Elements of Influenza Vaccination Programs That Predict Higher Vaccination Rates: Results of an Emerging Infections Network Survey

Philip M. Polgreen,[1,2] YiYi Chen,[3] Susan Beekmann,[1] Arjun Srinivasan,[4] Marguerite A. Neill,[5] Ted Gay,[6] and Joseph E. Cavanaugh,[3] for the members of the Infectious Diseases Society of America's Emerging Infections Network

[1]Department of Internal Medicine, University of Iowa Carver College of Medicine, and Departments of [2]Epidemiology and [3]Biostatistics, University of Iowa College of Public Health, Iowa City; [4]Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia; [5]Division of Infectious Disease, Memorial Hospital of Rhode Island, Brown Medical School, Providence; and [6]Tri-City Medical Center, Oceanside, California

Introduction. To address suboptimal influenza vaccination rates among health care workers, the Healthcare Infection Control Practices Advisory Committee and the Advisory Committee on Immunization Practices recently issued recommendations designed to increase the number of health care workers vaccinated against influenza. The purpose of the present study was to determine how widely these recommendations have been implemented and to identify important elements of successful influenza vaccine programs.

Methods. The Infectious Diseases Society of America Emerging Infections Network surveyed 991 infectious diseases consultants. Infectious diseases consultants were asked about vaccination programs and vaccination rates at their respective institutions. Multinomial logistic regression models based on proportional odds were used to determine predictors of vaccination-rate categories. All program elements were significant univariable factors in predicting vaccination rates. Because the program elements were highly associated with one another, principal components analysis was used to find combinations of the covariates that would serve as optimal predictors of higher vaccination rates.

Results. Most infectious diseases consultants indicated that the vaccination rate for all health care workers in their institution had a range of 41%–60%. Vaccination rates were significantly higher in institutions that required signed declination statements ($P = .004$). In the model based on principal components analysis for predicting institutional vaccination rates, only the first principal component warranted retention ($P < .001$). In this component, the program elements weighted the most heavily were (1) offering the influenza vaccine free of charge, (2) providing adequate staff and resources, and (3) educating targeted groups of health care workers. Requiring signed declinations was not heavily weighted.

Conclusion. Influenza vaccination rates remain suboptimal, and hospitals have not completely implemented the Healthcare Infection Control Practices Advisory Committee–Advisory Committee on Immunization Practices recommendations to maximize vaccination rates.

Vaccination of health care workers (HCWs) against influenza is the single-most effective measure for prevention of transmission of influenza within health care facilities [1]. Vaccination also helps to prevent absenteeism among HCWs. However, only ~40% of HCWs in the United States are vaccinated annually, despite long-standing recommendations from the Centers for Disease Control and Prevention to vaccinate all HCWs [2]. To address the persistently low influenza vaccination rates among HCWs, the Healthcare Infection Control Practices Advisory Committee (HICPAC) and the Advisory Committee on Immunization Practices (ACIP) recently issued evidence-based recommendations to administrators responsible for influenza vaccination programs [3]. These new recommendations

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Reprints or correspondence: Dr. Philip M. Polgreen, University of Iowa Dept. of Internal Medicine, 200 Hawkins Dr., Iowa City, IA 52242 (philip-polgreen@uiowa.edu).

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not only continue to emphasize the importance of HCW vaccination but also outline several specific measures aimed at encouraging influenza vaccination among HCWs. The recommendations include educating HCWs about the benefits of influenza vaccination, making the vaccine free and easy to obtain for all HCWs, providing feedback of vaccination rates, obtaining a signed declination from HCWs who refuse vaccination, and using the level of vaccination coverage as a measure of patient safety and quality of care [3].

Whether hospitals are implementing these recommendations is not known. We conducted this study to compare current practices with these recommendations, to identify important elements of successful influenza vaccine programs, and to report the views of IDCs about barriers to increasing vaccination rates.

METHODS

The Infectious Disease Society of America's Emerging Infections Network (EIN) is a provider-based sentinel network of IDCs who regularly engage in clinical practice and belong to either the Infectious Disease Society of America or the Pediatric Infectious Disease Society. The EIN was established in 1995 through a cooperative agreement with the Centers for Disease Control and Prevention. In June 2006, staff at the EIN coordinating center (Iowa City, IA) distributed a survey via e-mail or facsimile to 991 infectious diseases consultants (IDCs) caring for adult and/or pediatric patients in the United States. Nonresponding members received a second query 2 weeks later, followed by a third after 4 weeks.

The IDCs were asked about the influenza vaccination programs and vaccination rates at their respective institutions. If members worked at >1 institution, they were asked to answer the questions on the basis of the practices at the institution at which they spent the most time. Frequencies were tabulated for all responses. Because vaccination rates were classified into 5 groups (0%–20%, 21%–40%, 41%–60%, 61%–80%, and 81%–100%), multinomial logistic regression models based on proportional odds were used to determine predictors of vaccination rate categories. In fitting these models, the propriety of the proportional odds assumption was routinely tested.

Univariable models were used to assess the unconditional association between each predictor and the categorized vaccination rate. Traditional multivariable models were then fitted to the data, with use of those predictors that exhibited statistical significance in the univariable analyses. However, because the covariates are highly associated, these models were affected by problems related to multicollinearity (e.g., inaccurate parameter estimates and large partial-test P values). As a methodological alternative for identifying a meaningful set of predictors, we performed correspondence analysis, a weighted form of principal components analysis that is appropriate for frequency data.

Principal components analysis partitions the overall variance of the covariates by constructing linear functions of the underlying variables, called "principal components," which are mutually uncorrelated. The principal components are ranked in terms of the amount of overall covariate variability represented by each linear combination [4]. This method enables a large number of highly correlated variables to be represented in the form of several key linear combinations. The linear combinations are orthogonal to each other, thereby conveying unique information. Once the principal components are constructed, they can be used as predictors in fitting multivariable models. Typically, only the initial components will exhibit statistical significance.

The γ statistic was used to evaluate the general (unconditional) relationship between the vaccination rate and how well hospitals comply with the HICPAC/ACIP recommendations. The γ statistic is a correlation-type measure that quantifies the strength and direction of an association between 2 ordinal variables [5]. All statistical analyses were performed using SAS software, version 9.0 (SAS Institute); the procedure CORRESP was applied to conduct the correspondence analysis.

RESULTS

Overall, 478 IDCs (48.2%) responded, including 60 physicians who indicated that they were not involved with the influenza vaccination program at their institution and were not able to adequately respond to the questions; the responses of those 60 physicians were not included in our analysis. Of the remaining 418 respondents, 23% had pediatric practices, and 68% had adult-only practices. Thirty-nine percent worked at university-associated teaching hospitals, 37% worked at non–university-associated teaching hospitals, 22% worked at nonteaching hospitals, and 2% did not specify. Only 3% of the respondents were based primarily at institutions with <200 beds. Thirty-five percent of respondents worked in institutions with 200–350 beds, 22% in hospitals with 351–450 beds, 19% in hospitals with 451–600 beds, and 22% in hospitals with >600 beds.

Respondents and nonrespondents were similar with respect to geographic census region, practice location (urban, suburban, or rural), practice description (pediatric infectious disease, adult infectious disease, or general medicine), practice type (academic or private practice), teaching compared with nonteaching practice, hospital type, involvement in medical research, and system of payment (fee for service or salary). However, members involved in hospital epidemiology, infection control committees, or employee health were significantly more likely to respond to the survey (50% of respondents were involved in 1 of these areas, versus 35% of nonrespondents; $P < .001$).

Table 1. Implementation of Healthcare Infection Control Practices Advisory Committee–Advisory Committee on Immunization Practices influenza vaccination recommendations, as reported by infectious diseases consultants.

Does your hospital provide	No. (%) who answered Yes	No	P[a]
Vaccine free of charge to all HCWs with direct patient care?	410 (98)	10 (2)[a]	.017
Vaccine free of charge to all HCWs?	376 (91)	38 (9)	<.001
Vaccine free of charge to all volunteers?	342 (86)	56 (14)	.019
Adequate staff and resources for influenza vaccine campaigns?	354 (85)	63 (15)	.008
Vaccination in wards, clinics, and/or common areas (e.g., outside cafeteria)?	365 (87)	56 (13)	.015
Off-hours vaccination clinics?	236 (57)	178 (43)	.018
Vaccination at any staff and departmental meetings?	193 (47)	218 (53)	.011
Visible vaccination of key personnel?	208 (51)	198 (49)	.004
Tracking unit-based vaccine compliance for at least some units?	237 (59)	163 (41)	<.001
Reporting vaccination rates to HCWs and administration?	285 (72)	111 (28)	<.001
A mechanism for recording off-site vaccination?	115 (29)	280 (71)	.001
A mandatory declination form to HCWs refusing vaccination?	93 (23)	310 (77)	.004
Education to targeted groups of HCWs?	257 (84)	50 (16)	<.001
Active surveillance for health care–associated influenza?	67 (22)	238 (78)	.002

NOTE. HCWs, health care workers.

[a] P values are based on tests of association between the implementation of a specific recommendation and the levels of vaccination rates. Each P value is associated with a Wald test statistic, which is computed using a fitted univariable multinomial logistic regression model.

[b] Of the 10 respondents who answered "No" to this question, 1 wrote that "now only nurses get the vaccine free," and 2 indicated that residents get the vaccine free but staff physicians do not.

The results of this survey indicated that many hospitals had not completely implemented the new HICPAC/ACIP recommendations during the 2005–2006 influenza season. Table 1 displays the implementation rate for each of the recommendations. Only 2 IDCs indicated that their institutions had not implemented any of the recommendations; conversely, only 3 IDCs reported working in institutions in which all of the recommendations had been fully adopted. Almost all institutions provided vaccine free of charge to all HCWs, and most (87%) offered the vaccine in locations convenient for HCWs. However, few institutions provided the vaccine at staff meetings and/or at off-hours clinics. The 2 least implemented recommendations were requiring signed declination statements from those who refuse vaccination and practicing active surveillance for healthcare-acquired influenza. Of note, 9 physicians whose institutions did not require a signed declination during the 2005–2006 season indicated that such programs would be implemented during the 2006–2007 season.

Twenty-one percent of respondents did not know the vaccination rate at their institution, and 5% reported that it cannot be determined for their institution. Of those who reported rates, 62% of institutions vaccinated $\leqslant$60% HCWs, and only 10% reported influenza vaccination rates >80% (table 2). More than two-thirds of respondents reported that their institutions did not have a mechanism for recording off-site vaccination, so actual vaccination rates may be somewhat higher than those documented by employee health clinics. Interestingly, vaccination rates were significantly higher in institutions that required signed declination statements ($P = .004$).

In the multinomial logistic regression model based on principal components analysis for predicting institutional vaccination rates (figure 1), the first 6 principal components were examined. Of the overall variability among the covariates, ~70% was explained by these 6 components. Only the first principal component warranted retention in the multinomial logistic regression model ($P < .001$). In this component, the program elements weighted the most heavily were (1) offering the influenza vaccine free of charge, (2) providing adequate staff and resources for the influenza vaccination program, and (3) educating targeted groups of HCWs. The c-statistic for the fitted logistic regression model was 0.629. The estimated OR

Table 2. Institutional vaccination rates, as reported by infectious diseases consultants.

Rate or response category	No. (%) of respondents
Rate, %	
0–20	1 (0.2)
21–40	67 (16)
41–60	120 (29)
61–80	89 (21)
81–100	29 (7)
I do not know	89 (21)
Cannot be determined	22 (5)

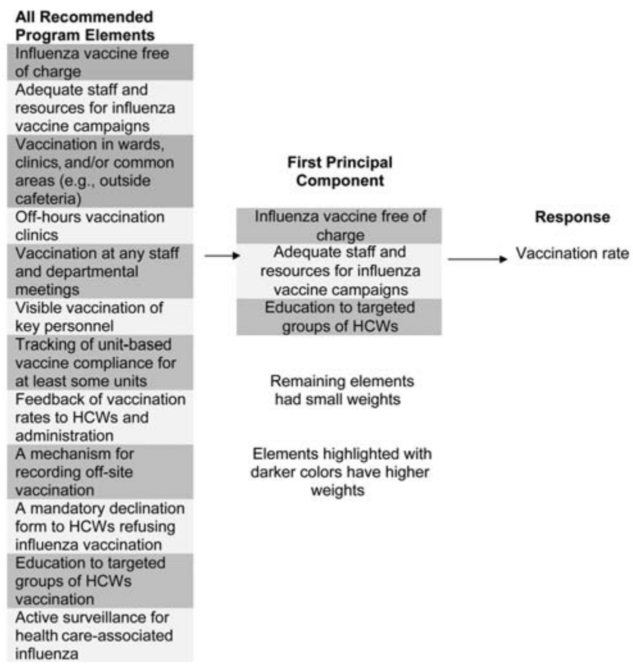

Figure 1. Principal components analysis of influenza vaccination program elements. The weights for the program elements "Influenza vaccine free of charge," "Adequate staff and resources for influenza vaccine campaigns," and "Education to targeted groups of HCWs" in the first principal component are 1.04 (averaged over 3 elements), 0.59, and 1.02, respectively. The mean weight for the remaining elements is 0.26. HCW, health care worker.

associated with the first principal component was 1.632 (95% CI, 1.360–1.957).

To evaluate the general association of hospital compliance with HICPAC/ACIP recommendations and vaccination rates, the γ statistic was used. The value of γ was 0.373 (95% CI, 0.275–0.470), indicating a significant, positive association between the vaccination rate and the compliance level.

EIN members also registered their opinions about various strategies to increase vaccination rates. Seventy-eight percent of members thought that HCWs should be required to sign a declination statement if they refuse annual influenza vaccination. Only 8% disagreed with this strategy, 2% disagreed strongly, and 11% reported a neutral position. When asked whether vaccination rates should be publicly reported, most agreed or strongly agreed (59%), whereas only 3% strongly disagreed.

Thirty-seven percent of respondents provided additional comments, most of whom described the factors that they perceived to be barriers to higher vaccination rates in their own institutions. Employee resistance was the most commonly reported barrier to higher vaccination rates, with IDCs indicating that some HCWs believe that they could become ill from the vaccine. IDCs also reported that a lack of resources and support from health care administrators were barriers. Finally, IDCs also perceived recent vaccine shortages and delayed vaccine delivery to be problems, in part because they prevented influenza vaccination campaigns from building momentum.

DISCUSSION

HCWs are at an especially high risk of contracting influenza [6], and once infected, HCWs can spread influenza virus to patients under their care [1, 7, 8]. Outbreaks of influenza in both hospitals and nursing homes can cause serious staff shortages [9]. All of these reasons seem to provide substantial incentive for hospitals to increase vaccination rates among their workforce. However, the IDCs responding to this survey indicate not only that vaccination rates remain unacceptably low but also that most health care institutions have not implemented the current HICPAC/ACIP recommendations for such programs.

Hospitals can increase influenza vaccination rates significantly among their employees if hospital administrators are committed to this goal and provide adequate financial resources. For example, the University of Virginia increased its influenza vaccination rate from 4% to almost 67% with a concerted effort over several years [10]. However, our results indicate that institutions with high vaccination rates are in the minority; only 7% of respondents report vaccination rates >80%.

Several investigators have described interventions that successfully increase vaccination rates, but these almost always describe the experiences of a single institution, limiting the generalizability of these results. Furthermore, most interventions to increase vaccination rates rarely occur in isolation; multiple interventions (e.g., vaccination carts and education campaigns) usually take place simultaneously. Thus, interventions may simply reflect a supportive hospital administration or effective leadership. Indeed, increased vaccination rates can be undermined with the loss of key personnel [11]; thus, the intensity of influenza vaccine campaign programs needs to be maintained from year to year.

By using principal components, we were able consider the experiences of hundreds of institutions to determine the most effective elements of a successful campaign: making the vaccine free of charge, devoting adequate resources to vaccination efforts (as judged by the IDC in that institution), and educating targeted groups of HCWs. These results are consistent with the literature and confirm the observation that making the influenza vaccine available to HCWs is not sufficient to increase vaccination rates [12]. The importance of educating targeted groups of HCWs was emphasized by the IDCs who reported that some HCWs still believe that they can get sick from the vaccine. In fact, employee resistance was the most commonly cited barrier to increasing vaccination rates. Lack of knowledge has been cited as a barrier to vaccination in other studies [13–

15]. HCWs commonly avoid vaccination because they think that they can get sick from the vaccine or because they perceive the vaccine to be ineffective. They also often fail to recognize the importance of vaccination for patient safety. Educational interventions have helped increase vaccination rates [16]. But studies from single institutions may not be generalizable. Clearly, more work is needed to define what specific attitudes and beliefs undermine vaccination efforts among HCWs. The effectiveness of specific educational materials and interventions should also be evaluated in studies involving >1 institution. In addition to studying the beliefs and attitudes of HCWs, it would be helpful to survey hospital administrators.

There are several limitations to our study. First, our sample might have been biased, given the fact that members involved in hospital epidemiology, infection control committees, or employee health were more likely to respond to this survey than were other members. It is possible that members with an infection control background work in hospitals with higher vaccination rates (or better compliance with recommendations) and were thus more likely to respond. This would lead to biased results in the upward direction. However, given that the results of this survey displayed both a dismal implementation rate of the HICPAC/APIC recommendations and suboptimal vaccination rates, it is likely that our results would have been worse (e.g., lower vaccination and implementation rates) with a more representative sample. Instead, we speculate that these members were more likely to respond because of greater interest in the topic and greater access to information about this issue. A second limitation to this study is that there is no way for us to confirm the accuracy of members' responses. We realized that some of the respondents' answers regarding influenza vaccination rates may have been estimates. For this reason, we asked respondents to report 1 of 5 categories of vaccination rates (0%–20%, 21%–40%, 41%–60%, 61%–80%, and 81%–100%) instead of the exact rate. Finally, a majority of respondents reported that their institution did not have a mechanism for recording off-site vaccination. Thus, the rates reported may be underestimates. However, the vaccination levels we report are, on average, higher than national estimates [2, 17]. Thus, it is unlikely that our results indicate a clinically significant underreporting of vaccination rates.

We are discouraged that most health care institutions have yet to implement recommendations that have been shown to increase vaccination rates or at least have strong theoretical rationale for doing so. However, the good news is that the widespread full implementation of these recommendations may boost vaccination rates significantly. Not surprisingly, all of the recommendations suggested by HICPAC/ACIP are associated with higher vaccination levels in our study. Institutions that had adopted all measures had, on average, rates of 60%–80%, far exceeding the national average.

Declination forms were not commonly used during the 2005–2006 season, and, interestingly, were one of the least implemented HICPAC/ACIP recommendations. Nonetheless, IDCs strongly support this measure and, given their influence in hospital epidemiology, infection control, and employee health organizations within hospitals, they could be key advocates for the implementation of declination forms. IDCs also generally support public reporting of HCW vaccination rates at the facility level. The widespread implementation of either or both of these measures may get the attention of administrators, who by actively supporting vaccination campaigns, both in terms of supplying the needed personnel and resources for education, appear to be the key to increasing HCW vaccination rates.

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