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The Cost of Universal Influenza Vaccination of Children in Pediatric Practices

Byung-Kwang Yoo, MD, PhD[#], Peter G. Szilagyi, MD, MPH^{*}, Stanley J. Schaffer, MD, MS^{*}, Sharon G. Humiston, MD, MPH^{*}, Cynthia M. Rand, MD, MPH^{*}, Christina S. Albertin, MPH^{*}, Phyllis Vincelli^{*}, Aaron K. Blumkin, MS^{*}, Laura P. Shone, DrPH, MSW^{*}, and Margaret S. Coleman, PhD[^]

[#] Department of Community and Preventive Medicine, University of Rochester School of Medicine and Dentistry

^{*} Department of Pediatrics, University of Rochester School of Medicine and Dentistry

[^] Centers for Disease Control and Prevention

Abstract

Context—Although all children 6 months to 18 years are now recommended to receive influenza vaccine, the total direct and indirect costs for pediatric practices of delivering childhood influenza vaccination are unknown.

Objective—To estimate nationally-representative pediatric practices' costs of providing influenza vaccination during the 2006–2007 season, and to simulate the costs pediatric practices might incur when implementing universal influenza vaccination for US children 6 months to 18 years.

Design and Setting—We surveyed a stratified, random sample of New York State pediatric practices (n=91) to obtain information from physicians and office managers about all practice resources associated with provision of influenza vaccination. We estimated vaccination costs for two practice sizes (small, large) and three geographic areas (urban, suburban, rural). We adjusted these data to obtain national estimates.

Main Outcome Measure(s)—Total practice cost for providing one influenza vaccine (2006 dollars) to children 6 months to 18 years.

Results—Among all respondents, the median total cost per vaccination was \$28.62 (range \$18.67 (25th percentile) to \$45.28 (75th percentile)). The median component costs were: (1) clinical personnel/labor- \$2.01, (2) non-clinical personnel/labor- \$7.96, and (3) all other (overhead) costs- \$10.43. Vaccine purchase costs averaged \$8.22. Smaller practices and urban practices had higher costs than larger or suburban practices. Assuming that vaccine administration reimbursement for all Vaccine For Children program (VFC) eligible children is the current Medicaid median of \$8.40, the

Contact information for the corresponding author: Byung-Kwang Yoo, M.D., M.S., Ph.D., University of Rochester, School of Medicine and Dentistry, Department of Community and Preventive Medicine, Division of Health Policy and Outcomes Research, 601 Elmwood Avenue, Box 644, Rochester, NY 14642, Phone: (585) 275-3276, Fax: (585) 461-4532; Byung-Kwang_Yoo@urmc.rochester.edu.

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Dr. Sharon Humiston serves on advisory boards and/or speaker bureaus for pharmaceutical companies that manufacture influenza vaccine including sanofi pasteur, GSK, and Novartis.

financial loss across all US pediatric practices through delivering VFC vaccines would be \$98 million if only one-third of children received influenza vaccine.

Conclusion—The total cost for pediatric practices to provide influenza vaccination is high, varies by practice characteristics, and exceeds average VFC reimbursement. Many pediatric practices may face financial risk unless both Medicaid and private vaccination reimbursement are increased.

Keywords

Cost analysis; provider practice; vaccine; delivery of care; universal influenza vaccination

Background

Influenza disease contributes to relatively high rates of pediatric emergency department visits, outpatient visits, and hospitalizations.^{1, 2} Consequently, in 2004, the Advisory Committee on Immunization Practices (ACIP) recommended universal influenza vaccination (UIV) for children ages 6–23 months³ and in 2007, expanded that recommendation to children 6–59 months of age.⁴ In February 2008, ACIP expanded immunization recommendations further to include all children 6 months to 18 years of age with a full implementation date of 2009–2010.

Most influenza vaccination will probably occur in primary care practices.^{5, 6} Most pediatricians have favored influenza vaccination recommendations.^{7, 8} However, primary care providers list practical barriers to vaccinating all children within their practices,⁸ and cost is one of the most important barriers.^{9, 10}

Because the cost of providing influenza and other vaccinations has become a major issue, pediatricians^{11, 12} and national public health leaders^{13–16} have emphasized the need for adequate reimbursement, from both Medicaid and private insurers, to cover the costs of vaccinating children in primary care practices. Inadequate reimbursement may impede full implementation of UIV.⁵ VFC providers receive vaccines at no cost for eligible children (uninsured, underinsured, and Medicaid eligible), but they are reimbursed a vaccine administration fee only for children enrolled in Medicaid.¹⁷

Determining reimbursement that would adequately cover practice costs requires knowledge of all practice costs related to vaccination, including both personnel and non-personnel costs. While the practice cost of adult influenza vaccination has been assessed,¹⁸ corresponding costs within pediatric practices remain unknown. The objectives of our study were to provide nationally-representative estimates of pediatric practices' costs to provide influenza vaccination, and to simulate the practice costs nationally of UIV for children 6 months to 18 years.

Methods

Study Design and Analytic Approach

We used two strategies for estimating pediatric practice costs. First, we performed a survey of a stratified, random sample of pediatric practices throughout New York State (NYS). This provided information from physicians and office managers about resources needed to deliver influenza vaccines. Practices were stratified into two practice sizes (fewer than 2 full time equivalent (FTE) physicians or 2 or more physicians) for each of three geographic types (urban, suburban, and rural), because prior studies have suggested that practice size and location are associated with vaccination costs^{18, 19} as well as physician influenza vaccination practices.²⁰ Second, we used the NYS survey data in conjunction with secondary sources to estimate national costs-per-vaccination.

We calculated four cost-components: (1) clinical personnel or labor (e.g., physician or nurse) cost, (2) non-clinical labor cost, (3) overhead (all other) cost, and (4) vaccine purchase cost. To allocate a proportion of total practice costs to one influenza vaccination, we used three key factors: staff time to vaccinate (from the literature),¹⁹ the total number of influenza vaccine doses obtained in 2006–07 (from the NYS survey), and the total number of healthcare visits to the practice (from the NYS survey) during an influenza vaccination time window that was assumed to vary from 3 to 5 months.

Throughout, results are presented at the median, 25th and 75th percentile values to display a range of estimates.

NYS Survey of Primary Care Practices

We randomly selected pediatricians from the American Academy of Pediatrics (AAP) Member Directory for New York State, selecting one pediatrician per practice. We sent two separate surveys: one asked pediatricians about their vaccination practices and perceptions about UIV; the other asked office managers regarding the detailed vaccination-related resource use. We sent up to three follow-up surveys as well as multiple telephone reminders for non-responders and for those who had incomplete responses. Ninety-one out of 126 practices responding had sufficiently complete responses to be included in our analyses: urban (small (n=16 out of (/) 21), large (3/10)); suburban (small (21/25), large (31/39)); and rural (small (16/24) and large (4/7)). Due to the smaller numbers of large clinics in urban/rural areas with complete responses, the accuracy for these clinics' estimates would be relatively lower than those in other strata. We used the survey responses to assess the four components of practice costs for influenza vaccination.

(1) Clinical labor cost (the component related to actually vaccinating the child)

—Clinical labor (physician and nurse) cost to counsel and vaccinate a child was estimated by multiplying the weighted wage, broken down to minutes, for a specific job category by the number of minutes of clinical time per vaccination. The weighted wage reflected both the type of clinician who provided vaccination and the time spent by each clinical staff member, obtained from the survey. We used national average hourly wages for 2006.²¹

Our main analyses assumed that vaccination required 3.6, 2.7, and 3.3 minutes for urban, suburban, and rural practices respectively. The first two were median values from a time-motion study of childhood influenza vaccination¹⁹ while the rural value – because it was unavailable – was assumed to be an average of urban and suburban. Sensitivity analyses assumed that vaccination time in urban and suburban clinics ranged between 25th and 75th percentile values of the previous study and that vaccination times in rural clinics ranged between 25th and 75th percentile values of urban and suburban clinics.

(2) Non-clinical labor cost (all other personnel or labor costs)—The non-clinical labor cost was calculated for tasks associated with vaccination other than clinical labor costs; these included personnel costs for scheduling, billing, running the office, etc. As an example, we assumed that if a practice devoted 5% of clinical labor to influenza vaccination, then 5% of non-clinical labor costs should be attributable to influenza vaccination as well.²² To estimate the non-clinical labor costs component, we multiplied: the number of FTE administrative personnel (15 job categories), with the national average annual salary for each specific job category,²¹ and the fraction attributed to influenza vaccination (FAIV).²²

Assuming the vaccination time window is 3 months, a practice-specific FAIV was calculated as follows:

$$[\text{FAIV}] = \frac{[\text{weighted number of influenza vaccination related visits}]}{[\text{number of flu – shot only visits}] + [\text{total number of healthcare visits during 3 months}]}$$

The denominator's "healthcare visits" excluded "flu-shot only visits". The "[weighted number of influenza vaccination related visits]" was the sum of influenza vaccine doses where (i) a dose counted as "one" if provided during a vaccination-only visit and (ii) a dose was measured as the "proportion of a visit" if provided during any other type of visit based on the proportion of visit time for influenza vaccination. The "proportion of a visit" was, for example, 0.33 when the time to provide one vaccination was 5 minutes and the practice's reported average time for a visit was 15 minutes ($0.33 = 5/15$).

(3) Overhead cost (non-personnel costs)—Overhead included all other non-personnel, non-vaccine-related items such as rent/mortgage, utility, non-medical/medical supplies, insurance, and vaccine-related costs other than vaccine purchase (e.g. refrigeration to store vaccine). This category was estimated by multiplying the survey respondent's annual costs for these items by the respondent-specific FAIV.

We multiplied the overhead costs in the NYS survey with a geographic adjustment rate, 0.9, to extrapolate to the US, using a range of 0.84–0.95 in sensitivity analyses.^{23, 24}

(4) Vaccine purchase cost—The practice-specific price per dose was calculated from survey responses and was a weighted average of \$0 vaccine covered by VFC, and \$13/\$11 for privately purchased single-dose/multi-dose vials.

Estimation of Total Costs in All Pediatric Practices Across the U.S

The total costs of influenza vaccination for all U.S. pediatric practices were calculated using the cost estimates for the six practice categories. Total cost in each category was the product of the cost-per-vaccination times the number of vaccinations delivered. We employed Monte Carlo simulation to estimate median and 25th and 75th percentile values of cost using @Risk software.²⁵ The simulation assumed a triangular distribution where mode, minimum and maximum were median, 25th and 75th percentile values of survey responses with 1,000 iterations per estimation.

10.8 million total pediatric influenza vaccine doses were used during the 2006–07 season.²⁶ We allocated total vaccine doses into the six categories defined earlier by estimating allocation proportions of each category based on vaccine use among 6–23 month old children during the 2003–04 season as reported in the National Immunization Survey²⁷ and an AAP Periodic Survey.²⁸

We estimated total costs for all pediatric practices during the 2006–2007 season and for three subsequent hypothetical future seasons under UIV. We assumed the vaccination coverage rate among this target population to be 33%, 66%, and 90% in successive future seasons to allow for uptake over time.

Data imputation for missing values

Despite extensive following up with practices by mail and telephone 78 had at least one missing value, although most were minor. In these cases imputations were made using the median values from practices within the same practice category.²³

Sensitivity analyses

The sensitivity analysis was conducted to examine the effects of the data imputation and the different assumptions on the total cost per vaccination. These assumptions dealt with the vaccination time window, the clinical time to vaccinate children, and geographic overhead cost adjustments.

Results

Demographics

Physician and practice characteristics are shown in Table 1. The majority of practices were suburban and office-based. Many employed fewer than 2 FTE physicians. There was no statistically-significant difference in characteristics across the three samples.

Practice Costs for Components of Influenza Vaccination

Table 2 shows the cost components of practice costs per single influenza vaccination for all practices, and according to practice size and geographic area. For all practices, the median total cost per influenza vaccination (bottom row in Table 2) was \$28.62 (2006 dollars), varying from \$18.67 (25 percentile) to \$45.28 (75 percentile). The median costs of components for all practices were (1) clinical labor costs: \$2.01, (2) non-clinical labor costs: \$7.96, (3) overhead (all other) costs: \$10.43, and (4) vaccine purchase costs: \$8.22. Excluding vaccine purchase costs, the proportions of the first three components in the median vaccination cost of \$20.40 were (1) clinical labor costs to provide vaccination: 10%, (2) non-clinical labor costs: 39%, and (3) overhead costs: 51%.

Variations in Practice Costs

Smaller practices tended to have higher median costs (\$34.41) than larger ones (\$25.23) (bottom row in Table 2). Urban practices and rural practices had the highest and the lowest costs among the three geographic groups. The median vaccine purchase cost reported by the practices was \$8.22, varying between \$6.13 (25th percentile) to \$8.98 (75th percentile). These variations reflected the practice-specific patient populations, with lower costs for practices serving more VFC-covered children.

Total U.S. Practice Costs

Table 3 reports the total cost estimates of influenza vaccination across the US, based on the assumed relative share of vaccinations delivered in small/large practices, and in urban/suburban/rural practices.^{26–28} Our simulation estimated median total costs per vaccination in each of six categories to range from a low of \$19.51 (large, rural practices) to \$45.87 (small, urban practices). The sum of total costs in the six categories during the 2006–2007 season was \$193 million.

Practice Costs Under UIV

Assuming 58% of child vaccine doses, not children, will be provided in pediatric practices in the future (based on an average of estimates of vaccinations in public and private sectors in the 1997–1998 and 2003–2004 seasons),^{27, 29, 30} 16.1 million, 25.3 million and 34.1 million doses will need to be provided in pediatric practices (1st column in Table 4) to achieve vaccine coverage rates of 33%, 66% and 90%. This assumption of 58% included children with private pediatric providers (44%) and around three-quarters of those with mixed private/public providers (14%). The estimated total practice costs will range from \$477 million (33% coverage) to \$1.011 billion (90% coverage) in 2006 dollars. The estimated practice costs excluding vaccine purchase will range from \$361 million (33% coverage) to \$765 million (90% coverage). The financial loss for VFC vaccination only was estimated to range from \$98 million

(33% coverage) to \$208 million (90% coverage) (far right column in Table 4) with additional assumptions^{28, 31} explained in Table 4. In one of these assumptions, we assumed that providers receive the same vaccine administration reimbursement for vaccinating all VFC-eligible children, regardless of reason for eligibility. For around 40% uninsured/underinsured children among VFC eligible children,³² providers were assumed to receive out-of-pocket payment and not insurance reimbursement. These assumptions produce a conservative estimate of loss from VFC vaccination. These financial loss estimates would provide critical information for public policy makers in allocating future resources to make up for the losses.

Sensitivity Analysis

Despite a large proportion of practices with imputed costs, imputation appeared to have little effect on the median total cost except to reduce the interval between the 25th and 75th percentile values (Table 5, top three rows). Among the three types of one-way sensitivity analyses, the changes in assumptions about the vaccination time window had the largest effect on the median total cost estimation. Extension of the vaccination period from 3-months to 5-months²⁶ reduced the total cost per vaccination from \$28.62 to \$22.45 (5th row in Table 5), due to a relatively smaller proportion of visits with vaccination among all visits in 5-months. The multiple-way sensitivity analysis yielded a median cost of \$29.16 with a narrower range of \$26.22–\$32.87.

The different assumptions concerning clinical time to implement a vaccination and the geographic adjustment rates led to a cost range of \$27.19–\$29.95, and \$29.55–\$28.41, respectively.

Discussion

We estimated that the median cost to US pediatric practices in 2006–07, to provide one influenza vaccination (excluding vaccine purchase costs), was \$20.40. Practice costs varied widely from \$12.54 (25th percentile) to \$36.30 (75th percentile). These variations mainly stemmed from non-clinical labor and overhead costs, which varied widely across both practice size and type of practice.

Two prior studies have estimated practice costs per vaccination. One studied general childhood vaccination costs in four Colorado pediatric practices and noted an average of \$12.56 (2006 dollars) per vaccination.³³ This group's estimated overhead cost per vaccination (\$3.47 = fixed cost (\$2.97) + cost of supplies (\$0.51)) was much lower than ours.³³ The second study focused on influenza vaccination among adults in 20 practices in three cities (Rochester, NY, Albuquerque, NM, and San Diego, CA). The estimated adult influenza vaccination costs were higher than costs in our study, ranging from \$24.13 to \$57.02 (in 2006 dollars).¹⁸ Differences between our findings and theirs are likely due to differences in patients' age, types of practices, geographic variations in costs, and study methods, particularly the breadth of relevant costs and the assumption about FAIV.

Reimbursement compared with practice costs (excluding vaccine purchase costs)

Our study noted that pediatric practices' costs per-influenza-vaccination are much higher than reimbursement in many cases. One study noted the average private insurance reimbursement rates for childhood influenza vaccination in Georgia to range between \$9.48 and \$20.67.³⁴ Although reimbursement rates from private insurers are known to vary geographically and even across plans in the same locality, efforts were not made to assess the adequacy of private reimbursement. Medicaid reimbursement is better understood, and known to vary widely among states, ranging from a vaccine administration fee of \$2.00 in Colorado to \$17.86 in NY, with a median of \$8.40 among 48 states in calendar year 2005.³⁵ However, even the state with the highest Medicaid reimbursement for vaccine administration (NY) falls short of covering

practice costs (excluding vaccine purchase costs) at the median practice cost of \$20.40 per vaccination. Even outside of overhead cost, the median labor cost (\$9.97) is still higher than the median Medicaid reimbursement (\$8.40).

Individual pediatric practices are unlikely to know their true costs for influenza vaccination because of the complexity in calculating practice costs. Nevertheless, if practices sense that their reimbursement for pediatric influenza vaccination are lower than their actual practice costs, negative consequences could occur, particularly under UIV. First, pediatric practices might simply absorb the losses, spreading out the costs across their general operations and perhaps reducing other services or raising other fees to compensate. Second, more children might be referred elsewhere for influenza vaccination,⁹ which could lower vaccination rates. Consequently, influenza associated health expenditures among children could increase. Third, because vaccination costs appear higher in practices that serve urban or poor populations, disparities in vaccination rates and influenza-associated health outcomes could become more pronounced. Overall, expansion to UIV of all children 6 months -18 years of age might be less successful than desired due to financial risks for pediatric practices.

Implications for policy and practice

Providing VFC vaccine for 46% of all US children was estimated to incur a \$98 million financial loss across all pediatric practices during one season with 33% coverage, \$154 million with 66% coverage, and \$208 million with 90% coverage. These estimates were conservative due to a set of conservative assumptions adopted, and hence actual loss might be even higher. One policy implication from our study is to enhance reimbursement rates to meet practice costs.

Pediatric practices could begin to incorporate more efficient strategies for influenza vaccination. One important strategy involves designated vaccination clinics, such as vaccination-only times on Saturdays or evenings. Although this strategy is often suggested,³⁶ and vaccination clinics were used by 51% of practices in this study, the impact of vaccination clinics on overall vaccination costs has not been assessed. Other strategies include lengthening the vaccination time period, improving show-rates at scheduled visits through patient reminders, and consideration of vaccination at other settings such as schools.^{37, 38} Our estimates about the cost per vaccination and total U.S costs of childhood UIV in pediatric practices might change considerably if the new vaccination strategies suggested above are implemented on a large scale.

Limitations

Our estimates were based, in part, on a relatively small number of survey responses (n=126 including those used for imputations only) in a single state. However, physician characteristics in our survey were very similar to those found in a recent national survey by the AAP.²⁸ It should be noted, also, that we based cost estimates on self-reports which could not be verified, and we imputed some data. We also did not have data regarding time to provide vaccination at rural practices. To handle these uncertainties, we conducted sensitivity analyses and adopted a set of conservative assumptions leading to a lower cost estimate and relied on quartile values in our survey data, instead of means and standard deviations that tend to be more sensitive to outlier values. The use of national average salary may under-estimate the labor cost in suburban/urban clinics, while it may over-estimate the labor cost in rural clinics. Despite such under/over-estimation of labor cost, the use of the national average salary is expected to yield reasonably accurate total cost at the national level. Finally, we were unable to find detailed estimates of numbers of influenza doses used during 2006–2007 for all children, hence imputed vaccine doses used by apportioning doses used by children age 6–35 months in earlier seasons.^{25,27}

Conclusions

We conclude that pediatric practices' costs for influenza vaccination are higher than most state's Medicaid administration reimbursement. The result is that many practices lose money on influenza vaccination. Under a scenario of childhood UIV, pediatric practices could incur considerable financial risk unless Medicaid and private reimbursement match practice costs for influenza vaccination.

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Abbreviations

UIV	universal influenza vaccination
VFC	Vaccine For Children program
NYS	New York State
FAIV	Fraction attributed to influenza vaccination

References

1. Rand CM, Shone LP, Albertin C, Auinger P, Klein JD, Szilagyi PG. National health care visit patterns of adolescents: implications for delivery of new adolescent vaccines. *Arch Pediatr Adolesc Med* 2007;161(3):252–259. [PubMed: 17339506]
2. Neuzil KM, Mellen BG, Wright PF, Mitchel EF Jr, Griffin MR. The effect of influenza on hospitalizations, outpatient visits, and courses of antibiotics in children. *N Engl J Med* 2000;342(4):225–231. [PubMed: 10648763]
3. Advisory Committee on Immunization Practices (ACIP). The Advisory Committee on Immunization Practices (ACIP) Vote to Recommend Influenza Vaccination for Children Aged 6 to 23 Months for Influenza Season 2004–2005. 2004. available at: <http://www.cdc.gov/nip/flu/acipflu-rec-2004.htm>
4. Fiore AE, Shay DK, Haber P, Iskander JK, Uyeki TM, Mootrey G, et al. Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2007. *MMWR Recomm Rep* 2007;56(RR-6):1–54. [PubMed: 17625497]
5. Szilagyi PG, Humiston SG, Shone LP, Barth R, Kolasa MS, Rodewald LE. Impact of vaccine financing on vaccinations delivered by health department clinics. *Am J Public Health* 2000;90(5):739–745. [PubMed: 10800422]
6. Gnanasekaran SK, Finkelstein JA, Lozano P, Farber HJ, Chi FW, Lieu TA. Influenza vaccination among children with asthma in medicaid managed care. *Ambul Pediatr* 2006;6(1):1–7. [PubMed: 16443176]
7. Humiston SG, Szilagyi PG, Iwane MK, Schaffer SJ, Santoli J, Shone L, et al. The feasibility of universal influenza vaccination for infants and toddlers. *Arch Pediatr Adolesc Med* 2004;158(9):867–874. [PubMed: 15351752]
8. Albertin, CS.; Schaffer, SJ.; Rand, CM.; Shone, LP.; Humiston, SG.; Blumkin, AK., et al. Pediatricians Perspectives on Universal Influenza Vaccination of Adolescents. *Pediatric Academic Societies' Annual Meeting*; Honolulu, Hawaii. 2008.

9. Szilagyi PG, Humiston SG, Pollard Shone L, Kolasa MS, Rodewald LE. Decline in physician referrals to health department clinics for immunizations: the role of vaccine financing. *Am J Prev Med* 2000;18(4):318–324. [PubMed: 10788735]
10. Kempe A, Daley MF, Parashar UD, Crane LA, Beaty BL, Stokley S, et al. Will pediatricians adopt the new rotavirus vaccine? *Pediatrics* 2007;119(1):1–10. [PubMed: 17200265]
11. Davis MM, Andrae M, Freed GL. Physicians' early challenges related to the pneumococcal conjugate vaccine. *Ambul Pediatr* 2001;1(6):302–305. [PubMed: 11888419]
12. Andrew, Pollack. Pediatricians Voice Anger Over Cost of Vaccines. *New York Times*. 2007 March 24;
13. National Vaccine Advisory Committee. The promise and challenge of adolescent immunization. *Am J Prev Med* 2008;35(2):152–157. [PubMed: 18617084]
14. National Vaccine Advisory Committee. Mandates for adolescent immunizations recommendations from the national vaccine advisory committee. *Am J Prev Med* 2008;35(2):145–151. [PubMed: 18617083]
15. Koriath, T. AAP News. American Academy of Pediatrics; 2005. AAP issues recommendations on use of meningococcal vaccines. available at: <http://aapnews.aappublications.org/cgi/content/full/e2005176v1>
16. Committee on the Evaluation of Vaccine Purchase Financing in the United States, Board on Health Care Services (HCS), Institute of Medicine (IOM). *Financing Vaccines in the 21st Century: Assuring Access and Availability* (2003). Washington, DC: National Academies Press; 2003.
17. Centers for Disease Control and Prevention. Vaccines for Children Program (VFC). 2008. <http://www.cdc.gov/vaccines/programs/vfc/default.htm>
18. Coleman MS, Fontanesi J, Meltzer MI, Shefer A, Fishbein DB, Bennett NM, et al. Estimating medical practice expenses from administering adult influenza vaccinations. *Vaccine* 2005;23(7):915–923. [PubMed: 15603893]
19. Szilagyi PG, Iwane MK, Humiston SE, Schaffer S, McInerney T, Shone L, et al. Time spent by primary care practices on pediatric influenza vaccination visits: implications for universal influenza vaccination. *Arch Pediatr Adolesc Med* 2003;157(2):191–195. [PubMed: 12580691]
20. Dombkowski KJ, Leung SW, Clark SJ. Physician perspectives regarding annual influenza vaccination among children with asthma. *Ambul Pediatr* 2008;8(5):294–299. [PubMed: 18922502]
21. Bureau of Labor Statistics, Department of Labor. *The Occupational Employment Statistics*. 2008. available at: <http://www.bls.gov/news.release/cpi.toc.htm>
22. Drummond, MF.; Sculpher, MJ.; Torrance, GW.; O'Brien, BJ.; Stoddart, GL. *Methods for the economic evaluation of health care programmes* Third edition. Oxford: Oxford University Press; 2005. Cost analysis; p. 55-92.
23. Centers for Medicare & Medicaid Services Medicare Program (CMS) Department of Health and Human Services. *Hospital Inpatient Prospective Payment Systems and Fiscal Year 2007 Rates*. *Federal Register* 2006;71(196)
24. Grubb and Ellis Company. *Office Market Trends North America*. Grubb and Ellis Research; Chicago, IL: 2007. www.grubb-ellis.com
25. Palisade Corporation. @Risk. 5.0. Ithaca, NY: 2008.
26. Centers for Disease Control and Prevention. *Estimates of Influenza Vaccination Targeted Populations Sizes in 2006 and Recent Vaccine Uptake Levels*. 2006. Accessed at: <http://www.cdc.gov/flu/professionals/vaccination/pdf/targetpopchart.pdf>
27. Santibanez TA, Santoli JM, Bridges CB, Euler GL. Influenza vaccination coverage of children aged 6 to 23 months: the 2002–2003 and 2003–2004 influenza seasons. *Pediatrics* 2006;118(3):1167–1175. [PubMed: 16951012]
28. American Academy of Pediatrics Division of Health Services Research. *Pediatricians' Attitudes and Practices Surrounding the Delivery of Immunizations*. *Periodic Survey of Fellows*. 2006;(66)
29. LeBaron CW, Lyons B, Massoudi M, Stevenson J. Childhood vaccination providers in the United States. *Am J Public Health* 2002;92(2):266–270. [PubMed: 11818303]
30. Freed GL, Nahra TA, Wheeler JR. Which physicians are providing health care to America's children? Trends and changes during the past 20 years. *Arch Pediatr Adolesc Med* 2004;158(1):22–26. [PubMed: 14706953]

31. Vaccine manufacturers' Biologics Surveillance Data. Pediatric and adolescent vaccine doses distributed by funding source, CY 2006. Cited in Assuring Vaccination without Financial Barriers: A DRAFT White Paper of the NVAC Vaccine Financing Working Group (VFWG). 2006. Accessed at: <http://www.hhs.gov/nvpo/nvac/documents/vfwgwhitepaper20080410.pdf>
32. Institute of Medicine (IOM) Committee on Immunization Finance Policies and Practices Division of Health Care Services and Division of Health Promotion and Disease Prevention. Calling the Shots: Immunization Finance Policies and Practices. Washington D.C: National Academies Press; 2000.
33. Glazner JE, Beaty BL, Pearson KA, Berman S. The cost of giving childhood vaccinations: differences among provider types. *Pediatrics* 2004;113(6):1582–1587. [PubMed: 15173477]
34. Coleman, MS. Economics of Pediatric Vaccine Delivery in Medical Practices. National Vaccine Advisory Committee Meeting; Washington D.C. 2008.
35. Centers for Medicare and Medicaid Services (CMS). Actual vs. allowable Medicaid administration fees paid for VFC vaccine administration, calendar year (CY) 2005. Cited in Assuring Vaccination without Financial Barriers: A DRAFT White Paper of the NVAC Vaccine Financing Working Group (VFWG); 2008.
36. Szilagyi PG, Iwane MK, Schaffer S, Humiston SG, Barth R, McInerney T, et al. Potential burden of universal influenza vaccination of young children on visits to primary care practices. *Pediatrics* 2003;112(4):821–828. [PubMed: 14523173]
37. King JC Jr, Stoddard JJ, Gaglani MJ, Moore KA, Magder L, McClure E, et al. Effectiveness of school-based influenza vaccination. *N Engl J Med* 2006;355(24):2523–2532. [PubMed: 17167135]
38. Schmier J, Li S, King JC Jr, Nichol K, Mahadevia PJ. Benefits and costs of immunizing children against influenza at school: an economic analysis based on a large-cluster controlled clinical trial. *Health Aff (Millwood)* 2008;27(2):w96–104. [PubMed: 18216044]

Table 1

Characteristics of MD survey respondents expressed as proportions, except where indicated

	Full Sample (n = 91)	Sample Without Rent Imputation [¶] (n = 65)	Sample With No Cost Imputation [‡] (n = 13)
Years after graduating medical school [mean (95% CI)] [†]	24 (22 – 26)	24 (21 – 27)	26 (20 – 31)
Gender: Female	41 (45%)	29 (45%)	5 (38%)
Ethnicity: Hispanic or Latino	4 (4%)	3 (5%)	0 (0%)
No Response	3 (3%)	2 (3%)	0 (0%)
Race:			
American Indian/ Alaska Native	1 (1%)	1 (2%)	0 (0%)
Asian	14 (15%)	11 (17%)	2 (15%)
Black	2 (2%)	1 (2%)	0 (0%)
White	72 (79%)	52 (80%)	11 (85%)
No Response	2 (2%)	0 (0%)	0 (0%)
Patient population			
Urban	19 (21%)	15 (23%)	3 (23%)
Suburban	52 (57%)	35 (54%)	7 (54%)
Rural	20 (22%)	15 (23%)	3 (23%)
Practice size			
< 2 FTE MDs	53 (58%)	37 (57%)	10 (77%)
≥ 2 FTE MDs	38 (42%)	28 (43%)	3 (23%)
Practice Type * §			
Private/Office-based	75 (82%)	56 (86%)	12 (92%)
Neighborhood health center	2 (2%)	0 (0%)	0 (0%)
Staff-model HMO practice	2 (2%)	2 (3%)	0 (0%)
Public health clinic	1 (1%)	0 (0%)	0 (0%)
Hospital-based clinic	4 (4%)	2 (3%)	0 (0%)
Other	6 (7%)	4 (6%)	1 (8%)
No response	1 (1%)	1 (2%)	0 (0%)
Offered Flu Clinic	46 (51%)	32 (49%)	5 (38%)

([†]) For this category only, numbers of observations were 86 (full sample), 61 (no rent imputation) and 13 (no cost imputation).

FTE: Full time equivalent.

([¶]) Sample with a missing value in an item other than rent fee, where a missing value was replaced by the median value from practices within the same practice category

([‡]) Sample without any missing value

(^{*}) Marginally different (p-value of 0.072) between the full sample (n=91) and the imputed sample (n = 65). All other characteristics were not statistically significant at alpha=0.05.

(§) Test using Fisher's exact test for categorical variables, because n is so small. None of these characteristics were statistically significant at $\alpha=0.05$.

Table 2

Pediatric practice's cost per single influenza vaccination: Median (25th percentile, 75th percentile) (in 2006 Dollars)

	All Subjects (n=91)	Practice Size			Geographic Area		
		Small (n=53) (2 or less MD)	Large (n=38) (>2 MD)		Urban (n=19)	Suburban (n=52)	Rural (n=20)
(1) Clinical personnel/labor cost	\$2.01 (\$1.95, \$2.73)	\$2.12 (\$1.96, \$2.94)	\$1.96 (\$1.95, \$2.17)		\$2.13 (\$1.96, \$3.20)	\$2.06 (\$1.94, \$2.80)	\$1.96 (\$1.96, \$2.50)
(2) Non-clinical labor cost	\$7.96 (\$4.19, \$15.98)	\$11.88 (\$5.46, \$25.74)	\$6.28 (\$3.70, \$8.49)		\$9.17 (\$6.22, \$35.33)	\$7.30 (\$4.12, \$15.87)	\$8.22 (\$3.59, \$13.59)
(3) Overhead (all other) cost ^(*)	\$10.43 (\$6.40, \$17.59)	\$12.89 (\$7.35, \$23.06)	\$8.36 (\$5.37, \$10.53)		\$16.50 (\$11.08, \$24.47)	\$9.56 (\$6.47, \$17.45)	\$7.21 (\$5.01, \$10.94)
Cost per Vaccination Excluding Vaccine Purchase (= (1)+(2)+(3))	\$20.40 (\$12.54, \$36.30)	\$26.89 (\$14.77, \$51.74)	\$16.60 (\$11.02, \$21.19)		\$27.80 (\$19.26, \$63.00)	\$18.92 (\$12.53, \$36.12)	\$17.39 (\$10.56, \$27.03)
(4) Vaccine Purchase Cost	\$8.22 (\$6.13, \$8.98)	\$7.52 (\$5.12, \$8.89)	\$8.63 (\$7.02, \$9.81)		\$6.40 (\$4.50, \$8.89)	\$8.85 (\$7.66, \$10.06)	\$5.64 (\$3.81, \$7.36)
Total Cost per Single Vaccination (= (1)+(2)+(3)+(4))	\$28.62 (\$18.67, \$45.28)	\$34.41 (\$19.89, \$60.63)	\$25.23 (\$18.04, \$31.00)		\$34.20 (\$23.76, \$71.89)	\$27.77 (\$20.19, \$46.18)	\$23.03 (\$14.37, \$34.39)

^(*) Costs of Urban/Suburban practices were discounted by 10% to adjust New York state costs to nationally representative costs

Table 3

Distribution of 6.5 Million Vaccine Doses used, Cost per Vaccination, and Total Cost in 6 Practice Settings in All U.S. Pediatric Practices During the 2006–07 Season [in Millions (M) of 2006 Dollars]

	Small Practice (24%)*	Large Practice (76%)*	Total
Urban (32%)*	0.55 million doses \$45.87 per vaccination \$25 M	1.53 million doses \$30.59 per vaccination \$47 M	2.08 million doses \$34.61 per vaccination \$72 M
Suburban (54%)*	0.65 million doses \$45.27 per vaccination \$29 M	2.86 million doses \$25.22 per vaccination \$72 M	3.51 million doses \$28.77 per vaccination \$101 M
Rural (14%)*	0.35 million doses \$24.59 per vaccination \$9 M	0.57 million doses \$19.51 per vaccination \$11 M	0.92 million doses \$21.74 per vaccination \$20 M
Total	1.55 million doses \$40.65 per vaccination \$63 M	4.96 million doses \$26.20 per vaccination \$130 M	6.51 million doses \$29.65 per vaccination \$193 M

* Proportional allocation by number of doses administered in 2006–07, according to practice size and geographic area (not number of practices).

Table 4

Total Costs and Financial Loss (VFC only) of Universal Influenza Vaccination of Children in All U.S. Pediatric Practices based on Simulations: Median (25th percentile, 75th percentile) [in Millions (M) of 2006 Dollars]

Scenario (Vaccination rate among < 19 years old; Vaccine doses provided)	Total cost: Median (25 percentile, 75 percentile)	Cost excluding vaccine purchase: Median (25 percentile, 75 percentile)	Financial Loss for VFC Vaccination Only ^(§)
2006-07 Season (20% vaccinated; 6.51M doses)	\$193 M (\$179 M, \$208 M)	\$146 M (\$134 M, \$161 M)	\$40 M (\$36 M, \$ 44 M)
Future UIV (33% vaccinated; 16.1M doses)	\$477 M (\$443 M, \$514 M)	\$361 M (\$331 M, \$398 M)	\$98 M (\$90 M, \$ 108 M)
Future UIV (66% vaccinated; 25.3M doses)	\$750 M (\$696 M, \$808 M)	\$567 M (\$521 M, \$626 M)]	\$154 M (\$141 M, \$ 170 M)
Future UIV (90% vaccinated; 34.1M doses)	\$1,011 M (\$938 M, \$1,090 M)	\$765 M (\$702 M, \$843 M)	\$208 M (\$191 M, \$ 229 M)

VFC: Vaccine For Children program; The number of doses does not increase proportional to coverage attained because of reductions in the number of children needing 2 doses;

(§) Calculated by multiplying [Cost excluding vaccine purchase (3rd column)]*[Proportion of VFC-covered vaccines]*[Proportion of financial loss]. [Proportion of VFC-covered vaccines] was assumed to be 46% ³¹ and [proportion of financial loss] was 59%(=100% - (median VFC reimbursement)/(estimated practice cost in row 4 column 1 in Table 2) = 100% - (\$8.4/\$20.4)).²⁸

Table 5

Sensitivity analyses of pediatric practices' cost per single influenza vaccination: Median (25th percentile, 75th percentile) (in 2006 Dollars)

	Range Of Parameter	Practice's Cost Per One Vaccination
Main Analysis (presented in Table 1) (n=91)		\$28.62 (\$18.67, \$45.28)
Sample without rent imputation (n=65)		\$28.04 (\$18.13, \$45.21)
Sample with no cost imputation (n=13)		\$29.44 (\$20.28, \$61.59)
One-way sensitivity analyses		
i. Vaccination time window (main analysis= 3 months)	4 months	\$25.10 (\$16.40, \$38.56)
	5 months	\$22.45 (\$14.92, \$33.64)
ii. Clinical time to implement a vaccination [minutes] (main analysis: median values of urban/suburban/rural= 3.64 / 2.7 / 3.3)	25 th percentile value	\$27.19 (\$17.89, \$43.85)
	75 th percentile value	\$29.95 (\$20.45, \$48.43)
iii. Geographic adjustment rate applied to all other (overhead) cost in urban/suburban practices in New York state to be a nationally representative cost (main analysis: 0.90)	0.95	\$29.55 (\$19.06, \$46.92)
	0.84	\$28.41 (\$18.51, \$44.77)
Multiple-way sensitivity analysis ^(*)	<ul style="list-style-type: none"> 3–5 months 25th–75th percentile values 0.84–0.95 	\$29.16 (\$26.22, \$32.87)
<ul style="list-style-type: none"> Vaccination time window Clinical time to implement a vaccination [minutes] Geographic adjustment rate applied to all other (overhead) cost 		

^(*) Based on Monte Carlo estimation (1000 iterations)