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Influenza Vaccination of Health Care Workers: Evaluation of Factors That Are Important in Acceptance

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Background. **We evaluated the associations between putative occupational and epidemiologic determinants and influenza vaccine acceptance among health care workers during two consecutive seasons.**

Methods. **Multiple logistic regression models were developed to identify predictors of vaccine acceptance during 1991–1992, then validated in the subsequent year. A combined repeated-measures regression model using generalized estimating equations was fit to examine workers' vaccine acceptance over the 2-year period.**

Results. **Nearly one-third of hospital employees received influenza vaccine each year [2,364 of 7,320 (32%) in 1991–1992 vs 2,679 of 8,632 (31%) in 1992–1993]. Independent predictors among nurse clinicians included older age, higher salary, longer employment, and minimal absenteeism. Female sex, marriage, higher salary, and employment duration were independent predictors for professional support staff. Older age was the only independent predictor among nonprofessional staff.**

Conclusions. **We conclude that older individuals, those with higher socioeconomic status, and those employed longer are more likely to accept the influenza vaccine. Sex, marital status, and prior work absenteeism are also important predictors in specific groups of health care workers.**

Key Words: **vaccine acceptance; influenza vaccine; epidemiologic methods; health care workers; health behavior; socioeconomic status.**

INTRODUCTION

Influenza continues to impact measurably the health and economy of the United States, despite the availability of a moderately effective vaccine. Each year influenza accounts for 4 million respiratory illnesses and 17 to 18 million days of restricted activity among adults in the country [*1*]. During the 1989–1990 influenza season, influenza and pneumonia accounted for nearly 160,000 excess hospitalizations in Medicare recipients at an estimated cost of more than $700 million [*2*]. The direct costs of influenza in the United States have been estimated at $3 to $5 billion per year [*3*].

Nosocomial influenza outbreaks occur frequently, and health care personnel infected while working may transmit influenza to patients [*4,5*]. Importantly, up to three-fourths of health care workers with influenza-like illness continue to work while ill [*6*]. Since 1984, the Centers for Disease Control and Prevention have recommended annual influenza vaccination of physicians, nurses, and other personnel in both hospital and outpatient-care settings to prevent infections and subsequent nosocomial transmission to patients [*7,8*]. However, numerous reports have documented low rates of influenza vaccine acceptance by health care workers, despite a variety of interventions [*6,9,10*].

Reasons given for not being vaccinated include inconvenience [*6,9,11–14*], perceptions of the vaccine's ineffectiveness or potential side effects [*6,9,11,13,14*], and the perception that health care workers are at low risk for acquiring and transmitting influenza [*9–11, 14*]. Perhaps the greatest misconception about the vaccine is that it may actually cause the recipient to acquire the "flu" [*13,14*]. In a recent placebo-controlled trial in healthy working adults, muscle soreness was the only side effect occurring significantly more often among those receiving the vaccine [*15*]. Despite concerns regarding potential vaccine side effects, two studies have found no increase in work absenteeism following influenza vaccination [*16,17*]. Importantly, the determinants of vaccine acceptance in this population are

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poorly understood. Improved identification of the determinants of vaccine acceptance may allow development and evaluation of vaccine delivery programs specifically targeted to underimmunized groups.

The overall goal of this study was to identify predictors of influenza acceptance in health care workers in order to help define and plan future vaccine delivery programs. The study was performed concurrently with an influenza outbreak in the state and following efforts to increase vaccination of health care workers. Current rates and determinants of influenza vaccine acceptance were assessed among employees at our hospital during two consecutive vaccination campaigns. All hospital employees were included in the study [*8,18*]. Multiple logistic regression analysis was used to evaluate potential determinants of influenza vaccine acceptance. This approach was taken due to the paucity of analytic epidemiologic data identifying independent determinants of influenza vaccination among health care workers.

Most prior studies among health care workers have been small and descriptive [*6,9,12,14,19,20*], have had relatively low response rates [*6,9,10,12,13*], and have primarily evaluated a limited number of closed-ended questions for their univariate associations with influenza vaccine acceptance [*6,9,10,12,13,19*]. The current study is unique in terms of its large sample, the linking of administrative and clinical databases to obtain complete data, and the development and validation of multivariate models of vaccine acceptance.

MATERIALS AND METHODS

The objectives of the current study were to evaluate the statistical associations between putative determinants of vaccine acceptance and actual vaccination, as well as to model the independent associations between the study variables and vaccine acceptance over time. Vaccine acceptance was examined among hospital workers during the 1991–1992 and 1992–1993 influenza seasons at our medical center.

The University of Iowa Hospitals and Clinics is a 900-bed facility located in a community of approximately 60,000 inhabitants and an additional 40,000 persons in the surrounding county. The hospital is part of a large multicollege educational and research institution with approximately 27,000 students, 1,700 faculty, and 9,500 other staff.

Vaccine Delivery Program

Hospital employees were offered the influenza vaccine at no charge by written invitation, and a hospital-wide information campaign was used to encourage participation. The influenza vaccine offered each year was a trivalent split virus preparation (Types A and B, Wyeth) which included the vaccine strains recommended that year [*21,22*]. The information campaign included announcements in the daily hospital news flyer, letters to program and department heads, and signs posted throughout the facility informing workers of the details of the vaccination clinics. The influenza vaccine was offered free of charge to all hospital employees during four mass immunization clinics (two full-day and two half-day clinics) in late October and early November of 1991 and 1992. Participants were required to read an information summary and to sign a consent form. The vaccine was also provided to workers visiting the employee health clinic. Similar measures were followed to deliver the vaccine the following season, with the same educational campaign and frequency and timing of employee vaccine clinics.

Influenza Case Activity

Data on influenza case activity from both the local county and the state health departments were reviewed to examine whether hospital employee vaccine acceptance was higher during a community outbreak. The peak month of laboratory-confirmed influenza cases for both the state and the surrounding county was December 1991. Data from the Iowa Department of Public Health demonstrated that influenza rates in the state were higher during the 1991–1992 season than at any time in the prior decade. Influenza rates in the state returned to baseline during the 1992–1993 season.

Vaccine Acceptance

We linked data on vaccine acceptance from the hospital staff vaccine clinics and employee health clinic to a database of demographic and employment data on all hospital workers from the university personnel department. Records of vaccination were based upon documented vaccination records obtained during the immunization clinics or at regular visits to the employee health clinic. Covariates selected for evaluation in the study included age, sex, race, occupation, specific job code, estimated median annual salary, duration of employment, patient contact, and prior work absenteeism.

Exclusion Criteria

Workers were excluded from consideration for the study if they were not employed during the first 5 months of the fiscal year (July–November) and therefore not working at the time of the vaccine campaign or if they were not salaried employees.

Data Categorization

Data on hospital employees were categorized on the basis of all available potential explanatory variables: sex, age (<30, 30–39, 40–49, and ⩾50 years), marital

status, and duration of employment (<5, 5–9, and ⩾10 years). Occupation was stratified into four groups based primarily upon education and training: "nurse clinicians" (registered nurses, nurse practitioners, and physician assistants), physicians (house officers, fellows, and faculty), professional support staff (physical therapists, pharmacists, social workers, laboratory technologists, and administrators), and nonprofessional support staff (licensed practical nurses, nursing assistants, housekeepers, technicians, maintenance, food service, and clerical workers).

Workers were also classified as to whether they had regular patient contact by their specific job classification code. Employees with patient contact included physicians and most workers in nursing, radiology, respiratory therapy, social services, and physical therapy. Workers without regular patient contact included those in housekeeping, dietary, material services, medical records, pathology, fiscal management, maintenance, and pharmacy. The specific job code for each position provides considerably more detail about the position and its responsibilities than does occupation alone. For example, upper level nurse administrators whose job responsibilities typically do not involve patient contact were coded as workers without patient contact. Head nurses or nurse clinicians, whose positions involve regular patient contact, were coded as having patient contact.

The median annual salary for each individual's specific job classification, which is based on occupation and job experience, was used as the income variable. Subsequently, annual salary was categorized as <$20,000; $20,000–29,999; $30,000–39,999; and ⩾$40,000 for the purposes of the regression analyses. Three or more sick days in a given month during the 3 months prior to the vaccine campaign (July–September) was a surrogate marker (prior absenteeism) for underlying health status. Race was not evaluated as an explanatory variable in the multivariate analyses since 95% (6,980 of 7,319) of the workers were white, non-Hispanic.

Statistical Analysis

Data from the entire cohort of hospital employees during 1991–1992 were used to develop a multiple logistic regression model to predict influenza vaccine acceptance. Data from the 1992–1993 cohort of hospital employees were used to validate the model in a subsequent year.

The univariate relationships between each explanatory variable and vaccination status were examined. Contingency table analyses of the associations between demographic and occupational variables and the outcome of vaccination were assessed with a likelihood ratio χ^2 test for nominal and ordinal variables. Continuous variables were examined individually in univariate logistic models. Ninety-five percent confidence intervals (CI_{95}) were calculated for the odds ratios. Alpha was set at 0.05 and all P values were two-sided. All statistical procedures were performed using SAS (SAS Institute, Cary, NC).

Univariate and stratified univariate tests were used to select a subset of important covariates. Occupation was very highly associated with vaccination status. Additionally, since the factors related to vaccine acceptance differed markedly by occupation, the variable selection procedure was performed separately for each occupational (educational) category. The variables with the largest Pearson χ^2 statistic per degrees of freedom was selected initially for inclusion in the model. After stratification by the levels of the first variable, the relationship between each of the remaining variables and vaccination status was assessed using the Cochran–Mantel–Haenszel general association statistic [*23*]. For dichotomous variables, this test reduces to the Mantel–Haenszel χ^2 test. The variable with the largest value of the Cochran–Mantel–Haenszel χ^2 statistic per degrees of freedom was then selected. After stratification by the levels of the preceding variables selected, the relationship between each of the remaining variables was then assessed, using the general association statistic. This procedure was terminated when the adjusted effect of each remaining variable was not statistically significant ($P < 0.05$).

Multiple logistic regression analysis was then performed to model the predictors in influenza vaccination. A model was initially developed for each occupational group, then a model for all of the data was fit based on the results of tests of the equality of effects across groups. Appropriate first-order interaction terms were considered for inclusion in the models. However, none of the interaction terms improved the fit of the model. Since all explanatory variables were categorical, a likelihood ratio χ^2 test was used to assess the goodness of fit of each model.

The purpose of initially fitting each occupational group separately was to provide clearer descriptions and interpretations of the possibly differing effects of covariates across occupational groups. That is, instead of fitting models with crossed effects (interactions) between the covariates and the occupation groups, the effect of the procedure that was followed was to fit nested effects within occupation groups. These separate effects were then tested for equality across occupation groups.

The performance of the final logistic model was evaluated on the entire cohort of hospital employees in 1992–1993, by comparison of the size and direction of each regression coefficient for the model fit to these data. Additionally, the goodness of fit of the model in this second year was evaluated. There were 1,588 workers in the second year's cohort who were not studied in the first year. Many of these workers were new employees, thus they differed systematically from the

overall population with regard to several important risk factors for acceptance (new house officers, younger, short duration of employment). Given the number of stratification variables, the size of the strata (many with more than two strata), and the stability of the workforce, the number of 1992–1993 workers not included in the 1991–1992 database was insufficient to permit formal validation of the model on an unstudied group of workers during the second year. However, the performance of the model was examined in the second study year in order to determine whether the same factors appeared to be important in vaccine acceptance during a period of baseline influenza case activity. Finally, following the model fitting and validation procedures, a combined model was fit to all the data. Since the repeated observations for individuals included in both data sets are correlated, the generalized estimating equation approach of Liang and Zeger [*24*] was used to model the marginal logit of vaccine acceptance as a function of the predictor variables from the initial 1991–1992 model. Since each subject contributed either one or two observations, the exchangeable working correlation model was assumed. This modeling was carried out using the program of Davis [*25*]. This procedure makes use of all the data from both years to estimate the regression parameters. In addition, it correctly accounts for the dependence among repeated measurements obtained from the same subject.

RESULTS

A total of 2,364 of 7,320 workers received the vaccine in the initial influenza season, an overall rate of 32% (Table 1). Vaccination rates ranged from 30% (449 of 1,070) among nurse clinicians and physician assistants, 25% (20 of 81) among licensed practical nurses, 31% (106 of 342) among nursing and dialysis assistants, 32% (129 of 402) among house officers, 26% (69 of 267) among staff physicians, to 27% (76 of 280) among laboratory technicians. During the second study year, 2,679 of 8,632 workers (31%) had received the vaccine. Overall, 80% of the workers in the initial study year were still employed during 1992–1993 and were included in that data set. Subjects in the 2 study years were quite similar with regard to vaccine acceptance among subgroups of workers and the explanatory variables examined.

Univariate Analysis of the 1991–1992 Data Set

Univariate factors associated with vaccine acceptance in the entire cohort included age, race, occupation, salary, and duration of employment (Table 2). Vaccine acceptance among nurse clinicians was significantly associated with older age, longer duration of employment, and prior absenteeism. Sex and marital status were not significant covariates, although most employees in this category were women. Since nearly all nurse clinicians had patient contact, this variable could not be evaluated in this group.

Similarly, nearly all physicians had patient contact and few had absenteeism in the 3-month baseline period; thus these two variables were excluded as predictors among physicians. The only variable significantly

TABLE 1

Description of the Sample and Acceptance of Influenza Vaccine in Relation to Selected Characteristics in the 1991–1992 Influenza Season (N = 7,320)

Characteristics	Total No. (% in category)[a] (n = 7,320)	Influenza vaccine acceptance No. (rate %)[b] (n = 2,364)
Sex		
Female	4,884 (67)	1,584 (32)
Male	2,436 (33)	777 (32)
Age		
<30 years	1,695 (23)	437 (26)
30–39 years	2,777 (38)	815 (29)
40–49 years	1,762 (24)	606 (34)
⩾50 years	1,083 (15)	504 (47)
Race		
White, non-Hispanic	6,980 (95)	2,281 (33)
Other	340 (5)	82 (24)
Marital status		
Married	4,720 (65)	1,534 (33)
Not married	2,596 (35)	826 (32)
Occupation		
Nurse clinicians	1,519 (21)	449 (30)
House officers	402 (6)	129 (32)
Staff physicians	267 (4)	69 (26)
Professional support staff	1,868 (26)	539 (29)
Nonprofessional support staff	3,138 (44)	1,052 (34)
Employment duration		
<5 years	3,583 (49)	1,019 (28)
5–9 years	1,661 (23)	542 (33)
⩾10 years	2,062 (28)	797 (39)
Patient contact		
Yes	4,001 (56)	1,264 (32)
No	3,180 (44)	961 (30)
Prior absenteeism		
None	6,993 (95)	2,266 (32)
1 or more months	327 (5)	98 (30)
Salary (annual)		
<$20,000	1,563 (22)	488 (31)
$20,000–29,999	1,899 (26)	592 (31)
$30,000–39,999	2,568 (36)	746 (29)
>$40,000	1,174 (16)	412 (35)

[a] Percentage in category represents the proportion of persons with each characteristic for whom the data are recorded or available.

[b] Rate percentage is the vaccine acceptance rate among persons in that row.

TABLE 2

Results of Univariate Logistic Regression Analyses, Relating Variables to Influenza Vaccination during the 1991–1992 Influenza Season (N = 7,320)

Variable (referent category)	Odds ratio	95% CI	P value
Age (<30 years)			<0.001
30–39 years	1.20	1.04–1.37	0.010
40–49 years	1.51	1.30–1.75	<0.001
⩾50 years	2.51	2.13–2.95	<0.001
Female sex (male)	1.02	0.92–1.14	NS
Married (unmarried)	1.03	0.93–1.14	NS
Non-white race (white, non-Hispanic)	0.66	0.51–0.85	0.001
Occupation (nurse clinicians)			0.002
Physicians	1.00	0.82–1.22	NS
Professional support	0.97	0.83–1.12	NS
Nonprofessional support	1.20	1.05–1.37	0.007
Patient contact (no patient contact)	0.94	0.85–1.04	NS
Salary (<$20,000 annually)			0.003
$20,000–29,999	1.01	0.87–1.16	NS
$30,000–39,999	0.90	0.79–1.03	0.139
⩾$40,000	1.20	1.01–1.40	0.033
Prior absenteeism (<3 days missed in 3 prior months)	0.89	0.70–1.14	NS
Duration of employment (<5 years)	1.03	1.02–1.04	<0.001
5–9 years	1.22	1.07–1.38	0.002
⩾10 years	1.58	1.41–1.78	<0.001

Note. CI, confidence interval; NS, nonsignificant.

associated with vaccination among physicians was duration of employment.

Female sex, marriage, increased prior absenteeism, duration of employment, higher socioeconomic status, and patient contact were all associated with vaccine acceptance for professional support personnel. Age was not a significant covariate, although it approached significance (P = 0.06). The only factor significantly associated with vaccine acceptance among nonprofessional support staff was older age (P < 0.001).

Multiple Logistic Regression Analysis of the Initial Data Set

In comparison with nurse clinicians, physicians were significantly more likely to receive the influenza vaccine (OR 1.8, CI_{95} 1.3–2.4) and professional support personnel were significantly less likely to receive the vaccine (OR 0.4, CI_{95} 0.2–0.6), after adjustment for other variables in the model. The vaccine acceptance of nonprofessional support personnel did not differ significantly (OR 1.3, CI_{95} 0.9–1.7) from that of nurse clinicians.

Older age, longer duration of employment, higher socioeconomic status, and prior absenteeism were independently associated with vaccine acceptance among nurse clinicians. Nurse clinicians earning more than $40,000 annually accepted the vaccine more frequently than those earning less (OR 2.6, CI_{95} 1.8–3.7, Table 3). Compared with a baseline strata under 30 years of age, those ages 40–49 (OR 1.4, CI_{95} 1.0–2.1) and those age 50 and older (OR 2.8, CI_{95} 1.7–4.4) were significantly more likely to receive the vaccine. Additionally, nurse clinicians employed 10 years or more had significantly higher rates of vaccine acceptance than those employed less than 5 years (OR 1.6, CI_{95} 1.2–2.1). Nurse clinicians without prior absenteeism in any of the preceding 3 months accepted the vaccine less frequently than those with prior absenteeism (OR 0.6, CI_{95} 0.4–0.9).

Physicians employed 5 to 9 years were significantly less likely to receive the vaccine than those with less than 5 years of employment (OR 0.3, CI_{95} 0.1–0.8). The difference between physicians with 10+ years of employment and those with less than 5 years of employment, however, was not statistically significant. Professional support staff with higher salary, increased employment duration, prior absenteeism, and female sex and if married were independently more likely to receive the influenza vaccine. Nonprofessional support personnel were more likely to receive the vaccine as their age increased. Goodness of fit assessment demonstrated that the model provided an adequate fit (χ^2 = 126.68, degrees of freedom (df) = 108, P = 0.11).

Evaluation of the Logistic Model in the Second Data Set

The final model from the 1991–1992 cohort was fit to the 1992–1993 data (Table 3). This model provided a good fit to the data for the second study year (lack-of-fit χ^2 = 96.82, df = 99, P = 0.54). Estimated parameters from the validation set agreed with the corresponding parameters from the initial data set with minor exceptions. The likelihood of vaccination among physicians

TABLE 3

Final Logistic Regression Model to Predict Influenza Vaccination during the 1991–1992 Influenza Season (N = 7,320), Performance of the Model during the 1992–1993 Season (N = 8,632), and Combined Repeated-Measures Regression Analysis Model Using Generalized Estimating Equations to Predict Influenza Vaccination during the 1991–1993 Influenza Seasons

	Logistic regression models				Combined repeated-measures regression model	
	1991–1992 season		1992–1993 season		1991–1993 seasons	
Variable (referent category)	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Occupation (nurse clinicians)						
Physicians	1.8 (1.3–2.4)	<0.001	2.0 (1.5–2.7)	<0.001	1.8 (1.4–2.3)	<0.001
Professional support staff	0.4 (0.2–0.6)	<0.001	0.3 (0.2–0.5)	<0.001	0.3 (0.2–0.5)	<0.001
Nonprofessional support staff	1.3 (0.9–1.7)	0.15	1.2 (0.9–1.7)	0.18	1.3 (1.0–1.6)	0.026
Nurse clinicians						
Salary ⩾$40,000 (<$40,000)	2.6 (1.8–3.7)	<0.001	2.5 (1.7–3.5)	<0.001	2.5 (1.8–3.3)	<0.001
Age 30–39 years (<30 years)	1.2 (0.9–1.7)	NS	1.4 (1.1–2.0)	0.02	1.3 (1.0–1.7)	0.019
Age 40–49 years	1.4 (1.0–2.1)	0.05	1.3 (0.9–1.9)	0.14	1.4 (1.1–1.9)	0.006
Age ⩾50 years	2.8 (1.7–4.4)	<0.001	1.8 (1.2–2.9)	0.01	2.1 (1.4–3.0)	<0.001
Employed 5–9 years (<5 years)	1.3 (1.0–1.7)	0.07	1.5 (1.1–2.0)	0.005	1.3 (1.1–1.6)	0.004
Employed ⩾10 years	1.6 (1.2–2.1)	0.004	2.0 (1.5–2.6)	<0.001	1.7 (1.4–2.2)	<0.001
Prior absenteeism (<3 days missed in 3 prior months)	0.6 (0.4–0.9)	0.03	0.6 (0.4–1.0)	0.05	0.7 (0.6–1.0)	0.024
Physicians						
Employed 5–9 years (<5 years)	0.3 (0.1–0.8)	0.01	1.1 (0.6–1.9)	NS	0.8 (0.5–1.2)	0.152
Employed ⩾10 years	1.6 (0.7–3.5)	NS	1.0 (0.4–2.3)	NS	1.3 (0.7–2.5)	0.238
Professional support staff						
Salary $30,000–39,999 (<$30,000)	1.9 (1.3–2.7)	<0.001	3.0 (2.1–4.3)	<0.001	2.4 (1.8–3.2)	<0.001
Salary ⩾$40,000	2.7 (1.8–4.0)	<0.001	3.9 (2.7–5.7)	<0.001	3.3 (2.4–4.5)	<0.001
Female sex (male)	1.6 (1.3–2.1)	<0.001	1.3 (1.0–1.6)	0.02	1.4 (1.2–1.7)	<0.001
Married (unmarried)	1.4 (1.1–1.8)	0.006	1.4 (1.1–1.8)	0.004	1.4 (1.1–1.7)	<0.001
Prior absenteeism (<3 days missed in 3 prior months)	2.7 (1.3–5.3)	0.005	1.1 (0.5–2.2)	NS	1.2 (0.8–1.9)	0.197
Employed 5–9 years (<5 years)	1.3 (1.0–1.8)	0.05	1.2 (0.9–1.6)	NS	1.2 (1.0–1.5)	0.024
Employed ⩾10 years	1.6 (1.2–2.0)	0.001	1.7 (1.3–2.1)	<0.001	1.5 (1.2–1.9)	<0.001
Patient contact (no routine contact)	1.4 (1.0–1.9)	0.05	1.5 (1.1–2.0)	0.008	1.5 (1.1–1.9)	0.003
Nonprofessional support staff						
Age 30–39 years (<30 years)	1.4 (1.2–1.8)	0.001	1.5 (1.2–1.8)	<0.001	1.4 (1.2–1.6)	<0.001
Age 40–49 years	1.8 (1.5–2.3)	<0.001	2.2 (1.8–2.8)	<0.001	2.0 (1.7–2.4)	<0.001
Age ⩾50 years	2.8 (2.2–3.6)	<0.001	3.2 (2.6–4.0)	<0.001	2.9 (2.4–3.5)	<0.001

Note. CI, confidence interval; NS, nonsignificant.

working 5 to 9 years was not significantly different from those working fewer than 5 years in the 1992–1993 data set (OR 1.1, P = 0.70). Nurse clinicians 40–49 years of age did not differ significantly in vaccine acceptance compared with those less than 30 years of age (OR 1.3, P = 0.14). In the second data set, professional support personnel with absenteeism prior to the vaccine season were not more likely to be vaccinated (OR 1.1, P = 0.84). Similarly, those working 5 to 9 years did not differ significantly from those with shorter employment duration (OR 1.2, P = 0.21).

Fitting a Combined Model

A combined model using both data sets was developed to identify predictors of influenza vaccine acceptance over the period from 1991 to 1993. This model included all of the effects considered in the initial model. As shown in Table 3, the assessments of statistical significance and the estimated odds ratios were generally in close agreement with the results of the initial model.

The estimated odds ratio of 1.3 for nonprofessional support staff relative to nurse clinicians was similar to that found in the initial model. In the combined effects model, this effect became significant (P = 0.026). Among nurse clinicians, the effects for ages 30–39, ages 40–49, and employed 5–9 years were also significant. Neither of the two statistically significant employment effects for physicians identified in the initial model are significant in the combined model. The two estimated odds ratios for duration of employment (5–9 years vs <5 years, 10+ years vs <5 years) are still in the same direction as in the 1991–1992 model, but are both considerably closer to the null value. Since the estimated odds ratios in the 1991–1992 data set were not monotonic, these effects may well have been artifacts.

The prior absenteeism effect in professional support staff is also not observed in the combined data. However, the employed 5–9 year effect in this group is sta-

tistically significant in the combined data, although the estimated odds ratio of 1.2 is somewhat smaller than that observed in the 1991–1992 data.

DISCUSSION

During the two influenza seasons, one-third of the hospital workers at our facility received the vaccine. The overall rates of vaccine acceptance were unrelated to the occurrence of a concurrent statewide influenza outbreak. Other authors have reported one-third or fewer hospital workers accepting the influenza vaccine in the setting of community-wide epidemics and extensive health care worker educational campaigns [*9,10, 14*]. These rates are similar to those from other published studies in which no specific interventions to increase compliance were performed, ranging from 2 to 30% [*6,9,13*]. Some of these estimates, however, were derived from relatively small questionnaire samples [*6,10,11*], compared with documented records of vaccination [*9,12,13,20*]. However, the overall worker vaccination rate is relatively low, thus potentially limiting the ability to prevent the spread of influenza, should it occur among unvaccinated workers in the institution.

The current study demonstrates that the epidemiological determinants of influenza vaccine vary across different health care occupations. In our study, physicians were significantly more likely to receive the vaccine than other occupational groups, adjusting for other factors in the model. Similar results were reported in another recent survey of health care workers in which occupation was independently associated with vaccination [*14*]. In another questionnaire study, rates of influenza vaccine acceptance also varied by occupation [*9*]. Workers in full-time positions were also slightly more likely to receive the vaccine than part-time workers.

Likewise, the frequency of adoption of other preventive health measures by health care providers has been shown to vary by occupation [*26–28*]. Differences in behavioral risk factors and in the adoption of preventive health measures among workers in different occupations may more accurately reflect educational level. Our categorization of occupations was based primarily on the education or training required for similar occupations. In the National Health Interview Survey (NHIS), individuals with higher levels of education have been more likely to utilize clinical preventive services [*29,30*], preventive dental practices [*31*], and other preventive health behaviors [*29,32*].

Influenza vaccine acceptance was significantly associated with advancing age among nurse clinicians and nonprofessional support staff. This finding may be due either to an acknowledged increased risk of acquiring influenza as one ages or to an increased perceived benefit from the vaccine. Data from two surveys of health care workers have found that influenza vaccine recipients were significantly older than those declining the vaccine [*9,14*]. In another study of patients at high risk for influenza, increasing age was associated with greater concerns about the health risks of influenza [*33*]. This observed age-related increase in influenza vaccine acceptance may also be due, in part, to an increase in indications for the vaccine (e.g., chronic cardiac or pulmonary disease) in older workers. Data from the NHIS found that utilization of certain other clinical preventive services increased with age [*29,30*].

In our study, women were more likely to receive the influenza vaccine in the professional support group. This difference was not observed in other occupational groups, although the gender distribution of the other three groups was less heterogeneous; nearly all the nurse clinicians were women. In general, women are more likely to adopt certain preventive health behaviors [*29,34*], to use clinical preventive services regularly [*29*], and to practice preventive dental behaviors than men [*29,31*].

Socioeconomic status was independently associated with vaccine acceptance among nurse clinicians and professional support staff. Salary was not a predictor of vaccination among physicians, although their salaries were higher than those of most other workers. Analogously, the salaries of most nonprofessional support personnel were in the lower salary strata. Since salary is closely linked to occupation, lack of an independent relationship between vaccine acceptance and salary in these two occupational categories was not unexpected. Other authors have found that different clinical preventive services [*29,30*], preventive dental practices [*31*], and some preventive health behaviors [*29*] are more frequently used by those earning higher salaries. Additionally, higher paid employees may have more access to vaccination clinics since they are likely to have greater flexibility in their schedules.

Marital status was independently associated with influenza vaccine acceptance among professional support staff. In a number of studies, married persons are more frequent users of clinical preventive services [*29,30*], and have fewer behavioral risk factors for disease, such as smoking and failure to wear seat belts. However, married persons are less likely to get regular exercise than are the never married [*29*].

Among patients, acceptance of influenza vaccine is decreased among non-white persons, obese patients, nonusers of seatbelts, and current smokers [*35*]. However, one of the best predictors in influenza vaccination is having had a medical checkup or routine health visit in the past year [*35*]. Factors associated with patient vaccination include intention to follow professional recommendations to be vaccinated, previous vaccination behavior, and, perhaps most importantly, health care provider recommendations [*14,36–38*]. Barriers to patient vaccination include previous side effects of the vaccine, not believing the vaccine is protective, and

never having received the pneumococcal or influenza vaccine [*36–39*].

Nichol and colleagues recently demonstrated that vaccination of the elderly against influenza was associated with a reduction in the rate of hospitalization for respiratory conditions, reductions in mortality due to influenza and its complications, and major cost savings [*40*]. Additionally, in another study they reported that vaccination of healthy adults against influenza is associated with fewer episodes of respiratory illness, fewer days of sick leave, and fewer physician visits due to respiratory illness, and an estimated cost savings of $46.85 per person vaccinated [*15*]. We strongly support the Advisory Committee on Immunization Practices' (ACIP) recommendation for annual influenza vaccination of health care workers and continue to stress the importance of vaccination to health care workers [*8,41*]. This support is based on the efficacy of the vaccine [*7,42*], as well as the need to protect providers of essential community services.

Novel methods are needed to address the relatively low rates of influenza vaccine acceptance among health care workers since traditional vaccine delivery approaches have been relatively unsuccessful in this population. Obtaining informed consent for administration of the influenza vaccine may not be necessary and may actually decrease compliance [*43*]. Studies in which specific interventions were introduced have shown apparent boosting of acceptance, compared with historical rates. By administering vaccine to medical students and house officers in clinics and conferences, Ohrt and McKinney increased vaccine acceptance from 20 to 62% at a teaching hospital [*13*]. Following an educational conference on influenza in another study, vaccine acceptance among house officers was increased by 27% [*19*]. Investigators at another hospital were able to increase their vaccination rate by one-third with a program including a small incentive, a coupon for a free frozen yogurt dessert [*44*]. The ACIP recommend using a mobile cart to deliver the vaccine on the wards or at other worksites, increased availability after hours, and a follow-up campaign early in the course of a community outbreak [*8*].

Based on these results, we would suggest evaluating whether focusing immunization efforts on groups with low levels of vaccine acceptance will increase the likelihood of benefit of a given intervention. Vaccine delivery efforts could be targeted to groups of workers that appear less susceptible to routine appeals for immunization. Efforts to immunize younger, more recently employed workers in departments with low rates of acceptance through educational programs that include offering the vaccine at the worksite and during departmental meetings may be particularly effective. Additionally, further investigation of barriers to immunization in those occupational groups most resistant to vaccination efforts may be beneficial, controlling for the factors identified as important in the current study.

Strengths and Limitations of the Study

Several aspects of the study design enhance its internal validity. This study utilized documented vaccination records, rather than self-reported data, thus decreasing the likelihood of bias due to misclassification. It is possible that some employees received the vaccine from their personal physicians and were therefore misclassified. However, since the vaccine is routinely provided at no charge to hospital employees, it seems unlikely that many workers would have been vaccinated by their private physicians. An informal poll of workers at our facility suggests that influenza vaccination of workers rarely occurs outside the hospital. All hospital employees were included in the study, thus minimizing the potential for selection bias. Additionally, the size of the study population is an obvious strength. Finally, absenteeism and employment data were obtained from a well-documented computer database used for personnel and payroll services.

A number of potential limitations of the study should be noted as well. Income data were based upon the median salary for the given individual's job classification, not on the actual salary for each employee. Although actual salary is one of the best measures of socioeconomic status, a given individual's salary may have been misclassified within the ranges of salaries for a given job classification. However, this effect is likely minimized by the categorization of income. Variables other than those evaluated, such as attitudinal factors and administration or organizational barriers, appear to play an important role in vaccine acceptance. Although prior absenteeism was used as a surrogate marker for health status, it may not adequately reflect the individual's general health. This variable may more accurately reflect a socioeconomic or attitudinal marker than be a true measure of health status. The health status of the workers who were vaccinated was not otherwise assessed.

The study population used for validating the model was not a truly independent population, since most of the initial sample were still employed during the second study year. Due to sample size limitations, it was not possible to validate the model just among newly employed workers, particularly given the stratified study design. Additionally, several factors selected in the initial model were not important in the subsequent model. These minor differences may have been because the effect changed over time or the effects initially observed may not have been real. However, the study model developed in the initial study year predicted hospital workers vaccination behavior adequately in the subsequent year. Finally, validation in other clinical settings would be desirable.

Relatively little data are available on influenza vaccine acceptance among workers in community or other settings [*12,14*]. Given the similarity of the characteristics of our study participants, including age, gender, occupation, patient contact, and previous immunization, with other community-based [*12,14*] and national [*45*] samples of health care workers, we would expect many of the same factors identified in the current study to be operative in influenza acceptance among health care workers in community settings. However, until these models are evaluated in other settings, it is uncertain whether the results are completely generalizable to other occupational groups.

The major implication of this study is that different health care worker occupational groups often refuse the influenza vaccine and may be targeted for interventions to improve its delivery. Specifically, professional support staff with patient contact should be considered for targeted efforts. Similarly, younger hospital workers, those recently employed, and lower paid employees may be targeted. It may also be beneficial to specifically target vaccine delivery programs to address the concerns of specific occupational groups. Factors which influence the behavior of health care workers to accept vaccine and other important work-related preventive health measures are complex and have yet to be fully elucidated. A better understanding of epidemiological risk factors and barriers to vaccination in this population should facilitate the development of programs to make health care facilities a safer environment for both health care workers and patients.

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