

## Trends in influenza and pneumococcal vaccination among adults in Connecticut, years 2001-2010

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**OBJECTIVES:** Trends in vaccination among Connecticut adult residents against seasonal flu and pneumococcal infection were studied for years 2001-2010. **METHODS:** General linear regression was conducted on estimates of vaccination prevalence, obtained from the Connecticut Behavioral Risk Factor Surveillance System. Analysis was conducted among adults who reported having the flu vaccine in the past 12 months, and who reported ever having had the pneumococcal vaccination, for ages 18-64 years and at least 65 years. **RESULTS:** Across the decade from 2001-2010, there was a significant increase in flu vaccinations among adults 18-64 years old ( $p < 0.0001$ ), with an annual increase of 1.36% (SE: 0.18%), but no significant increase among adults at least 65 years old ( $p = 0.20$ ). For pneumococcal vaccination, there was no significant increase across the decade among adults 18-64 years old ( $p=0.8039$ ), but a modest increase among adults at least 65 years old ( $p=0.0954$ ) with an annual increase of 0.35% (SE: 0.18%). Vaccination coverage for flu was significantly higher than coverage for pneumococcal infection ( $p < 0.05$ ) among both age groups. **CONCLUSIONS:** Although vaccinations against seasonal flu increased from 2001-2010 among adults less than 65 years old in Connecticut, there was no concomitant increase among older adults in the state. There was a modest increase in pneumonia vaccination among adults at least 65 years old. These data indicate that, although vaccination coverage increased during the previous decade against both seasonal flu and pneumococcal infection, continued education is needed among older adults in Connecticut of the benefits of vaccination .

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### Introduction

Seasonal influenza (flu) and pneumococcal infections are among a class of diseases that can be prevented with vaccination. Flu is caused by a virus, and presents with respiratory symptoms [1]. Pneumococcal disease is caused by a bacterium that can most commonly lead to pneumococcal pneumonia [2]. Both infections are contagious and can have serious, and even deadly, consequences for younger and older people, as well as those with chronic conditions.

Vaccination in the population against flu and pneumococcal infection are health objectives in the Connecticut State Health Improvement Plan [3], and are among a class of vaccine-preventable illnesses that were recently identified as priorities for the state [4].

Vaccines against flu and pneumococcal infection are available. Vaccination coverage is monitored regularly by the U.S. Centers for Disease Control and Prevention (CDC) [5,6], as well as within Connecticut by the Department of Public Health [7]. One source for tracking vaccination coverage in the state against these infections is the Connecticut Behavioral Risk Factor Surveillance System (CT BRFSS) [8]. The survey includes annual questions about both

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vaccinations, and is an ideal way to monitor vaccination coverage within the population.

During the decade from 1993 to 2002, Connecticut experienced a steady increase in the prevalence of residents 65 years of age and older who received vaccination against seasonal flu, as well as pneumococcal vaccination for the same age group [9]. Trend analysis of the most recent decade, however, has not been evaluated in Connecticut.

This report describes the trend in vaccination coverage for flu and pneumococcal infection among the Connecticut adult population from 2001 through 2010, using data from the CT BRFSS. The results indicate that vaccination coverage in the state against flu increased steadily across the decade among adults 18-64 years old, while vaccination coverage against pneumococcal infection increased steadily among adults at least 65 years old. These results provide information about how education and outreach efforts can be focused to reduce the incidence of flu and pneumococcal infection in Connecticut.

## Methods

### *Data Selection and Variable Construction*

Prevalence estimates for flu and pneumococcal vaccination in Connecticut were obtained from the CT BRFSS [8]. The CT BRFSS is an anonymous landline/cell phone population-based survey in Connecticut of randomly selected adult (18 years and older) citizen volunteers that monitors the health and well-being of state residents. The survey is, in part, funded by CDC. Each year, CDC works with states to ensure the highest possible data quality, and assigns for each survey response a weight that permits generalization to state populations, using a methodology previously

described [10,11].

Data analyzed in this study were obtained from questions in the CT BRFSS during calendar years 2001 through 2010. Annual prevalence estimates for pneumococcal infection were obtained from responses to the question, “Have you ever received a vaccination shot for pneumonia? This shot is usually given only once or twice in a person’s lifetime and is different from the flu shot. It is also called the pneumococcal vaccine.” The variable name in each of the annual CT BRFSS datasets across the decade was PNEUVAC3.

The method of flu vaccination changed from 2001 to 2010 to include nasal sprays. Questions in the CT BRFSS on flu vaccination, therefore, were modified several times during the decade, in 2004, 2005, and 2010. Prior to 2004, the question stated, “During the past 12 months, have you had a flu shot?” In 2004, a second question was added that included the possibility of receiving the vaccine by nasal spray. This additional question stated, “During the past 12 months, have you had a flu vaccine that was sprayed in your nose?” From 2005 through 2010, both questions were modified to state, “A flu shot is an influenza vaccine injected into your arm. During the past 12 months, have you had the flu shot?” and “During the past 12 months, have you had a flu vaccine that was sprayed in your nose? The flu vaccine sprayed in the nose is also called FluMist™.” The variable name in the CT BRFSS dataset was FLUSHOT for years 2001 through 2003, FLUSHOT2 for year 2004, and FLUSHOT3 for years 2005 through 2010.

Possible responses to all flu and pneumococcal vaccination questions were “Yes,” “No,” “Don’t Know/Not Sure,” or

“Refused.” All “Refused” responses were changed to missing responses. Responses of “Don’t Know/Not Sure” were retained for additional analysis.

The total sample size of all responses to the CT BRFSS questions varied across the decade. The number of completed responses for each year was: 2001: 7,752; 2002: 5,563; 2003: 5,317; 2004: 6,030; 2005: 5,254; 2006: 8,501; 2007: 7,523; 2008: 6,155; 2009: 6,496; and 2010: 6,776.

Prevalence estimates for flu and pneumococcal vaccination were evaluated for “Yes” and “Don’t Know/Not Sure” responses. Estimates were conducted with SAS (Statistical Analysis System, Cary, NC), using the SURVEYFREQ procedure, in which the weight was \_LLCPWT, and the stratification variable was \_STSTR.

### *Trend Analysis*

Annual trend rates, with intercept, of annual percent prevalences were evaluated by general linear regression using the GLM routine in SAS. A weight (WEIGHT) for each annual estimate was included that varied according to its coefficient of variation (CV). With this strategy, estimates with a high CV contributed less weight to the regression model than estimates with a low CV, according to the formula:  $WEIGHT = 1.0/CV$ , where 1.0 was the highest possible weight. This weighting strategy allowed the contribution of each estimate to vary in direct proportion to its validity.

Goodness-of-fit for each regression model was evaluated by F-statistic and the multiple correlation coefficient ( $R^2$ ), and significance of the regression trend rate was evaluated by

one-sided T-tests. Outliers were identified by the ratio of the residual (r) and mean predicted value (MPV) for each data point in the regression model. Outliers were defined as those data points with a ratio of at least 16%. Of the annual estimates for seasonal flu vaccination among adults 18-64 years old, regression across all years revealed that for year 2005,  $r = -10.6$  and  $MPV = 28.7$ , resulting in an r-to-MPV ratio of 36.8%. This data point was subsequently eliminated from the regression as an outlier. No other outliers were identified in the regression analyses.

The BRFSS has been classified as exempt by the DPH Human Investigation Committee (protocol number 54E), as well as the CDC Human Research Protection Office (protocol number 2988.0).

## **Results**

### *Prevalence of Influenza (flu) and Ever Had Pneumococcal Vaccination*

The percent prevalence of flu vaccination in the past 12 months among adults 18-64 in Connecticut is shown in **Table I** for years 2001 through 2010. Among adults 18-64 years old, the percent prevalence varied across the decade from a low of 24.4% in year 2001 to a high of 38.0% in year 2010, except for a very low prevalence of 18.1% in year 2005.

In 2005, the prevalence of flu vaccination among adults 18-64 years old was substantially lower than expected (prevalence 18.1%; **Table I**), with a concomitant substantial decrease in the number of respondents who reported having received the vaccine (n=774). Although the coefficient of variation for the estimate was less than 15%,

Table I  
Percent Prevalence of Vaccination Against Seasonal Flu  
Connecticut 2001 - 2010, Adults 18-64 years old and at least 65 years old

Year	Adults 18 -64 years old				Adults 65 years and older			
	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>
2001	1,516	510,000	24.4%	(23.1%, 25.7%)	1,007	330,000	69.1%	(66.3%-71.9%)
2002	1,157	540,000	25.7%	(24.1%, 27.4%)	782	340,000	71.5%	(68.3%-74.6%)
2003	1,208	590,000	27.9%	(26.4%, 29.5%)	786	360,000	74.3%	(71.4%-77.3%)
2004	1,436	620,000	29.6%	(28.0%, 31.1%)	1,020	350,000	73.1%	(70.7%-75.8%)
2005	774 <sup>d</sup>	390,000 <sup>d</sup>	18.1% <sup>d</sup>	(16.6%, 19.6%) <sup>d</sup>	887	340,000	71.1%	(68.1%-74.0%)
2006	1,833	600,000	27.8%	(26.4%, 29.3%)	1,573	340,000	71.1%	(68.9%-73.3%)
2007	1,888	740,000	34.0%	(32.3%, 35.8%)	1,706	360,000	74.7%	(72.5%-76.8%)
2008	1,501	730,000	33.6%	(31.5%, 35.6%)	1,440	360,000	74.6%	(72.2%-76.9%)
2009	1,640	740,000	34.6%	(32.5%, 36.6%)	1,513	350,000	74.0%	(71.4%-76.0%)
2010	1,817	820,000	38.0%	(35.9%, 40.1%)	1,554	350,000	71.7%	(69.4%-74.1%)

<sup>a</sup> n is the number of respondents who answered "Yes."

<sup>b</sup> Weighted Frequency is the estimated number of residents in the state who reported being vaccinated against seasonal flu in the past 12 months.

<sup>c</sup> Percent Prevalence is the estimated percent of all residents in the state who reported being vaccinated against the seasonal flu in the past 12 months; CI = 95% confidence interval for the percent prevalence.

<sup>d</sup> Prevalence estimate in 2005 was eliminated from regression analysis as an outlier (see **Methods** section).

Data Source: CT BRFSS, 2001 - 2010

initial inclusion in the regression trend analysis indicated that the estimate for 2005 was an outlier (*data not shown*; see **Methods** section).

By comparison of annual confidence intervals across the decade, the percent prevalence was significantly different from years 2001 to 2003, 2003 to 2007, and 2007 to 2010 ( $p < 0.05$ ). The estimated number of adults between 18 and 64 years old who received the seasonal flu vaccine ranged from 510,000 in year 2001 to 820,000 in year 2010.

Among adults at least 65 years old, the percent prevalence of flu vaccination in the past 12 months varied from a low of 69.1% in year 2001 to a high of 74.7% in year 2007 (**Table I**). There were no years in which the percent prevalence was significantly different from any other year ( $p < 0.05$ ). Further, the estimated number of adults at least 65 years old who reported having had the vaccine in the past 12 months ranged from 330,000 in year 2001 to 360,000 in year 2007.

The percent prevalence of ever having had a pneumococcal vaccination among adults 18-64 years old varied from a low of 10.0% in year 2008 to a high of 13.1% in year 2010 (**Table II**). The estimated number of adults of this age group who reported ever having had the vaccine varied from 230,000 to 380,000 across the decade. Despite this change, during no year did the percent prevalence of pneumococcal vaccination change significantly for this age group ( $p < 0.05$ ). The percent prevalence of pneumococcal vaccination for ages 18-64 years was significantly less than the prevalence of seasonal flu vaccination across all years from 2001-2010 ( $p < 0.05$ ; **Table I** and **Table II**).

Among adults at least 65 years old, the percent prevalence of pneumococcal vaccination varied from a low of 61.2% in year 2001 to a high of 66.8% in year 2005, ending with a percent prevalence of 65.8% in year 2010 (**Table II**). The number of adults aged 65 and older who reported ever having had the vaccine varied from 290,000



Year	Adults 18-64 years old				Adults 65 years and older			
	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>
2001	635	230,000	10.7%	(9.7%-11.7%)	895	290,000	61.2%	(58.3%-64.1%)
2002	477	240,000	11.5%	(10.1%-12.8%)	701	300,000	62.8%	(59.4%-66.2%)
2003	492	260,000	12.4%	(11.2%-13.6%)	676	310,000	62.7%	(59.4%-66.0%)
2004	530	260,000	12.1%	(10.9%-13.3%)	924	310,000	64.9%	(62.1%-67.7%)
2005	468	230,000	10.7%	(9.3%-12.1%)	812	320,000	66.8%	(63.8%-69.8%)
2006	760	340,000	11.0%	(9.9%-12.0%)	1,429	310,000	64.8%	(62.5%-67.2%)
2007	615	240,000	11.0%	(9.7%-12.2%)	1,423	300,000	61.6%	(59.2%-64.0%)
2008	483	220,000	10.0%	(8.8%-11.2%)	1,236	310,000	64.2%	(61.6%-66.8%)
2009	566	240,000	11.2%	(9.9%-12.4%)	1,378	310,000	65.7%	(63.2%-68.2%)
2010	646	380,000	13.1%	(11.6%-14.5%)	1,421	320,000	65.8%	(63.3%-68.2%)

<sup>a</sup> n is the number of respondents who answered "Yes."

<sup>b</sup> Weighted Frequency is the estimated number of residents in the state who reported ever being vaccinated against pneumococcal infection.

<sup>c</sup> Percent Prevalence is the estimated percent of all residents in the state who reported ever being vaccinated against pneumococcal infection; CI = 95% confidence interval for the percent prevalence.

Source: CT BRFSS, 2001-2010

to 320,000. During no individual year did the percent prevalence change significantly ( $p < 0.05$ ).

Across the decade, the percent prevalence of pneumococcal vaccination among adults at least 65 years old was significantly higher than that among adults 18-64 years old (**Table II**). Among adults at least 65 years old, the percent prevalence of pneumococcal vaccination was significantly lower than the percent prevalence of flu vaccination for all years ( $p < 0.05$ ; **Table I** and **Table II**).

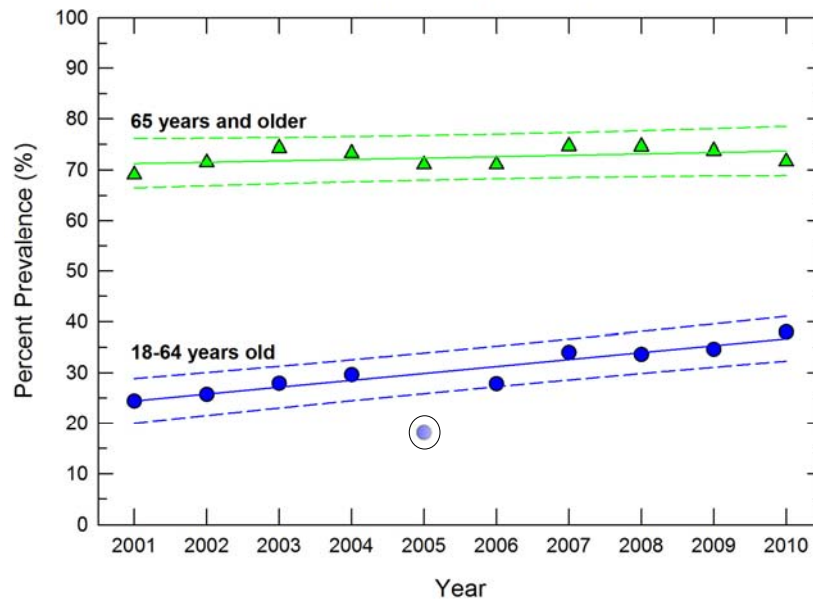
#### *Trend in Prevalence of Influenza (flu) Vaccination and Ever Had Pneumococcal Vaccination*

Results of linear regression analysis for estimated percent prevalence of flu vaccinations from years 2001 through 2010 are shown in **Figure 1** for adults 18-64 years old and for adults 65 years and older. Analysis was conducted without the estimate for 2005 for only the 18-64 year age

group, which was determined to be an outlier (see **Methods** section). Among adults 18-64 years old, the percent prevalence of flu vaccination within the past 12 months increased steadily across the years, and the linear regression model was statistically significant, (F-statistic = 59.42,  $p = 0.0001$ ;  $R^2 = 0.895$ ). The rate of increase in flu vaccination among adults 18-64 years old was also statistically significant, with an estimated annual rate of 1.36% (SE = 0.18%).

Among adults at least 65 years old, the linear regression from years 2001 through 2010 for reported vaccinations against seasonal flu was not significant (**Figure 1**; F-statistic = 1.90,  $p = 0.205$ ;  $R^2 = 0.19$ ). The average percent prevalence of flu vaccinations among adults at least 65 years old across all ten years was 72.5% (SE = 0.6%) (**Table I**). Compared to the estimated percent prevalence across all ten years for ages 18-64 years old, the percent prevalence of adults 65 years and older remained significantly higher across the decade ( $p < 0.05$ ).

Figure 1  
Trend in Seasonal Flu Vaccination  
Adults 18-64 years old, and 65 years and older  
Connecticut, 2001-2010



Linear regression analysis was performed on percent prevalence estimates of vaccination against seasonal flu for adults 18-64 years old (●) and adults at least 65 years old (▲) in Connecticut from years 2001 through 2010. The 2005 percent prevalence estimate among adults 18-64 years old was eliminated from analysis as an outlier (●). Predicted prevalence for adults 18-64 years old with 95% individual predicted confidence intervals (—, and --, respectively) and for adults at least 65 years old (—, and --, respectively) are shown. Linear regression among adults 18-64 years old was statistically significant ( $F=59.41$ ;  $p < 0.0001$ ) with a statistically significant annual percent prevalence increase of 1.36% (standard error = 0.18%). Regression among adults at least 65 years old was not statistically significant ( $F=1.90$ ;  $p=0.20$ ).

Data source: CT BRFSS, 2001-2010

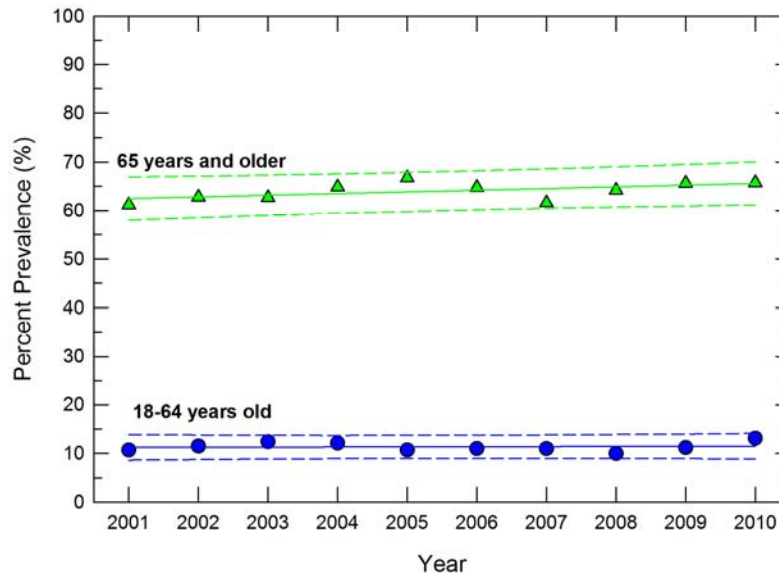
Among adults 18-64 years old, regression for the percent prevalence reporting that they had ever had the pneumococcal vaccine from years 2001 through 2010 was not significant ( $F$ -statistic = 0.10,  $p = 0.80$ ;  $R^2 = 0.008$ ) (Figure 2). The average percent prevalence across the decade was 11.4% (SE = 0.3%) (Table I). Regression among adults at least 65 years old, however, was mildly significant ( $F$ -statistic = 3.57;  $p = 0.0954$ ;  $R^2 = 0.309$ ), resulting in an annual increase in vaccination coverage of 0.4% (SE = 0.2%). Across the decade, the prevalence of pneumococcal vaccination among older adults remained significantly higher than that among younger adults ( $p < 0.05$ ).

#### Unknown/Unsure Responses to Ever Had Pneumococcal Vaccination

The BRFSS question on pneumococcal vaccination asks if adults have ever had the vaccination. To better understand the prevalence of adults in the state who reported not knowing whether they have had the vaccination, trend analysis was conducted for this response, among both adults 18-64 years old and adults at least 65 years old.

Among adults 18-64 years old, the percent prevalence of residents who reported not knowing if they had ever received the pneumococcal vaccination varied from a low of 6.2% in year

Figure 2  
Trend in Ever Had Pneumococcal Infection Vaccination  
Adults, 18-64 years old, and 65 years and older  
Connecticut, 2001-2010



Linear regression analysis was performed on percent prevalence estimates of vaccination against pneumococcal infection among adults 18-64 (●) and adults at least 65 years old (▲) in Connecticut from years 2001 through 2010. Predicted prevalence for adults 18-64 years old with 95% individual predicted confidence intervals (—, and --, respectively) and for adults at least 65 years old (—, and --, respectively) are shown. Regression among adults 18-64 years old (—) was not statistically significant ( $F=0.07$ ;  $p=0.8039$ ). Linear regression among adults at least 65 years old (—) was mildly statistically significant ( $F=3.57$ ;  $p=0.0954$ ), with a significant annual increase of 0.347% (standard error = 0.183%).

Data source: CT BRFSS

2001 to a high of 15.8% in year 2010 (Table III). The percent who reported not knowing among adults 65 years and older varied from a low of 4.1% in year 2009 to a high of 5.0% in years 2007 and 2010.

The number of respondents who reported not knowing whether they had the vaccination was low among adults at least 65 years old, and for 2001, 2002, 2003, and 2005, valid estimates were not possible (Table III).

Trend analysis of respondents who reported not knowing if they had ever had the pneumococcal vaccination is shown in Figure 3. Analysis reveals that among adults 18-64 years old, the percent who reported not knowing if they had ever

had the pneumococcal vaccination increased significantly ( $F$ -statistic = 119.2,  $p < 0.0001$ ;  $R^2 = 0.937$ ), at an annual rate of 10.9% ( $SE = 0.1\%$ ). Analysis across the decade among adults at least 65 years old, however, revealed no significant trend across the decade ( $F$ -statistic = 0.02,  $p = 0.89$ ). Across all years, the average percent prevalence of older adults who reported not knowing if they had ever received the pneumococcal vaccination was 4.5% ( $SE = 0.2\%$ ) (Table II), a value significantly less than that among younger adults across the decade ( $p < 0.05$ ).

Year	Adults 18-64 years old				Adults 65 years and older			
	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>	n <sup>a</sup>	Weighted Frequency <sup>b</sup>	Percent Prevalence (%) <sup>c</sup>	95% CI <sup>c</sup>
2001	335	130,000	6.2%	(5.4%-7.0%)	53	*	*	*
2002	285	170,000	8.0%	(6.9%-9.2%)	33	*	*	*
2003	376	220,000	10.4%	(9.3%-11.5%)	33	*	*	*
2004	360	210,000	10.1%	(8.9%-11.3%)	58	20,000	4.2%	(3.1%-5.4%)
2005	307	220,000	10.2%	(8.6%-11.9%)	51	*	*	*
2006	589	250,000	11.8%	(10.6%-13.0%)	102	20,000	4.8%	(3.7%-5.9%)
2007	570	300,000	13.6%	(12.2%-15.0%)	113	20,000	5.0%	(3.8%-6.2%)
2008	431	280,000	13.0%	(11.4%-14.7%)	83	20,000	3.9%	(2.8%-5.0%)
2009	431	300,000	14.1%	(12.3%-15.8%)	90	20,000	4.1%	(3.0%-5.2%)
2010	523	340,000	15.8%	(14.0%-17.6%)	127	20,000	5.0%	(3.9%-6.0%)

<sup>a</sup> n is the number of respondents who answered "Don't Know" or "Not sure."

<sup>b</sup> Weighted Frequency is the estimated number of residents in the state who reported "Don't Know" or "Not sure" if they have ever been vaccinated against pneumococcal infection.

<sup>c</sup> Percent Prevalence is the estimated percent of all residents in the state who reported "Don't Know" or "Not sure" if they have ever been vaccinated against pneumococcal infection; CI = 95% confidence interval for the percent prevalence.

\* - Estimate not shown because coefficient of variation was at least 15%.

Source: CT BRFS

## Discussion

The results of this study indicate that vaccination coverage against seasonal flu from years 2001 through 2010 in Connecticut increased significantly among adults 18-64 years age. During the same time period, vaccination coverage against pneumococcal infection increased significantly among adults at least 65 years old. Individuals who did not know their vaccination status against pneumococcal infection increased steadily among adults 18-64 years old, but remained constant among adults at least 65 year old.

### Seasonal Flu

Annual vaccination against seasonal flu prior to 2003 was recommended by the Advisory Council on Immunization Practice (ACIP; <http://www.cdc.gov/vaccines/acip/>) only for adults 65 years and older. With the availability of nasal spray vaccine delivery, recommendations by the

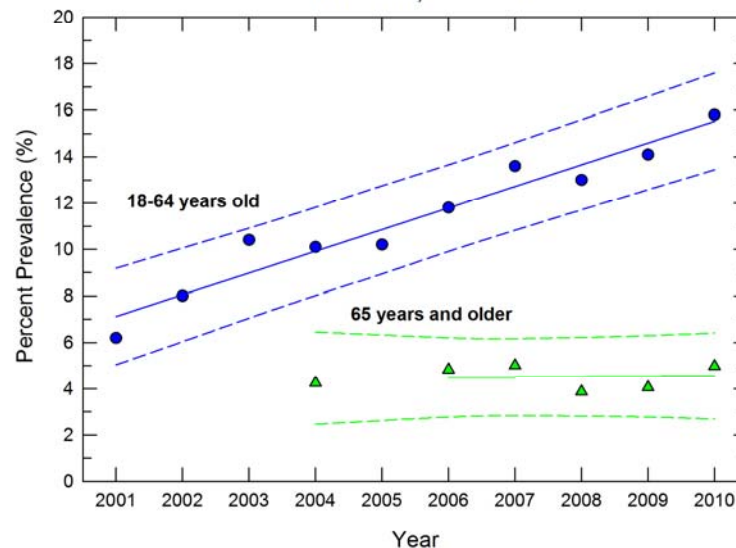
ACIP broadened in year 2003 to include children six to 23 months old [12], and in years 2007 and 2008, broadened again the recommended age for flu vaccine to two to five years, and then six months to 18 years old. In year 2010, the ACIP made its most recent recommendation to include all people six months and older [12].

Changes in ACIP recommendation across the decade for flu vaccinations coincide with increased vaccination coverage observed in this study among adults 18-64 years old. The recommendation among adults 65 years and older did not change significantly during this time period; the lack of increased coverage among this age group over time suggests that older adults were no more likely to receive flu vaccinations in year 2010, compared to year 2001.

An extremely low prevalence of flu vaccine among adults 18-64 years old occurred in year 2005. During the prior year, the country



Figure 3  
Trend in Unknown/Not Sure Responses  
Ever Had Pneumococcal Infection Vaccination  
Adults, 18-64 years old, and 65 years and older  
Connecticut, 2001-2010



Linear regression analysis was performed on percent prevalence estimates of “Don’t Know/Not Sure” responses for vaccination against pneumococcal infection among adults 18-64 (●) and adults at least 65 years old (▲) in Connecticut for years 2001 through 2010. Prevalence estimates among adults at least 65 years old are not shown for years 2001 through 2003, and 2005 because coefficients of variation were greater than 15%. Predicted prevalence for adults 18-64 years old with 95% individual predicted confidence intervals (—, and - -, respectively) and for adults at least 65 years old (—, and - -, respectively) are shown. Linear regression among adults 18-64 years old (—) was statistically significant ( $F=119.2$ ;  $p < 0.0001$ ), with a statistically significant annual increase of 0.93% (standard error = 0.09%). Regression among adults at least 65 years old (—) was not statistically significant ( $F=0.02$ ;  $p = 0.8969$ ).

Data source: CT BRFSS

experienced a shortage in the vaccine, and the ACIP temporarily tightened its recommendation to vaccinate only high risk persons [12]. Since the BRFSS question asks about vaccination coverage in the past 12 months, the flu shortage in 2004 may have led to the extreme low reported prevalence in 2005. The low prevalence in 2005 was unlikely simply the result of a change in the question or addition of another vaccination method, because one would have then expected an effect in both the 18-64 age group, as well as the 65 and older age group, yet the extreme estimate was limited to the 18-64 year age group.

The questions for seasonal flu vaccination continue to change with changes in delivery methods (CT BRFSS: <http://www.ct.gov/dph/>

BRFSS). For instance, starting in year 2011, the two questions for flu, one for the shot and one for the nasal spray, were combined into a single question that stated, “During the past 12 months, have you had either a seasonal flu shot or a seasonal flu vaccine that was sprayed in your nose?” In year 2013, an addition was made to the question that stated, if asked by a respondent, “A new flu shot came out in 2011 that injects vaccine into the skin with a very small needle. It is called Fluzone Intradermal vaccine. This is also considered a flu shot.” Changes in delivery methods and accompanying CT BRFSS question changes, though a potential source of variation are, like the previous decade, small and incremental, and are not likely to have had a large

impact on prevalence estimates for seasonal flu vaccination.

In June, 2009, the World Health Organization declared the beginning of the flu pandemic that included the H1N1 strain [12]. The BRFSS was a primary means for monitoring the epidemic and provided to CDC biweekly initially, and then later monthly data about vaccination against the flu [13]. The BRFSS is a powerful mechanism for obtaining timely information about the health and wellbeing of the population.

### *Pneumococcal Infection*

In contrast to recommendations for flu vaccination, the ACIP recommendation for vaccination against pneumococcal infection remained the same across the decade: all people at least 65 years old should be vaccinated against pneumococcal infection [14].

The CT BRFSS does not sample residents of long-term care facilities, including nursing homes, yet, in 2005, the Medicare program began to require pneumococcal vaccination for all long-term facilities [15]. The vaccination coverage reported in this study, therefore, is likely an underestimation of coverage among all older residents in the state.

The percent of adults at least 65 years old who reported not knowing their vaccination status against pneumococcal infection remained constant across the decade at an average of 4.5% (**Table III, Figure 3**). These data suggest that, of the 29.3% in 2010 who did not report being vaccinated against pneumococcal infection, about one in four were aware of their unvaccinated status. It is unclear from this study why about one in three residents in Connecticut at least 65 years old knew of their susceptibility to pneumococcal infection, and yet remained unvaccinated. Several possibilities exist: 1) A conscious choice was made to refuse the vaccination; 2) Vaccination

was not possible due to a lack of healthcare access; 3) The respondent was confused about the questions; or 4) Vaccination was not medically recommended. Further research is needed to understand the barriers to vaccination against pneumococcal infection, and to explore ways to eliminate these barriers.

The immunization recommendations for pneumococcal infection do not include people less than 65 years old, so it is not surprising that vaccination coverage among adults 18-64 years old remained low across the decade (**Table II, Figure 2**). The percent of younger adults who didn't know if they had been vaccinated against pneumococcal infection was higher than among older adults, and this is also not a surprising result. It is unclear, however, why the percent of respondents among younger adults who reported being unaware of their vaccination status increased significantly across the decade. It is possible that this younger age group became more aware that this disease had not been discussed during health care visits. The increase in seasonal flu vaccinations among this age group supports this possibility.

### *Limitations*

Surveys such as the CT BRFSS are subject to sources of bias that include nonresponse bias, recall bias, and selection bias. This survey depends on anonymous responses from citizen volunteers, and all questions within the survey are voluntary and, therefore, subject to nonresponse bias. The survey is offered within a 20-25 minute time period, with some questions asking respondents to remember events years before the interview. Also, although the survey sampling methodology selects respondents at random, participation in the survey is voluntary.

This survey was conducted among adults in Connecticut who lived during years 2001 through

2010 in residential units, and did not include long-term group quarters, such as nursing homes. Further, the survey was conducted by phone, excluding responses from those who were hearing-impaired, or those suffering from moderate to severe cognitive impairment. These exclusions likely introduced selection bias into the estimates.

With the added administration method of nasal sprays between years 2001 and 2010 came a concomitant shift in the CT BRFSS questions. Whereas earlier questions were limited to shots, later questions included nasal sprays, and wording of the questions were also modified periodically across the decade. Each change in the question introduced a potential shift in responses, and the variation observed across the years in this study may, in part, be the results of these changes.

### *Public Health Implications*

The CDC has declared vaccinations against infectious diseases one of the top 10 achievements in public health during the decade from 2001-2010 [16]. With an increase in the number of diseases targeted by vaccines to 17, the CDC estimates that, within each annual U.S. birth cohort, 42,000 deaths are prevented, saving \$69 billion in societal costs [17].

Vaccination coverage in the U.S. for both flu and pneumococcal infection in 2010, and across the prior decade, remained below the Healthy People 2010 objective of 90% each [14]. Although this percent was also not achieved in Connecticut, a significant increase was observed of 13.5% over the decade from years 2001-2010 to a high of 65.8% (**Table II, Figure 2**).

Assuming a constant continued rate of vaccination coverage across the current decade, the percent vaccination coverage among adults at least 65 years old is expected in year 2020 to be 72%, and 61%, for pneumococcal, and seasonal flu, respectively (*C. Stone, personal communication*).

These estimates remain below the Healthy People 2020 objective of 90% [18].

The results of this study indicate that, although the percent vaccination coverage increased in the state from years 2001 through 2010, more work is needed to encourage vaccinations against both seasonal flu and pneumococcal infection among older adults in Connecticut. To meet the HP 2020 objectives of 90% vaccination coverage against both seasonal flu and pneumococcal infection [18], the rate of vaccination coverage needs to be increased among this older age group. This may involve increasing awareness among citizens, partnering with the state American Association of Retired Persons, as well as state and local social networking organizations. Among younger adults, continued education is also needed to increase vaccination coverage against flu.

In addition to being an objective of Healthy People 2020 [18], vaccination against flu and pneumococcal infections are objectives in the Connecticut State Health Improvement Plan [3]. Vaccine-preventable diseases have also been designated a priority for the state by Dr. J. Mullen, Commissioner of Public Health [4], and as president of the Association of State and Territorial Health Officers, she has established a priority nationwide for Healthy Aging [19]. This initiative focuses on increasing the health and wellbeing among older Americans. Increased vaccination coverage in Connecticut among older adults against flu and pneumococcal infections would contribute to these initiatives.

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