# Influenza Vaccination Rates of Children in Households with High-Risk Adults

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## SYNOPSIS

**Objectives.** Household contacts of people at high risk for influenza complications should receive yearly influenza vaccination to reduce potential viral transmission. We evaluated influenza vaccine coverage among children to determine whether or not living with a high-risk adult predicts the likelihood of being vaccinated.

**Methods.** Using the 2006 National Health Interview Survey, we examined influenza vaccination rates among children (aged 1–17 years) who did and did not reside in a household with an adult at high risk for influenza-related complications.

**Results.** Among 24,195 sampled families, there were 8,976 high-risk adults, 18.9% of whom reported living with a person 17 years of age of younger. Influenza vaccination rates by age group among children living with high-risk adults were 41.7% (1 year), 30.3% (2–4 years), and 20.0% (5–17 years). Unadjusted influenza vaccination rates were significantly higher for school-aged children who lived with a high-risk adult compared with those who did not (20.0% vs. 15.0%, $p<0.001$). Among children younger than 5 years of age, for whom vaccination was universally recommended at the time of the survey, the rates did not differ. After adjusting for the child's age, gender, race, insurance coverage, medical visits, and chronic conditions, children who lived with a high-risk adult were not statistically more likely than those who did not live with a high-risk adult to receive influenza vaccination (odds ratio = 1.16, 95% confidence interval 0.99, 1.36).

**Conclusions.** Children had low rates of influenza vaccination, and those who lived with high-risk adults were not significantly more likely to be vaccinated. Clinicians caring for high-risk adults should remind eligible household contacts to receive influenza vaccine.

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Yearly influenza epidemics cause an estimated 200,000 hospitalizations and 36,000 deaths in the United States, mostly among chronically ill or elderly people. The Centers for Disease Control and Prevention (CDC) and the Advisory Committee on Immunization Practices (ACIP) recommend annual influenza vaccination for these high-risk adults and those living with or caring for them.[1]

Many high-risk adults remain susceptible to influenza infection either because they have not been vaccinated, are exposed to a non-vaccine strain, or fail to respond to vaccine because of chronic medical conditions or advanced age.[2–4] A complementary strategy for protecting these people is to vaccinate their close contacts to limit exposure by virus transmission. In a typical epidemic, influenza affects children first, then spreads to the rest of the community.[5,6] Influenza vaccination is particularly important for children, who shed higher titers of viruses than adults and have infection rates as high as 50%.[5–8] Therefore, vaccinating children may provide protection to immediate household members, as well as the broader community. Ecologic studies suggest that universal vaccination programs in Japan and Canada, including schoolchildren or all eligible citizens, respectively, prevent more deaths when such programs are in place.[9,10]

In this population-based, cross-sectional study, we used the 2006 National Health Interview Survey (NHIS) data to examine influenza vaccination coverage among children living in a household with adults at higher risk for influenza-related morbidity and mortality. At the time of the survey, influenza vaccine was universally recommended for children aged 6 months to 5 years.[11] We compared vaccination rates of children who both did and did not live with a high-risk adult to see whether this was an independent predictor for influenza vaccine use among children. We also reviewed characteristics of sampled household adult and child pairs to determine factors predictive of who received influenza vaccination.

## METHODS

### Subjects and setting

The NHIS is an annual national survey conducted by CDC's National Center for Health Statistics. It includes a face-to-face interview with one adult and one child per selected family within a household. Data are weighted to adjust for sampling probability and nonresponse to reflect the demographic profile of the U.S. The survey collects information on current health conditions and practices of the civilian, noninstitutionalized U.S. population, as described elsewhere.[12]

The four components we used in this analysis of the 2006 survey were the Household Core, Family Core, Sample Adult Core, and Sample Child Core. Our analysis focused on households with a high-risk adult (aged 18–64 years with chronic conditions or ≥65 years) who lived with a child (aged ≤17 years). We grouped children as "toddler" (1 year of age), "preschooler" (2–4 years of age), and "school-aged" (5–17 years of age). Chronic conditions among adults included diseases of the lung, heart, liver, or kidney; diabetes; non-skin cancer; and neurologic conditions. Chronic conditions in children included heart or lung disorders, diabetes, and sickle-cell anemia. Other variables of interest included demographic characteristics (e.g., gender, race, adult's education and income level, and availability of health insurance), health-care access and utilization (e.g., number of visits to health-care provider in the past year), and adult functional status and selected behaviors (e.g., smoking and pneumococcal vaccination status).

### Outcome measures

We assessed influenza vaccination status with the question: "During the past 12 months, have you had a flu vaccination? A flu vaccination is usually given in the fall and protects against influenza for the influenza season." Available responses were yes, no, refused, or don't know. This survey did not query the number of doses of vaccine given. We excluded children younger than 12 months of age from the analysis because of limited ability to ascertain both the infants' exact age during their first influenza season and when they became eligible for influenza vaccination. We further grouped sampled adult and child dyads within families based on their influenza vaccination status (Figure 1).

### Statistical analysis

NHIS data were weighted and were the result of multistage sampling, so we used SUDAAN® software for

**Figure 1. Classification by group of adult and child living within the same household and their influenza vaccination status, 2006 National Health Interview Survey**

| | *Influenza vaccination status among adult/child dyads* | |
|---|---|---|
| *Group* | *High-risk adult* | *Child* |
| 1 | Vaccinated | Vaccinated |
| 2 | Vaccinated | Unvaccinated |
| 3 | Unvaccinated | Vaccinated |
| 4 | Unvaccinated | Unvaccinated |

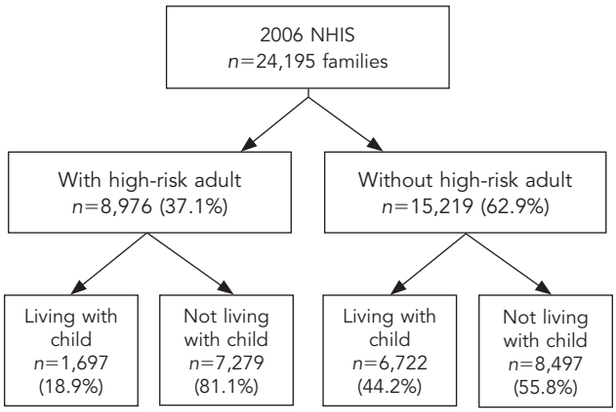
categorical and multivariable data analysis.[13] Statistical analysis included Chi-square test for bivariate comparisons of categorical data (e.g., vaccination status) and logistic regression techniques. The primary outcome of interest was to compare influenza vaccination rates for age cohorts of sampled children who were, or were not, living with a high-risk adult. We used multivariate logistic regression techniques to estimate the probability of vaccine use among children according to whether or not they lived with a high-risk adult, while adjusting for the child's age, gender, race, insurance coverage, number of medical visits, and presence of chronic conditions.

## RESULTS

The 2006 NHIS survey approached 33,468 households in all 50 U.S. states, 4,264 (12.7%) of which were not surveyed because they either refused to participate (65.7%), were not home (24.7%), had language problems (1.5%), or indicated other reasons (8.1%). Among the 29,204 surveyed households, there were 29,868 families (<2% of households were multifamily), yielding data for 75,716 people; 20,903 respondents were children (≤17 years of age) and 54,813 respondents were adults (>17 years of age). Response rates were 90.7% and 82.3% for children and adults, respectively.

Among the surveyed families, 5,673 (19.0%) were excluded from analysis because of missing data (i.e., adult not sampled [98.6%] or lack of information on adult chronic disease status [1.4%]). Of the remaining 24,195 families, there were 8,976 high-risk adults, 1,697 (18.9%) of whom reported living with a family member ≤17 years of age (Figure 2). Nearly 30% of adults aged 18–64 years with a chronic medical condition lived with a child, compared with only 3% of community-dwelling elderly people. Of the high-risk adults living with a child, 1,437 (86.9%) were aged 18–64 years and had a chronic medical condition, while 260 (13.2%) were ≥65 years of age.

**Figure 2. 2006 NHIS according to adult (>18 years of age) risk status for influenza complications and whether or not they live with children (≤17 years of age)**




NHIS = National Health Interview Survey

**Table 1. Child influenza vaccination coverage rates for 2005–2006 according to whether or not they live with an adult at high risk for influenza complications, 2006 National Health Interview Survey**

| | *Influenza vaccination rate (percent)* | |
|---|---|---|
| *Sampled children by age* | *Family with high-risk adult (n=1,570)* | *Family without high-risk adult (n=7,351)* |
| Toddler (1 year) (*n*=584) | 41.7 | 40.3 |
| Preschool (2–4 years) (*n*=1,541) | 30.5 | 30.4 |
| School-aged (5–17 years) (*n*=6,796) | 20.0 | 15.0[a] |

[a]$p<0.001$, comparing influenza vaccination rates of children living in a family with a high-risk adult vs. children living in a family without a high-risk adult

The overall influenza vaccination rate among children was 20.0%. It was highest among the toddler group (40.5%), followed by the preschool group (30.4%) and school-aged group (16.0%). School-aged children living with a high-risk adult family member reported higher influenza vaccination rates (20.0% vs. 15.0%, $p<0.001$) than counterparts not living with a high-risk adult (Table 1). We did not observe this difference among younger-aged children (<5 years of age), for whom influenza vaccination is universally recommended. Among families with children, influenza vaccination rates were 26.2% for adults aged 18–64 years with at least one chronic condition and 43.7% for people ≥65 years of age.

Compared with unvaccinated children, those who received influenza vaccination were younger or more likely to have a chronic medical condition, health insurance, and frequent clinic visits (Table 2). The number of people living in the household was not significantly related to the odds of vaccination (data not shown). After adjusting for the child's age, gender, race, presence of a chronic medical condition, insurance coverage, and number of provider visits in the past year, those living with a high-risk adult were not significantly more likely to have received influenza

**Table 2. Comparison of characteristics between vaccinated and unvaccinated children, and examination of characteristics associated with influenza vaccination among children using univariate and multivariate regression techniques, 2006 National Health Interview Survey**

| *Child characteristics* | *Vaccinated child aged 1–17 years (n=1,824)* N *(percent)* | *Unvaccinated child aged 1–17 years (n=7,097)* N *(percent)* | P-*value*[a] | *Univariate odds ratio*[b] *(95% CI)* | *Multivariate odds ratio*[c] *(95% CI)* |
|---|---|---|---|---|---|
| Age group | | | | | |
| Toddler (1 year) | 234 (13.0) | 350 (4.8) | <0.001 | Ref. | Ref. |
| Preschool (2–4 years) | 471 (26.1) | 1,070 (15.0) | | 0.64 (0.52, 0.79) | 0.74 (0.59, 0.93) |
| School-aged (5–17 years) | 1,119 (60.9) | 5,677 (80.3) | | 0.28 (0.23, 0.34) | 0.32 (0.26, 0.41) |
| Male | 950 (51.7) | 3,575 (50.8) | 0.607 | 1.03 (0.91, 1.17) | 1.01 (0.89, 1.15) |
| Race | | | | | |
| Non-Hispanic white | 787 (58.1) | 3,349 (62.5) | <0.001 | Ref. | Ref. |
| Non-Hispanic black | 351 (15.1) | 1,321 (15.0) | | 1.08 (0.92, 1.26) | 1.10 (0.93, 1.31) |
| Hispanic | 521 (19.4) | 2,001 (17.9) | | 1.17 (1.01, 1.35) | 1.29 (1.10, 1.50) |
| Other | 165 (7.4) | 426 (4.7) | | 1.70 (1.35, 2.15) | 1.96 (1.53, 2.52) |
| Covered by medical insurance | 1,696 (94.3) | 6,173 (89.0) | <0.001 | 2.06 (1.65, 2.57) | 1.76 (1.40, 2.22) |
| Provider visits in past year | | | | | |
| 0–1 | 400 (21.0) | 2,841 (38.9) | <0.001 | Ref. | Ref. |
| 2–3 | 626 (34.3) | 2,450 (35.2) | | 1.81 (1.53, 2.14) | 1.57 (1.32, 1.87) |
| 4–5 | 360 (20.7) | 919 (13.2) | | 2.90 (2.40, 3.52) | 2.16 (1.76, 2.66) |
| ≥6 | 416 (24.1) | 824 (12.7) | | 3.52 (2.93, 4.23) | 2.49 (2.04, 3.05) |
| At least one chronic condition present | 440 (23.8) | 969 (13.6) | <0.001 | 1.99 (1.74, 2.27) | 2.02 (1.74, 2.35) |
| Living with a high-risk adult | 401 (22.7) | 1,355 (19.4) | 0.011 | 1.22 (1.05, 1.41) | 1.16 (0.99, 1.36) |

[a]Comparing vaccinated child with unvaccinated child, using Chi-square comparison

[b]Comparing vaccinated child with unvaccinated child, using univariate logistic regression

[c]Comparing vaccinated child with unvaccinated child, using multivariate logistic regression including all variables within the table

CI = confidence interval

Ref. = referent group

vaccination (odds ratio = 1.16, 95% confidence interval 0.99, 1.36).

Among high-risk adult and child pairs, 61.3% belonged in group 4, in which neither received influenza vaccination (Table 3). Only 11.3% of sampled pairs reported influenza vaccine use in both adult and child. Receiving influenza vaccination was correlated with adults being older, being educated, having insurance coverage, having more chronic medical conditions, and exhibiting positive health behaviors, including abstinence from smoking and receipt of pneumococcal vaccination. Vaccine coverage in children was associated with younger age, presence of asthma or other chronic medical conditions, and more frequent health-care office visits. Of note, among families with an unvaccinated high-risk adult living with a vaccinated child, 20.7% of the adults reported no medical visits in the past year and 66.0% reported functional limitations. About 90.0% of unvaccinated children had at least one medical visit, and about 30.0% reported more than five visits in the previous year.

## DISCUSSION

Children have the highest rates of symptomatic influenza infection and introduce disease into their households.[6] Because 18.9% of adults at high risk for influenza complications live with children, it is important to learn about influenza vaccination rates of these adults and their young household contacts. This U.S. population-based survey revealed that the influenza vaccination rate for these children was low. In fact, the majority of high-risk adult and child pairs were unvaccinated, despite the recommendation by ACIP for high-risk adults and their household contacts to receive influenza vaccination. Further, living with a high-risk adult was not predictive of vaccine use in children. This finding highlights the poor adoption of risk-based recommendations for influenza vaccination.

After Ontario, Canada, initiated a universal influenza immunization program, vaccine coverage among those aged 50–64 years more than doubled (from 21.0% to 47.0%); many of these individuals were at high risk for influenza.[10] In this study, among families with an

unvaccinated high-risk adult living with a vaccinated child, one-fifth of the adults reported no medical visits in the past year and two-thirds reported functional limitations. Access to medical care may be a barrier to vaccination among these adults, which further highlights the importance of vaccinating young family members. As the majority of unvaccinated children had at least one medical visit, and about a third reported more visits in the previous year, these visits may represent missed opportunities for receiving influenza vaccination (although not confirmed, as timing of the clinic visits was not available).

Fewer than half of U.S. children aged 1–4 years, for whom universal influenza vaccination was recommended, received influenza vaccine. Young children with influenza have high rates of symptomatic infection, are often treated with antibiotics, and occasionally suffer severe complications.[14–17] In addition to receiving influenza vaccine for their own protection, children should be vaccinated to prevent them from contributing to the spread of influenza within the household and community.[5–7] Vaccination of U.S. daycare attendees aged 2–4 years was shown to reduce respiratory illnesses among unvaccinated household contacts.[18] Vaccination of Italian children aged 6 months to 9 years reduced respiratory tract infections, respiratory

**Table 3. Comparison of sociodemographic and health characteristics of high-risk adult and child[a] living within a household, according to group classification based on influenza vaccination coverage, 2006 National Health Interview Survey**

| *Characteristics of sampled adult* | *Vaccinated high-risk adult and vaccinated child* N *(percent)* | *Vaccinated high-risk adult and unvaccinated child* N *(percent)* | *Unvaccinated high-risk adult and vaccinated child* N *(percent)* | *Unvaccinated high-risk adult and unvaccinated child* N *(percent)* | P-*value*[b] |
|---|---|---|---|---|---|
| *(n=1,553)* | *(n=175)* | *(n=254)* | *(n=182)* | *(n=942)* | |
| Age (in years) | | | | | <0.001 |
| 18–49 | 121 (69.0) | 143 (58.3) | 149 (82.5) | 712 (77.4) | |
| 50–64 | 27 (17.0) | 55 (23.0) | 13 (7.4) | 139 (14.5) | |
| ≥65 | 27 (14.0) | 56 (18.8) | 20 (10.1) | 91 (8.0) | |
| Gender | | | | | 0.544 |
| Male | 47 (27.9) | 83 (33.3) | 62 (35.7) | 306 (32.4) | |
| Race | | | | | 0.471 |
| Non-Hispanic white | 88 (67.4) | 137 (68.9) | 90 (63.4) | 497 (67.4) | |
| Non-Hispanic black | 32 (13.3) | 49 (14.6) | 44 (18.6) | 186 (14.8) | |
| Hispanic | 33 (10.1) | 51 (12.1) | 37 (13.1) | 211 (13.5) | |
| Other | 22 (9.2) | 17 (4.5) | 11 (5.0) | 48 (4.3) | |
| Education | | | | | 0.053 |
| <High school | 42 (18.7) | 50 (17.1) | 45 (20.9) | 238 (20.2) | |
| High school completed | 33 (19.5) | 69 (24.9) | 48 (29.2) | 258 (29.7) | |
| >High school | 99 (61.7) | 131 (58.0) | 88 (50.0) | 436 (50.2) | |
| Income | | | | | 0.014 |
| <$20,000 | 38 (35.4) | 35 (19.6) | 42 (32.3) | 191 (29.0) | |
| ≥$20,000 | 38 (49.2) | 96 (67.9) | 50 (45.2) | 314 (52.2) | |
| Unknown | 20 (15.4) | 22 (12.5) | 30 (22.5) | 127 (18.8) | |
| Has insurance coverage | 159 (91.6) | 230 (93.0) | 147 (81.3) | 751 (80.3) | <0.001 |
| Has seen any provider or specialist in past year | 156 (90.8) | 233 (91.6) | 143 (79.3) | 712 (76.6) | <0.001 |
| Number of chronic conditions | | | | | 0.006 |
| 0 | 8 (3.5) | 18 (5.5) | 7 (3.7) | 44 (3.8) | |
| 1 | 112 (64.1) | 162 (66.9) | 137 (76.6) | 707 (76.5) | |
| 2 | 30 (20.6) | 42 (17.0) | 30 (16.1) | 114 (12.2) | |
| ≥3 | 22 (11.8) | 27 (10.7) | 8 (3.7) | 65 (7.5) | |
| Smoker | 34 (20.3) | 49 (19.3) | 50 (27.8) | 274 (31.1) | <0.001 |
| Pneumococcal vaccination | 48 (29.0) | 84 (30.2) | 18 (9.2) | 77 (8.0) | <0.001 |

*continued on p. 197*

**Table 3 (continued). Comparison of sociodemographic and health characteristics of high-risk adult and child[a] living within a household, according to group classification based on influenza vaccination coverage, 2006 National Health Interview Survey**

| *Characteristics of sampled child* | *Vaccinated high-risk adult and vaccinated child* N *(percent)* | *Vaccinated high-risk adult and unvaccinated child* N *(percent)* | *Unvaccinated high-risk adult and vaccinated child* N *(percent)* | *Unvaccinated high-risk adult and unvaccinated child* N *(percent)* | P-*value*[b] |
|---|---|---|---|---|---|
| Age | | | | | <0.001 |
| Toddler (1 year) | 17 (8.6) | 5 (2.0) | 20 (10.5) | 43 (4.4) | |
| Preschool (2–4 years) | 22 (12.9) | 25 (9.6) | 43 (21.9) | 109 (12.3) | |
| School-aged (5–17 years) | 136 (78.4) | 224 (88.5) | 119 (67.7) | 790 (83.2) | |
| Gender | | | | | |
| Male | 90 (50.8) | 136 (50.9) | 92 (51.8) | 468 (49.9) | 0.977 |
| Race | | | | | 0.223 |
| Non-Hispanic white | 85 (65.3) | 126 (65.2) | 81 (58.7) | 476 (65.3) | |
| Non-Hispanic black | 30 (12.6) | 50 (14.7) | 50 (21.6) | 195 (15.9) | |
| Hispanic | 40 (13.1) | 62 (16.1) | 42 (15.5) | 219 (14.2) | |
| Other | 20 (8.9) | 16 (4.1) | 9 (4.2) | 52 (4.6) | |
| Chronic condition | | | | | <0.001 |
| Healthy | 119 (69.3) | 199 (79.2) | 111 (61.5) | 717 (77.4) | |
| With asthma | 54 (30.3) | 50 (19.5) | 60 (33.3) | 207 (21.2) | |
| With other chronic conditions | 1 (0.4) | 4 (1.3) | 10 (5.2) | 16 (1.4) | |
| Number of office visits in past year | | | | | <0.001 |
| 0 | 8 (5.8) | 30 (10.2) | 8 (3.4) | 123 (11.8) | |
| 1 | 22 (12.5) | 42 (16.9) | 24 (13.9) | 196 (20.3) | |
| 2–3 | 65 (40.1) | 106 (43.1) | 63 (35.9) | 315 (34.0) | |
| 4–5 | 32 (16.8) | 37 (15.2) | 43 (22.7) | 148 (16.0) | |
| ≥6 | 46 (24.9) | 36 (14.7) | 42 (24.1) | 155 (17.9) | |
| Has insurance coverage | 162 (93.6) | 234 (94.0) | 173 (96.0) | 816 (87.9) | 0.001 |

[a]Analysis was limited to families with a child ≥1 year of age.

[b]Chi-square comparison across all groups

illness-associated medical visits, antibiotic prescriptions, and work absenteeism among their parents.[19]

In this study, the lowest vaccination rates were among school-aged children. In the initial stages of a typical influenza epidemic, more than half of all influenza infections occur in schoolchildren, who then spread the infection to preschool children and adults.[20] Mathematical models suggest that vaccinating 50.0% of schoolchildren in a community can reduce the likelihood of epidemic spread of influenza from 90.0% to 36.0%, and to as low as 4.0% by increasing the vaccination rate to 70.0%.[21] Studies investigating the benefits of vaccinating children in school have demonstrated that it provides indirect immunity at both household and community levels, leading to significantly fewer influenza illnesses, related treatments, and work absenteeism.[9,22–26] Vaccination rates among school-aged children are likely to increase following the ACIP and American Academy of Pediatrics recommendations for universal vaccination of all children that began in the 2008–2009 influenza season, expanding beyond the previous recommendation of 6 months to 5 years. It will be important to evaluate the effect this recommendation has on preventing influenza illness in this age group and in the community in general.

**Limitations**

This study had several limitations. Because only one adult and child per family were selected for detailed interview, vaccination status of other adults or children could not be considered. Furthermore, the risk status of other household members, which may have influenced vaccine use among those sampled, could not be ascertained. Other types of bias included nonresponse due to exclusion of people without complete health information, and recall, as influenza vaccination status is by self- or proxy-report. Finally, the 2006 survey results were obtained year-round and included both the 2005–2006 and 2006–2007 influenza seasons. Therefore, vaccination rates in children, especially those aged 2–4 years, may not completely reflect responses to the new recommendations in 2006 to extend universal vaccination for children aged 2–5 years.

## CONCLUSION

Influenza vaccination rates for U.S. children who live with high-risk adults were low and, after adjustments, not significantly higher than for children in households without high-risk adults. This finding suggests that risk-based vaccine recommendation resulted in modest adherence. Clinicians caring for high-risk adults should ask about the influenza vaccination status of family members, including children, and recommend vaccination to eligible household contacts.

This article was based upon work supported by the Research and Development Medical Research Service, Department of Veterans Affairs (VA), and by a VA career development award. The data in this study were presented, in part, at the American Geriatrics Society annual meeting on May 2, 2008.

The views in the article are those of the authors and do not necessarily represent the views of the VA.

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