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ORIGINAL PAPER

Associations between ACA-related policies and a clinical recommendation with HPV vaccine initiation

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Abstract

Purpose We examined associations between the 2010 Affordable Care Act (ACA) provisions, 2011 Advisory Committee on Immunization Practices (ACIP) recommendation, and 2014 ACA-related health insurance reforms with HPV vaccine initiation rates by sex and health insurance type.

Methods Using 2009–2015 public and private health insurance claims for 551,764 males and females aged 9–26 years (referred to as youth) from Maine, New Hampshire, and Massachusetts, we conducted linear regression models to examine the associations between three policy changes and HPV vaccine initiation rates by sex and health insurance type.

Results In 2009, HPV vaccine initiation rates for males and females were 0.003 and 0.604 per 100 enrollees, respectively. Among males, the 2010 ACA provisions and ACIP recommendation were associated with significant increases in HPV vaccine uptake among those with private plans (0.207 [0.137, 0.278] and 0.419 [0.353, 0.486], respectively) and Medicaid (0.157 [0.083, 0.230] and 0.322 [0.257, 0.386], respectively). Among females, the 2010 ACA provisions were associated with significant increases in HPV vaccine uptake among Medicaid enrollees only (0.123 [0.033, 0.214]). The ACA-related health insurance reforms were associated with significant increases in HPV vaccine uptake for male and female Medicaid enrollees (0.257 [0.137, 0.377] and 0.214 [0.102, 0.327], respectively), but no differences among privately insured youth. By 2015, there were no differences in HPV vaccine initiation rates between males (0.278) and females (0.305).

Conclusions Both ACA provisions and the ACIP recommendation were associated with significant increases in HPV vaccine initiation rates among privately and publicly insured males in three New England states, closing the gender gap. In contrast, females and youth with private insurance did not exhibit the same changes in HPV vaccine uptake over the study period.

Keywords Human papillomavirus · Vaccine · Affordable care act · Policy · Health disparity

Abbreviations

ACA	Patient protection and affordable care act
ACIP	Advisory committee on immunization practices
APCD	All-payer claims database
HPV	Human papillomavirus
MA	Massachusetts
ME	Maine
NH	New Hampshire
VFC	Vaccines for children

Introduction

Human papillomavirus (HPV) vaccination is recommended as an important public health intervention to reduce incidence of and mortality from cervical and other HPV-related cancers [1, 2]. While the Advisory Committee on Immunization Practices (ACIP) has recommended that females receive the HPV vaccine since 2006 [3], it was approved for use in males in 2009 [4]. Although ACIP gave a permissive recommendation for HPV vaccination in males that same year [4], it did not recommend routine vaccination among males until October 2011 [5]. Consequently, surveillance of

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HPV vaccination for males did not begin until the National Immunization Survey-Teen started collecting data in 2010. That year, 48.7% of females received ≥ 1 dose of the HPV vaccine compared to 1.4% of males [6]. In 2014, ACIP recommended that all 11- or 12-year-olds receive the HPV vaccine, with vaccination recommended for females through age 26 years and males through age 21 years [1, 2]. Although HPV vaccine initiation among males has increased as a result of the recommendation [7], uptake remains suboptimal among both groups. Over the past seven years, national vaccination coverage of ≥ 1 dose of the HPV vaccine has increased to 68.6% of females and 62.6% of males [8].

Health care providers, parents, and young women have reported that the financial burden of the HPV vaccine is a major barrier to uptake [9–11]. This barrier was removed for the majority of insured patients in September 2010 when the Patient Protection and Affordable Care Act (ACA) required that non-grandfathered private plans cover some ACIP-recommended vaccines, including the HPV vaccine, with no patient cost sharing (i.e., no out-of-pocket costs, including co-payments, deductibles, or coinsurance) [12]. The dependent care provision came into effect at the same time, which allowed young adults to stay on their parents' private health insurance plans up to age 26 years. Adolescents themselves or their families who qualified for Medicaid in expansion states also gained coverage for the vaccine, with most states expanding coverage in 2014 [13]. Furthermore, for over 20 years, the Vaccines for Children (VFC) Program has provided free vaccines for children ages 18 years and younger who are uninsured, underinsured, eligible for Medicaid, or American Indian or Alaskan Native [14]. Low vaccine uptake may be due to costs for adolescents and young adults with insurance who do not meet plan deductibles or other visit fees [14] as well as parental and adolescent beliefs about the vaccine, including concerns about safety, low perceived risk, and vaccine benefits [9–11]. Youth with no insurance are less likely to initiate HPV vaccination than their insured counterparts [15, 16], but adolescents enrolled in Medicaid are more likely to have ≥ 1 dose of the HPV vaccine than those with private insurance [8].

While there have been increases in HPV vaccine initiation rates over the time period since the ACA has been implemented [6, 8, 17–19], evaluations of the ACA have been limited and conducted only among females. None of the national surveys collected HPV vaccine data on males prior to the ACA. Studies using repeated cross-sectional surveys have found that the 2010 ACA provisions increased the likelihood of HPV vaccine initiation among females [20, 21]. Rates increased independent of insurance status, suggesting that factors other than health insurance may have increased awareness or reduced barriers to uptake [20]. The more recent ACA-related health insurance reforms of 2014 may have increased access to insurance coverage through different mechanisms—for the privately insured as a result of the ban on pre-existing conditions and opening of the insurance Marketplaces, while for publicly insured through Medicaid expansion. However, the effects of the 2010 ACA provisions and ACIP recommendation on HPV vaccine initiation among males and 2014 insurance reforms on uptake among males and females are largely unknown.

The All-Payer Claims Databases (APCDs) from New Hampshire (NH), Maine (ME), and Massachusetts (MA) present unique opportunities to assess the relationships between three policy changes and HPV vaccine uptake as data are available on 9- to 26-year-olds from 2009 to 2015. The aims of this study were to examine associations between the ACA, ACIP recommendation for males, and ACA-related health insurance reforms with HPV vaccine initiation rates by sex as well as to test differences by health insurance type.

Methods

Sample and setting

APCDs are population-based datasets of health insurance claims from most public and private insurers. Currently, APCDs are operational and mandated (non-voluntary) in only 17 states [22]. We obtained health insurance claims data from the APCDs of NH (Comprehensive Health Care Information System), ME (Maine Health Data Organization), and MA (Center for Health Information and Analysis) [22]. These centralized state databases collect health insurance enrollment and claims records for the states' population covered by most insurance categories (Medicaid, Medicare, private). APCDs are mandated by law in NH, ME, and MA, which ensures that most of the privately and publicly insured populations are represented in each state. Insurers' submission requirements are fairly standardized across states, including the collection of consistent data elements in enrollment files and claims records, resulting in similar file structures that allow cross-state analyses. APCD data availability differed across states: January 2009 through June 2015 in ME and NH (for NH there were no public claims available from April 2013 to November 2013 (personal communication with Rose Hess on 17 April 2018)); January 2011 through June 2015 in MA. We restricted the analytic sample for children and young adults from ages 9 to 26 years (referred to as youth). The Boston College Institutional Review Board reviewed this study and considered it exempt.

Outcome variable

We identified 551,764 individuals receiving the HPV vaccine during the study period based on claims associated with Current Procedural Terminology codes 90649 (Gardasil), 90650 (Cervarix), and 90651 (Gardasil 9). As up-to-date HPV vaccination consisted of a series of three shots [1, 2], we used the first claim for each person in order to avoid confounding factors that may affect completion rates differently across states.

State policies

We identified three policy changes related to HPV vaccine uptake during the study period. First, in September 2010, the ACA facilitated dependent care coverage and HPV vaccination without cost sharing. The latter applies to young people enrolled in non-grandfathered private insurance plans and Medicaid expansion plans, but coverage varies by state for traditional Medicaid plans [23]. Second, in October 2011, ACIP recommended that males also receive routine HPV vaccination [5]. Third, in 2014 multiple ACA reforms could influence HPV vaccination by extending access to health insurance coverage: Medicaid expansion in MA (1 January 2014) and NH (15 August 2014), but not ME [24]; introduction of the health insurance Marketplaces as standardized platforms to purchase publicly subsidized health plans [25]; and ban of insurers' rating practices based on pre-existing conditions [26]. We constructed indicator variables for each of these policy changes.

Participant characteristics

Based on information reported in APCD enrollment files, we generated age groups (9–13, 14–18, 19–26 years), sex (male, female), and insurance type (private, Medicaid). Additional participant socio-demographic information, including participant race/ethnicity, was not consistently collected across the APCDs.

Statistical analysis

We constructed the population denominator by state, month, sex, insurance type, and age group of all enrollees aged 9–26 years. We aggregated the individual-level enrollment information in the eligibility files of the APCDs into these categories using the individual characteristics of enrollees and the insurance product type code (private, Medicaid) of a given record. Enrollees may have medical claims listed multiple times if they receive health insurance coverage through more than one source, such as dual eligibility or supplemental coverage. To avoid duplicating enrollees with multiple health insurance contracts, we counted only one eligibility record per individual–insurance product type–month as HPV vaccine guidance recommends spacing doses [2] and participants should not receive multiple HPV vaccine doses within a month. We then aggregated these individual-level enrollment records into monthly enrollee counts. We calculated the rate of HPV vaccinations by state, month, sex, insurance type, and age group per 100 enrollees in each month–state over the study period. We obtained these rates by first aggregating the individual-level claims into the same categories as the denominator. As individuals received their first HPV vaccine dose, they were no longer vaccine naïve and removed from the denominator in the subsequent month. Therefore, we adjusted the denominator for the number of vaccine naïve individuals in each age group–sex–insurance type cohort for each month. We constructed the monthly HPV vaccine initiation rate by dividing the group-specific number of HPV vaccine claims by the respective number of enrollees. The final sample was a panel dataset where each observation corresponded to a state–month pair. To calculate annual average rates across age groups, sex, and insurance type, we constructed group-specific averages from the monthly level data for each year.

We estimated linear regression models to examine the associations between the monthly HPV vaccine initiation rate per 100 enrollees and the ACA preventive care provisions introduced in 2010, the ACIP recommendation for males in 2011, and the ACA's health insurance reforms in 2014. As our primary goal was to detect any differential policy responses between males and females, we initially ran stratified models by sex to identify heterogeneous policy effects, control variables, and state-level outcomes. We then constructed a combined model to reflect these differential impacts across males and females and directly compare estimates. We also aimed to test differential policy responses by insurance type as each policy may have heterogeneous effects based on access to insurance coverage for the privately insured (no co-pay, dependent care provision, ban on pre-existing conditions, opening of the Marketplaces) and Medicaid enrollees (Medicaid expansion). In the final specification we included three-way interactions to decompose the main effects of each policy indicator by sex and insurance type and to estimate differential responses across groups. We controlled for age group and included state fixed effects (i.e., time-invariant variable indicating the state of residence) in all regression models to control for state-level time-invariant factors, such as the overall vaccination rate of the population or social norms. Therefore, the final estimates were obtained from the following regression specification:

$$y_{ist} = \beta_1 male_{ist} + \beta_2 instype_{ist} + \sum_{j=1}^{3} \Upsilon_j Policy_{ist} + \sum_{j=1}^{3} \lambda_j (male_{ist} \times Policy_{ist}) + \sum_{j=1}^{3} \phi_j (instype_{ist} \times Policy_{ist}) + \sum_{j=1}^{3} \psi_j (male_{ist} \times instype_{ist} \times Policy_{ist}) + \delta_s + \theta_i + \epsilon_{ist}$$

where $Policy = (ACA_{2010}, ACIP_{2011}, ACA_{2014})$ are indicator functions which are set to 1 after the respective policy change, $male_{ist}$ and $instype_{ist}$ are indicators for male and Medicaid, δ_s is the state fixed effect, and θ_i is the age category fixed effect.

Due to the large number of parameters in our model and to ease the interpretation of the estimates, we report the stratum-specific average marginal effects based on the interaction terms of interest to determine the percentage point increase or decrease in the HPV vaccine initiation rate following each policy break by sex and insurance type. The average marginal effects describe the rate of change in response to each policy with all other factors held constant. Furthermore, we converted the parameter estimates to predictive margins and tested for statistical significance by sex and insurance type over time using F tests. We conducted analyses using Stata statistical software version 15.1 (StataCorp, College Station, TX) with robust standard errors.

Results

Over the study period, HPV vaccine initiation rates were the highest in the 14–19 years age group and the lowest among those aged 20–26 years (Table 1). Rates were also higher in NH and ME than MA. Decomposing the annual rate by demographic groups revealed substantial differences between males and females. In 2009, prior to the ACA, HPV vaccine initiation rates for males and females were 0.003 and 0.604 per 100 enrollees, respectively. In the following years, male vaccination rates caught up and converged with female rates. By 2015, there were no differences in HPV vaccine rates between males (0.278) and females (0.305) ($p = 0.5$). While the HPV vaccine initiation rate among Medicaid enrollees was lower than the privately insured at the beginning of the study period (0.055 and 0.356, respectively), Medicaid rates converged with private rates by 2015 (0.306 and 0.286, $p = 0.6$). In contrast, rates for females and youth

Table 1 Descriptive statistics of HPV vaccine initiation among 9- to 26-year-olds in Massachusetts, Maine, and New Hampshire (average annual rates per 100 enrollees)

	2009 (95% CI)	2010 (95% CI)	2011 (95% CI)	2012 (95% CI)	2013 (95% CI)	2014 (95% CI)	2015 (95% CI)
Total	0.302 (0.237, 0.366)	0.238 (0.208, 0.267)	0.266 (0.241, 0.291)	0.389 (0.318, 0.459)	0.416 (0.350, 0.482)	0.372 (0.329, 0.415)	0.291 (0.242, 0.339)
State							
Massachusetts	–	–	0.251 (0.229, 0.273)	0.357 (0.287, 0.426)	0.399 (0.330, 0.467)	0.332 (0.295, 0.370)	0.252 (0.209, 0.296)
Maine	0.307 (0.227, 0.388)	0.189 (0.152, 0.225)	0.347 (0.278, 0.416)	0.520 (0.454, 0.585)	0.429 (0.369, 0.489)	0.541 (0.490, 0.593)	0.476 (0.404, 0.547)
New Hampshire	0.298 (0.245, 0.350)	0.278 (0.245, 0.312)	0.328 (0.262, 0.395)	0.596 (0.488, 0.704)	0.623 (0.521, 0.725)	0.750 (0.609, 0.891)	0.687 (0.563, 0.811)
Sex							
Female	0.604 (0.478, 0.730)	0.455 (0.405, 0.505)	0.441 (0.398, 0.484)	0.370 (0.324, 0.415)	0.403 (0.343, 0.463)	0.380 (0.341, 0.418)	0.305 (0.262, 0.348)
Male	0.003 (0.002, 0.004)	0.041 (0.021, 0.061)	0.106 (0.071, 0.141)	0.405 (0.311, 0.500)	0.427 (0.356, 0.499)	0.366 (0.319, 0.412)	0.278 (0.224, 0.332)
Age (years)							
9–13	0.246 (0.213, 0.279)	0.249 (0.203, 0.294)	0.315 (0.284, 0.345)	0.442 (0.369, 0.515)	0.512 (0.417, 0.607)	0.507 (0.437, 0.576)	0.421 (0.337, 0.504)
14–19	0.438 (0.331, 0.544)	0.349 (0.301, 0.396)	0.426 (0.365, 0.488)	0.790 (0.618, 0.963)	0.910 (0.745, 1.075)	0.809 (0.704, 0.913)	0.598 (0.493, 0.702)
20–26	0.196 (0.146, 0.247)	0.109 (0.094, 0.125)	0.124 (0.106, 0.142)	0.114 (0.100, 0.128)	0.116 (0.104, 0.128)	0.101 (0.093, 0.108)	0.081 (0.074, 0.089)
Insurance type							
Private	0.356 (0.284, 0.428)	0.250 (0.214, 0.285)	0.286 (0.256, 0.316)	0.424 (0.340, 0.508)	0.478 (0.396, 0.559)	0.391 (0.342, 0.440)	0.286 (0.233, 0.339)
Medicaid	0.055 (0.022, 0.088)	0.207 (0.168, 0.245)	0.201 (0.188, 0.215)	0.263 (0.233, 0.292)	0.181 (0.166, 0.195)	0.310 (0.275, 0.344)	0.306 (0.268, 0.343)

Enrollment-weighted monthly average rates across states, averaged over year

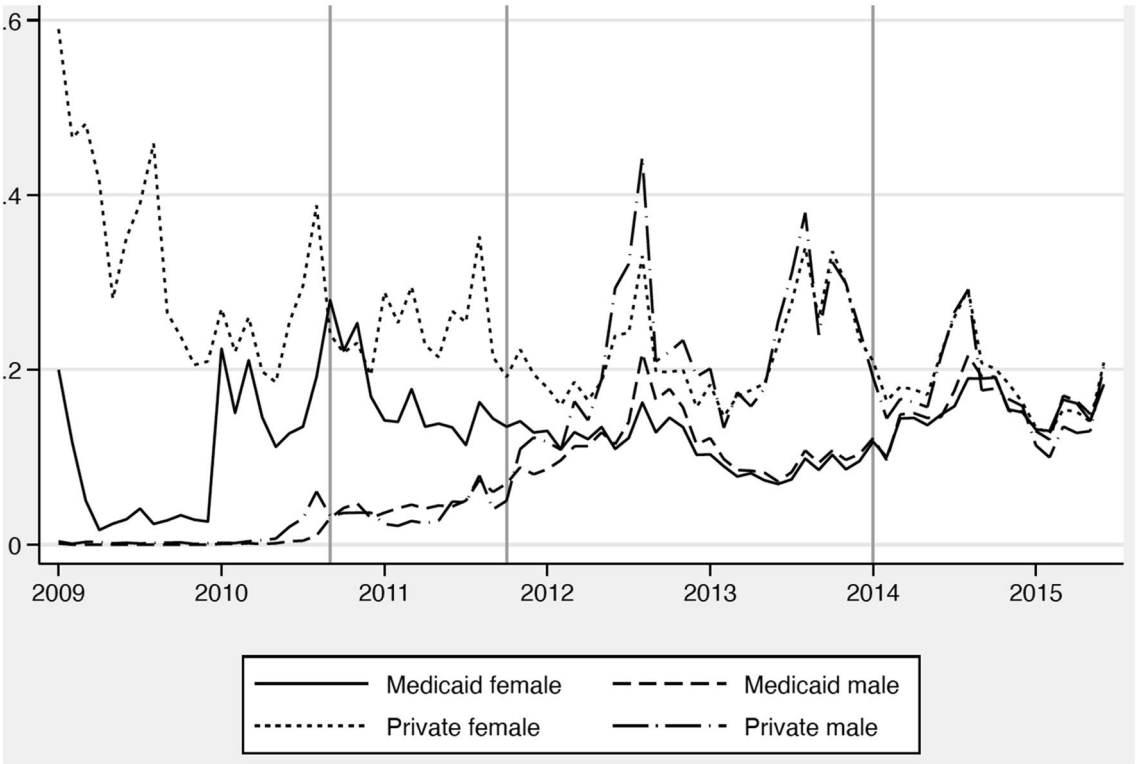

Fig. 1 HPV vaccine initiation rate (per 100 enrollees) by sex and insurance type. The Patient Protection and Affordable Care Act (ACA) came into effect in September 2010; the Advisory Committee on Immunization Practices recommendation for males to receive the HPV vaccine came into effect in October 2011; and ACA-related health insurance reforms came into effect in January 2014 for most states

with private insurance did not exhibit the same increases in HPV vaccine uptake over the study period. Figure 1 presents the trends in monthly vaccination rates (per 100 enrollees) by sex and insurance type, illustrating the closing of the gap in HPV vaccine initiation rates over the study period.

Among males, the ACA's preventive care provisions introduced in 2010 were associated with significant increases in HPV vaccine uptake among those with private insurance by 20.7 percentage points ($p < 0.01$) and with Medicaid by 15.7 percentage points ($p < 0.01$) (Table 2). Among females, the same policy was followed by a significant increase in

Table 2 Marginal effects of the associations between policy changes on HPV vaccine initiation by sex and insurance type*

	ACA no cost sharing and dependent care provisions 2010		ACIP recommendation for males 2011		ACA insurance reforms 2014	
	Marginal effect (95% CI)	*p* value	Marginal effect (95% CI)	*p* value	Marginal effect (95% CI)	*p* value
Male						
Private insurance	0.207 (0.137, 0.278)	< .01	0.419 (0.353, 0.486)†	< .01	0.003 (− 0.061, 0.068)‡	.9
Medicaid	0.157 (0.083, 0.230)	< .01	0.322 (0.257, 0.386)	< .01	0.257 (0.137, 0.377)§	< .01
Female						
Private insurance	− 0.043 (− 0.131, 0.045)	.3	0.099 (0.032, 0.167)	< .01	− 0.046 (− 0.100, 0.008)	.09
Medicaid	0.123 (0.033, 0.214)	.01	0.079 (0.015, 0.143)	.02	0.214 (0.102, 0.327)	< .01

ACA patient protection and affordable care act, *ACIP* advisory committee on immunization practices, *CI* confidence interval

*Model includes interaction between policy breaks, sex, and insurance type; adjusted for age group and state fixed effects

†No statistically significant difference in vaccine initiation rates among males by insurance type ($p = .04$)

‡No statistically significant difference in vaccine initiation rates among the privately insured by sex ($p = .2$)

§No statistically significant difference in vaccine initiation rates among Medicaid enrollees by sex ($p = .6$)

HPV vaccine initiation rates among Medicaid enrollees by 12.3 percentage points ($p=0.01$), but there were no changes in rates for privately insured females ($p=0.3$). While we found that the ACA provisions were associated with significantly higher HPV vaccine initiation rates for both males and females (interaction $p<0.01$), we found no significant differences by insurance type among males ($p=0.3$).

The 2011 ACIP recommendation for males was associated with significant increases in HPV vaccine initiation rates among males with private insurance by 41.9 percentage points ($p<0.01$) and Medicaid by 32.2 percentage points ($p<0.01$), with differences in vaccination rates by insurance types ($p=0.04$). The ACIP recommendation was also associated with increases in HPV vaccine uptake among females with private insurance by 9.9 percentage points and public insurance by 7.9 percentage points ($p<0.01$ and $p=0.02$, respectively).

Overall, we found that the 2014 ACA-related health insurance reforms were associated with increases in uptake for Medicaid enrollees, but no differences among privately insured males and females. Among males and females with Medicaid, HPV vaccine initiation rates significantly increased by 25.7 ($p<0.01$) and 21.4 ($p<0.01$) percentage points, respectively. In contrast, there were no changes in rates among privately insured males and females ($p=0.9$ and $p=0.09$, respectively). Effect sizes were comparable across insurance type for both males and females as there were no differences by sex ($p=0.2$ for privately insured and $p=0.6$ for Medicaid enrollees).

Discussion

Over this period of active policy change, we found that ACA-related policies and a clinical recommendation had differential impacts on HPV vaccine uptake for males and females. Based on our estimates, among males, the HPV vaccine initiation rate increased 135-fold from 2009 before the ACA to 2012 after the ACIP recommendation. Males who were privately insured or on Medicaid benefitted equally by these policies. Among females, the ACA provision significantly increased HPV vaccine initiation rates for Medicaid enrollees and had no effect for those who were privately-insured. We found that females also benefitted by the ACIP recommendation in 2011, such that both the privately- and publicly insured increased HPV vaccine uptake. In contrast, there were differential responses to the 2014 ACA-related health insurance reforms by insurance type and not sex. For males and females, HPV vaccine initiation rates significantly increased among Medicaid enrollees, but had no effect among the privately insured. By the end of the study period in 2015, there was no longer a gap in HPV vaccine uptake between males and females and Medicaid recipients had higher HPV vaccine initiation rates than those with private insurance. Despite these positive gains, we found that HPV vaccine initiation rates among females and youth with private insurance decreased or plateaued over the study period, while rates among males and Medicaid recipients steadily increased. Further research is needed on the longer-term impact of these policies to determine whether increasing rates are sustained among these groups, or whether they plateau after an initial catch-up period.

APCDs are population-based data sources currently operational in only 17 states [22]. Use of APCDs from NH, ME, and MA in this analysis allowed us to compare HPV vaccine initiation rates among privately and publicly insured youth as well as among males and females. Despite data on trends in HPV vaccine initiation over this time of policy change [6, 8, 17–19], previous evaluations have focused on females only. Lipton and Decker found that the 2010 ACA provision increased HPV vaccine initiation by 7.7 percentage points for women ages 19–25 years compared to 18-year-olds and 26-year-olds [21]. Corriero and colleagues found that women aged 9–33 years were 3.3 times more likely to receive the HPV vaccine post-ACA compared to those pre-ACA [20]. Although neither study examined differential uptake in HPV vaccine by insurance status, one study adjusted for insurance in their model [20]. We identified significant differences by insurance type, such that the 2010 ACA provisions increased HPV vaccine initiation rates among Medicaid recipients with no effect among privately insured females. We also found that HPV vaccine initiation rates among females increased as a result of the ACIP recommendation, suggesting that changes in guidelines may have increased awareness among parents and/or providers for all youth. As noted below, these discrepancies could be due to differences in the higher rate of HPV vaccine initiation among youth in these three New England states than nationally [8], access to vaccines, and social norms related to vaccination uptake. We also found that both privately and publicly insured males significantly increased HPV vaccine initiation in response to the 2010 ACA provisions and ACIP recommendation, which is consistent with a rise in male HPV vaccination over this time period [7].

While earlier studies of nationally representative samples of youth did not include state fixed effects, we used population-level data from three New England states which, as a region, have the highest prevalence of HPV vaccine initiation in the country [8]. Differences in results may be due to variations in vaccine access, social norms related to vaccination, and health care practices related to insurance type. Despite high levels of HPV vaccination in the region, we still found significant associations between policy changes and HPV vaccine initiation rates, specifically among males. This suggests that our effect sizes may underestimate the true impact of the ACA policy changes

and ACIP recommendation on HPV vaccine initiation for regions with a lower prevalence of HPV vaccination. Furthermore, we are not aware of prior evaluations of the ACA insurance reforms in 2014 on HPV vaccine initiation. Using APCD data through 2015, our study provides some of the first evidence of the effects of Medicaid expansion and Marketplace insurance on HPV vaccine uptake among males and females. While we found that publicly insured males and females significantly increased HPV vaccine initiation rates in response to Medicaid expansion, introduction of Marketplace insurance had no effect on vaccine uptake among privately insured youth. Research in other populations is needed to corroborate our findings, particularly the longer-term effects of ACA policies among privately insured males and females.

HPV vaccine uptake remains suboptimal among US adolescents and young adults [8]. Cost, parental attitudes toward vaccination, perceived risks and benefits, and provider recommendations are the most common barriers hindering HPV vaccine uptake [9–11]. Although the ACA, VFC, and other public funding initiatives should provide a safety net by reducing financial concerns [13, 14], the HPV vaccine is still considered voluntary. Only Rhode Island, Virginia, and Washington, DC have HPV vaccine mandates in middle school [13]. An evaluation of the Rhode Island school mandate found that HPV vaccine initiation in boys significantly increased compared to boys in control states, but there were no differences in uptake among girls [27]. In 2017, Washington, DC (91.9%) and Rhode Island (88.6%) had the highest overall point estimates of HPV vaccine initiation across all states [8]. Nationally, the current prevalence of HPV vaccine initiation is below 70% for males and females [8], which is suboptimal for herd immunity [28]. Taken together, expanding Medicaid in the 14 remaining states [24] and school mandates may continue to reduce the gender gap in HPV vaccine initiation across the US as well as increase uptake overall.

Our study has several limitations. We did not include uninsured youth as APCDs only record health insurance claims among enrollees with private or public insurance. Furthermore, there are known racial/ethnic disparities in HPV vaccine uptake, such that young Black women are less likely to initiate HPV vaccination than young white women [15]. However, health insurance claims do not routinely collect race/ethnicity information on members and was not consistently recorded across the APCDs, so we were not able to assess disparities in HPV vaccine initiation. One of the eligibility criteria of the VFC program is that children can be underinsured, meaning they have insurance but it does not cover the HPV vaccine or does but has a fixed dollar limit for vaccines and children are ineligible after that cap is reached [14]. Since the federal government purchases the vaccine through the VFC program, Medicaid pays for the vaccine administration fee, which varies by state, but there is no fee for the cost of the vaccine itself [29]. Children who are underinsured and receive the vaccine through the VFC program would not have their claim recorded in the APCD, despite having insurance, which may underestimate the true HPV vaccine initiation rate. Although public claims for NH are not available from April–November 2013, there were two years of data post-ACIP recommendation for males in October 2011 and nearly one year of data pre-Medicaid expansion in mid-August 2014. As the modeling approach utilized all existing data, we anticipate these missing months had minimal effects on our estimates. Lastly, even though we adjusted our denominator for the number of vaccine naïve individuals, we do not observe the full history of claims and cannot identify those who were vaccinated prior to the study period. Thus, our HPV vaccine initiation rates should not be compared to state estimates of HPV vaccine uptake.

In conclusion, we found that both ACA provisions and the ACIP recommendation were associated with significant increases in HPV vaccine initiation rates among males in NH, MA, and ME, closing the gender gap. In contrast, females and youth on private insurance did not exhibit the same changes in HPV vaccine uptake over the study period. Further research is needed to examine whether these policy effects translate to other states as well as their longer-term impacts on HPV vaccine initiation and completion of the vaccine series.

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Data availability The All-Payer Claims Databases are available by application from state agencies and cannot be provided upon request.

Declarations

Conflict of interest All the authors have no conflict of interest relevant to this article to disclose.

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