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KEY WORDS

cost analysis, provider practice, vaccine, delivery of care, universal influenza vaccination

ABBREVIATIONS

UIV—universal influenza vaccination
VFC—Vaccines for Children
NYS—New York State
FAIV—fraction attributed to influenza vaccination
FTE—full-time equivalent
AAP—American Academy of Pediatrics

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abstract

OBJECTIVES: The goals were 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 aged 6 months to 18 years.

METHODS: 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 2 practice sizes (small and large) and 3 geographic areas (urban, suburban, and rural). We adjusted these data to obtain national estimates of the total practice cost (in 2006 dollars) for providing 1 influenza vaccination to children aged 6 months to 18 years.

RESULTS: Among all respondents, the median total cost per vaccination was $28.62 (interquartile range: $18.67–45.28). The median component costs were as follows: clinical personnel labor costs, $2.01; nonclinical personnel labor costs, $7.96; 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. With the assumption of vaccine administration reimbursement for all Vaccines for Children (VFC)-eligible children at the current Medicaid median of $8.40, the financial loss across all US pediatric practices through delivery of VFC vaccines would be $98 million if one third of children received influenza vaccine.

CONCLUSION: The total cost for pediatric practices to provide influenza vaccination is high, varies according to practice characteristics, and exceeds the average VFC reimbursement. *Pediatrics* 2009;124:S499–S506

Influenza disease contributes to relatively high rates of pediatric emergency department visits, outpatient visits, and hospitalizations.[1,2] Consequently, the Advisory Committee on Immunization Practices in 2004 recommended universal influenza vaccination (UIV) for children 6 to 23 months of age[3] and in 2007 expanded that recommendation to children 6 to 59 months of age.[4] In February 2008, the Advisory Committee on Immunization Practices expanded immunization recommendations to include all children 6 months to 18 years of age, with a full implementation date of 2009–2010.

Most influenza vaccinations 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] Vaccines for Children (VFC) providers receive vaccines at no cost for eligible children (uninsured, underinsured, and Medicaid-eligible children), but they receive a vaccine administration fee only for children enrolled in Medicaid.[17]

Determining reimbursement that would cover practice costs adequately requires knowledge of all practice costs related to vaccination, including both personnel and nonpersonnel costs. Although the practice costs of adult influenza vaccination have 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 for providing influenza vaccination and to simulate the national practice costs of UIV for children 6 months to 18 years of age.

METHODS

Study Design and Analytic Approach

We used 2 strategies to estimate 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 2 practice sizes (<2 or ≥ 2 full-time–equivalent [FTE] physicians) for each of 3 geographic types (urban, suburban, and rural), because previous studies suggested that practice size and location are associated with vaccination costs[18,19] and physician practices regarding influenza vaccination practices.[20] Second, we used the NYS survey data in conjunction with secondary sources to estimate national costs per vaccination.

We calculated 4 cost components: (1) clinical personnel or labor (eg, physician or nurse) costs; (2) nonclinical labor costs; (3) overhead (all other) costs; and (4) vaccine purchase costs. To allocate a proportion of total practice costs to 1 influenza vaccination, we used 3 key factors, that is, staff time to vaccinate (from the literature),[19] total number of influenza vaccine doses obtained in 2006–2007 (from the NYS survey), and total number of health care 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 as median and 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 NYS, selecting 1 pediatrician per practice. We sent 2 separate surveys; one asked pediatricians about their vaccination practices and perceptions about UIV and the other asked office managers about detailed vaccination-related resource use. We sent up to 3 follow-up surveys and multiple telephone reminders for nonresponders and for those with incomplete responses. Ninety-one of 126 responding practices had sufficiently complete responses to be included in our analyses (urban: small, 16 of 21 practices; large, 3 of 10 practices; suburban: small, 21 of 25 practices; large, 31 of 39 practices; rural: small, 16 of 24 practices; large, 4 of 7 practices). Because of the smaller numbers of large clinics with complete responses in urban and rural areas, the accuracy of estimates for those clinics would be relatively lower, compared with those in other strata. We used the survey responses to assess the 4 components of practice costs for influenza vaccination.

Clinical Labor Costs

Clinical labor (physician and nurse) costs to counsel and to vaccinate a child were estimated by multiplying the weighted wage (per minute) for a specific job category by the clinical time (in minutes) per vaccination. The weighted wage reflected both the type of clinician who provided the vaccination and the time spent by each clinical staff member, as 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 min-

utes for urban, suburban, and rural practices, respectively. The first 2 were median values from a time-motion study of childhood influenza vaccination,[19] whereas the rural value was assumed (because it was unavailable) to be an average of urban and suburban values. Sensitivity analyses assumed that vaccination times in urban and suburban clinics ranged between 25th and 75th percentile values from the previous study and that vaccination times in rural clinics ranged between 25th and 75th percentile values for urban and suburban clinics.

Nonclinical Labor Costs

The nonclinical labor costs were calculated for tasks associated with vaccination other than clinical labor costs, including personnel costs for scheduling, billing, and running the office. As an example, we assumed that, if a practice devoted 5% of clinical labor to influenza vaccination, then 5% of nonclinical labor costs should be attributable to influenza vaccination.[22] To estimate the nonclinical labor cost 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] With the assumption that the vaccination time window was 3 months, a practice-specific FAIV was calculated as follows: FAIV = weighted number of influenza vaccination-related visits/(number of influenza vaccination-only visits + total number of health care visits in 3 months). The denominator component of health care visits excluded influenza vaccination-only visits. The weighted number of influenza vaccination-related visits was the sum of influenza vaccine doses; a dose counted as 1 if it was provided during a vaccination-only visit, and a dose was measured as the "proportion of a visit," on the basis of the proportion of visit time for influenza vaccination, if it was provided during any other type of visit. For example, the proportion of a visit was 0.33 when the time to provide 1 vaccination was 5 minutes and the practice's reported average time for a visit was 15 minutes (0.33 = 5/15).

Overhead Costs

Overhead included all nonpersonnel, non–vaccine-related items, such as rent/mortgage, utilities, nonmedical/medical supplies, insurance, and vaccine-related costs other than vaccine purchase (eg, refrigerator to store vaccines). 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 by a geographic adjustment rate (ie, 0.9) to extrapolate results to the United States, using a range of 0.84 to 0.95 in sensitivity analyses.[23,24]

Vaccine Purchase Costs

The practice-specific price per dose was calculated from survey responses and was a weighted average of $0 vaccine covered by VFC and $13 and $11 for privately purchased, single-dose and multidose vials, respectively.

Estimation of Total Costs in All Pediatric Practices Across the United States

The total costs of influenza vaccination for all US pediatric practices were calculated by using the cost estimates for the 6 practice categories. Total cost in each category was the product of the cost per vaccination and the number of vaccinations delivered. We used Monte Carlo simulation to estimate median and 25th and 75th percentile values of costs with @Risk 5.0 software (Palisade, Ithaca, NY). The simulation assumed a triangular distribution in which the mode, minimum, and maximum were the median, 25th percentile, and 75th percentile values of survey responses, respectively, with 1000 iterations per estimation.

A total of 10.8 million pediatric influenza vaccine doses were used during the 2006–2007 season.[25] We allocated total vaccine doses into the 6 categories defined earlier by estimating allocation proportions of each category on the basis of vaccine use among 6- to 23-month-old children during the 2003–2004 season, as reported in the National Immunization Survey[26] and an AAP Periodic Survey.[27] We estimated total costs for all pediatric practices during the 2006–2007 season and 3 hypothetical future seasons under UIV. We assumed the vaccination coverage rates 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 follow-up efforts by mail and telephone, 78 practices had ≥1 missing value, although most omissions were minor. In those cases, imputations were made by using the median values from practices within the same practice category.[23]

Sensitivity Analysis

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

Demographic Features

Physician and practice characteristics are shown in Table 1. The majority of practices were suburban and office-based. Many employed <2 FTE physicians. There was no statistically significant difference in characteristics across the 3 samples.

TABLE 1 Characteristics of Physician Survey Respondents

	Full Sample ($N = 91$)	Sample Without Rent Imputation ($N = 65$)[a]	Sample With No Cost Imputation ($N = 13$)[b]
Years after graduating medical school, mean (95% confidence interval)	24 (22–26)	24 (21–27)	26 (20–31)
Female, *n* (%)	41 (45)	29 (45)	5 (38)
Ethnicity, *n* (%)			
Hispanic	4 (4)	3 (5)	0 (0)
No response	3 (3)	2 (3)	0 (0)
Race, *n* (%)			
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, *n* (%)			
Urban	19 (21)	15 (23)	3 (23)
Suburban	52 (57)	35 (54)	7 (54)
Rural	20 (22)	15 (23)	3 (23)
Practice size, *n* (%)			
<2 FTE physicians	53 (58)	37 (57)	10 (77)
≥2 FTE physicians	38 (42)	28 (43)	3 (23)
Practice type, *n* (%)[d]			
Private/office-based	75 (82)	56 (86)	12 (92)
Neighborhood health center	2 (2)	0 (0)	0 (0)
Staff-model health maintenance organization 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 influenza clinic, *n* (%)	46 (51)	32 (49)	5 (38)

[a] Sample with a missing value for an item other than rent fee, where a missing value was replaced by the median value from practices within the same practice category.
[b] Sample without any missing value.
[c] For this category only, numbers of observations were 86 (full sample), 61 (no rent imputation), and 13 (no cost imputation).
[d] Marginally different ($P = .072$) between the full sample ($N = 91$) and the imputed sample ($N = 65$). All other characteristics were not statistically significant at $\alpha = .05$.

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 was $28.62 (2006 dollars), varying from $18.67 (25th percentile) to $45.28 (75th percentile) (Table 2). The median costs of components for all practices were as follows: clinical labor costs, $2.01; nonclinical labor costs, $7.96; overhead (all other) costs, $10.43; vaccine purchase costs, $8.22. With exclusion of vaccine purchase costs, the proportions of the first 3 components in the median vaccination cost of $20.40 were as follows: clinical labor costs to provide vaccination, 10%; nonclinical labor costs, 39%; overhead costs, 51%.

Variations in Practice Costs

Smaller practices tended to have higher median costs ($34.41) than did larger ones ($25.23) (Table 2). Urban practices and rural practices had the highest and lowest costs, respectively, among the 3 geographic groups. The median vaccine purchase cost reported by the practices was $8.22, varying between $6.13 (25th percentile) and $8.98 (75th percentile). These variations reflected the practice-specific patient populations, with lower costs for practices serving more VFC-covered children.

Total US Practice Costs

Table 3 reports the total cost estimates for influenza vaccination across the United States, on the basis of the

TABLE 2 Pediatric Practices' Cost per Single Influenza Vaccination

	Cost, Median (Interquartile Range), $[a]					
	All Subjects ($N = 91$)	Practice Size		Geographic Area		
		Small (≤2 Physicians) ($N = 53$)	Large (>2 Physicians) ($N = 38$)	Urban ($N = 19$)	Suburban ($N = 52$)	Rural ($N = 20$)
Clinical personnel/labor costs	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)
Nonclinical labor costs	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)
Overhead (all other) costs[b]	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)
Total cost per vaccination excluding vaccine purchase	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)
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	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)

[a] Costs are in 2006 dollars.
[b] Costs of urban/suburban practices were discounted by 10% to adjust NYS costs to nationally representative costs.

TABLE 3 Distribution of 6.5 Million Vaccine Doses Used, Cost per Vaccination, and Total Cost (2006 Dollars) in 6 Practice Settings in All US Pediatric Practices During the 2006–2007 Season

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

[a] Proportional allocation according to number of doses administered in 2006–2007, according to practice size and geographic area (not number of practices).

assumed relative share of vaccinations delivered in small or large practices and in urban, suburban, or rural practices.[25–27] Our simulation estimated median total costs per vaccination in each of 6 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 6 categories during the 2006–2007 season was $193 million.

Practice Costs Under UIV

With the assumption that 58% of child vaccine doses (not children) will be provided in pediatric practices in the future (on the basis of an average of estimates of vaccinations in the public and private sectors in the 1997–1998 and 2003–2004 seasons),[26,28,29] 16.1 million, 25.3 million, and 34.1 million doses will need to be provided in pediatric practices to achieve vaccine coverage rates of 33%, 66%, and 90% (Table 4). This assumption of 58% included children with private pediatric providers (44%) and approximately three fourths of children with mixed private/public providers (14%). The estimated total practice costs range from $477 million (33% coverage) to $1.011 billion (90% coverage), in 2006 dollars. The estimated practice costs excluding vaccine purchase range from $361 million (33% coverage) to $765 million (90% coverage).

TABLE 4 Total Costs and Financial Loss (VFC Only) (2006 Dollars) of UIV for Children in All US Pediatric Practices Based on Simulations

Scenario (Vaccination Rate Among <19-y-Old Adolescents and Vaccine Doses Provided)	Costs and Loss, Median (Interquartile Range), Million $		
	Total Cost	Cost Excluding Vaccine Purchase	Financial Loss for VFC Vaccination Only[a]
2006–2007 season (20% vaccinated; 6.51 million doses)	193 (179–208)	146 (134–161)	40 (36–44)
Future UIV			
33% vaccinated; 16.1 million doses	477 (443–514)	361 (331–398)	98 (90–108)
66% vaccinated; 25.3 million doses	750 (696–808)	567 (521–626)	154 (141–170)
90% vaccinated; 34.1 million doses	1011 (938–1090)	765 (702–843)	208 (191–229)

The number of doses does not increase in proportion to coverage attained because of reductions in the number of children needing 2 doses.

[a] Calculated as (cost excluding vaccine purchase) × (proportion of VFC-covered vaccines) × (proportion of financial loss). The proportion of VFC-covered vaccines was assumed to be 46%,[30] and the proportion of financial loss was 59% (ie, 100% − [median VFC reimbursement]/[estimated practice cost from Table 2] = 100% − [$8.4/$20.4]).[27]

The financial loss for VFC vaccination only was estimated to range from $98 million (33% coverage) to $208 million (90% coverage) (Table 4), with additional assumptions[27,30] explained in Table 4. In one of those assumptions, we assumed that providers would receive the same vaccine administration reimbursement for vaccinating all VFC-eligible children, regardless of the reason for eligibility. For around 40% uninsured/underinsured children among VFC-eligible children,[31] providers were assumed to receive out-of-pocket payment and not insurance reimbursement. These assumptions produced a conservative estimate of loss from VFC vaccination. These financial loss estimates would provide critical information for public policymakers for allocation of future resources to make up for the losses.

Sensitivity Analysis

Despite a large proportion of practices with imputed costs, imputation seemed to have little effect on the median total cost, except to reduce the interval between the 25th and 75th percentile values (Table 5). Among the 3 types of 1-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 months[25] reduced the total cost per vaccination from $28.62 to $22.45 (Table 5), because of 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 to $32.87. The different assumptions concerning clinical time to implement a vaccination and the geographic adjustment rates led to cost ranges of $27.19 to $29.95 and $29.55 to $28.41, respectively.

TABLE 5 Sensitivity Analyses of Pediatric Practices' Cost per Single Influenza Vaccination

	Range of Parameter	Practice's Cost per 1 Vaccination, Median (Interquartile Range), $[a]
Main analysis (Table 1) ($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		
Vaccination time window (main analysis: 3 mo)	4 mo	25.10 (16.40–38.56)
	5 mo	22.45 (14.92–33.64)
Clinical time to implement vaccination (main analysis: median: urban, 3.64 min; suburban, 2.7 min; rural, 3.3 min)	25th percentile value	27.19 (17.89–43.85)
	75th percentile value	29.95 (20.45–48.43)
Geographic adjustment rate applied to all other (overhead) costs in urban/suburban practices in NYS (main analysis: 0.90)	0.95	29.55 (19.06–46.92)
	0.84	28.41 (18.51–44.77)
Multiple-way sensitivity analysis[b]		
Vaccination time window	3–5 mo	29.16 (26.22–32.87)
Clinical time to implement vaccination	25th–75th percentile values	
Geographic adjustment rate applied to all other (overhead) costs	0.84–0.95	

[a] Costs are in 2006 dollars.

[b] Based on Monte Carlo estimation (1000 iterations).

DISCUSSION

Vaccination Costs

We estimated that the median cost to US pediatric practices to provide 1 influenza vaccination (excluding vaccine purchase costs), in 2006–2007, was $20.40. Practice costs varied widely, from $12.54 (25th percentile) to $36.30 (75th percentile). These variations mainly stemmed from nonclinical labor and overhead costs, which varied widely across both practice size and type of practice.

Two previous studies estimated practice costs per vaccination. One studied general childhood vaccination costs in 4 Colorado pediatric practices and noted an average of $12.56 (2006 dollars) per vaccination.[32] That group's estimated overhead cost per vaccination ($3.47 = fixed cost of $2.97 + cost of supplies of $0.51) was much lower than ours.[32] The second study focused on influenza vaccination among adults in 20 practices in 3 cities (Rochester, New York; Albuquerque, New Mexico; and San Diego, California). 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 likely are attributable to differences in patient ages, 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 were 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.[33] 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 is known to vary widely among states, ranging from a vaccine administration fee of $2.00 in Colorado to $17.86 in NYS, with a median of $8.40 among 48 states in calendar year 2005.[30] However, even the state with the highest Medicaid reimbursement for vaccine administration (NYS) fell short of covering practice costs (excluding vaccine purchase costs) at the median practice cost of $20.40 per vaccination. Besides overhead cost, the median labor cost ($9.97) was 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 of calculating practice costs. However, if practices sense that their reimbursement for pediatric influenza vaccination is lower than their actual practice costs, then 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 increasing other fees to compensate. Second, more children might be referred elsewhere for influenza vaccination,[9] which might decrease vaccination rates. Consequently, influenza-associated health expenditures among children might increase. Third, because vaccination costs seem higher in practices that serve urban or poor populations, disparities in vaccination rates and influenza-associated health outcomes might become more pronounced. Overall, expansion to UIV for all children 6 months to 18 years of age might be less successful than desired, because of financial risks for pediatric practices.

Policy and Practice Implications

Providing VFC vaccines for 46% of all US children was estimated to incur a

$98 million financial loss across all pediatric practices during 1 season with 33% coverage, $154 million with 66% coverage, and $208 million with 90% coverage. These estimates were conservative because a set of conservative assumptions was adopted; therefore, actual loss might be even greater. One policy implication of 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[34] and vaccination clinics were used by 51% of the 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 rates of attendance at scheduled visits through patient reminders, and considering vaccination in other settings, such as schools.[35,36] Our estimates of the cost per vaccination and total US costs of childhood UIV in pediatric practices might change considerably if the 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.[27] It also should be noted that we based cost estimates on self-reports, which could not be verified, and we imputed some data. We did not have data regarding the time to provide vaccinations in rural practices. To handle these uncertainties, we conducted sensitivity analyses, 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 SDs, which tend to be more sensitive to outlier values. The use of national average salaries may underestimate labor costs in suburban/urban clinics, whereas it may overestimate labor costs in rural clinics. Despite such underestimation/overestimation of labor costs, the use of national average salaries is expected to yield reasonably accurate total costs at the national level. Finally, we were unable to find detailed estimates of numbers of influenza doses used in 2006–2007 for all children and imputed vaccine doses used by apportioning doses used for children 6 to 35 months of age in earlier seasons.[26]

CONCLUSIONS

We conclude that pediatric practices' costs for influenza vaccination are higher than most states' 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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