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ARTICLE

Adolescent Immunizations: Missed Opportunities for Prevention

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What's Known on This Subject

Three new adolescent vaccines have been approved for use since 2005. To optimize the implementation of these new vaccines, a better understanding of immunization practices for established adolescent vaccines is needed.

What This Study Adds

Adolescent immunization rates for established vaccines remain well below childhood immunization rates. This study describes the frequency and types of missed opportunities for adolescent immunization and highlights the role of preventive care visits in timely immunization.

ABSTRACT

OBJECTIVES. The goals were (1) to describe immunization rates for tetanus-diphtheria, hepatitis B, and measles-mumps-rubella vaccines among 13-year-old adolescents; (2) to identify missed opportunities for tetanus-diphtheria immunization among adolescents 11 to 17 years of age; and (3) to evaluate the association between preventive care use and tetanus-diphtheria immunization.

METHODS. Adolescents born between January 1, 1986, and December 31, 1991, and enrolled in Harvard Pilgrim Health Care and Harvard Vanguard Medical Associates for ≥1 year in 1997–2004 were included. Immunization rates for tetanus-diphtheria, hepatitis B, and measles-mumps-rubella were assessed at 13 years of age. Missed opportunities for tetanus-diphtheria immunization within 14 days after a health care visit were measured. Multivariate models were used to determine predictors of timeliness of tetanus-diphtheria vaccination, particularly the use of preventive care services.

RESULTS. A total of 23 987 eligible adolescents were enrolled in Harvard Pilgrim Health Care and Harvard Vanguard Medical Associates between 1997 and 2004. Among 13-year-old adolescents in the most recent birth cohort, 84%, 74%, and 67% were up to date for tetanus-diphtheria, hepatitis B, and measles-mumps-rubella, respectively. When the analysis was limited to those with ≥1 vaccine received before 2 years of age (a proxy measure for complete records), 92%, 82%, and 85% were up to date for tetanus-diphtheria, hepatitis B, and measles-mumps-rubella, respectively. Missed opportunities for tetanus-diphtheria immunization occurred at 84% of all health care visits. Adolescents who did not seek preventive care were less likely to receive tetanus-diphtheria in a timely manner.

CONCLUSIONS. Adolescent immunization rates lag far behind childhood rates, and missed opportunities are common. Additional strategies are needed to increase the use of preventive services among adolescents and to enable providers to vaccinate adolescents at every opportunity. *Pediatrics* 2008;122:711–717

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Key Words
adolescents, immunization, missed opportunities, preventive visits

Abbreviations
Td—tetanus-diphtheria
MMR—measles-mumps-rubella
HPHC—Harvard Pilgrim Health Care
HVMA—Harvard Vanguard Medical Associates
UTD—up to date
ED—emergency department

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SINCE 2005, 3 new vaccines, to prevent invasive meningococcal disease, pertussis, and human papillomavirus, have been approved and recommended for use among adolescents in the United States. Current immunization guidelines also recommend that all adolescents be immunized against hepatitis B, measles-mumps-rubella (MMR), tetanus-diphtheria (Td), and varicella.[1] Although immunization programs have been shown clearly to provide health benefits for the population,[2,3] adolescent immunization rates have remained relatively low, especially in comparison with the high level of childhood immunization currently achieved in the United States.[4] According to national reports, only 59% and 52% of adolescents were up to date (UTD) in 2003 for hepatitis B and MMR vaccines in commercial plans and Medicaid, respectively.[5] A recent report on adolescent coverage in the United States found coverage levels of 49% for Td and >80% for hepatitis B and MMR.[6]

A frequently cited reason for low immunization rates among adolescents includes the lack of regular preventive care visits in this age group.[7,8] Other barriers reported by pediatricians and family physicians include the lack of awareness regarding the need for immunizations among adolescents, inaccurate risk assessments by parents and adolescents regarding vaccine-preventable diseases, financial barriers, and record scattering.[9,10] Missed opportunities for immunization also contribute significantly to lower immunization rates among young children and adults; however, this has not been evaluated for the adolescent population.[11–14]

We sought to understand adolescent immunization rates in a large cohort of children enrolled in a health insurance plan and seen in a large medical group practice. Our specific aims were (1) to describe immunization rates for Td, hepatitis B, and MMR vaccines among 13-year-old adolescents; (2) to identify missed opportunities for Td immunization among adolescents 11 to 17 years of age; and (3) to evaluate the association between preventive care use and Td immunization.

METHODS

Study Population

The study population consisted of adolescents who were enrolled in Harvard Pilgrim Health Care (HPHC) and who received care at Harvard Vanguard Medical Associates (HVMA) between 1997 and 2004. HPHC is the largest nonprofit health maintenance organization in New England. It currently serves >1 million members in Massachusetts, New Hampshire, and Maine in a variety of organizational settings, including medical groups, community health centers, independent physician practices, and a preferred provider network. HVMA is a large, multispecialty, private group practice consisting of 14 health centers serving ~300 000 members in the Boston metropolitan area.

Inclusion criteria for our study were adolescents 11 to 17 years of age (1) born between January 1, 1986, and December 31, 1991, and (2) enrolled in HPHC and HVMA between 1997 and 2004 (when adolescent immunization recommendations for Td, hepatitis B, and MMR were published and when all birth cohorts would be ≥13 years of age), for a ≥1-year consecutive period. Adolescents who were enrolled for multiple periods during this period were included as long as they had ≥1 enrollment period of 1-year consecutive duration between 11 and 17 years of age. Adolescents were divided into 2 birth cohorts, those born in 1986–1988 and in 1989–1991, to compare how rates might have changed over time.

Study Design

Information from HPHC databases and automated medical records from HVMA were available for use in this study as part of the Vaccine Safety Datalink Project, a collaborative project that provides comprehensive medical and immunization histories from a network of managed care organization sites in the United States. These data include (1) date of birth, (2) gender, (3) dates of enrollment, (4) dates and types of immunization during childhood and adolescence, and (5) dates and associated International Classification of Diseases, Ninth Revision, diagnoses for outpatient visits, emergency department (ED) visits, and hospitalizations. All documented immunizations were available in the electronic medical record and were included in the analysis, regardless of the dates of enrollment. Visits were classified as preventive care outpatient visits, vaccine-only outpatient visits, nonpreventive care outpatient visits, ED visits, or hospitalizations. Outpatient visits were considered preventive if they were associated with the following V codes: 20.2 (routine infant or child health check), 70.0 (routine general medical examination at a health care facility), or 70.3 (other medical examination for administrative purposes). Outpatient visits that were associated only with International Classification of Diseases, Ninth Revision, codes indicating receipt of any vaccine were classified as vaccine-only visits. All other outpatient visits were considered non–preventive care visits.

Immunization rates for adolescents at 10 and 13 years of age in each birth cohort were evaluated for Td, hepatitis B, and MMR (Fig 1). Adolescents were considered UTD if they had received 1 Td vaccine, 3 hepatitis B vaccines, and 2 MMR vaccines. We did not assess varicella vaccination status because we were unable to determine accurately whether adolescents had a history of varicella disease. Minimal intervals of 4 weeks between the first and second hepatitis B doses and 8 weeks between the second and third doses were required for the dose to be counted as a valid dose. A minimal interval of 4 weeks between MMR doses also was required.[15]

To estimate the degree to which record scattering occurs, particularly for hepatitis B and MMR vaccines, which are also routinely recommended for children before 2 years of age, we compared immunization rates of those who were documented to have received ≥1 childhood vaccine before the age of 2 years (a proxy measure for complete records) and those who did not have any record at HVMA of receiving childhood vaccines before 2 years of age (a proxy measure for incomplete records). We constructed this proxy measure for our study because of our concern over the potential impact of incomplete immunization records.

Missed opportunities for Td immunization were considered in this study by determining whether the vaccine was indicated and administered during any health care encounter occurring in adolescence (Fig 1). To do this, we assessed whether an adolescent 11 to 17 years of age was eligible for Td vaccine at the time of a health care visit. If an adolescent was eligible and the Td vaccine was not administered within a 14-day time period from the time of the health care visit, then we considered it to be a missed opportunity. We chose a 14-day window in case some adolescents who had concurrent illnesses were advised by their health care provider to return to the clinic at a later date for immunizations. We focused our analysis of missed opportunities on the Td vaccine alone because it was the only non–catch-up adolescent vaccine recommended during the study period (because it is not recommended until age 11–12 and is not given to young children).

Our primary outcome measures included immunization rates at 13 years of age for 1 dose of Td, 3 doses of hepatitis B, and 2 doses of MMR. We also chose to

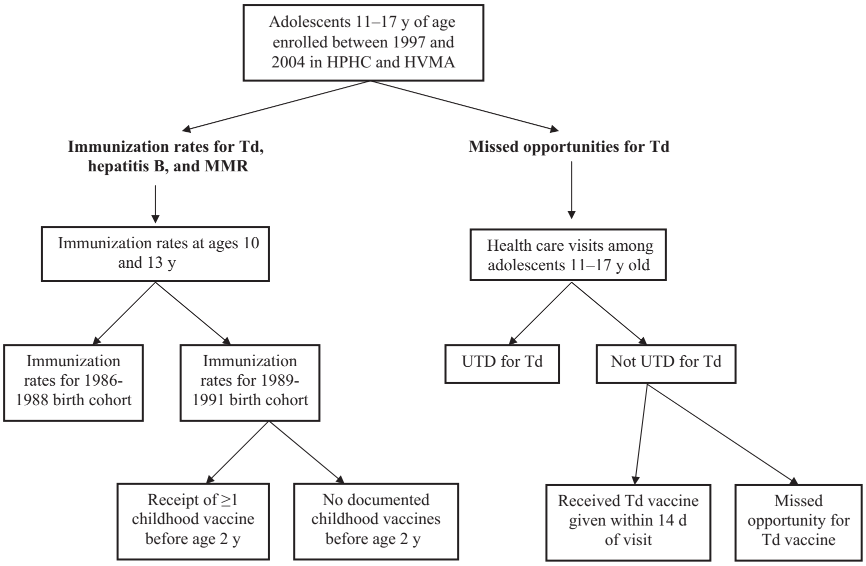

FIGURE 1
Study design and outcomes.

examine immunization rates at 10 years of age to understand the proportion of 11- to 12-year-old adolescents who received vaccines at their recommended young adolescent visit. The 11- to 12-year-old well-child visit has been the primary immunization platform promulgated by the Advisory Committee on Immunization Practices in the past.[16] We measured the rate of missed opportunities for Td immunization during the eligible adolescent's period of enrollment with the health plan. Secondary outcome measures included UTD immunization rates for the subset of adolescents with a record of receipt of vaccines before the age of 2 years.

Data Analysis

We calculated the proportion of adolescents in each birth cohort who received the full recommended series of immunizations for Td, hepatitis B, and MMR at 10 and 13 years of age. We also calculated UTD immunization rates for 13-year-old adolescents with and without documented childhood vaccines. Missed opportunities were calculated as the proportion of health care visits that did not result in Td immunization for adolescents who had not yet received the Td vaccine. To assess the timeliness of Td immunization among adolescents, we used survival analysis techniques. Vaccination uptake over time was estimated as the complement of the Kaplan-Meier survival function ($1 - S_{KM}$) with age in years on the time scale, where $1 - S_{KM}(t)$ is the cumulative probability of being vaccinated by age t.[17,18] Data were censored at the time of receipt of Td vaccine or at the end of the final enrollment period. Cox regression analysis was performed to calculate proportional hazard ratios for timely Td immunization in bivariate and multivariate models for the following predictors: gender, birth cohort (1986–1988 vs 1989–1991), presence of documented childhood immunizations at ≤2 years of age, and preventive care use. P values of $<.05$ were considered statistically significant. All analyses were performed with Stata 9.0 (Stata, College Station, TX).

RESULTS

Study Population

There were 23 987 eligible adolescents enrolled in HPHC and HVMA for a consecutive ≥1-year period between 1997 and 2004, for a total of 83 955 person-years of follow-up time during the study period (Table 1). The average duration of enrollment per eligible adolescent was 3.5 years (range: 1–7 years). Eighty-eight percent of adolescents had a single enrollment period of ≥1-year duration. The remaining 12% of adolescents were enrolled in a health insurance plan (HPHC) multiple times between 1997 and 2004. In this adolescent population, there were a total of 362 970 visits, including 1722 hospitalizations (0.5%), 13 171 ED visits (3.6%), and 348 077 outpatient visits (95.9%), from 1997 to 2004. Of outpatient visits, 77% were for non–preventive care, 18% were for preventive care, and 5% were considered vaccine-only visits.

Immunization Rates

According to the record review, 3%, 20%, and 28% of children had received the full series of Td, hepatitis B,

TABLE 1 **Characteristics of the Study Population (N = 23 987)**

Characteristics	
Age, mean (range), y	13.3 (11–17)
Female, *n* (%)	11 776 (49)
Duration of enrollment, mean (range), y	3.5 (1–7)
No. of enrollment periods per person, *n* (%)	
1	23 987 (88)
2	2769 (10)
≥3	534 (2)
Birth cohort, *n* (%)	
1986–1988	13 450 (56)
1989–1991	10 537 (44)
≥1 documented childhood vaccination by 2 y of age, *n* (%)	8274 (34)

TABLE 2 **Immunization Rates for Td, Hepatitis B, and MMR at 10 and 13 Years of Age According to Birth Cohort ($N = 23\,987$)**

Vaccine	n (%)			
	Birth Cohort of 1986–1988 ($N = 13\,450$)		Birth Cohort of 1989–1991 ($N = 10\,537$)	
	Age 10 y[a]	Age 13 y[b]	Age 10 y[a]	Age 13 y[b]
Td	464 (3)	8449 (63)[c]	364 (3)	8899 (84)[d]
Hepatitis B				
1 dose	2115 (16)[e]	10 735 (80)[c]	4987 (47)[f]	9212 (87)[d]
2 doses	1606 (12)[e]	9889 (74)[c]	4548 (43)[f]	8865 (84)[d]
3 doses	956 (7)[e]	8187 (61)[c]	3862 (37)[f]	7844 (74)[d]
MMR				
1 dose	3418 (25)[e]	11 182 (83)[c]	8399 (80)[f]	9489 (90)[d]
2 doses	191 (1)[e]	748 (6)[c]	6639 (63)[f]	7044 (67)[d]

[a] $P < .001$ for e vs f.
[b] $P < .001$ for c vs d.

and MMR vaccines, respectively, by 10 years of age, compared with 72%, 67%, and 32% by 13 years of age. Immunization rates were also examined according to birth cohort (Table 2). By 10 years of age, 3%, 37%, and 63% of children were UTD for Td, hepatitis B, and MMR, respectively, in the 1989–1991 birth cohort. By 13 years of age, 84% of adolescents were UTD for Td, 74% for hepatitis B, and 67% for MMR. In comparison, UTD immunization rates for the 1986–1988 birth cohort were significantly lower for all vaccines at both 10 and 13 years of age.

To determine the impact of record scattering on immunization rates for adolescents, we compared immunization rates for adolescents in the most recent birth cohort who also had ≥1 documented immunization (proxy for complete records) received before 2 years of age ($N = 8026$) and adolescents without documented immunizations (proxy for incomplete records) before 2 years of age ($N = 2511$). We found that UTD immunization rates by 13 years of age in this subset were significantly higher for all vaccines among adolescents with documentation, compared with those without (Td: 92% vs 59%; hepatitis B: 82% vs 49%; MMR: 85% vs 7%; $P < .001$ for each vaccine). Because MMR rates were so low for those without documentation of childhood vaccines, we also examined the age of receipt of the first MMR dose, and we found that the mean age for those without documentation was 10.2 years (median: 10.9 years), compared with a mean age of 2.5 years (median: 1.3 years) for those with documentation.

Missed Opportunities for Td Immunization

We examined the potential for missed opportunities for Td immunization at any time during enrollment in the health plan. We found that children were eligible for Td vaccination at 29% of all health care visits (Table 3). Adolescents were most likely to receive the vaccine at a preventive care outpatient visit (53%) and least likely to receive it at the time of hospitalization (2%). Therefore, there were 87 046 missed opportunities (84%) for Td immunization in this adolescent population, most associated with nonpreventive visits.

When we calculated the number of missed opportunities per adolescent, we found that there were 18 011 adolescents (75%) who had contact with the health care system and were eligible for vaccination at the time of the health care visit. Among those adolescents, a mean of 4.8 missed opportunities per adolescent occurred (median: 3 missed opportunities per adolescent; 25th to 75th percentile range: 1–6 missed opportunities per adolescent; data not shown).

Predictors of Timely Td Immunization

Figure 2 shows the timeliness of Td immunization according to the use of preventive care. Adolescents who used preventive care services were significantly more likely to be UTD for Td, in a timely manner, compared with those who did not use preventive care services ($P < .001$). In bivariate models, we found that the most recent birth cohort (1989–1991) and the presence of documented childhood immunizations before 2 years of age were both significant predictors of timely Td immunization (Table 4). Multivariate regression models included gender, birth cohort, presence of documented childhood immunizations, and no preventive care use. We also included an interaction term between the latter 2 variables, to examine the possible association between lack of preventive service use and absence of documented childhood immunizations. In this multivariate adjusted model, adolescents who did not use preventive care remained significantly less likely to receive Td in a timely manner, independent of the association between no preventive care use and the presence of documented childhood immunizations at ≤2 years of age (Table 4).

TABLE 3 **Eligibility Status and Missed Opportunities for Td Immunization at Health Care Visits**

	No. of Visits	n (%)		
		Eligible for Td at Time of Visit	Received Td	Missed Opportunities for Td
Hospitalizations	1722	449 (26)	10 (2)	439 (98)
ED visits	13 171	3560 (27)	193 (5)	3367 (95)
Preventive outpatient visits	61 066	22 299 (37)	11 745 (53)	10 554 (47)
Vaccine-only outpatient visits	17 794	7404 (42)	2123 (29)	5281 (71)
Nonpreventive outpatient visits	269 217	70 027 (26)	2622 (4)	67 405 (96)
Total visits	362 970	103 739 (29)	16 693 (16)	87 046 (84)

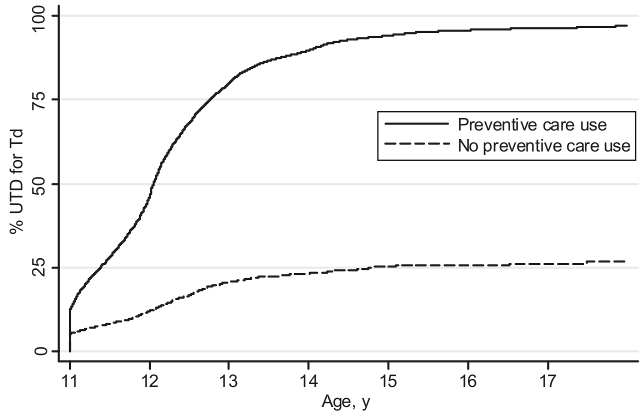

FIGURE 2
Time to Td immunization according to utilization of preventive care services.

DISCUSSION

We found that adolescents were most likely to be UTD for Td (84%) and hepatitis B (74%) at 13 years of age in the most recent birth cohort. Immunization rates for 2 doses of MMR (67%) seemed to be much lower than expected, especially because most children in our study population lived in Massachusetts and were subject to school entry laws, which have required ≥2 doses of measles-containing vaccine since 2001.[19,20] We were unable to assess varicella immunization rates accurately, because of lack of information about the natural disease history in this population. Compared with a recent report of adolescent vaccination coverage rates in the United States, our Td coverage rate at 13 years of age was much higher than national estimates of 48.3% for Td or tetanus toxoid-reduced diphtheria toxoid-acellular pertussis.[6] Conversely, our hepatitis B and MMR coverage rates at 13 years of age were lower than recent national estimates of 88.6% and 87.0%, respectively.

Although the methods for our study and the national study were different, incomplete documentation of childhood vaccines likely contributed to lower observed rates in our study population, particularly for vaccines such as MMR and hepatitis B, which are routinely recommended for young children, with an opportunity for catch-up vaccination during adolescence. However, our vaccination rates at 13 years of age did significantly increase over the time period. Among adolescents with available childhood vaccination records before 2 years of age, whom we presume to be those with the most-complete records, UTD immunization rates were significantly higher for 3 doses of hepatitis B (82% vs 49%) and 2 doses of MMR (85% vs 7%). We also found that the mean age of receipt of the first MMR dose was 10.2 years for adolescents without complete records, compared with 2.5 years for those with childhood vaccination records.

Our immunization rates were notably lower than those reported by the Massachusetts Department of Public Health, in which 90% and 99% of seventh-graders were UTD for the hepatitis B and MMR series in 2004–2005.[21] The higher immunization rates reported by the Massachusetts Department of Public Health are likely to be more accurate, especially because Massachusetts has longstanding school immunization requirements for Td, hepatitis B, and MMR.[22] The difference in reported immunization rates between our study population and the Massachusetts Department of Public Health again highlight the problem of record scattering in the adolescent population, because this group may be receiving vaccines from different types of providers over time, including school-based health centers.[10] Our findings underscore the need for providers to assess accurately the UTD status of all adolescents, especially for vaccines that are also given in early childhood. Furthermore, the extremely high immunization rates seen among adolescents enrolled in middle school in Massachusetts emphasize the importance of school immunization laws in boosting immunization coverage among adolescents.[20,23]

Our study is one of the first to examine explicitly the association between preventive care use and immunization rates in the adolescent population. Importantly, preventive care service use was a significant independent predictor of timely Td immunization. Unfortunately, our adolescent population was less likely to interact with the health care system through preventive care visits, similar to findings reported previously,[8,9,24–26] because such visits accounted for only 18% of all outpatient visits made by adolescents. Because the overall rate of preventive care visits was low in the population, we also examined the importance of missed opportunities for immunization.

Although the vast majority of missed opportunities occurred during nonpreventive visits, it is notable that many adolescents also were not immunized during preventive care visits, as part of their routine care. A commonly cited barrier to vaccination during outpatient visits is lack of complete immunization records.[27] However, we think that providers should consider using any opportunity that occurs during an outpatient visit to assess the immunization status of adolescents and either take the opportunity to obtain complete records or vaccinate the adolescent at that outpatient visit. Although missed opportunities were also found to occur during ED visits and hospitalizations for adolescents, these encounters may not represent the ideal time to immunize, because of the reasons for these high-acuity

TABLE 4 **Bivariate and Multivariate Cox Regression Analyses for Timely Td Immunization**

	Bivariate		Multivariate	
	Hazard Ratio (95% CI)	*P*	Hazard Ratio (95% CI)	*P*
Male	1.0 (0.97–1.03)	.90	0.98 (0.95–1.01)	.14
Birth cohort (1989–1991)	2.00 (1.94–2.05)	<.001	1.38 (1.31–1.45)	<.001
Documented childhood immunizations	2.81 (2.73–2.90)	<.001	1.94 (1.84–2.04)	<.001
No preventive care use	0.12 (0.11–0.13)	<.001	0.09 (0.08–0.10)	<.001
Documented childhood immunizations × no preventive care use			2.70 (2.29–3.20)	<.001

CI indicates confidence interval.

visits and the lack of access to immunization records at these sites.[28]

Potential areas of improvement for adolescent immunization are evident. First, adolescents and their parents should be encouraged to seek preventive care services at least once per year.[29] This approach would improve access not only to all adolescent vaccines but also to other needed preventive health interventions. Second, health care providers for adolescents may need to refocus their approach toward immunizing adolescents when the opportunity arises, such as during nonpreventive visits. Identifying these visits as opportunities for vaccination would improve care for this difficult-to-reach population, particularly because 3 new adolescent vaccines are now available.

A third approach to optimizing immunization rates in adolescents is to consider working with schools to deliver these vaccines. School entry requirements and school-based vaccination programs are among the few interventions shown to increase consistently the use of these vaccines. Middle school immunization laws have been demonstrated to be effective in increasing both MMR and hepatitis B immunization rates.[20,23] School-based vaccination programs were shown previously to improve immunization rates for children, and high immunization rates are likely to be achieved with this approach.[30,31] However, some physicians argue that school-based immunization programs may limit opportunities for health care providers to provide counseling or treatment for other adolescent health care needs.[10] Also, school-based programs may not be universally feasible because of issues pertaining to availability of resources, financing of vaccines, and obtaining consent.[7,32] Furthermore, the use of school-based immunization programs may complicate the issue of record scattering among adolescents, unless information systems such as immunization registries are in place and accessible to multiple providers.[33]

The major limitation of this study is that we might not have had complete immunization records for all adolescents. We believe this is the case for our population because, when we compared our overall immunization rates with the rates for adolescents who had documented childhood immunizations, we found significant discrepancies. Among adolescents with incomplete documentation of childhood vaccines, none seemed to have received the first dose of MMR vaccine as a young child, which is unlikely because nearly all children in the United States receive their first dose at 1 year of age. Another limitation is that our study population included only adolescents enrolled in a health insurance plan from the Northeast, thus limiting generalizability to the US population. Furthermore, the majority of the study population resided in Massachusetts, where middle school entry requirements for immunization might have resulted in higher immunization rates among adolescents, compared with the rest of the United States. Finally, breaks in health insurance plan coverage might have resulted in incomplete documentation of vaccines given during adolescence and higher estimates for rates of missed opportunities to receive Td vaccine.

CONCLUSIONS

Our findings suggest that there is room for significant improvement in providing and documenting immunizations given to adolescents, as well as tracking immunizations from childhood into adolescence. Furthermore, the use of preventive care services is associated with timely immunization among insured adolescents. Clearly, additional strategies are needed to increase the use of preventive services among adolescents and to enable providers to vaccinate adolescents at every opportunity.

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THE CORPORATE FREE RIDE

"Here is a crazy idea to address the United States' gaping fiscal deficit: persuade corporate America to start paying taxes. An investigation by the Government Accountability Office found that almost two-thirds of companies in the United States usually pay no corporate income taxes. Big companies, those with more than $50 million in sales or $250 million in assets, are less likely to avoid Uncle Sam altogether. Still, about a quarter of them report no tax liability either. The GAO, which looked at tax returns from 1998 through 2005, does not tell us exactly how so many corporations managed to avoid the taxman. It simply notes that they were able to record sufficient expenses—salaries, interest and 'other deductions'—to cancel out their taxable income. We find it hard to believe that some two-thirds of American companies fail to turn a profit. What we find easier to believe is that corporations have become increasingly skilled at tax-avoidance strategies, including transfer pricing—overcharging their American units for products and services provided by subsidiaries abroad to artificially reduce their profits here."

Editorial. *New York Times*. August 18, 2008
Noted by JFL, MD

Adolescent Immunizations: Missed Opportunities for Prevention

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