 of the following symptoms: fever, muscle aches, headache, cough, sore throat, sinus congestion, or runny nose. This surveillance program was in place during the entire 8-year study period.

Respiratory virus screening via the rapid shell vial culture technique was performed on all specimens during the study period. The first reading of the shell vials occurred between 15 and 24 hours, and the final reading was taken at 48 hours. All vials were read and developed at appropriate times, and results were confirmed using immunofluorescent staining. Hemadsorption was performed on days 2, 5, and 7. Both pool and individual reagents were used containing monoclonal antibodies to adenovirus, influenza A, influenza B, parainfluenza 1-4, and respiratory syncytial virus (Light Diagnostics 3105 and 3108; EMD Millipore, Billerica, MA). Direct fluorescent antibody tests were also performed for detecting influenza, parainfluenza, metapneumovirus, and respiratory syncytial virus antigens in respiratory samples (Light Diagnostics/SimulFluor RSV/Flu A, 3129; EMD Millipore).

Nosocomial influenza infection was defined as a laboratory-confirmed diagnosis of influenza in a patient admitted >48 hours (average time of the incubation period of this virus which is between 1 and 4 days) before the onset of symptoms. Once a respiratory viral diagnosis is suspected based on symptoms or microbiologically confirmed, the patient is placed on contact isolation precautions with a mask, and not only on droplet isolation as recommended, to provide an additional barrier for horizontal transmission.

Infection control measures

During the influenza season, signage is prominently displayed throughout the institution to remind patients, family members and caregivers, and institutional workforce members to cover their cough, perform hand hygiene often, and refrain from touching mucous membranes (eg, eyes, nose, mouth) with their hands. All patients, family members, and visitors are screened for signs and symptoms of upper respiratory illness. Those identified with the respiratory illness receive a supply of masks to wear while inside

the institution and are restricted from visiting high-risk patients until signs and symptoms subside. HCWs with direct patient care responsibilities are required to wear a mask during all times when they have upper respiratory symptoms in the absence of fever. HCWs are required to change masks when wet, contaminated, or when the HCW leaves the patient care area. Those HCWs who have fever >38°C and uncontrollable secretions, cough, or other communicable respiratory symptoms are excluded from direct patient care until 24 hours after resolution of fever in the absence of antipyretics. These institutional policies did not change over the study period.

Statistical analysis

HCW vaccination rates were determined by the percentage of HCWs who received influenza vaccination. Cochran-Armitage trend tests were used to assess the changes in HCW vaccination rates and the proportion of nosocomial influenza infections over the study period (2006-2014). During this study period, we evaluated the vaccination rates of all employees but with a focus on 4 specific HCW groups: personnel in high-risk areas, nursing staff, clinical operations (only from 2009-2014), and patient care facilities (only from 2010-2014). Poisson regression analysis was used to assess the association between the proportion of nosocomial influenza infections and HCW vaccination rates (2006-2014) for all employees, personnel in high-risk areas, and the nursing staff. A 2-tailed *P* value <.05 was considered significant for our analyses. All analyses were performed using SAS software, version 9.3 (SAS Institute, Cary, NC).

RESULTS

HCW influenza vaccination rates

Table 1 depicts the vaccination rates during the study period for all employees and for the 4 targeted HCW groups. For each group, the initial vaccination rate is from the baseline year before the interventions were implemented. Cochran-Armitage trend analysis showed that the annual influenza vaccination rate of all employees at our institution significantly increased during the study period, from 56% (8,762/15,693) in 2006-2007 to 94% (17,927/19,114) in 2013-2014, which was a 38% increase ($P < .0001$). Similarly, vaccination rates significantly increased in each of the targeted groups ($P < .0001$) (Table 1). The nursing staff (55%) had the highest increase over the study period compared with HCWs in high-risk areas (49%), patient care facilities (47%), and clinical operations (28%). Implementation of our mandatory participation program in 2009 increased HCW vaccination rates in high-risk areas by 30% and in nursing by 23% in 1 year. The addition of an institutional policy in the 2012 mandatory vaccination program requiring influenza vaccination or surgical mask use with each patient contact increased vaccination rates by 10%-18% in the targeted groups in 1 year.

Nosocomial influenza infections

Figure 1 compares the proportion of laboratory-confirmed nosocomial influenza infections with the community-acquired infections in our patients. Cochran-Armitage trend analysis showed a statistically significant decrease in the annual proportion of nosocomial influenza infections during 2006-2014 ($P = .045$).

Association between vaccination rates and nosocomial influenza infections

Poisson regression analyses demonstrated a statistically significant inverse association between the proportion of nosocomial influenza infections and the HCW vaccination rates in the nursing

Table 1
Employee influenza vaccination rates at the University of Texas MD Anderson Cancer Center (2006-2014)

Influenza vaccination group	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	*P* value
All employees	56 (8,762/15,693)	56 (9,505/16,843)	59 (10,356/17,656)	70 (11,996/17,113)	78 (13,765/17,601)	75 (13,824/18,489)	93 (17,883/19,279)	94 (17,927/19,114)	<.0001
High-risk departments	47 (732/1,552)	61 (912/1,498)	60 (864/1,429)	90 (963/1,075)	87 (1,061/1,224)	86 (1,335/1,544)	96 (1,453/1,515)	96 (2,084/2,181)	<.0001
Nursing staff	41 (252/611)	51 (724/1,427)	54 (775/1,445)	77 (914/1,180)	81 (1,107/1,373)	83 (1,194/1,447)	95 (1,757/1,851)	96 (1,963/2,045)	<.0001
All clinical operations*				65 (5,921/9,150)	80 (8,202/10,241)	81 (8,462/10,498)	92 (10,162/11,032)	93 (10,623/11,405)	<.0001
Patient care facilities†					47 (279/592)	78 (440/567)	94 (535/572)	94 (546/582)	<.0001

NOTE. Values are % (n/N) or as otherwise indicated.
*Missing data from 2006-2009.
†Missing data from 2006-2010.

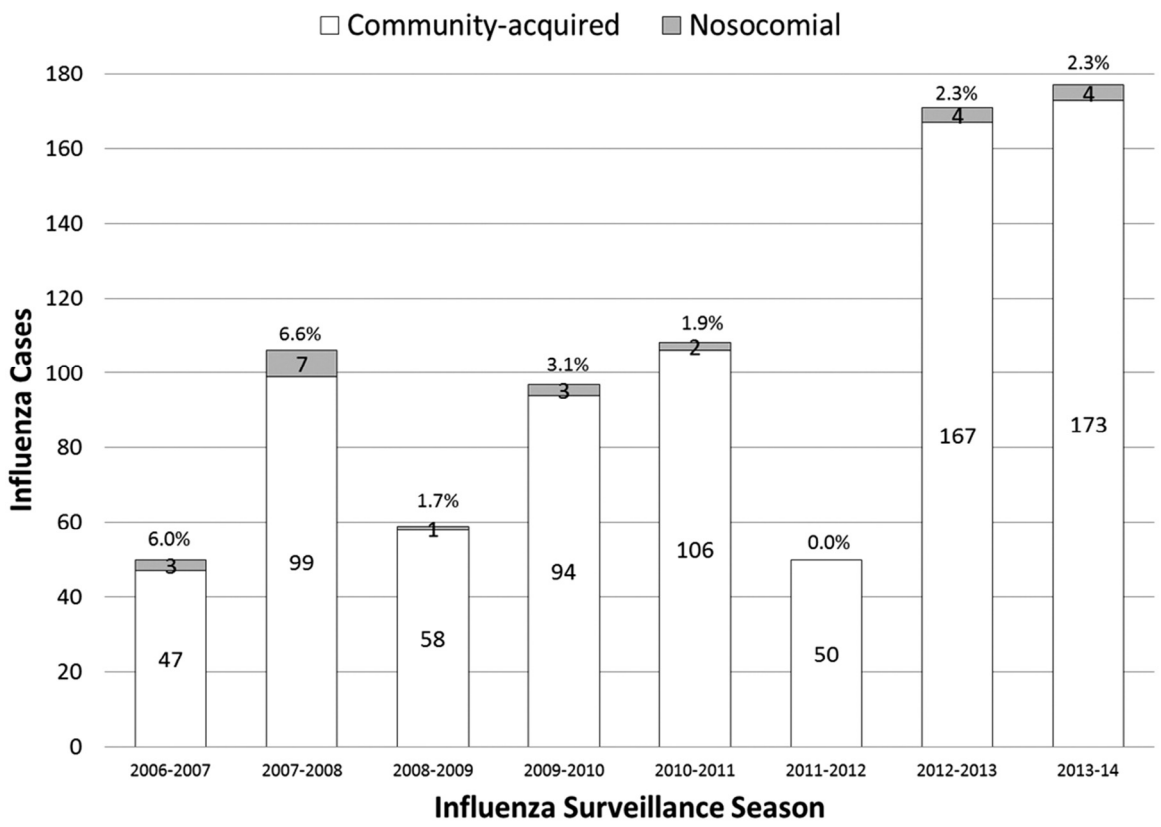

Fig 1. Proportion of laboratory-confirmed nosocomial influenza infections versus community-acquired infections by season at our institution (2006-2014).

staff ($P = .043$) and in high-risk areas ($P = .0497$), respectively. Although the annual HCW vaccination rates in the nursing staff and in high-risk areas increased from 2006-2014, the annual proportion of nosocomial influenza infections decreased. Additionally, we observed that the increase in overall employee vaccination rates was associated with the decreased proportion of nosocomial influenza infections ($P = .07$). Figure 2 depicts the increased vaccination rates stratified by HCW group and the decreased proportion of nosocomial influenza infections during the study period.

DISCUSSION

Influenza vaccination rates for the 4 targeted HCW groups and for all employees significantly increased, and the proportion of nosocomial influenza infections significantly decreased during the 8-year study period. Specifically, we found that the significant reduction in the proportion of nosocomial influenza infections was associated with increased HCW vaccination rates in both the nursing staff and HCWs in high-risk areas.

Mandatory vaccination programs, supported by institutional policy initiatives and compliance tracking, are an effective mechanism to increase HCW influenza vaccination rates. Sequential expansion of the program over several years was a key element to the success of our comprehensive, multifaceted influenza vaccination program. Two years before implementing the mandatory participation program in 2009, EH spearheaded initiatives to increase HCW vaccination rates in high-risk areas and inpatient nursing. These initiatives included enhanced communication campaigns to all employees to advertise the expanded vaccination opportunities, to promote vaccination as a critical patient safety measure, and to provide educational information on the safety and efficacy of influenza vaccination. Weekly reports to supervisors and senior leadership created awareness of vaccination rates and familiarity with the practice of compliance tracking. Senior leadership supported our initiative by aligning institutional goals with the 2007 Joint Commission requirement to increase HCW influenza vaccination rates.

The 2009 mandatory participation program, which included HCWs in high-risk areas and nursing staff, added a waiver-declination form, and required active program participation by all targeted HCWs, led to a substantial increase in vaccination rates in the targeted groups (up to 30% in 1 year). Additionally, the mandatory participation program expansion to all clinical operations employees in 2010 and patient care facilities employees in 2011 also led to a substantial increase in vaccination rates in these targeted groups compared with rates from the baseline year. The use of mandatory declination forms has been associated with better HCW vaccine acceptance; however, the precise effect is unclear because of the simultaneous implementation of other strategies to increase vaccination rates, as in our program.[4-6]

On the other hand, the 2011 Texas state law requiring health care facilities to implement a vaccine-preventable diseases policy by 2012 for HCWs with routine and direct exposure to patients provided the legislative directive and impetus for our institution to implement a fully comprehensive mandatory influenza vaccination program. This mandatory program required employees who requested a vaccination exemption for medical contraindications or for reasons of conscience to wear a surgical mask when caring for patients; the 2012 program also required compliance tracking and employment actions for noncompliant individuals.

The placement of a compliance sticker on institutional identification badges for all HCWs, including employees, contractors,

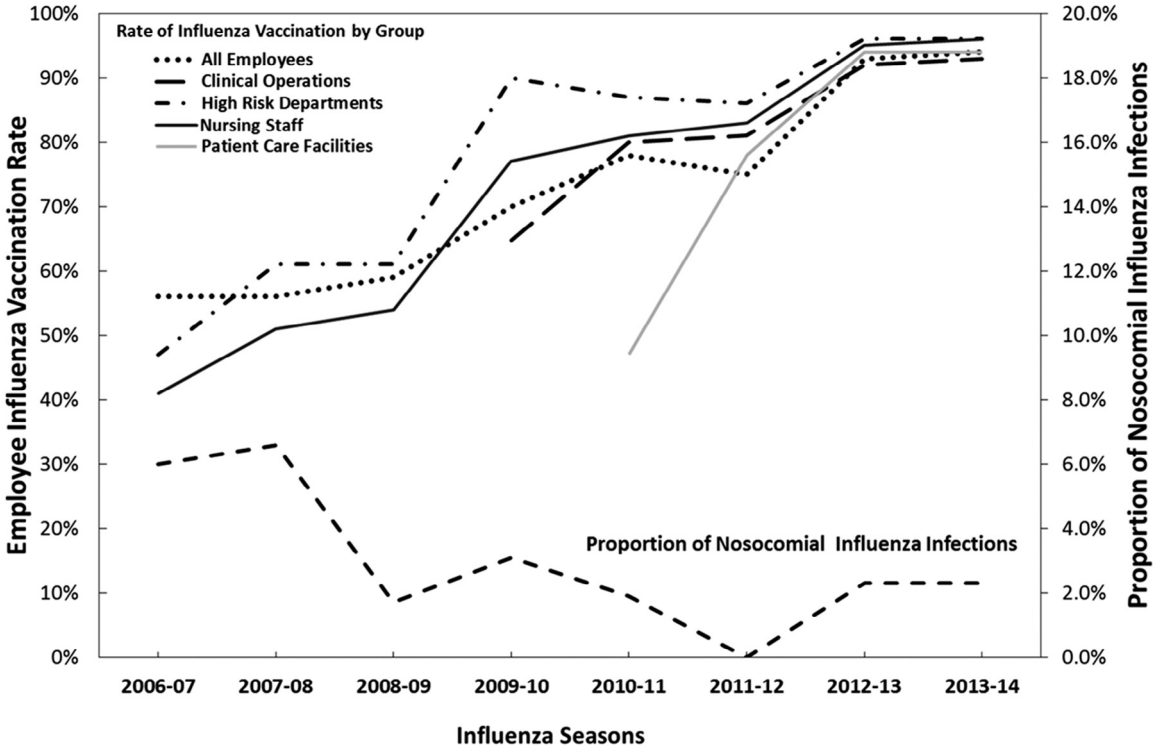

Fig 2. Health care worker vaccination rates and proportion of nosocomial influenza infections at our institution (2006-2014).

trainees, and volunteers, as visual confirmation of influenza vaccination provided a readily accessible mechanism for supervisors to identify HCWs who had received vaccination. Unvaccinated HCWs did not have a sticker and were required to wear a surgical mask. The compliance stickers also promoted positive reinforcement from coworkers and patients who perceived vaccination as an important patient safety measure. Implementation of this policy and the subsequent mandatory vaccination program led to markedly increased vaccination rates in all targeted groups (up to 18% in 2012-2013); HCW vaccination rates increased or maintained the same the following year.

Our data support several studies concluding that comprehensive mandatory influenza vaccination programs are the most effective mechanism for increasing HCW vaccination rates.[7-9] Additionally, state laws requiring HCW vaccination as part of a comprehensive infection control program can provide an impetus and legal justification for employers to implement mandatory vaccination programs, as in our institution.[10,11] Furthermore, effective educational and communication strategies that promote influenza vaccination as a core patient and HCW safety measure[4] and that address beliefs and concerns about vaccination are critical for positively affecting HCWs' attitudes toward influenza vaccination and other vaccines.

The proportion of nosocomial influenza infections in our patients significantly decreased during the study period. Because of seasonal variability in the severity of influenza, Taylor et al[12] note the importance of a multiyear surveillance program to assess trends in the occurrence of health care–associated influenza infections. A study of Canadian acute care hospitals during a 6-year surveillance period observed substantial year-to-year variability in the proportion of nosocomial influenza infections by season ranging from 6.6%-33.1%.[12] We also observed variability over our 8-year study period, with the proportion of nosocomial influenza infections ranging from 0% in 2011-2012 to 6.6% in 2007-2008. Interestingly, during the 2012-2013 and 2013-2014 influenza seasons, we experienced the highest overall number of influenza infections in our patients during the study period (171 and 177 cases, respectively); however, the nosocomial influenza infections were only 2.3% of the total influenza infections in both seasons. This time period coincided with the implementation of the mandatory vaccination program and the peak in HCW vaccination rates (96%) in the high-risk areas and in the nursing staff.

Another potential factor for the proportion of nosocomial infections in 2012-2014 could be the efficacy of the influenza vaccine during each season. For example, in 2007-2008, when 2 of the predominant circulating wild-type influenza strains were not included in the vaccine, both the number of nosocomial cases and the proportion of our nosocomial influenza infections peaked at 7% and 6.6%, respectively; however, our comprehensive vaccination program had not yet been fully implemented. Further studies are needed to determine the effect of our program on transmission of nosocomial influenza in future years when vaccine efficacy is suboptimal.

To our knowledge, this is the first published study to examine an association between increased HCW influenza vaccination rates and decreased nosocomial influenza infections in immunocompromised cancer patients within a single institution over multiple influenza seasons. Increasing vaccination rates in HCWs with the most frequent and prolonged patient contact and in those dealing with our high-risk immunocompromised patient population, consisting of patients with hematologic malignancies or hematopoietic stem cell transplant recipients, probably contributed to this significant reduction in the proportion of nosocomial influenza infections. We also observed a trend between increased overall employee vaccination rates and decreased proportions of nosocomial influenza infections. This finding supports an environment of care concept and the Society for Healthcare Epidemiology

of America recommendation that all HCWs, regardless of direct patient contact, should receive influenza vaccination as a core patient and health care personnel safety practice.[4]

One of the potential limitations of this study is that these findings are based on the proportion of nosocomial cases rather than the nosocomial influenza incidence density rates because of the small number of nosocomial influenza cases observed during the 8-year study period. Furthermore, different cutoffs ranging from 2-7 days have been used to define nosocomial infections; however, at our institution, we use 2 days as the cutoff for nosocomial consideration based on the average incubation period of influenza. Another limitation of our study is that polymerase chain reaction assay was not used for influenza diagnosis during the reported study period and we do not test asymptomatic patients for influenza; therefore, this may have potentially led to an underestimation of the incidence of influenza in our study population. Additionally, our data may not be fully generalizable to other health care settings because our program was implemented at a single tertiary care cancer center with a large population of immunocompromised cancer patients and transplant recipients. Annual differences in influenza vaccine efficacy and strain infectivity may have led to some variability in the incidence of influenza infections over the years. However, our study setting is also its strength because our institution has an established comprehensive infection control program; a prospective systematic influenza surveillance program; and consistent respiratory virus screening techniques, surveillance periods, and the same definition of nosocomial infection over the study period. Our institution's patient population, which is comprised of immunocompromised patients who are prone to nosocomial infection, also supports the significant value of our findings.

Our results showed that multifaceted mandatory influenza vaccination programs, supported by institutional policy initiatives, achieved sustained increases in HCW influenza vaccination rates with subsequent reduction in nosocomial influenza infections in immunocompromised cancer patients and hematopoietic stem cell transplant recipients.

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