The Impact of the Medicaid Reimbursement Bump on Influenza Vaccination Rates Among US Teens: Evidence from the National Immunization Survey–Teen 2011–2020

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Background: **Many adolescents do not receive basic preventive care such as influenza vaccinations. The Affordable Care Act (ACA) temporarily increased Medicaid reimbursements for primary care services, including vaccine administration, in 2013 to 2014. The objective of this study is to assess the impact of reimbursement increases on influenza vaccination rates among adolescents with Medicaid.**

Methods: **This repeated cross-sectional study used a difference-in-difference approach to compare changes in annual influenza vaccination rates for 20,884 adolescents 13 to 17 years old covered by Medicaid with adequate provider-reported data in 18 states with larger extended (>$5, 2013 to 2019) versus larger temporary (2013 to 2014 only) versus smaller reimbursement changes. We used linear probability models with individual-level random effects, adjusting for state and individual characteristics and annual time trends to assess the impact of a Medicaid vaccine administration reimbursement increase on annual influenza vaccination.**

Results: **Mean Medicaid reimbursements for vaccine administration doubled from 2011 to 2013 to 2014 (eg, from $11 to $22 for CPT 90460). States with smaller reimbursement changes had higher mean reimbursements and higher adjusted vaccination rates at baseline (2011) compared with states with larger temporary and extended reimbursement changes. The reimbursement change was not associated with increases in influenza vaccination rates.**

Discussion: **Influenza vaccination rates were low among adolescents with Medicaid throughout the study period, particularly in states with lower Medicaid reimbursement levels before the ACA.**

Conclusion: **That reimbursement increases were not associated with higher vaccination rates suggests additional efforts are needed to improve influenza vaccination rates in this population. (J Am Board Fam Med 2024;37:137–146.)**

Keywords: **Affordable Care Act, Adolescent, Cross-Sectional Studies, Health Policy, Immunization, Influenza, Medicaid**

Introduction

Since 2010 yearly influenza vaccination has been recommended by the Centers for Disease Control and Prevention for all persons ≥ 6 months of age.[1] Influenza epidemics place both children and adolescents with high-risk conditions at risk for serious illness and death, and contribute to missed school.[2] Rates of influenza vaccination among children have remained suboptimal, with 58% of children ages 6 to 17 years old receiving the influenza vaccine in the 2017 to 2018 season, and even lower rates among adolescents age 13 to 17 (47% in 2017 to 2018).[3,4]

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Many factors contribute to low rates of influenza vaccination among adolescents, including missed opportunities, lack of proper vaccination records, and vaccine hesitancy.[5–8] In some states, the cost of vaccines to providers, including both the cost of purchasing vaccines and administering them relative to reimbursement discourage vaccine delivery.[9]

Vaccine purchase in the public sector occurs through the Vaccine for Children (VFC) Program, Section 317 of state grants and state discretionary funds.[10] The federal VFC Program provides vaccines at no cost for vaccine providers of eligible children, including those insured through Medicaid.[11] Medicaid reimbursements for vaccine administration varies widely by state, but are often lower than those of Medicare or private payers.[12] Many private providers perceive reimbursements for vaccine purchase and administration as inadequate.[13,14] Some providers reported considering dropping patients or ceasing to vaccinate members with certain insurance types.[13,15] Prior studies have found that vaccine administration costs to practices often exceed reimbursement by payers,[16] and that vaccine administration reimbursement levels are positively associated with receipt of immunization services for children.[12,17]

To address concerns that low reimbursements in Medicaid could limit access to care for enrollees, the Affordable Care Act (ACA) increased Medicaid reimbursements for primary care providers in 2013 to 2014, including vaccine administration reimbursements. This included vaccines administered through the VFC. The ACA left at the states' discretion whether to increase Medicaid vaccine administration reimbursements to the level of the Medicare or to the VFC regional maximum reimbursement.[18] After 2014, some states chose to maintain the reimbursement bump.

Studies examining the impact of the overall ACA Medicaid reimbursement bump have focused on its impact on provider participation in Medicaid and primary care visits. One study found that pediatricians reported increased Medicaid participation with the reimbursement bump, whereas another study of primary care physicians found no significant changes.[19,20] Findings with respect to utilization have largely been null, with the exception of changes in appointment availability.[21–23] Few studies have examined the effects of this policy in pediatric populations, and none have examined changes in vaccination rates.

We examine associations between the magnitude and duration of the Medicaid reimbursement increase for vaccine administration with the ACA and changes in influenza vaccination rates among adolescents aged 13 to 17 years old.

Methods

Study Sample and Population

We used a difference-in-difference design and public-use data from the 2011 to 2020 National Immunization Survey (NIS-Teen). The NIS-Teen is an annual, two-phase national survey of adolescents 13 to 17 years old; the first phase is a telephone interview survey administered to parents/guardians, and the second is a provider questionnaire to obtain immunization history. Vaccine coverage is estimated based on provider-reported information. Details of the NIS-Teen methodology have been described elsewhere.[3,24,25]

Because our primary outcome was administration of influenza vaccination, adolescents with inadequate vaccine provider data (1,702 of 22,586 participants) were excluded. Among these participants, the sample was further limited to participants living in the 18 states with reliable data on vaccine administration reimbursements described below. In 2014 the definition of having adequate provider data in the NIS-Teen changed, which slightly decreased vaccination coverage estimates.[26] We adjusted the definition of adequate provider data for 2011 to 2013 to match the new 2014 definition, though the difference in sample size between old and new definitions was minimal (see Explanation S1). This study was approved by the Mass General Brigham Institutional Review Board.

Vaccine Administration Reimbursement Measures

We obtained Medicare and Medicaid fee-for-service reimbursements in each year of the study for Current Procedural Terminology (CPT) codes 90460 (immunization administration for the first or only component of each vaccine administered, with counseling by physician or other qualified health care professional) and 90471 (immunization administration of any vaccine without counseling).

We obtained Medicaid reimbursement values for each year from 2011 to 2019 using multiple data sources. For 2011 to 2012, we calculated the modal reimbursement value for CPT code 90460 and 90471 for each state from Medicaid Analytic eXtract (MAX) Other Services File by state, similar to prior studies.[12,27] To improve the reliability of these estimates, we excluded 32 states with fewer than 1000 fee-for-service claims per year. As

expected, states included in the analysis had lower mean Medicaid managed care penetration rates (eg, 53% (range 0.5% to 87%) in 2011) compared with states excluded from the analysis (eg, 61% (range 4% to 97%) in 2011). Data on 2013 to 2014 reimbursements, whether a state chose to reimburse for vaccine administration at the VFC regional maximum or the Medicare reimbursement level, came from each state's Medicaid State Plan Amendment (SPA), attachment 4.19-B (see Appendix Table 2).[28] For the period after the mandatory reimbursement bump, 2015 to 2019, we obtained reimbursements from state Medicaid reimbursement schedules. Data in the prepolicy period from claims and Medicaid reimbursement schedules were consistent.

The resulting sample included 18 states: Colorado, Connecticut, Iowa, Idaho, Massachusetts, Michigan, Minnesota, Missouri, Mississippi, Montana, New Hampshire, New Mexico, Nevada, Oklahoma, South Carolina, Texas, Vermont, and Wyoming (see Appendix Figure 1 for map). Characteristics of respondents with Medicaid and influenza vaccination rates in states included in the analysis are comparable to individuals in excluded states (see Appendix Table 3).

Outcome

We obtained seasonal influenza vaccine administration information from vaccine provider-reported immunization history, which asked separate questions about any influenza vaccine administration in the past 3 years. Thus, survey participants could have potentially contributed up to 3 years of outcome data. We considered influenza vaccine up-to-date for each year's peak influenza season if the adolescent received at least one influenza shot between September 1 of each year in question and January 31 of the following year (ie, Adolescents who received at least one influenza vaccination between September 1, 2011, and January 31, 2012, were considered up-to-date for calendar year 2011). Hence, the outcome is observed in years 2011 to 2019 only, though we pooled NIS-Teen data from 2011 to 2020.

Statistical Analysis

To assess the association between changes in Medicaid reimbursements and changes in influenza vaccination rates before and after the ACA reimbursement bump occurred, we used a state-level difference-in-difference approach to compare vaccination rates for adolescents living in states with larger reimbursement increases between 2012 to 2013 (≥ $5) versus smaller reimbursement increases (<$5), we further stratified states with larger increases by the duration of the reimbursement increase. Specifically, we identified states with smaller reimbursement increases for both vaccine administration CPT codes (n = 2); states with larger temporary reimbursement increases in 2013 to 2014 only for at least one code (n = 11); and states with larger extended reimbursement increases for both codes through at least 2019 (n = 5) (Appendix Table 4 and Appendix Table 5). We chose the $5 cut off based on the distribution of the changes in reimbursements (Appendix Table 4). States with a change in reimbursements of < $5 had a change of 25% or less in reimbursements, compared with the average reimbursement change of 104% in the remaining states.

We used linear probability models with an interaction term between state group and time period (during the reimbursement bump (2013 to 2014) and after the mandated reimbursement bump (2015 to 2019) versus before the reimbursement bump (2011 to 2012)), adjusting for 2 annually updated state Medicaid characteristics, the Medicaid managed care penetration rate for children[29] and whether the state expanded Medicaid to low-income adults. We included a random person effect to account for any intraperson correlation across years. These models also adjusted for the following participant characteristics: age, sex, race (non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic Other), number of doctor visits in the previous year (none, 1, 2+), vaccination facility type (all public, all hospital, all private, all STD/School clinic/Teen clinic/other type, mixed type), household poverty status (above, below poverty), mother's age (≤ 34, 35 to 44, ≥45), and mother's marital status (married, not married). All analyses were weighted to account for the complex sampling design of the NIS-Teen and performed using Stata version 16.1 (StataCorp, College Station, Texas). All p-values were two-sided and $P < .05$ was considered statistically significant.

In sensitivity analyses, we classified states based on changes in reimbursements for each of the CPT codes separately. We also conducted sensitivity analyses in which we dropped 2012 from the analysis, because vaccinations received after the reimbursement bump increase between January 1st to January 31st, 2013 are included in 2012 rates.

Lastly, we also assessed the direct association between vaccination administration reimbursement levels and influenza vaccination rates in each year using multivariable mixed-effects linear probability models adjusted for the covariates above and state fixed effects.

Results

The study sample included 1641 adolescents in 2011; 35% of participants were White, 60% had household incomes below poverty, and 34% received their vaccines in all private facilities (see Table 1). NIS-Teen Medicaid beneficiaries in 2019 (n = 2121) had similar baseline characteristics to 2011 participants.

Medicaid Vaccine Administration Reimbursements

The overall unadjusted mean reimbursement for CPT 90460 increased from $10.64 in 2012 to $21.70 in 2013 and 2014, then decreased to $13.40 in 2015 and leveled off at $13.53 by 2019. Mean reimbursements for CPT 90471 followed a similar trend. There was, however, substantial state variation in Medicaid vaccination reimbursements from 2011 to 2019, for example, a range of $6.00 to $21.00 in 2011 for CPT 90460 (Appendix Figure 2). Mean Medicaid-to-Medicare reimbursement ratios for CPT 90460 increased from 0.46 in 2012 to 0.91 in 2014 (Appendix Figure 3).

For states classified as having smaller reimbursement changes, average reimbursements changed from $19.59 in 2011 to $21.27 in 2013 and leveled off at $19.22 in 2019; for states with larger-extended reimbursement changes, average reimbursements changed from $10.26 in 2011 to $20.70 in 2013 and $20.02 in 2019; and for states with larger-temporary reimbursement changes, average reimbursements changed from $10.50 in 2011 to $22.12 in 2013 and $10.17 in 2015 for CPT code 90460 (Figure 1 and Appendix Figure 4). Medicaid reimbursements leveled in 2015 through 2019. There was significant variation in vaccine reimbursement reimbursements by state during the study period (Appendix Figure 5).

Influenza Vaccination Rates

The overall percentage of participants who received annual influenza vaccinations slightly increased over time, from 19% (95% CI: 17%, 22%) in 2011% to 21% (95% CI: 19%, 23%) in 2015% and 26% in 2019 (95% CI: 23%, 30%) (Appendix Figure 6). Unadjusted differences in mean influenza vaccination rates across the state groups were similar in 2011, before the reimbursement bump (Figure 2 and Appendix Figure 7).

Medicaid Reimbursement Bump and Influenza Vaccination Rates

After adjusting for adolescent and state characteristics, states with larger extended reimbursement changes had significantly lower vaccination rates before the reimbursement change (2011 to 2012) compared with states with smaller reimbursement increases (−6.7 percentage points, 95% CI: −12.5, −0.8). However, changes in influenza vaccination rates in states with larger temporary or extended reimbursement changes for vaccine administration in 2013 to 2014 and 2015 to 2019 versus 2011 to 2012 were not significantly different from changes in states with smaller reimbursement increases (eg, 2.9 (95% CI −4.2, 10.0) in 2015 to 2019 versus 2011 to 2012 in states with larger extended versus smaller reimbursement changes) (see Table 2).

In these models, vaccination rates were significantly lower among adolescents who were older, had mothers who were unmarried (versus married), received their vaccinations in public versus private facilities, and lived in states with higher managed care penetration rates; vaccination rates were higher among adolescents of Hispanic or Other race/ethnicity versus White, with a 1 or 2+ doctors visits (versus none) in the prior year, and lived in states that expanded Medicaid to low-income adults (Appendix Table 6).

In sensitivity analyses examining reimbursement increases for each CPT code (Appendix Table 7) and excluding 2012 (Appendix Table 8) were consistent with the main analyses. Similarly, we found no significant association between Medicaid vaccination administration reimbursement levels and probability of receiving an influenza vaccination (eg, 0.1 percentage points, 95% CI −0.1, 0.3 for CPT 90460, Appendix Table 9).

Discussion

Our study showed wide variation across states in vaccine administration reimbursements at baseline. With the advent of the ACA, states with lower baseline reimbursements experienced larger reimbursement increases in 2013 to 2014 as the ACA attempted to increase Medicaid reimbursement

Table 1. Characteristics of Adolescents with Medicaid Coverage in 2011 and 2019—National Immunization Survey–Teen

Year N	2011 1,641 N (weighted %)	2019 2,121 N (weighted %)
Age		
13	391 (24.9)	482 (22.1)
14	335 (17.0)	464 (22.2)
15	339 (23.9)	430 (21.1)
16	320 (19.3)	413 (18.8)
17	256 (14.8)	332 (15.9)
Sex		
Male	796 (49.3)	1,124 (52.0)
Female	845 (50.7)	997 (48.0)
Race		
White, non-Hispanic	653 (34.9)	962 (37.3)
Black, non-Hispanic	291 (24.6)	182 (18.2)
Hispanic	536 (30.7)	767 (37.0)
Other, non-Hispanic	161 (9.8)	210 (7.6)
Poverty status		
Above poverty	701 (35.3)	1,119 (48.8)
Below poverty	873 (60.2)	897 (43.4)
Missing	67 (4.5)	105 (7.8)
Mother's age		
≤34	295 (22.5)	299 (15.9)
35 to 44	809 (51.6)	1,136 (54.8)
≥45	537 (25.9)	686 (29.3)
Mother's marital status		
Married	809 (40.0)	970 (38.7)
Not married	832 (60.0)	1,151 (61.3)
Number of visits to doctors in a previous year[a]		
None	233 (15.4)	259 (13.9)
1	375 (23.3)	499 (25.9)
2+	1,012 (61.3)	1,332 (60.1)
Vaccination providers facility type		
Private	563 (34.0)	801 (41.7)
Public	425 (27.6)	446 (20.9)
Hospital	130 (7.6)	260 (10.2)
STD/School/Teen clinic/other	59 (3.8)	42 (2.4)
Mixed	330 (18.8)	434 (16.5)
Missing	134 (8.2)	138 (8.3)
Medicaid Expansion status		
Not expanded	NA	1,162 (60.0)
Expanded	NA	959 (40.0)
Mean state Medicaid managed care penetration rate (SD)	53.0% (33.3%)	71.4% (38.8%)

Notes. [a]Sum does not equal sample size because of missing (n = 1,620 for 2011, n = 2,090 for 2019).
Abbreviation: SD, standard deviation.

across states at least temporarily. The ACA reimbursement bump was associated with substantial increases in reimbursements on average, but variation remained across states and mean Medicaid reimbursements remained below the Medicare rate in 2013 to 2014 because most states opted to use the VFC maximum rate instead of the Medicare rate.

Influenza vaccination rates also varied substantially across states and but were low throughout the

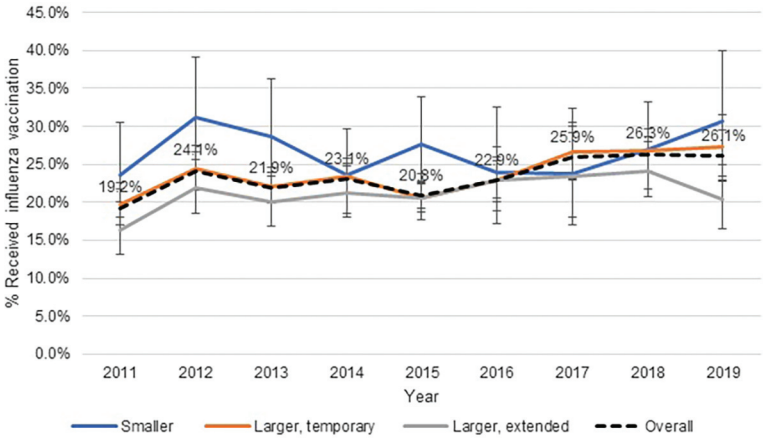
Figure 1. Medicaid vaccination administration reimbursements by reimbursement size change and return to baseline reimbursement for Medicaid insured participants.[a] *Abbreviation:* CPT, current procedural terminology.

Notes: [a]A smaller reimbursement increase was defined as a change in 2012-2013 vaccine reimbursement < $5; larger reimbursement increase was defined as ≥ $5. In addition, we identified states with smaller reimbursement increases for both vaccine administration CPT codes (N = 2) (blue line); states with larger temporary reimbursement increases in 2013-2014 only for at least one code (N = 11) (orange line); and states with larger extended reimbursement increases for both codes through at least 2019 (N = 5) (gray line). Top panel: vaccine administration with counseling, CPT 90460; bottom panel: vaccine administration without counseling, CPT 90471.

study period. At baseline, adjusted vaccination rates were lower among adolescents in states that implemented larger extended reimbursement increases in vaccine administration reimbursements. However, neither the temporary nor extended reimbursement changes appeared to be associated with significant increases in the likelihood of receiving an annual influenza vaccine compared with those in states with smaller reimbursement increases after the reimbursement bump took effect.

Our findings are consistent with reports from Medicaid stakeholders that the temporary nature of the reimbursement bump could have discouraged providers and clinics from joining or expanding their participation in Medicaid.[19] Moreover, many states experienced delays in the implementation of the reimbursement bump, including making the increased payments.[30] Among the 15 states in our study with larger reimbursement increases for either vaccination administration CPT code, only 5 extended the reimbursement increase for both codes in 2015. Nationally, 19 states continued the reimbursement bump fully or partially.[31] Our study, along with others that have found limited

Figure 2. Unadjusted trends in influenza vaccination completion by magnitude and duration of reimbursement increase for patients with Medicaid.[a] *Abbreviation:* CPT, current procedural terminology.



Notes: [a]A smaller reimbursement increase was defined as a change in 2012-2013 vaccine reimbursement < $5; larger reimbursement increase was defined as ≥ $5. In addition, we identified states with smaller reimbursement increases for both vaccine administration CPT codes (N = 2) (blue line); states with larger temporary reimbursement increases in 2013-2014 only for at least one code (N = 11) (orange line); and states with larger extended reimbursement increases for both codes through at least 2019 (N = 5) (gray line).

impacts of the reimbursement bump on provider participation in Medicaid and use of other preventive care services highlight the importance of policy implementation, such as outreach efforts to increase providers' awareness of the policy and assistance for signing up for the program.[22,23,32]

Moreover, it is possible that even with the reimbursement bump Medicaid vaccine administration reimbursements remained lower than those of commercial insurance plans. Most states did not increase vaccine administration reimbursements to Medicare rates and instead opted for lower VFC maximum rates. This may be another reason for the limited effect of the reimbursement bump on influenza vaccinations. Moreover, other previously identified barriers to providers' participation in Medicaid, such as administrative barriers and provider reluctance to treat potentially more complex Medicaid enrollees, were not addressed by the reimbursement bump and could have continued to limit participation.[22,31] Indeed, qualitative data from semistructured interviews with state Medicaid officials and stakeholders suggest that the reimbursement bump had little effect on new provider participation in Medicaid.[33,34] Nevertheless, the reimbursement increases may have provided benefits that are unobserved in our study. For example, higher reimbursements could contribute to increases in provider satisfaction or continuation with the Medicaid program, enable providers to hire new staff,[34] or increase the percentage of patients with Medicaid seen within facilities or clinics.

Prior studies examining the association between Medicaid reimbursements and preventive care use among adults have had mixed findings.[35–37] Two studies in pediatric populations found positive associations between Medicaid vaccine administration reimbursements and receipt of vaccination using data before the ACA reimbursement bump.[12,17] For example, Tsai et al. demonstrated that higher Medicaid vaccine administration reimbursements increased the probability of children having any vaccination visit[12]; it is possible that associations differ for influenza vaccinations, specifically, given their seasonal nature. Yoo et al. found higher Medicaid reimbursements increased influenza vaccination among children up to age 23 months of age.[17] Increasing vaccination rates among adolescents compared with young children could be more challenging, for example, due to less frequent routine visits with primary care providers. Most participants in our sample had at least one doctor's visit in the past year, which could provide valuable opportunities to address other potential barriers to vaccination, such as perceptions about safety or efficacy.[8] In addition, our study implies that targeting

Table 2. Difference-in-Difference Estimates of the Association Between Medicaid Reimbursement Change and Duration and Influenza Vaccination Rates[a]

	Coeff (95% CI)
Differences by state group at baseline	
Smaller reimbursement change states	(ref)
Larger temporary reimbursement change states	−3.5 (−9.1, 2.1)
Larger extended reimbursement change states	−6.7 (−12.5, −0.8)*
Differences by time period	
Before (2011 to 2012)	(ref)
During (2013 to 2014)	−2.7 (−9.0, 3.6)
After (2015 to 2019)	−2.8 (−9.0, 3.4)
Difference-in-Difference estimates	
Temporary reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	3.0 (−3.8, 9.8)
Temporary reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	3.3 (−3.4, 10.0)
Larger extended reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	1.8 (−5.3, 8.9)
Larger extended reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	2.9 (−4.2, 10.0)

Notes. [a]Models adjusted for age (continuous), sex, race/ethnicity, poverty status, mother's age, mother's marital status, type of vaccination facility, number of doctor visits in the past year, Medicaid managed care penetration rates (continuous), and state expansion status. Estimates were also weighted using sampling weights and include individual-level random effects. *$P < .05$.
Abbreviation: CI, confidence interval.

resources to adolescents who were less likely to receive the influenza vaccine, such as those who are older, receive vaccines in public facilities, and live in states that did not expand Medicaid, could be an effective strategy to increase vaccination rates in this population. Influenza vaccination rates in this sample were not sensitive to increases or decreases in vaccine administration reimbursements suggesting that other targets are necessary to improve vaccination rates in this population.

Our study adds to this limited literature in pediatric populations by examining longitudinal changes among adolescents and including immunization data among adolescents enrolled in both Medicaid FFS and managed care. An additional strength of our study is that we obtained Medicaid reimbursements during the reimbursement bump period using data from Medicaid State Plan Amendments, which could more accurately reflect reimbursement levels compared with paid amounts in claims. Although managed care penetration varies across states, more than two-thirds of children nationwide were in comprehensive managed care plans in 2013.[38] Vaccine administration reimbursements in managed care generally reflect fee-for-service reimbursement rates, and managed care plans were required to pass the reimbursement bump on to their primary care providers. There were reports of greater delays and confusion in implementing this policy in the managed care versus fee-for-service context.[30,34,39] Given the large share of children in Medicaid managed care plans, including incentives in state contracts with plans to increase vaccinations could help bolster rates.

Limitations

We were unable to distinguish respondents enrolled in Medicaid fee-for-service versus managed care to assess possible differences in the policy effects across these groups. Lastly, the 18 states included in our study have lower levels of managed care penetration, on average, compared with states not included, and it is possible that our findings do not generalize to these states.

Our study has other limitations. We used provider reporting-phase weights to better approximate the overall NIS-Teen sample of completed household records, however, differences could remain.[40] In addition, federally qualified health centers and rural health clinics were not eligible for the reimbursement bump.[18] We are not able to directly observe whether respondents received their influenza vaccination from a provider eligible for the reimbursement bump, but we adjusted for type of vaccination provider seen at the individual-level and facility type. In addition, some adolescents may be employed and have received an influenza vaccine from their place of employment, which would not be captured in the provider-reported immunization data. Lastly, we

cannot determine which CPT code was used to administer influenza vaccinations. Further studies are needed to shed light on the mechanisms that might explain our findings.

Information on the potential impact of increases in vaccine administration reimbursements on seasonal vaccination rates for low-income adolescents could be particularly valuable in the context of the COVID-19 pandemic. Currently, COVID-19 vaccine reimbursement reimbursements are higher than reimbursement reimbursements for the seasonal influenza vaccination[41]; it remains to be seen how states will adjust COVID-19 vaccine reimbursement reimbursements.

In conclusion, influenza vaccination rates for adolescents with Medicaid were low throughout the study period. There was wide variation in the ACA Medicaid reimbursement increase across states for influenza vaccine administration. The increased reimbursements mandated by the ACA were not associated with increased influenza vaccination rates, suggesting that a temporary increase in vaccine administration reimbursement is not an effective lever for improving seasonal influenza vaccination rates for adolescents covered by Medicaid.

Felippe O. Marcondes obtained the dataset, conducted data analyses, and drafted the manuscript. Mary Price, Alex McDowell, Joseph P. Newhouse, and John Hsu provided comments and edits on the manuscript draft. Vicki Fung supervised and worked with Felippe O. Marcondes on all aspects of manuscript development.

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References

1. Fiore AE, Uyeki TM, Broder K, et al. Prevention and control of influenza with vaccines: recommendations of the Advisory Committee on Immunization Practices (ACIP), 2010. MMWR Recommendations and Reports 2010;59:1–61.
2. Fragaszy EB, Warren-Gash C, White PJ, Flu Watch Group, et al. Effects of seasonal and pandemic influenza on health-related quality of life, work and school absence in England: results from the Flu Watch cohort study. Influenza Other Respir Viruses 2018; 12:171–82.
3. Nidhi J, James AS, Margrethe M, Benjamin S. Determining accurate vaccination coverage rates for adolescents: The National Immunization Survey-Teen 2006. Public health reports (1974) 2009;124: 642–51.
4. Centers for Disease Control and Prevention. Estimates of flu vaccination coverage among children—United States, 2017–18 flu season. In: 2018.
5. Nakamura MM, Lee GM. Influenza vaccination in adolescents with high-risk conditions. Pediatrics (Evanston) 2008;122:920–8.
6. Stockwell MS, Kharbanda EO, Martinez RA, Vargas CY, Vawdrey DK, Camargo S. Effect of a text messaging intervention on influenza vaccination in an urban, low-income pediatric and adolescent population: a randomized controlled trial. JAMA 2012;307: 1702–8.
7. Lu P-J, Dorell C, Yankey D, Santibanez TA, Singleton JA. A comparison of parent and provider reported influenza vaccination status of adolescents. Vaccine 2012;30:3278–85.
8. Kempe A, Saville AW, Albertin C, et al. Parental hesitancy about routine childhood and influenza vaccinations: a national survey. Pediatrics (Evanston) 2020; 146:e20193852.
9. Lindley MC, Shen AK, Orenstein WA, Rodewald LE, Birkhead GS. Financing the delivery of vaccines to children and adolescents: challenges to the current system. Pediatrics 2009;124 Suppl 5:S548–S557.
10. Medicine Io. *Financing vaccines in the 21st century: assuring access and availability*. National Academies Press; 2003.
11. Lee GM, Santoli JM, Hannan C, et al. Gaps in vaccine financing for underinsured children in the United States. JAMA 2007;298:638–43.
12. Tsai Y. Payments and utilization of immunization services among children enrolled in fee-for-service Medicaid. Med Care 2018;56:54–61.
13. Freed GL, Cowan AE, Clark SJ. Primary care physician perspectives on reimbursement for childhood immunizations. Pediatrics 2008;122: 1319–24.
14. O'Leary ST, Allison MA, Lindley MC, et al. Vaccine financing from the perspective of primary care physicians. Pediatrics (Evanston) 2014;133:367–74.
15. Freed GL, Cowan AE, Gregory S, Clark SJ. Variation in provider vaccine purchase prices and payer reimbursement. Pediatrics 2008;122:1325–31.
16. Glazner JE, Beaty B, Berman S. Cost of vaccine administration among pediatric practices. Pediatrics 2009;124 Suppl 5:S492–S498.
17. Yoo B-K, Berry A, Kasajima M, Szilagyi PG. Association between Medicaid reimbursement and child influenza vaccination rates. Pediatrics (Evanston) 2010;126:e998–e1010.
18. Centers for Medicare and Medicaid Services. Medicaid program; payments for services furnished by certain primary care physicians and charges for vaccine administration under the Vaccines for Children program. Final rule. Federal register 2012; 77:66669.
19. Decker SL. No association found between the Medicaid primary care fee bump and physician-reported participation in Medicaid. Health Aff (Millwood) 2018;37:1092–8.

20. Tang S-fS, Hudak ML, Cooley DM, Shenkin BN, Racine AD. Increased Medicaid payment and participation by office-based primary care pediatricians. Pediatrics (Evanston) 2018;141:e20172570.
21. Polsky D, Richards M, Basseyn S, et al. Appointment availability after increases in Medicaid payments for primary care. N Engl J Med 2015;372:537–45.
22. Mulcahy AW, Gracner T, Finegold K. Associations between the patient protection and affordable care act Medicaid primary care payment increase and physician participation in Medicaid. JAMA Intern Med 2018;178:1042–8.
23. Fung V, Price M, Hull P, Cook BL, Hsu J, Newhouse JP. Assessment of the patient protection and Affordable Care Act's increase in fees for primary care and access to care for dual-eligible beneficiaries. JAMA Netw Open 2021;4:e2033424.
24. Centers for Disease Control and Prevention. About the National Immunization Surveys (NIS). 2019. In: 2017.
25. Centers for Disease Control and Prevention. NIS-Teen data and documentation for 2015 to present. Atlanta (GA): Centers for Disease Control and Prevention; 2018. In: 2019.
26. Centers for Disease Control Prevention. National Immunization Survey-Teen. A user's guide for the 2014 public-use data file. In: 2015.
27. Medicaid Analytic eXtract (MAX) General Information. Centers for Medicare & Medicaid Services. Available at: https://www.cms.gov/Research-Statistics-Data-and-Systems/Computer-Data-and-Systems/MedicaidDataSourcesGenInfo/MAXGeneralInformation. Updated March 20, 2021. Accessed March 22, 2021.
28. Centers for Medicare and Medicaid Services. Medicaid State Plan Amendments. Available at: https://www.medicaid.gov/medicaid/medicaid-state-plan-amendments/index.html?search_api_fulltext=&field_approval_date%5Bmin%5D=06/01/2001&field_approval_date%5Bmax%5D=07/15/2021&field_effective_date%5Bmin%5D=01/01/2013&field_effective_date%5Bmax%5D=07/15/2023&sort_by=field_approval_date&sort_order=ASC&items_per_page=10&f%5B0%5D=state%3A716#content#content#content#content#content#content#content#content. Accessed July 1, 2021.
29. Medicaid and CHIP Payment Access Commission. MACStats: Medicaid and CHIP data book. In: Medicaid and CHIP Payment and Access Commission Washington, DC.
30. Medicaid and CHIP Payment and Access Commission. An update on the Medicaid primary care payment increase. Washington, DC. In: 2015.
31. Zuckerman S, Skopec L, Epstein M. Medicaid physician fees after the ACA primary care fee bump. Washington, DC: Urban Institute. 2017.
32. Fung V, McCarthy S, Price M, et al. Payment discrepancies and access to primary care physicians for dual-eligible Medicare-Medicaid beneficiaries. Med Care 2021;59:487–94.
33. (MACPAC) MaCsHIPPaAC. An update on the Medicaid primary care payment increase. In: 2015.
34. Timbie JW, Buttorff C, Kotzias VI, Case S, Mahmud A. *Examining the implementation of the Medicaid primary care payment increase*. RAND; 2017.
35. Atherly A, Mortensen K. Medicaid Primary care physician fees and the use of preventive services among Medicaid enrollees. Health Serv Res 2014; 49:1306–28.
36. Callison K, Nguyen BT. The effect of Medicaid physician fee increases on health care access, utilization, and expenditures. Health Serv Res 2018; 53:690–710.
37. Saulsberry L, Seo V, Fung V. The impact of changes in Medicaid provider fees on provider participation and enrollees' care: a systematic literature review. J Gen Intern Med 2019;34:2200–9.
38. Medicaid and CHIP Payment and Access Commission. Enrollment and spending on Medicaid managed care. Available at: https://www.macpac.gov/subtopic/enrollment-and-spending-on-medicaid-managed-care/. Accessed October 8, 2021.
39. Tolle L. *Medicaid primary care parity*. Project HOPE; 2015.
40. Jain N, Singleton JA, Montgomery M, Skalland B. Determining accurate vaccination coverage rates for adolescents: The National Immunization Survey-Teen 2006. Public Health Rep 2009;124:642–51.
41. Centers for Medicare & Medicaid Services. Medicare COVID-19 vaccine shot payment web site. Available at: https://www.cms.gov/medicare/covid-19/medicare-covid-19-vaccine-shot-payment. Updated December 23, 2022. Accessed March 20, 2023.

Appendices.

Adjustment in Definition of Adequate Provider Data in 2011 to 2013 to Match 2014 Definition

Before 2014, an adolescent had adequate provider data if at least one of three criteria was met: 1) be up-to-date by provider report with ≥1 Td/Tdap, ≥3 hepatitis B, ≥2 MMR and ≥1 varicella vaccines (or parental or provider report of history of varicella disease); or 2) be completely unvaccinated by parental report; or 3) a) if a shot card was used: have no more doses of measles-containing, varicella, hepatitis A, hepatitis B and Td/Tdap vaccines by household report than by provider report; or b) if a shot card was not used: if a parent/guardian indicated that the adolescent had received "all" of his or her vaccinations in any of the measles-containing, varicella, hepatitis A or hepatitis B categories, have at least 2 unique vaccination dates across all vaccinations reported by the adolescent's providers (refer to NIS-Teen 2014 Data User Guide). Beginning in 2014, any adolescent with vaccination reported by 1 or more named providers or deemed completely unvaccinated by parental or provider report are classified as having adequate provider data. Vaccine coverage estimates before 2014 are therefore not comparable to estimates after 2014, as the change in definition likely decreased vaccination coverage estimates.

In 2014, the household questionnaire was shortened leading to a change in the definition of having adequate provider data. Vaccine coverage estimates before 2014 are not directly comparable to estimates after 2014, as the change in definition of adequate provider data likely decreases vaccination coverage estimates.

To account for that, we adjusted the definition of adequate provider data for 2011 to 2013 to match the 2014 definition by classifying as having adequate provider data any adolescent with:

vaccine data reported by at least one name provider by an Immunization History Questionnaire (IHQ) (variable N_PRVR greater than 0)
PLUS
completely unvaccinated adolescents
(defined as not having received any vaccines by parental report or vaccine provider or no IHQ provided, (N_PRVR = 0 and HEPA_NUM_TOT = 0 and HEPB_NUM_TOT = 0 and HPVI_NUM_TOT = 0 & MCV_NUM_TOT = 0 and MEN_NUM_TOT = 0 and (VRC_NUM_TOT = 0 or VRC_NUM_TOT = 77) and P_NUMFLU = 0 and (P_NUMH1N = 0 or P_NUMH1N=.) and P_NUMHEPA = 0 and P_NUMHEPB = 0 and P_NUMHPV = 0 and P_NUMMCV = 0 and P_NUMMEN = 0 and P_NUMMMR = 0 and P_NUMPPS = 0 and P_NUMTDP = 0 and P_NUMVRC = 0 and (TET_NUM_SC = 0 or TET_NUM_SC=.)).

Appendix Table 1 shows the unadjusted, unweighted proportions of influenza vaccination completion by year for unadjusted adequate provider data definition compared with adjusted adequate provider data definition.

Appendix Table 1. Unweighted and Unadjusted Influenza Vaccination Completion by Year by Adequate Provider Data Definition[a]

Year	Unweighted % (95% CI) (unadjusted adequate provider data definition)	Unweighted % (95% CI) (adjusted adequate provider data definition)
2011	21.1 (19.7, 22.6)	20.8 (19.4, 22.3)
2012	24.9 (23.5, 26.4)	24.8 (23.4, 26.3)
2013	23.9 (22.6, 25.2)	23.9 (22.6, 25.2)
2014	23.3 (22.1, 24.5)	23.3 (22.1, 24.5)
2015	22.3 (21.2, 23.5)	22.3 (21.2, 23.5)
2016	23.5 (21.9, 25.1)	23.5 (21.9, 25.1)
2017	25.2 (23.4, 27.1)	25.2 (23.4, 27.1)
2018	26.8 (25.5, 28.2)	26.8 (25.5, 28.2)
2019	28.0 (26.1, 29.9)	28.0 (26.1, 29.9)

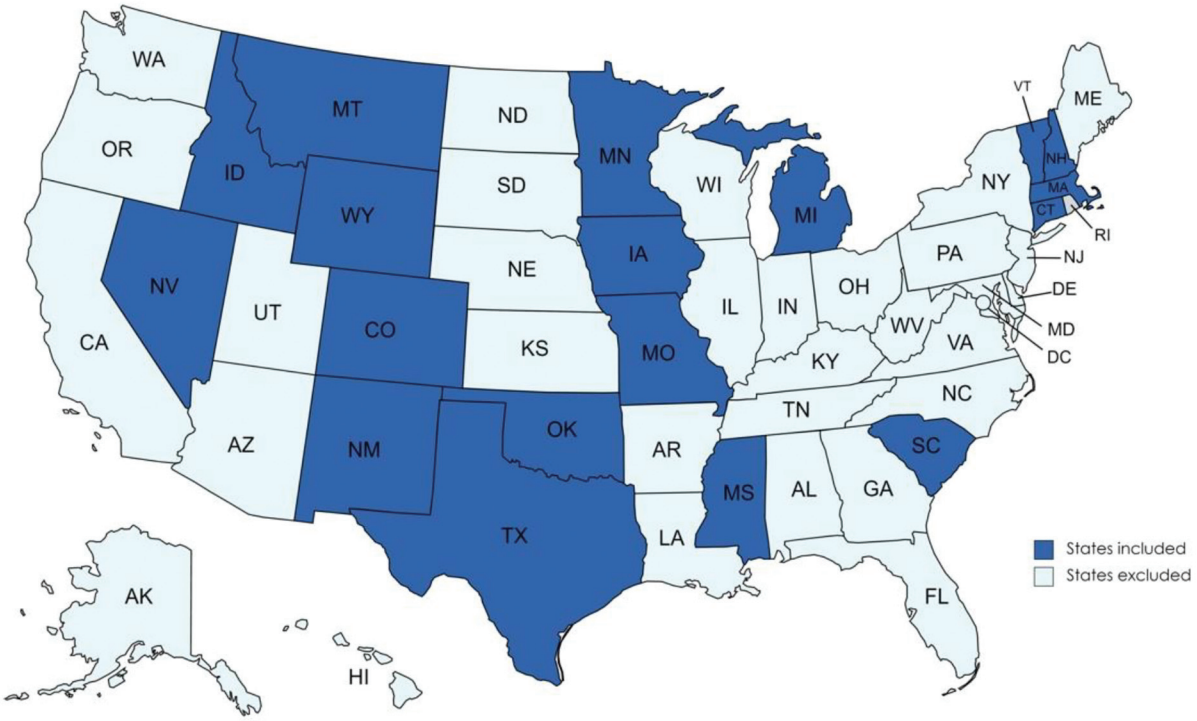
Notes. [a]Unadjusted adequate provider data definition means calculation of unadjusted vaccination rates were based on original 2011-2013 definition of adolescents having adequate provider data in the NIS-Teen for those years. Adjusted adequate provider data definition means calculation of unadjusted vaccination rates were based on adjusted definition of adolescents having adequate provider data in 2011-2013, as per new definition proposed in 2014 and after; therefore, only vaccination rates for 2011-2013 should differ between unadjusted and adjusted adequate provider definitions (grayed rows).
Abbreviation: CI, confidence interval.

Appendix Table 2. Vaccine Administration Reimbursement Comparison Chart for 2013-2014 (for CPT Code 90460)

State	VFC Regional Maximum (Updated Nov 2012)[a] US$	Medicare Reimbursement Schedule 2013 US$	Medicare Reimbursement Schedule 2014 US$	Vaccine Administration Reimbursement Level (VFC versus Medicare)[b]
CO	21.68	25.89	25.22	VFC
CT	23.41	28.25	27.47	VFC
IA	19.68	23.44	22.88	VFC
ID	20.13	23.66	22.98	Medicare
MA	23.29	27.09	26.25	VFC
MI	23.03	24.36	23.63	VFC
MN	21.22	25.85	25.12	VFC/Medicare
MO	21.53	22.93	22.28	VFC
MS	19.79	23.13	22.45	VFC
MT	21.32	25.89	25.14	VFC
NH	22.02	26.68	25.98	VFC
NM	20.80	24.20	23.58	VFC
NV	22.57	27.08	26.15	VFC
OK	19.58	22.93	22.47	VFC/Medicare
SC	20.16	23.90	23.28	VFC
TX	22.06	24.06	23.45	VFC
VT	21.22	25.86	25.05	VFC
WY	21.72	25.94	25.16	VFC/Medicare

Notes. [a]Per Table 1 in Centers for Medicare & Medicaid Final rule.[19]
[b]Information obtained from Medicaid State Plan Amendment (SPA), attachment 4.19-B for each state accessed at medicaid.gov/medicaid/medicaid-state-plan-amendments. For reimbursement frequency, a state could have chosen to adjust its reimbursement schedule to make payment as the service was provided (FFS) or reimbursed a supplemental amount equal to the difference between the Medicaid rate in effect on July 1, 2009 and the minimum payment required either a monthly or quarterly interval. For vaccine administration reimbursement method, a state could have opted to reimburse at the VFC regional maximum or the Medicare reimbursement level.
Abbreviation: CPT, current procedural terminology.

Appendix Figure 1. US map with included and excluded states from the study analysis. *Abbreviation:* CPT, current procedural terminology.



Notes: [a]We excluded 31 states (light blue) with fewer than 1,000 fee-for-service claims per year due to high enrollment of children in Medicaid managed care plans. The resulting sample included 18 states with adequate data on Medicaid reimbursements for CPT codes 90460 and 90471 (dark blue): Colorado (CO), Connecticut (CT), Iowa (IA), Idaho (ID), Massachusetts (MA), Michigan (MI), Minnesota (MN), Missouri (MO), Mississippi (MS), Montana (MT), New Hampshire (NH), New Mexico (NM), Nevada (NV), Oklahoma (OK), South Carolina (SC), Texas (TX), Vermont (VT), and Wyoming (WY).

Appendix Table 3. Characteristics of 2011 NIS-Teen Medicaid Insured Participants in States Included Versus Excluded from the Analysis Due to Lack of Reliable Vaccine Administration Reimbursement Data from Medicaid MAX Files[a]

Year	2011		2019	
	Enrollees in States with Reliable Reimbursement Data (included) 1,641 N (Weighted %)	Enrollees in States with Unreliable Reimbursement Data (excluded) 2,955 N (Weighted %)	Enrollees in States with Reliable Reimbursement Data (included) 2,121 N (Weighted %)	Enrollees in States with Unreliable Reimbursement Data (excluded) 3,245 N (Weighted %)
Age				
13	391 (24.9)	653 (20.2)	482 (22.1)	721 (20.3)
14	335 (17.0)	626 (21.4)	464 (22.2)	715 (23.6)
15	339 (23.9)	583 (20.1)	430 (21.1)	654 (20.2)
16	320 (19.3)	585 (21.4)	413 (18.8)	610 (16.4)
17	256 (14.8)	508 (16.9)	332 (15.9)	545 (19.6)
Sex				
Male	796 (49.3)	1,548 (50.8)	1,124 (52.0)	1,772 (52.4)
Female	845 (50.7)	1,407 (49.2)	997 (48.0)	1,473 (47.6)
Race				
White, non-Hispanic	653 (34.9)	1,319 (38.0)	962 (37.3)	1,418 (31.9)
Black, non-Hispanic	291 (24.6)	747 (25.9)	182 (18.2)	497 (21.7)
Hispanic	536 (30.7)	558 (27.1)	767 (37.0)	873 (36.2)
Other, non-Hispanic	161 (9.8)	331 (9.0)	210 (7.6)	457 (10.2)
Poverty status				
Above poverty	701 (35.3)	1,386 (40.8)	1,119 (48.8)	1,743 (48.1)
Below poverty	873 (60.2)	1,425 (54.0)	897 (43.4)	1,346 (44.3)
Missing	67 (4.5)	144 (5.2)	105 (7.8)	156 (7.6)
Mother's age				
≤34	295 (22.5)	521 (20.1)	299 (15.9)	471 (14.7)
35 to 44	809 (51.6)	1,438 (51.2)	1,136 (54.8)	1,722 (55.7)
≥45	537 (25.9)	996 (28.7)	686 (29.3)	1,052 (29.7)
Mother's marital status				
Married	809 (40.0)	1,338 (42.7)	970 (38.7)	1,428 (39.2)
Not married	832 (60.0)	1,617 (57.3)	1,151 (61.3)	1,817 (60.8)
Number of visits to doctors in a previous year				
None	233 (15.4)	374 (14.2)	259 (13.9)	399 (16.5)
1	375 (23.3)	707 (24.6)	499 (25.9)	844 (29.1)
2+	1,012 (61.3)	1,842 (61.2)	1,332 (60.1)	1,949 (54.4)
Vaccination providers facility type				
Private	563 (34.0)	1,121 (43.2)	801 (41.7)	1,174 (39.0)
Public	425 (27.6)	683 (22.4)	446 (20.9)	726 (22.5)
Hospital	130 (7.6)	337 (10.1)	260 (10.2)	453 (10.0)
STD/School/Teen clinic/other	59 (3.8)	91 (3.0)	42 (2.4)	70 (1.8)
Mixed	330 (18.8)	484 (15.2)	434 (16.5)	588 (17.2)
Missing	134 (8.2)	239 (6.0)	138 (8.3)	234 (9.5)
Medicaid Expansion status				
Not expanded	NA	NA	1,162 (60.0)	779 (27.6)
Expanded	NA	NA	959 (40.0)	2,466 (72.4)
Mean state Medicaid managed care penetration rate (SD)	53.0% (33.3%)	60.7% (31.0%)	71.4% (38.8%)	82.1% (21.4%)

Notes. [a]There were missing responses for number of visits to doctors in the past year.
Abbreviations: STD, sexually transmitted disease; SD, standard deviation.

Appendix Table 4. Vaccine Administration Reimbursement Change Magnitude and Duration for Each CPT Code

State	2011 Medicaid Reimbursement US$	2012 Medicaid Reimbursement US$	2013 Medicaid Reimbursement US$	2014 Medicaid Reimbursement US$	2015 Medicaid Reimbursement US$	2016 Medicaid Reimbursement US$	2017 Medicaid Reimbursement US$	2018 Medicaid Reimbursement US$	2019 Medicaid Reimbursement US$	2022 Medicaid Reimbursement	Reimbursement Change Category (% Change)[j]	Temporary (2013-2014) Versus Extended (2013-2015) Reimbursement Change[j]
a) Vaccine administration with counseling, CPT Code 90460[c]												
CO	6.00[a]	6.00[a]	21.68[d]	21.68[d]	18.93[b]	18.93[b]	18.93	18.93	19.12	19.75	Large	Extende[d]
CT	15.00[a]	15.00[a]	23.41[d]	23.41[d]	15.05	15.05	15.05	15.05	15.05	15.05	Large	Temporary
IA	21.00[a]	21.00[a]	19.68[d]	19.68[d]	19.68	19.68	19.68	19.68	19.68	19.68	Smaller	NA
ID	20.00[b]	20.00[a]	24.00[d]	23.00[d]	22.98	23.28	23.28	23.73	19.23	19.29	Smaller	NA
MA	20.00[a]	16.00[a]	23.29[d]	23.29[d]	16.00	16.00	16.78	16.78[b]	16.78[b]	17.70	Large	Temporary
MI	8.00[a]	8.00[a]	23.03[d]	23.03[d]	7.00	7.00	7.00	7.00	7.00	7.00	Large	Temporary
MN	13.00[a]	13.00[a]	22.00[d]	22.00[d]	12.15	12.15	12.15	12.15	12.15	12.15	Large	Temporary
MO	12.00[a]	12.00[a]	21.53[d]	21.53[d]	12.84[e]	12.84[f]	12.84[f]	12.84[f]	12.84[f]	13.73	Large	Temporary
MS	10.00[a]	10.00[a]	19.79[d]	19.79[d]	19.79	22.67	22.70	23.08	18.78	12.98	Large	Extende[d]
MT	15.52	15.52	21.32[d]	21.32[d]	21.32	21.32	21.32	20.68	21.32	21.32	Large	Extende[d]
NH	6.00[a]	6.00[a]	22.02[d]	22.02[d]	6.20[e]	6.20[f]	6.20[f]	6.20[f]	6.20[f]	6.39	Large	Temporary
NM	12.00[a]	12.00[a]	20.80[a]	20.80[a]	20.80	20.80	20.80	20.80	20.80	20.80	Large	Extende[d]
NV	8.00[a]	8.00[a]	22.57[a]	22.57[a]	22.22	22.22	22.22	22.22	22.22	22.22	Large	Extende[d]
OK	12.90	12.90	20.00[d]	20.00[d]	17.48	16.96	16.96	16.96	17.47	18.34[g]	Large	Temporary
SC	12.00[a]	12.00[a]	20.16[a]	20.16[a]	20.16	20.16	20.16	20.16	20.16	20.16	Large	Extende[d]
TX	7.84	7.84	22.06[d]	22.06[d]	7.84	7.84	7.84	7.84	7.84	7.84	Large	Temporary
VT	14.00	19.39	20.65	20.08	21.21	21.21	25.99	20.94	16.95	13.87	Smaller	NA
WY	14.00[a]	14.00[a]	21.72[d]	21.72[d]	21.00[b]	21.00[b]	21.00	21.00	21.00	20.48	Large	Extended[d]

Continued

Appendix Table 4. Continued

State	2011 Medicaid Reimbursement US$	2012 Medicaid Reimbursement US$	2013 Medicaid Reimbursement US$	2014 Medicaid Reimbursement US$	2015 Medicaid Reimbursement US$	2016 Medicaid Reimbursement US$	2017 Medicaid Reimbursement US$	2018 Medicaid Reimbursement US$	2019 Medicaid Reimbursement US$	2022 Medicaid Reimbursement	Reimbursement Change Category (% Change)[j]	Temporary (2013-2014) Versus Extended (2013-2015) Reimbursement Change[j]
b) Vaccine administration without counseling, CPT Code 90471[c]												
CO	6.00[a]	6.00[a]	21.68[d]	21.68[d]	18.93[b]	18.93[b]	18.93	18.93	19.12	19.75	Larger	Extended
CT	13.00[a]	13.00[a]	23.41[d]	23.41[d]	12.52	12.52	12.52	12.52	12.52	12.52	Larger	Temporary
IA	5.00[a]	5.00[a]	19.68[d]	19.68[d]	5.09	5.09	5.09	5.09	5.09	5.09	Larger	Temporary
ID	20.00[h]	20.00[a]	24.00[d]	23.00[d]	22.98	23.28	23.28	23.73	19.29	19.29	Smaller	NA
MA	17.00[a]	18.00[a]	23.29[d]	23.29[d]	16.00	16.00	16.78	16.78[b]	16.78[b]	17.70	Larger	Temporary
MI	8.00[a]	8.00[a]	23.03[d]	23.03[d]	7.00	7.00	7.00	7.00	7.00	7.00	Larger	Temporary
MN	15.00[a]	15.00[a]	22.00[d]	22.00[d]	12.15	12.15	12.15	12.15	12.15	12.15	Larger	Temporary
MO	12.00[a]	12.00[a]	21.53[d]	21.53[d]	12.34[e]	12.34[f]	12.34[f]	12.34[f]	12.34[f]	13.21	Larger	Temporary
MS	10.00[a]	10.00[a]	19.79[d]	19.79[d]	22.6	22.67	22.7	23.08	18.78	12.98	Larger	Extended
MT	14.00[a]	14.00[a]	21.32[d]	21.32[d]	21.32	21.32	21.32	20.68	21.32	21.32	Larger	Extended
NH	3.00[a]	3.00[a]	22.02[d]	22.02[d]	6.20[e]	6.20[f]	6.20[f]	6.20[f]	6.20[f]	5.32	Larger	Temporary
NM	11.00[a]	11.00[a]	20.80[d]	20.80[d]	20.80	20.80	20.80	20.80	20.80	20.80	Larger	Extended
NV	8.00[a]	8.00[a]	22.57[d]	22.57[d]	22.22	22.22	22.22	22.22	22.22	22.22	Larger	Extended
OK	12.90	12.90	20.00[d]	20.00[d]	20.05	19.83	19.86	20.36	17.2	12.62[g]	Larger	Extended

Continued

Appendix Table 4. Continued

State	2011 Medicaid Reimbursement US$	2012 Medicaid Reimbursement US$	2013 Medicaid Reimbursement US$	2014 Medicaid Reimbursement US$	2015 Medicaid Reimbursement US$	2016 Medicaid Reimbursement US$	2017 Medicaid Reimbursement US$	2018 Medicaid Reimbursement US$	2019 Medicaid Reimbursement US$	2022 Medicaid Reimbursement	Reimbursement Change Category (% Change)[j]	Temporary (2013-2014) Versus Extended (2013-2015) Reimbursement Change[j]
SC	13.00[a]	3.00[a]	20.16[d]	20.16[d]	3.72	3.72	3.72	3.72	3.72	3.72	Larger	Temporary
TX	7.84	7.84	22.06[d]	22.06[d]	7.84	7.84	7.84	7.84	7.84	7.84	Larger	Temporary
VT	19.00	19.86	20.65	20.08	21.21	21.21	25.99	20.94	16.95	13.87	Smaller	NA
WY	10.00[a]	10.00[a]	21.72[d]	21.72[d]	9.67[i]	9.67[i]	9.67[i]	9.67	9.67	16.94	Larger	Temporary

Notes. [a]reimbursement values obtained from the modal reimbursement value for CPT code 90460 and 90471 for each state from Medicaid Analytic eXtract (MAX) Other Services File.

[b]imputed values from year 2017 Medicaid state reimbursement schedule.

[c]unless otherwise specified, reimbursements were obtained from Medicaid state reimbursement schedules.

[d]source was the CMS Final rule.[19]

[e]2015 American Academy of Pediatrics Survey.

[f]imputed from year 2015 Medicaid state reimbursement schedule.

[g]imputed from year 2023 (data not shown) Medicaid state reimbursement schedule.

[h]imputed values from year 2012 Medicaid state reimbursement schedule.

[i]imputed values from year 2018 Medicaid state reimbursement schedule.

[j]A smaller reimbursement increase was defined as a change in 2012-2013 vaccine reimbursement < $5; larger reimbursement increase was defined as ≥ $5. In addition, we identified states with larger reimbursements are either temporary (if the higher reimbursements only lasted through 2014) or extended (if the higher reimbursements lasted beyond 2015).

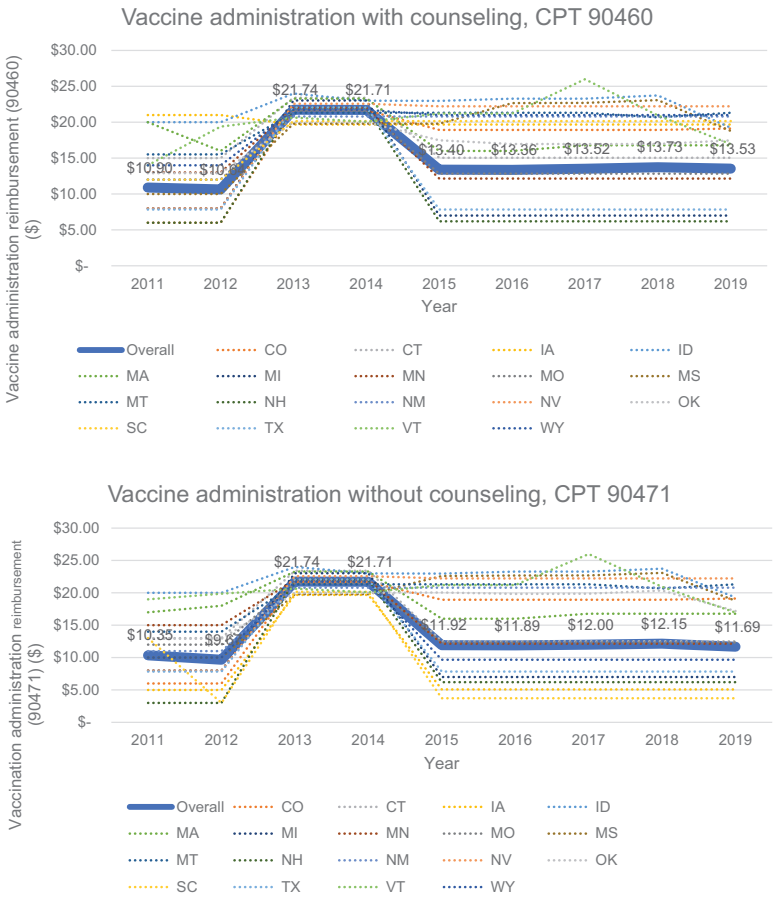
Abbreviation: CPT, current procedural terminology.

Appendix Table 5. Vaccine Administration Reimbursement Change Magnitude and Duration for Both Vaccine Administration CPT Codes[a]

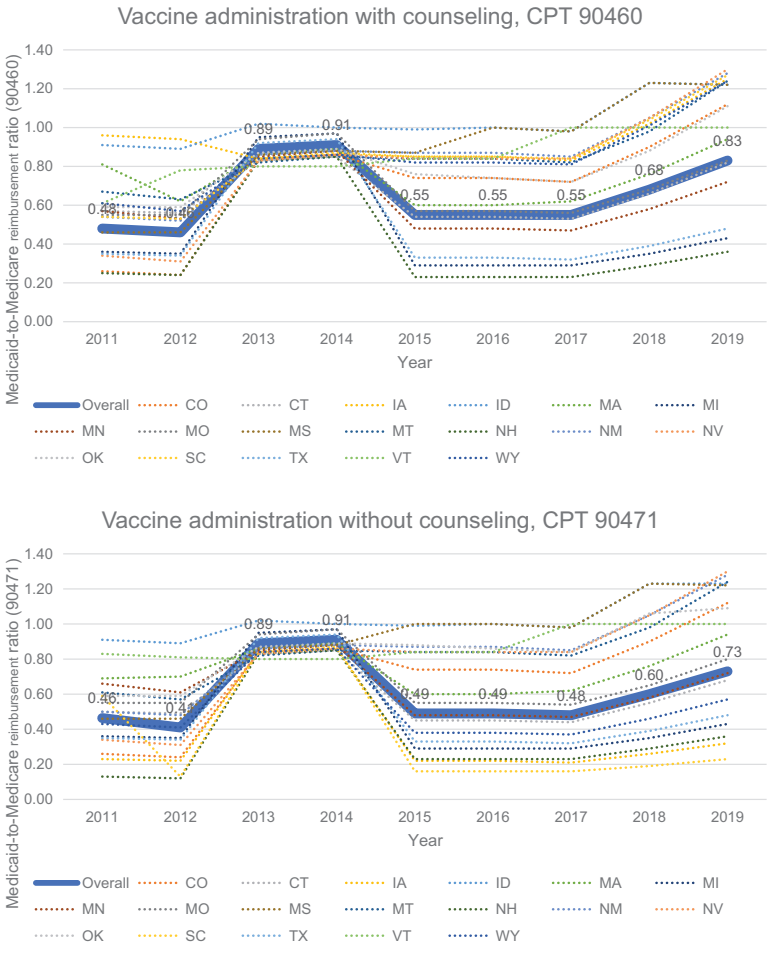
State	Reimbursement Change Size and Duration Category
CO	Larger extended
CT	Larger temporary
IA	Larger temporary
ID	Smaller
MA	Larger temporary
MI	Larger temporary
MN	Larger temporary
MO	Larger temporary
MS	Larger extended
MT	Larger extended
NH	Larger temporary
NM	Larger extended
NV	Larger extended
OK	Larger temporary
SC	Larger temporary
TX	Larger temporary
VT	Smaller
WY	Larger temporary

Notes. [a]An unified reimbursement change category and reimbursement duration was a compiled from information for CPT codes 90460 and 90471 (see Appendix Table 4). We stratified states with smaller reimbursement increases for both CPT codes as smaller reimbursement change states. States with larger increases that extended the reimbursement bump into 2019 for both CPT codes were classified as larger extended reimbursement states. All other states were categorized as temporary reimbursement states.

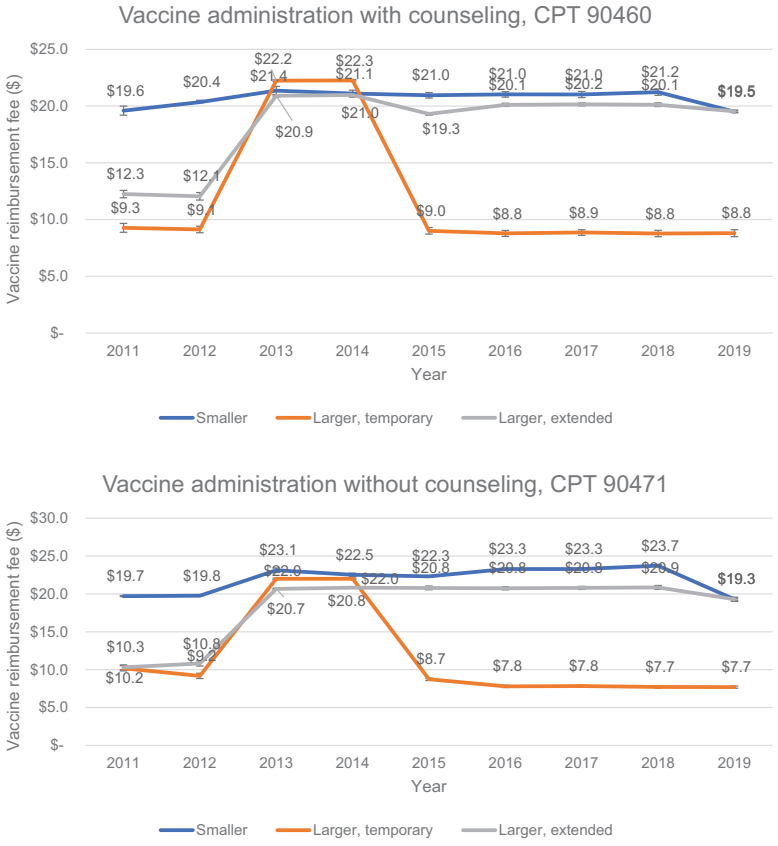
Appendix Figure 2. Medicaid vaccination administration reimbursements by year overall and by state for Medicaid insured participants.



Appendix Figure 3. Medicaid-to-Medicare vaccination reimbursement ratios by year overall for Medicaid insured participants.

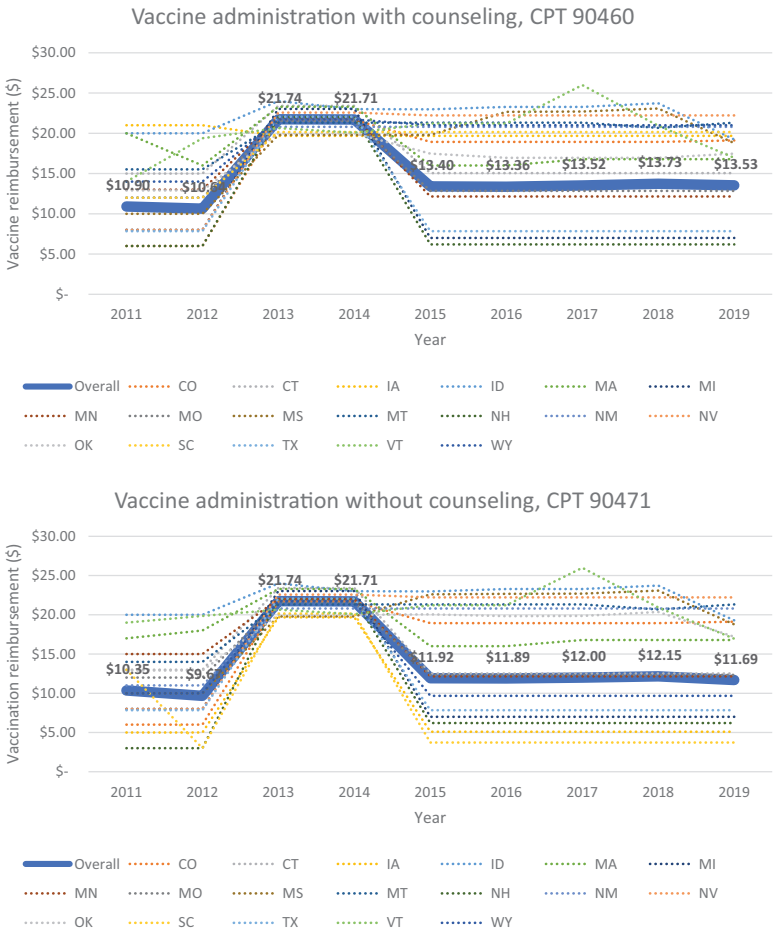


Appendix Figure 4. Medicaid vaccination administration reimbursements by reimbursement size change and return to baseline reimbursement for Medicaid insured participants—by CPT code. ***Abbreviation:*** **CPT, current procedural terminology.**

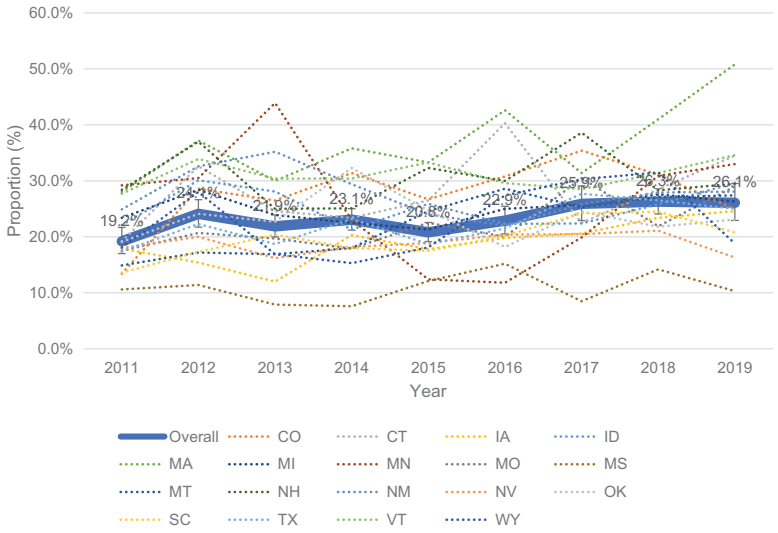


Notes: [a]A smaller reimbursement increase was defined as a change in 2012-2013 vaccine reimbursement < $5; larger reimbursement increase was defined as ≥ $5. In addition, we identified states with smaller reimbursement increases for both vaccine administration CPT codes (N =2) (blue line); states with larger temporary reimbursement increases in 2013-2014 only for at least one code (N = 11) (orange line); and states with larger extended reimbursement increases for both codes through at least 2019 (N = 5) (gray line).

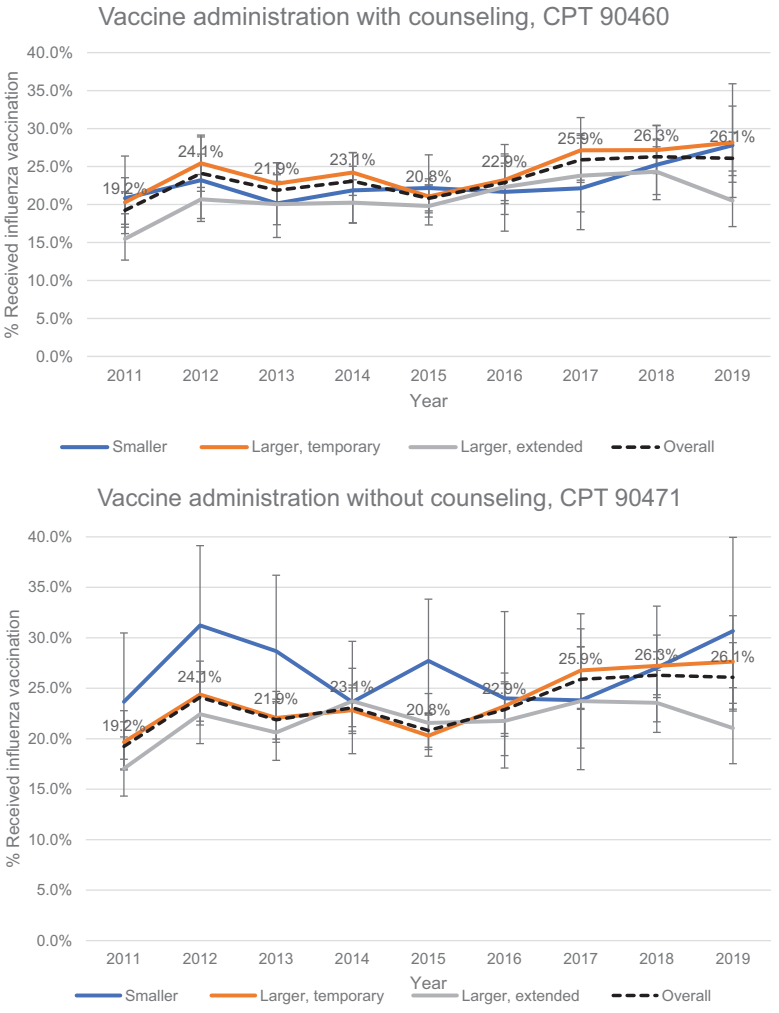
Appendix Figure 5. Medicaid vaccination administration reimbursements overall and by state for Medicaid insured participants – by CPT code. ***Abbreviation:*** **CPT, current procedural terminology.**



Appendix Figure 6. Unadjusted trends in influenza vaccination completion by year overall and by state for Medicaid insured participants. ***Abbreviation:*** **CPT, current procedural terminology.**



Appendix Figure 7. Unadjusted trends in influenza vaccination completion by reimbursement size change and return to baseline reimbursement for patients with Medicaid – by CPT code. ***Abbreviation:*** **CPT, current procedural terminology.**



Notes: [a]A smaller reimbursement increase was defined as a change in 2012-2013 vaccine reimbursement < $5; larger reimbursement increase was defined as ≥ $5. In addition, we identified states with smaller reimbursement increases for both vaccine administration CPT codes (N = 2) (blue line); states with larger temporary reimbursement increases in 2013-2014 only for at least one code (N = 11) (orange line); and states with larger extended reimbursement increases for both codes through at least 2019 (N = 5) (gray line).

Appendix Table 6. Full Model Results: Difference-in-Difference Estimates of the Association Between Medicaid Reimbursement Change and Duration and Influenza Vaccination Rates – Unified CPT Categorization[a]

	Coeff (95% CI) Diff-in-Diff Estimate (pct pts)
Differences by state group at baseline	
Smaller reimbursement change states	(ref)
Larger temporary reimbursement change states	−3.5 (−9.1, 2.1)
Larger extended reimbursement change states	−6.7 (−12.5, −0.8)
Differences by time period	
Before (2011 to 2012)	(ref)
During (2013 to 2014)	−2.7 (−9.0, 3.6)
After (2015 to 2019)	−2.8 (−9.0, 3.4)
Difference-in-Difference estimates	
Larger temporary reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	3.0 (−3.8, 9.8)
Larger temporary reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	3.3 (−3.4, 10.0)
Larger extended reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	1.8 (−5.3, 8.9)
Larger extended reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	2.9 (−4.2, 10.0)
Age (years)	−1.5 (−2.1, −0.8)
Sex	
Male	(ref)
Female	0.6 (−1.2, 2.5)
Race	
White, non-Hispanic	(ref)
Black, non-Hispanic	1.0 (−1.8, 3.8)
Hispanic	3.8 (1.5, 6.1)
Other, non-Hispanic/multi-race	5.0 (1.8, 8.1)
Poverty status	
Above poverty	(ref)
Below poverty	−0.1 (−2.1, 1.9)
Missing	−1.2 (−5.8, 3.4)
Mother's age	
≤34	(ref)
35 to 44	−0.1 (−2.8, 2.5)
≥45	2.3 (−0.6, 5.2)
Mother's marital status	
Married	(ref)
Not married	−3.9 (−5.8, −2.0)
Number of visits to doctors in a previous year	
None	(ref)
1	3.1 (−0.4, 5.8)
2+	9.4 (7.0, 11.8)
Facility type for teen's vaccination providers	
All private	(ref)
All public	−6.1 (−8.5, −3.8)
All hospital	−2.2 (−5.6, 1.2)
All STD/School/Teen clinic/other	−4.6 (−11.1, 1.9)
Mixed	−0.1 (−2.6, 2.5)
Missing	−3.8 (−7.4, −0.2)

Continued

Appendix Table 6. Continued

	Coeff (95% CI) Diff-in-Diff Estimate (pct pts)
Medicaid Expansion status	
Not expanded	(ref)
Expanded	5.5 (3.4, 7.6)
Managed Care penetration rate	−3.3 (−5.7, −0.9)

Notes. [a]Adjusted multivariable regression model also includes adjustment for Medicaid vaccination reimbursements (in US$), state fixed effects for states with reliable data (CO, CT, IA, ID, MA, MI, MN, MO, MS, MT, NH, NM, NV, OK, SC, TX, VT, WY). Medicaid Managed Care penetration rates for children in comprehensive Medicaid plans in states with reliable data were obtained from Medicaid and CHIP Payment and Access Commission (MACPAC) reports.[30] Medicaid expansion status was determined by whether a state expanded Medicaid in each year between 2014-2019. The models also included state fixed effects (dummy variable for each state) and a random effect at the person level.
Abbreviations: STD, sexually transmitted disease; CI, confidence interval; CPT, current procedural terminology.

Appendix Table 7. Difference-in-Difference Estimates of the Association Between Medicaid Reimbursement Change and Duration and Influenza Vaccination Rates – Sensitivity Analyses by CPT Code[a]

	Coeff (95% CI) Vaccine Admin with Counseling, CPT 90,460	Coeff (95% CI) Vaccine Admin without Counseling, CPT 90,471
	Diff-in-Diff Estimate (pct pts)	Diff-in-Diff Estimate (pct pts)
Differences by state group at baseline		
Smaller reimbursement change states	(ref)	(ref)
Larger temporary reimbursement change states	2.3 (−2.4, 7.0)	−2.6 (−8.3, 3.1)
Larger extended reimbursement change states	−2.0 (−6.7, 2.7)	−5.8 (−11.5, −0.2)
Differences by time period		
Before (2011 to 2012)	(ref)	(ref)
During (2013 to 2014)	−4.2 (−9.3, 0.9)	−2.6 (−8.9, 3.7)
After (2015)	−0.9 (−5.9, 4.1)	−2.7 (−8.9, 3.5)
Difference-in-Difference estimates		
Larger temporary reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	4.6 (−1.2, 10.3)	2.7 (−4.1, 9.5)
Larger temporary reimbursement change versus smaller change in 2015 versus 2011 to 2012	1.1 (−4.6, 6.8)	3.4 (−3.4, 10.2)
Larger extended reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	4.7 (−1.0, 10.5)	3.6 (−3.4, 10.5)
Larger extended reimbursement change versus smaller change in 2015 versus 2011 to 2012	2.8 (−2.9, 8.6)	3.6 (−3.3, 10.5)
Age (years)	−1.5 (−2.1, −0.8)	−1.5 (−2.1, −0.8)
Sex		
Male	(ref)	(ref)
Female	0.6 (−1.2, 2.5)	0.6 (−1.2, 2.5)
Race		
White, non-Hispanic	(ref)	(ref)
Black, non-Hispanic	0.9 (−1.9, 3.7)	0.9 (−1.9, 3.6)
Hispanic	3.2 (0.9, 5.5)	3.7 (1.4, 5.9)
Other, non-Hispanic/multi-race	4.5 (1.4, 7.6)	5.1 (2.0, 8.3)
Poverty status		
Above poverty	(ref)	(ref)
Below poverty	−0.1 (−2.1, 1.9)	−0.2 (−2.1, 1.8)
Missing	−1.3 (−5.9, 3.3)	−1.2 (−5.8, 3.4)
Mother's age		
≤34	(ref)	(ref)
35 to 44	−0.05 (−2.7, 2.6)	−0.1 (−2.7, 2.5)
≥45	2.4 (−0.5, 5.3)	2.3 (−0.6, 5.2)
Mother's marital status		
Married	(ref)	(ref)
Not married	−3.9 (−5.9, −2.0)	−3.9 (−5.9, −2.0)
Number of visits to doctors in a previous year		
None	(ref)	(ref)
1	3.1 (0.4, 5.8)	3.1 (0.4, 5.8)
2+	9.5 (7.1, 11.9)	9.4 (7.0, 11.8)
Facility type for teen's vaccination providers		
All private	(ref)	(ref)
All public	−6.1 (−8.5, −3.8)	−6.2 (−8.5, −3.8)
All hospital	−2.0 (−5.4, 1.4)	−2.1 (−5.5, 1.3)
All STD/School/Teen clinic/other	−4.7 (−11.1, 1.7)	−4.6 (−11.1, 1.8)
Mixed	0.02 (−2.6, 2.6)	−0.02 (−2.6, 2.6)

Continued

Appendix Table 7. Continued

	Coeff (95% CI) Vaccine Admin with Counseling, CPT 90,460	Coeff (95% CI) Vaccine Admin without Counseling, CPT 90,471
	Diff-in-Diff Estimate (pct pts)	Diff-in-Diff Estimate (pct pts)
Missing	−3.9 (−7.4, −0.3)	−3.8 (−7.4, −0.2)
Medicaid Expansion status		
Not expanded	(ref)	(ref)
Expanded	5.1 (3.0, 7.1)	4.8 (2.8, 6.9)
Managed Care penetration rate	−4.0 (−6.3, −1.7)	−4.3 (−6.8, −1.7)

[a]Adjusted multivariable regression model also includes adjustment for Medicaid vaccination reimbursements (in US$), state fixed effects for states with reliable data (CO, CT, IA, ID, MA, MI, MN, MO, MS, MT, NH, NM, NV, OK, SC, TX, VT, WY). Medicaid Managed Care penetration rates for children in comprehensive Medicaid plans in states with reliable data were obtained from Medicaid and CHIP Payment and Access Commission (MACPAC) reports.[30] Medicaid expansion status was determined by whether a state expanded Medicaid in each year between 2014 and 2019. The models also included state fixed effects (dummy variable for each state) and a random effect at the person level.
Abbreviations: STD, sexually transmitted disease; CI, confidence interval; CPT, current procedural terminology.

Appendix Table 8. Sensitivity Analysis of Difference-in-Difference Estimates of the Association between Medicaid Reimbursement Change and Duration and Influenza Vaccination Rates – Excluded 2012 from Pre-Policy Time Period[a]

	Coeff (95% CI)
Differences by state group at baseline	
Smaller reimbursement change states	(ref)
Larger temporary reimbursement change states	−1.8 (−8.9, 5.1)
Larger extended reimbursement change states	−4.9 (−12.2, 2.5)
Differences by time period	
Before (2011 to 2012)	(ref)
During (2013 to 2014)	−4.3 (−12.7, 4.0)
After (2015 to 2019)	−9.1 (−18.1, −0.2)
Difference-in-Difference estimates	
Larger temporary reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	1.3 (−7.2, 9.8)
Larger temporary reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	2.1 (−6.0, 10.1)
Larger extended reimbursement change versus smaller change in 2013 to 2014 versus 2011 to 2012	−0.2 (−9.1, 8.8)
Larger extended reimbursement change versus smaller change in 2015 to 2019 versus 2011 to 2012	1.4 (−7.1, 9.9)

[a]Models adjusted for age (continuous), sex, race/ethnicity, poverty status, mother's age, mother's marital status, type of vaccination facility, number of doctor visits in the past year, Medicaid managed care penetration rates (continuous), and state expansion status. Estimates were also weighted using sampling weights and include individual-level random effects.
Abbreviation: CI, confidence interval.

Appendix Table 9. Multivariable Association Between Changes in Medicaid Reimbursements for Vaccine Administration and Receipt of Influenza Vaccination[a]

	Coeff (95% CI) Vaccine Admin with Counseling, CPT 90460 (pct points)	Coeff (95% CI) Vaccine Admin without Counseling, CPT 90471 (pct points)
Medicaid reimbursement ($1 increase)	0.1 (−0.1, 0.3)	0.05 (−0.1, 0.2)
Age (years)	−1.5 (−2.1, −0.8)	−1.5 (−2.1, −0.8)
Year (observation year)	1.0 (0.4, 1.5)	0.9 (0.3, 1.5)
Sex		
Male	(ref)	(ref)
Female	0.5 (−1.3, 2.4)	0.5 (−1.3, 2.4)
Race		
White	(ref)	(ref)
Black, non-Hispanic	2.0 (−0.9, 4.9)	2.0 (−0.8, 4.9)
Hispanic	3.5 (1.0, 6.0)	3.5 (1.0, 6.1)
Other, non-Hispanic/multi-race	4.6 (1.4, 7.7)	4.6 (1.4, 7.7)
Poverty status		
Above poverty	(ref)	(ref)
Below poverty	0.4 (−1.6, 2.4)	0.4 (−1.6, 2.4)
Missing	−1.1 (−5.6, 3.5)	−1.1 (−5.6, 3.5)
Mother's age		
≤34	(ref)	(ref)
35 to 44	−0.08 (−2.7, 2.6)	−0.08 (−2.7, 2.6)
≥45	2.0 (−0.9, 4.9)	2.1 (−0.8, 5.0)
Mother's marital status		
Married	(ref)	(ref)
Not married	−4.0 (−6.0, −2.1)	−4.0 (−6.0, −2.1)
Number of visits to doctors in a previous year		
None	(ref)	(ref)
1	2.8 (0.2, 5.5)	2.9 (0.2, 5.5)
2+	9.4 (7.1, 11.8)	9.4 (7.1, 11.8)
Facility type for teen's vaccination providers		
All private	(ref)	(ref)
All public	−5.9 (−8.3, −3.6)	−5.9 (−8.2, −3.6)
All hospital	−2.5 (−5.9, 1.0)	−2.5 (−5.9, 1.0)
All STD/School/Teen clinic/other	−4.5 (−11.2, 1.7)	−4.8 (−11.2, 1.7)
Mixed	0.5 (−2.1, 3.1)	0.5 (−2.1, 3.1)
Missing	−3.9 (−7.5, −0.3)	−3.9 (−7.5, −0.3)
Medicaid Expansion status		
Not expanded	(ref)	(ref)
Expanded	−1.5 (−5.3, 2.4)	−1.4 (−5.2, 2.5)
Managed Care penetration rate	−1.9 (−6.9, 3.1)	−1.2 (−6.1, 3.7)

[a]Adjusted multivariable regression model also includes adjustment for Medicaid vaccination reimbursements (in US$), state fixed effects for states with reliable data (CO, CT, IA, ID, MA, MI, MN, MO, MS, MT, NH, NM, NV, OK, SC, TX, VT, WY). Medicaid Managed Care penetration rates for children in comprehensive Medicaid plans in states with reliable data were obtained from Medicaid and CHIP Payment and Access Commission (MACPAC) reports.[30] Medicaid expansion status was determined by whether a state expanded Medicaid in each year between 2014-2019. The models also included a random effect at the person level.
Abbreviations: STD, sexually transmitted disease; CI, confidence interval; CPT, current procedural terminology.