Does Influenza Vaccination of Older Adult Medicare Beneficiaries Lower Treatment Costs for Acute and Chronic Respiratory Disease?

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ABSTRACT

Background: Influenza accounts for a large proportion of hospitalizations and deaths among older adults, resulting in substantial health care expenses. Influenza vaccinations are effective in reducing respiratory infections in younger populations, but it is less certain whether they reduce costs associated with respiratory infections among older adults.

Objective: The purpose of this study was to determine whether influenza vaccination of older adult Medicare beneficiaries reduced costs associated with acute and chronic respiratory conditions during 3 recent influenza seasons.

Methods: This study analyzed the relationship between influenza vaccination and costs for respiratory conditions among Medicare beneficiaries ≥55 years of age in influenza seasons (October–May) between 2002 and 2005 using data from the Medicare Current Beneficiary Survey. Two-part multiple regressions of vaccination status were estimated on the probability and cost of treating respiratory conditions in each influenza season controlling for influenza risk factors and other covariates. Various sensitivity tests were conducted by type of service, subgroup analysis for specific population risk segments, propensity score-matched comparisons, and difference equations.

Results: The study sample included 13,402 Medicare beneficiaries for the 3 influenza seasons examined. Vaccination rates varied between 67.3% and 74.9% over the 3 influenza seasons. In unadjusted comparisons, no significant difference in the cost of treating respiratory conditions was found between vaccinated and unvaccinated beneficiaries in 2002/2003 (–$104), but vaccinated beneficiaries had significantly higher mean cost differentials in the more recent influenza seasons ($258 in 2003/2004, $P = 0.012$; $254 in 2004/2005, $P = 0.003$). Based on 2-part multiple regressions of vaccine status over the 3 seasons combined, costs of respiratory conditions were $142 dollars higher on average for vaccinated beneficiaries ($P = 0.014$). The base regression models showed no significant cost savings from vaccination in any year. Results of 2 of the 54 sensitivity tests that were conducted indicated significant savings from vaccination (inpatient costs for 2002/2003 and difference in total costs for persons unvaccinated in 2002/2003 but vaccinated in 2003/2004).

Conclusion: In this study of older adults, no significant cost savings were found with influenza vaccines in the 3 influenza seasons examined (2002–2005) when the outcome was measured in terms of differential spending for acute and chronic respiratory conditions. (*Am J Geriatr Pharmacother*. 2010;8:201–214) © 2010 Excerpta Medica Inc.

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INTRODUCTION

Adults ≥65 years of age account for >90% of ~36,000 deaths attributed to pneumonia and influenza each year.[1] In addition, it is estimated that an average of 186,000 influenza-associated hospitalizations occur every year among persons aged ≥65 years. When the vaccine and circulating viruses are similar antigenically, influenza vaccine typically prevents influenza illness and hospitalizations for 30% to 70% of older persons living in the community.[2] Vaccination is 50% to 60% effective in preventing severe illness, secondary complications, and death among older persons residing in nursing homes. Among adults ≥65 years of age with high-risk medical conditions, vaccination for influenza has been reported to be vital in preventing secondary complications and in reducing the risk of hospitalization and death by 14% to 60%.[3–7]

It has been estimated that influenza exacts an economic burden of >$87 billion per year in the United States, about two thirds of which is accounted for by persons ≥65 years of age.[8] Several studies have reported that vaccinating older adults, particularly those considered at high risk because of additional medical conditions, generates cost offsets in other health care spending.[6,7,9–12] Some research has found an economic benefit to vaccinating individuals >50 years of age.[13–15]

Among the 9 articles reviewed, there were 3 cross-sectional analyses and 1 person-period analysis of health care databases and chart reviews.[6,7,9,12] The remaining 5 articles dealt with economic simulations of the impact of vaccination on quality of life and estimated cost savings.[10,11,13–15] Overall, studies using health care databases found a range in direct medical savings of $3 to $118 among older adults and $12 to $2938 among high-risk older adults.[6,7,9,12] Predicted savings from the simulation articles had estimated net savings ranging from $17 to $71 per-person vaccination in the United States.[10,14] However, this literature has limitations. First, most of the previous studies on this topic used convenience samples[6,7,10–12] and thus are not generalizable to the entire population of older adults. For example, studies of vaccination-related cost offsets in health maintenance organization settings[7] are unlikely to reflect outcomes in the fee-for-service sector. Second, most of the studies[6,7,10–12] used medical claims to determine vaccination status and therefore missed vaccinations that were obtained free of charge or in nonmedical settings. The resulting misclassification bias can seriously underestimate the true cost savings from vaccination. Third, although some studies differentiated between low- and high-risk individuals,[6,7,12] others failed to control for preinfluenza-season differences in health status between vaccinated and unvaccinated persons. Lastly, the predominate outcome variable in most of these studies was inpatient hospitalization[6,7,10–12]; outpatient and physician service costs usually were ignored. One prominent study, by Gilman et al,[9] examined the cost-effectiveness of influenza vaccination with a nationally representative sample of Medicare beneficiaries over multiple influenza seasons (1999–2003), using survey- and claim-based measures to determine vaccination status and outcomes, including inpatient and physician services associated with acute and chronic respiratory conditions.

The present study was designed to build on the work of Gilman et al.[9] The end points used in the present study were the same as those used by Gilman et al for 3 influenza seasons (2002–2005), including one overlapping season (2002–2003). In addition, the present study extended the work by Gilman et al by using a nationally representative data set for the Medicare population (the Medicare Current Beneficiary Survey [MCBS]),[16] which contains a richer set of variables than the Medicare CAHPS (Consumer Assessment of Health Plans Survey) used by Gilman et al.[9] Two important differences exist between the 2 studies: the present study included long-term care residents and controlled for differences in baseline risk between vaccinated and unvaccinated beneficiaries using a set of factors specific to influenza risk. Based on the literature, the hypothesis for this study was that vaccination would generate Medicare cost offsets each season controlling for baseline risk.

The purpose of this study was to determine whether influenza vaccination of older adult Medicare beneficiaries reduced costs associated with acute and chronic respiratory conditions during 3 recent influenza seasons.

METHODS

Data

This study used data from the 2002–2005 MCBS conducted by the Centers for Medicare and Medicaid Services.[16] The MCBS is a nationally representative survey of Medicare beneficiaries. Once inducted into the survey, respondents are surveyed 3 times a year for up to 4 consecutive years. Among the unique qualities of the MCBS is that sampled individuals are selected from both the community and long-term care facilities and are tracked through residential transitions. Community respondents are surveyed about their demographic characteristics, health insurance coverage, use of and payments for health care services, and health status and functioning. Survey information for residents of long-term care facilities is obtained from administrative staff and medical records. MCBS interview data are linked to Medicare claims and other program administrative data. More information about the survey is available on the MCBS Web site.[16]

Study Sample and Data Structure

The study sample consisted of 3 cohorts of MCBS respondents observed during the 2002/2003, 2003/2004, and 2004/2005 influenza seasons. The sample inclusion criteria were: (1) age ≥55 years, (2) interviewed for the MCBS Access to Care survey for 2 consecutive years, (3) received Medicare services through fee-for-service providers, (4) have continuous Part A and B enrollment, and (5) have complete information pertaining to all study variables for each influenza season examined. Because the study focused on older adults, Medicare-eligible disabled beneficiaries <55 years of age were excluded. The remaining criteria were designed to ensure complete information capture for each subject before and during a particular influenza season. Persons enrolled in Medicare+ Choice capitated plans (now known as *Medicare Advantage* plans) were excluded because they lacked the Medicare claims data necessary to characterize both influenza risk factors and expenditure outcomes. Continuous Part A and B enrollment was required for the same reason. People who died during an influenza season were excluded because information on self-reported vaccination status was only available during the ensuing fall survey round.

The data structure for analyzing each influenza season consisted of a pre–influenza-season period (week 1 in January through week 39 in September of the initial year) and the influenza season itself (week 40 in October of the initial year through week 19 in May of the next year), for a total of 31 weeks.[17] Information from Medicare claims with service dates during the pre–influenza-season period was used to risk-adjust the subjects in each cohort. Vaccination status and outcomes were measured during the 31-week influenza season.

Measures

The primary independent variable of interest was receipt of a flu shot. Vaccination status was determined from 2 sources. Each fall, the MCBS asks respondents if they received a flu shot in the previous influenza season. Answers to this question were obtained in the second-year MCBS survey for each cohort member and were combined with evidence on Medicare claims that a flu shot was administered within the influenza season. Vaccination status from claims was derived from 3 sets of codes: (1) Current Procedural Terminology[18] codes 90645–90648, 90657–90660, 90720, 90724, and 90748; (2) Healthcare Common Procedural Coding System[19] code G0008; and (3) *International Classification of Diseases, 9th Revision, Clinical Modification* (*ICD-9-CM*)[20] code 9952.

The outcome measures were the prevalence of and Medicare reimbursement for acute respiratory infections and chronic respiratory conditions, including pneumonia and influenza, chronic obstructive pulmonary disease, pneumoconiosis, other lung diseases, and other diseases of the respiratory system. The *ICD-9-CM* codes for these conditions are 460, 462, 465, 466, 480–487, 490–496, and 500–518. This set of conditions has been used for outcomes related to influenza cost offsets in previous research.[6,9–12] In addition, one study found that defining outcomes to include all acute and chronic respiratory conditions resulted in higher cost offsets from vaccinations than restricted solely to influenza and pneumonia (cost offsets were $3.50 per vaccination in a model restricted to just influenza and pneumonia, compared with $71 per vaccination in a model that included all acute and chronic respiratory conditions).[10] Medicare payments for respiratory disease–related services were identified from Part A and B claims containing the above codes in any position. Payments for all such claims with service dates during the influenza season were summed at the individual level and then converted to constant 2005 US dollars to permit comparisons over time. To permit sensitivity analysis of vaccination effects by type of service, respiratory condition claims were separated for inpatient hospital and physician services.

Selection of control variables was based on previous work and theoretical considerations. These variables included basic demographic characteristics for age, sex, race/ethnicity, and urban/rural residence. Distinctions between community-dwelling and long-term care facility residents were made to account for differences in population characteristics and provision of care. Indicators of educational attainment were included on the assumption that individuals with higher levels of education would be more likely to seek influenza vaccination.[9] The analysis controlled for Medicare supplementation and drug coverage, which were hypothesized to increase the demand for vaccinations and other services not fully covered by Medicare.

The most important control variables were health status indicators that could be correlated with both vaccination status and the study outcomes. These included self-reported health status, hospitalization in the 9 months preceding the influenza season, and a set of risk factors for influenza-related complications developed by Hak et al[3] in a study examining the influence of high-risk medical conditions on the effectiveness of influenza vaccination. The *ICD-9-CM* codes for each condition are listed in the **appendix**.[3,20] These risk factors are widely used by clinicians to identify the persons most in need of vaccination and were used to more accurately determine differences in baseline health status between the vaccinated and unvaccinated groups.[21] The presence of these conditions was determined from Medicare claims with service dates during the first 9 months of the year preceding the current influenza season start date.

Statistical Analysis

The analysis proceeded in 2 phases. The first phase evaluated vaccination-related Medicare cost offsets in each of the 3 influenza seasons individually and pooled together. These analyses resulted in unanticipated null findings. This unexpected consistency in null findings led us to suspect the presence of unobserved confounders or lack of balance in characteristics between vaccinated and unvaccinated beneficiaries. In the second phase of the research, a series of alternative estimators (54 tests in total), ranging from subgroup analyses for specific population risk segments, propensity score (PS)-matched comparisons, and difference equations, were tested. These estimators are described in greater detail below.

The initial statistical analysis included unadjusted and adjusted comparisons of the prevalence and cost of treating respiratory conditions for study subjects with and without a flu shot in each influenza season and for the 3 seasons combined. A base regression model was developed for the multivariate analysis; various aspects of the model specifications were then selectively changed to test the robustness of the findings to alternative assumptions. The base regression model comprised a standard 2-part estimator in which vaccination status and covariates were regressed against the presence of any respiratory condition, using logistic regression in the first part. Then, for persons who were treated for such conditions, a second model was estimated with respiratory treatment costs as the dependent variable, using a generalized linear model with a log link to accommodate the right-skewed distribution of the expenditure data.[22] Model variants included: (1) estimating respiratory treatment costs separately for inpatient and physician services, (2) separate regressions for males and females, and (3) models restricted to persons with ≥1 Hak risk factor.[3] All regressions were estimated with Stata 10 (StataCorp LP, College Station, Texas). Regression models with pooled observations were estimated with a robust estimator to correct the standard errors for multiple observations of the same individual.

The next phase of the multivariate analysis entailed 2 additional analytic strategies: PS matching and difference equations. PS matching was conducted to remove disparities in sample characteristics between the vaccinated and unvaccinated groups. PS values were created using probit regression, with vaccination status as the dependent variable and all covariates from the original regression models as independent variables. Estimated probabilities of vaccination (the PS values) were calculated for each individual in the sample. Using the Stata command PSMATCH2,[23] vaccinated and unvaccinated beneficiaries were then matched 1:1 based on the closest PS match, repeating the process until the smaller group (the unvaccinated sample) was exhausted. Unmatched vaccinated beneficiaries were dropped from the analysis. As a final step, the probability of having respiratory disease was compared with respiratory treatment costs for each group of PS-matched observations.

The difference equations were estimated for subgroups of Medicare beneficiaries observed in the MCBS data over 2 consecutive influenza seasons. Difference equations have an advantage over cross-sectional regression in that unobserved time-invariant individual effects that might bias the estimated marginal effects in standard covariate-control models are netted out. The drawback is that they have low power when relatively few individuals change their vaccination behavior over time. Difference equations were determined to be an appropriate way to test the effects of a natural experiment presented by the vaccine shortage in the 2004/2005 influenza season.[24] The a priori hypothesis was that a nontrivial proportion of individuals vaccinated in 2003/2004 would not be vaccinated in 2004/2005 due to the shortage of vaccines, and this difference would help power the test and reduce bias associated with individual-level selection effects. In contrast, a difference equation was estimated for individuals observed during the 2002/2003 and 2003/2004 influenza seasons.

In each difference model, the dependent variable (respiratory treatment costs) and Hak variables[3] were measured as year-2 minus year-1 values. Vaccination status was coded as 3 dummy variables (yes in year 1, no in year 2; no in year 1, yes in year 2; and yes in both years), with the excluded category being no in both years. All other covariates were measured at their baseline year-1 values. Because the differenced values for the dependent variable were approximately normally distributed, these regressions were estimated with ordinary least squares. To accommodate negative values in the differenced variables, these models were estimated as single equations rather than 2-part models.

Before conducting any of these analyses, the data were checked for extreme outliers; one beneficiary with respiratory treatment costs of $327 in the 2003/2004 influenza season and $186,230 in the following season was excluded. This exclusion had no substantive effect on study outcomes except for the second set of difference equations. Estimations were as follows: 8 base regressions, 16 service-specific equations, 16 sex-specific models, 8 equations restricted to persons with ≥1 Hak risk variable, 8 PS-matched equations, and 6 difference equations.

RESULTS

The final study sample represented 4450 Medicare beneficiaries for the 2002/2003 influenza season, 4324 for the 2003/2004 season, and 4628 for the 2004/2005 season. Annual and 3-year mean vaccination rates are shown by beneficiary characteristic in **Table I**[16]; the values were weighted by the MCBS sample weights to be representative of the Medicare population (≥55 years of age). Influenza vaccination rates ranged from 73.9% in the 2002/2003 influenza

Table I. Distribution of Medicare beneficiaries, by influenza vaccination status (2002–2005).[16]

	Vaccination Status by Influenza Season, %*							
	2002/2003 (n = 4450)		2003/2004 (n = 4324)		2004/2005 (n = 4628)		3 Years Pooled (N = 13,402)	
Beneficiary Characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Mean vaccination rate	73.9	26.1	74.9	25.1	67.3	32.7	71.8	28.2
Self-report only	30.3		29.0		29.7		29.7	
Claim only	1.4		1.4		0.9		1.2	
Self-report and claim	42.2		44.5		36.7		40.9	
Age, y								
55–64	5.1	7.6†	5.5	9.8†	5.0	9.9†	5.2	9.2†
65–69	15.4	22.7†	18.3	22.8†	17.3	23.3†	17.0	23.0†
70–74	24.7	24.7	24.6	24.6	23.3	25.3	24.2	24.9
75–79	23.8	19.5†	21.6	19.1	23.2	18.0†	22.9	18.8†
≥80	30.9	25.5†	30.1	23.8†	31.1	23.4†	30.7	24.1†
Sex								
Male	40.4	42.8	41.7	42.6	43.4	41.9	41.9	42.3
Female	59.6	57.2	58.3	57.4	56.6	58.1	58.1	57.7
Race/ethnicity								
White/non-Hispanic	85.1	73.2†	85.4	73.1†	86.2	74.8†	85.6	73.8†
Black/non-Hispanic	6.8	13.2†	6.6	13.5†	5.9	13.2†	6.4	13.3†
Hispanic	4.9	9.9†	4.3	9.3†	3.8	7.7†	4.3	8.8†
Other	3.3	3.7	3.8	4.2	4.1	4.3	3.7	4.1
Location								
Urban	69.6	69.3	70.1	71.7	70.2	73.5‡	70.0	71.7‡
Rural	30.4	30.7	29.9	28.3	29.8	26.5‡	30.0	28.3‡
Residence								
Community	94.3	97.4†	94.6	97.0†	93.9	97.1†	94.3	97.2†
Long-term care facility	5.7	2.6†	5.4	3.0†	6.1	2.9†	5.7	2.8†

(continued)

Table I (continued).

	Vaccination Status by Influenza Season, %*							
	2002/2003 (n = 4450)		2003/2004 (n = 4324)		2004/2005 (n = 4628)		3 Years Pooled (N = 13,402)	
Beneficiary Characteristics	Yes	No	Yes	No	Yes	No	Yes	No
Education								
Less than high school	14.8	21.7†	13.7	19.6†	12.1	17.1†	13.5	19.2†
High school graduate	30.1	24.8†	30.5	27.6	30.9	31.4	30.5	28.4‡
Some college	23.2	19.9‡	23.2	21.4	24.4	24.0	23.6	22.1
College graduate	15.9	12.9‡	17.7	12.6†	19.4	11.8†	17.7	12.3†
Medicare supplement								
None	6.7	14.6†	6.9	13.7†	5.6	12.3†	6.4	13.4†
Medicaid	14.6	20.1†	14.5	21.9†	14.4	20.5†	14.5	20.8†
Employer-sponsored	44.7	35.0†	46.2	34.8†	47.5	39.3†	46.1	36.7†
Other public	7.5	6.1	7.3	7.6	6.5	7.6	7.1	7.2
Self-purchased	43.9	35.1†	42.2	33.2†	43.8	34.3†	43.3	34.2†
Self-reported health status								
Excellent/very good	41.4	44.7	42.9	42.1	42.4	45.1	42.2	44.1‡
Good	33.2	30.3	32.8	32.7	34.3	31.1‡	33.5	31.3‡
Fair	19.2	18.8	18.4	18.8	17.4	17.3	18.3	18.2
Poor	6.2	6.2	5.9	6.5	5.8	6.5	5.9	6.4
Preinfluenza season hospitalization	17.1	12.5†	15.4	13.6†	16.9	11.5†	16.4	12.4
Individual risk factors§								
Pulmonary plus cardiac disease	22.6	13.5†	22.3	16.4†	23.9	16.8†	22.9	15.7
Pulmonary disease (no cardiac disease)	15.5	12.2†	15.5	12.0†	14.0	13.4	15.0	12.7
Cardiac disease (no pulmonary disease)	25.3	22.3‡	25.2	21.3†	25.0	20.5†	25.2	21.3
Diabetes or other endocrine disorder	24.6	22.0	25.3	22.3	26.5	24.4	25.5	23.1
Immunosuppression	25.8	15.7†	25.5	16.6†	26.0	19.1†	25.8	17.4
Other comorbidities	13.6	9.2†	12.2	8.4†	12.4	8.9†	12.7	8.9

* Two-tailed *t*-test analysis was conducted for all variables for significant differences between vaccinated and unvaccinated beneficiaries within each influenza season. All values weighted to be representative of the Medicare population (≥55 years of age). Sums may not total 100% due to rounding.
† $P < 0.01$.
‡ $P < 0.05$.
§ Details are provided in the **appendix**.

season to 74.9% in 2003/2004, before declining to 67.3% in 2004/2005. Vaccination rates were thought to be lower during the 2004/2005 influenza season because of a serious shortage of vaccines that year.[24]

The source of vaccination ascertainment is presented in **Table I**. Overall, 40.9% of respondents had both a self-report and a claim for flu shots over the 3 influenza seasons, 29.7% had a self-report only, and 1.2% had a claim for the shot but no self-report. The high proportion of beneficiaries reporting a flu shot without a claim for confirmation is not surprising, given the wide variety of venues offering flu shots to older adults. The combination of a high correspondence of self-reports plus claims, together with a small proportion of individuals with vaccine claims but no self-reports, would appear to validate self-reports as a means of verifying vaccination ascertainment.

Specific characteristics were significantly associated with higher-than-average vaccination rates in all 3 seasons: being older (persons ≥80 years of age represented 30.9% of the vaccinated group vs 24.1% of the unvaccinated group; $P < 0.01$), white/non-Hispanic (85.6%

of the vaccinated vs 73.8% of the unvaccinated; $P < 0.01$), more highly educated (college graduates represented 17.7% of the vaccinated vs 12.3% of the unvaccinated; $P < 0.01$), and residence in a long-term care facility (5.7% of the vaccinated vs 2.8% of the unvaccinated; $P < 0.01$). In unadjusted comparisons, no significant difference in the cost of treating respiratory conditions was found between vaccinated and unvaccinated beneficiaries in 2002/2003 (–$104), but vaccinated beneficiaries had significantly higher mean cost differentials in the more recent influenza seasons ($258 in 2003/2004, $P = 0.012$; $254 in 2004/2005, $P = 0.003$) (**Table II**). Over all 3 seasons, the prevalence of respiratory conditions was higher among vaccinated beneficiaries (32% vaccinated vs 24% unvaccinated; $P < 0.001$). The same was true for respiratory treatment costs over the 3 seasons combined ($612 vaccinated vs $470 unvaccinated; $P = 0.014$).

The hypothesis for this study was that influenza vaccination reduces the incidence of respiratory disease; hence, it is important to know whether influenza vaccinations typically precede the incidence of respiratory events in the Medicare population. That appeared to be the case. Vaccinations paid for by Medicare tend to cluster in October and November of the influenza season, whereas respiratory events typically occur in December or later in the season (results not shown).

Adjusted results from the 2-part base regression models are presented in **Tables III** and **IV**. The conditional odds of incurring any respiratory treatment costs over the 3 influenza seasons combined (**Table III**) were 24% higher among vaccinated beneficiaries ($P < 0.01$). Among individuals with respiratory condition claims, vaccinated beneficiaries had slightly lower costs (–$36.70), but the difference was not statistically significant. Individual influenza season results are shown

Table II. Unadjusted differences in respiratory condition prevalence and costs, by influenza season (2002–2005).

Outcomes*	Vaccination Status: Yes	Vaccination Status: No	Unadjusted Difference	P†
2002/2003 Influenza season				
Respiratory condition prevalence, %	0.29	0.23	0.07	<0.001
Mean respiratory condition–related costs for those with diagnosis, $	1829	2850	−1021	0.012
Mean respiratory condition–related costs for all subjects, $	537	641	−104	0.339
2003/2004 Influenza season				
Respiratory condition prevalence, %	0.32	0.24	0.08	<0.001
Mean respiratory condition–related costs for those with diagnosis, $	2060	1667	393	0.270
Mean respiratory condition–related costs for all subjects, $	655	397	258	0.012
2004/2005 Influenza season				
Respiratory condition prevalence, %	0.34	0.25	0.08	<0.001
Mean respiratory condition–related costs for those with diagnosis, $	1901	1530	371	0.184
Mean respiratory condition–related costs for all subjects, $	643	389	254	0.003
3 Influenza seasons combined				
Respiratory condition prevalence, %	0.32	0.24	0.08	<0.001
Mean respiratory condition–related costs for those with diagnosis, $	1932	1956	−24	0.903
Mean respiratory condition–related costs for all subjects, $	612	470	142	0.014

* All $ values expressed in constant 2005 US dollars.
† Based on 2-tailed *t* test.

Table III. Adjusted results from 2-part base regression model, with pooled data from 3 influenza seasons (2002–2005).

Variable (reference)	Part 1: Any Respiratory Condition–Related Cost, Odds Ratio (95% CI)	Part 2: Respiratory Condition–Related Costs for Those With an ACRC Diagnosis, Marginal Effect (95% CI)
Vaccination status (vaccinated)	1.24* (1.12 to 1.38)	−37 (−368 to 295)
Age 55–64 y (65–69 y)	1 (0.8 to 1.25)	184 (−482 to 851)
70–74 y	1.07 (0.93 to 1.23)	47 (−414 to 507)
75–79 y	0.88 (0.77 to 1.02)	159 (−323 to 641)
≥80 y	1.04 (0.92 to 1.19)	336 (−103 to 776)
Female (male)	0.95 (0.87 to 1.04)	−312* (−586 to −38)
Nonwhite (white)	0.89 (0.78 to 1.01)	3 (−390 to 396)
Urban (rural)	0.96 (0.87 to 1.05)	14 (−260 to 288)
Resident of long-term care facility (community dwelling)	0.91 (0.75 to 1.10)	148 (−340 to 635)
Less than high school graduate (graduate)	1.03 (0.91 to 1.18)	−69 (−405 to 268)
Some post high school education	1.05 (0.94 to 1.17)	−187 (−498 to 124)
College graduate	0.79* (0.69 to 0.90)	−158 (−594 to 278)
Medicaid (no drug coverage)	1.34* (1.15 to 1.55)	182 (−279 to 642)
Employer drug coverage	1.05 (0.94 to 1.19)	−473* (−813 to −134)
Other public drug coverage	1.21† (1.02 to 1.43)	7 (−415 to 429)
Self-purchased drug coverage	1.11 (0.99 to 1.24)	−342† (−673 to −10)
Self-reported health (very good–excellent)	1.26* (1.13 to 1.40)	270 (−91 to 631)
Fair health	1.51* (1.33 to 1.71)	898* (430 to 1367)
Poor health	1.67* (1.39 to 2.02)	2162* (1204 to 3119)
Hospitalization in preinfluenza period (none)	0.78* (0.69 to 0.89)	650* (293 to 1008)
Individual risk factors—Hak[3] cardiac & pulmonary disease‡	12.42* (10.94 to 14.1)	810* (330 to 1290)
Hak cardiac no pulmonary disease	10.03* (8.81 to 11.41)	109 (−394 to 612)
Hak pulmonary no cardiac disease	1.41* (1.24 to 1.61)	−493† (−949 to −36)
Hak diabetes/other endocrine	1.06 (0.96 to 1.18)	181 (−88 to 450)
Hak immunosuppression	1.24* (1.12 to 1.37)	85 (−204 to 374)
Hak other comorbid condition	1.1 (0.95 to 1.26)	277 (−100 to 655)
Influenza season 2003–2004 (2002–2003)	1.13† (1.01 to 1.26)	−63 (−387 to 261)
2004–2005	1.26* (1.13 to 1.40)	−245 (−566 to 75)
Model fit statistics		
Wald χ^2	2938.37	–
AIC/BIC	–	17/−18,278

ACRC = acute and chronic respiratory condition; AIC/BIC = Akaike information criterion/Bayesian information criterion.
* $P < 0.01$.
† $P < 0.05$.
‡ Details are provided in the **appendix**.

Table IV. Summary of parameter coefficients and 95% CIs for the variable: Influenza vaccination = yes in various multivariate models.

Variable	Part 1: Any Respiratory Condition–Related Cost, Odds Ratio (95% CI)	Part 2: Respiratory Condition–Related Costs for Those With an ACRC Diagnosis, Marginal Effect (95% CI)
Individual influenza season models		
2002–2003	1.13 (0.94 to 1.36)	−707 (−1490 to 76)
2003–2004	1.27* (1.05 to 1.54)	334 (−112 to 780)
2004–2005	1.31† (1.11 to 1.54)	163 (−239 to 565)
Service-specific models, by influenza season		
Inpatient		
2002–2003	0.66* (0.45 to 0.98)	−3081* (−5455 to −706)
2003–2004	1.23 (0.81 to 1.88)	860 (−704 to 2425)
2004–2005	1.36 (0.93 to 1.98)	394 (−1399 to 2187)
3 Influenza seasons combined	1.07 (0.86 to 1.35)	−524 (−1837 to 788)
Physician		
2002–2003	1.06 (0.88 to 1.27)	−23 (−86 to 41)
2003–2004	1.24* (1.02 to 1.5)	20 (−33 to 72)
2004–2005	1.35† (1.15 to 1.6)	58† (16 to 100)
3 Influenza seasons combined	1.22† (1.10 to 1.36)	23 (−10 to 56)
Sex-specific models, all costs, by influenza season		
Males		
2002–2003	1.10 (0.82 to 1.49)	−192 (−1204 to 821)
2003–2004	1.45* (1.06 to 1.98)	117 (−508 to 742)
2004–2005	1.25 (0.97 to 1.61)	67 (−618 to 753)
3 Influenza seasons combined	1.27† (1.08 to 1.49)	−208 (−845 to 429)
Females		
2002–2003	1.15 (0.91 to 1.47)	−424 (−1109 to 261)
2003–2004	1.15 (0.90 to 1.46)	708† (182 to 1235)
2004–2005	1.37† (1.10 to 1.7)	218 (−146 to 582)
3 Influenza seasons combined	1.23† (1.08 to 1.41)	43 (−322 to 407)
Models limited to persons with ≥1 Hak condition,[3] by influenza season‡		
2002–2003	1.09 (0.89 to 1.34)	−507 (−1240 to 226)
2003–2004	1.29* (1.05 to 1.59)	445 (−63 to 952)
2004–2005	1.24* (1.03 to 1.49)	224 (−169 to 617)
3 Influenza seasons combined	1.21† (1.08 to 1.35)	88 (−251 to 426)
Propensity score–matched samples, all costs, by influenza season		
2002–2003	0.92 (0.72 to 1.19)	−218 (−921 to 484)
2003–2004	1.17 (0.90 to 1.51)	205 (−429 to 839)
2004–2005	1.32† (1.08 to 1.62)	424 (−34 to 881)
3 Influenza seasons combined	1.14* (1.00 to 1.31)	164 (−247 to 576)

(continued)

Table IV (continued).

Variable	Part 1: Any Respiratory Condition–Related Cost, Odds Ratio (95% CI)	Part 2: Respiratory Condition–Related Costs for Those With an ACRC Diagnosis, Marginal Effect (95% CI)
Difference equations		
Vaccinated only in first influenza season	98[§] (−504 to 699)	−115[‖] (−764 to 534)
Vaccinated only in second influenza season	−1066[†§] (−1773 to −358)	−194[‖] (−911 to 524)
Vaccinated in both influenza seasons	−133[§] (−386 to 121)	272[‖] (−40 to 585)

ACRC = acute and chronic respiratory condition.
*$P < 0.05$.
†$P < 0.01$.
‡Details are provided in the **appendix**.
§Change in ACRC-related costs from 2002/2003 to 2003/2004 influenza seasons.
‖Change in ACRC-related costs from 2003/2004 to 2004/2005 influenza seasons.

in the top panel of **Table IV** (for brevity, only the odds ratios and marginal effects associated with the vaccination variable are presented). As in the unadjusted findings, vaccinated beneficiaries had higher conditional odds of incurring any respiratory treatment costs compared with unvaccinated individuals. No significant conditional differences in level of costs were found between vaccinated and unvaccinated beneficiaries in any of the 3 influenza seasons.

The results of 54 sensitivity tests, by service, sex, and Hak risk group, are presented in the next 5 panels of **Table IV**. With the exception of hospital costs in 2002/2003, the odds ratios in the part-1 service-specific models were >1, reflecting a greater likelihood of incurring respiratory condition expenditures among vaccinated beneficiaries. Likewise, no evidence of significant savings was associated with vaccination in the part-2 models except for hospital costs in 2002/2003 (–$3081; 95% CI, –$5455 to –$706).

Results from the remaining sensitivity tests are presented in the last 2 sections of **Table IV**. Comparisons of the PS-matched samples generated findings broadly similar to the base regression results, with vaccination associated with small, nonsignificant cost savings in 2002/2003 and no effect or cost-incurring in the remaining influenza seasons. The PS-matching algorithm resulted in a high degree of similarity between the vaccinated and unvaccinated pairs. Most of the significant differences in characteristics seen in the unmatched samples (**Table I**) disappeared, and those that remained were <4 percentage points apart. It should be emphasized, however, that balancing on observable covariates does not necessarily control for potential differences between the 2 groups on nonobservable characteristics that may influence both vaccination status and cost outcomes.

The first set of difference equation results shown in the last panel of **Table IV** reflects the experience of 204 individuals vaccinated in either 2002/2003 or 2003/2004, but not both. The second set reflects the experience of 327 individuals vaccinated in either 2003/2004 or 2004/2005, but not both. As expected, given the vaccine shortage in 2004/2005, more individuals who were vaccinated the previous year failed to be vaccinated that year (229 compared with 71 who were vaccinated in 2002/2003 but not in 2003/2004). Nonetheless, the absolute number of individuals with nonpersistent vaccination status was too small to detect significant effects except among those vaccinated in 2003/2004 but not in 2002/2003.

DISCUSSION

Vaccination rates for older adult Medicare beneficiaries ranged between 67.3% (2004/2005) and 74.9% (2003/2004). These rates were higher than the 59.6% (2004/2005) to 65.6% (2002/2003) rates reported by the Centers for Disease Control and Prevention (CDC) for persons ≥65 years of age.[25] Estimates from the present study were higher for 3 reasons. First, unlike the CDC study, the present study included institutionalized beneficiaries in the sample. Long-term care residents were between 11% and 14% more likely to be vaccinated than were community-dwelling residents during the study period. Second, the present study included persons with claim-based evidence of vaccination, some of whom failed to provide self-reports. Finally, the sample in the present study included Medicare disabled beneficiaries 55 to 64 years of age.

Although several previous studies have examined the relationship between influenza vaccination and Medicare costs,[6,7,9,14,26] only one study, by Gilman et al,[9] overlapped with the present study period. Gilman et al found evidence of significant Medicare savings during the 2002/2003 season, whereas the present study found some evidence of savings in hospitalization costs during the 2002/2003 influenza season but no evidence of overall cost savings.

Although the present study built on the work of Gilman et al,[9] the 2 studies differed in important ways. The previous study used a larger sample (350,000) and therefore had greater power to detect small differences. Those investigators also excluded long-term care residents and beneficiaries between 55 and 64 years of age. Long-term care residents have higher burdens of disease and functional limitations than do community dwellers, but they also are more likely to be vaccinated (**Table I**). Medicare beneficiaries <65 years of age qualify under the Social Security Disability Insurance program and, like nursing home residents, generally are sicker than the average Medicare beneficiary. Inclusion of these populations was believed to be important to the generalizability of the findings of the present study. Unlike the earlier study, the present study controlled for specific risk factors for influenza-related complications. Because individuals with these risk factors are more likely to be vaccinated and have higher expenditures for respiratory conditions, it is important to include them as confounders in the multivariate analysis.

Other investigators also have failed to find evidence of vaccine effectiveness in older populations. Jefferson et al[27] reviewed 64 studies on the effectiveness of influenza vaccines for people ≥65 years of age and found that vaccines were not significantly effective against influenza, influenza-like illness, or pneumonia among community-dwelling older adults. This finding is buttressed by the fact that the rate of hospitalization from complications of influenza has increased steadily since 1979 despite a rising trend in vaccination rates.[28] In addition, several recent studies have called into question conclusions about vaccine effectiveness based on cohort studies that controlled inadequately for unrecognized selection bias.[24,26–32]

Every effort was made in the present study to avoid such biases through a combination of traditional covariate control regression, risk stratification models, PS matching, and difference equations. The striking consistency in results across these various techniques leads us to conclude that vaccination of Medicare beneficiaries during the 2003/2004 and 2004/2005 influenza seasons likely had no impact in reducing Medicare costs for acute and chronic respiratory conditions. The evidence for cost savings during the 2002/2003 influenza season was slight and limited to inpatient hospitalization. Although the present study did not include beneficiary coinsurance or third-party payments in the dependent variable, such payments were generally proportional to Medicare payments; hence, the findings may be generalizable to all health care spending for influenza-related outcomes.

These findings are, of course, subject to the usual caveats associated with observational designs, including the possibility that the findings are biased by unobserved factors correlated with vaccination status and study outcomes. It was believed that inclusion of specific influenza risk factors helped control for confounding variables that may have biased previous studies. One major limitation of the present study was the exclusion of persons who died during or shortly after an influenza season. This exclusion was necessitated by the source documentation for self-reported influenza vaccinations. It is not clear how this exclusion affected the generalizability of the results. On the one hand, because Medicare costs are generally much higher for beneficiaries in their final year of life, the exclusion of influenza-related deaths will bias the findings to the null. On the other hand, some research has found that the mortality rate for vaccinated older adults tends to be lower before the influenza season begins.[30,31] To the extent that is true, the bias is in the opposite direction.

The explanation for null findings may also lie, in part, on influenza severity and vaccine match. The CDC considered the 2002/2003 influenza season to be mild, and the vaccine and virus were well matched.[33] The 2003/2004 influenza season was considered moderately severe, but the vaccine and virus were not optimally matched.[34] The 2004/2005 influenza season was considered moderately severe, with a good match between vaccine and virus,[35] but the shortage of vaccine that year may have reduced its protective effects.

CONCLUSION

Vaccination status in 3 recent influenza seasons was examined in relation to costs associated with acute and chronic respiratory conditions among Medicare beneficiaries ≥55 years of age. Contrary to previous research findings, no significant cost savings were found in the 3 influenza seasons examined.

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Appendix. Individual risk factors for influenza-related complications.[3,20]

Disease	*ICD-9-CM* Codes
Pulmonary disease	011, 460, 462, 465–466, 480–511, 512.8, 513–517, 518.3, 518.8, 519.9, 714.81
Cardiac disease	093, 112.81, 130.3, 391, 393–398, 402, 404, 410–429, 745–746, 747.1–747.49, 759.82, 785.2, 785.3
Diabetes and other endocrine disorders	250–251
Immunosuppression	
Renal disease	274.1, 403, 580–591, 593.71–593.73, 593.9
Immunodeficiency or receipt of organ transplant	042, 079, 279, V08, V42
Hematologic cancer	200–208
Nonhematologic cancer	140–198, 199.1
Other comorbidities	
Dementia or stroke	290–294, 331, 340–341, 348, 438
Vasculitis or rheumatologic disease	446, 710, 714.0–714.4, 714.8, 714.89, 714.9

ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification.[20]