Technical Appendix A.1: Regression Specification and Full Regression Results

Our regression specification was of the following form:

$$Y_{it} = \beta_1 Age_i^{19-25} + \beta_2 Post_t + \beta_3 Age_i^{19-25} \times Post_t + \beta_4 X_i + \epsilon_{it}$$

Where Y_{it} represents the outcome variable of interest for individual *i* at time *t*, Age_i^{19-25} is a dummy variable indicating whether an individual was in the 19-25 year age group, $Post_t$ is a dummy variable indicating an interview date after October 1, 2010 (unless the outcome was vaccine completion, in which case this dummy variable indicated an interview date after April 1, 2011), and X_i is a vector of demographic characteristics. The coefficient estimate, $\widehat{\beta_3}$, represents the difference-in-difference estimate of the effect of policy implementation for 19-25-year-olds relative to 18 or 26 year-olds. Exhibit A.1 shows the full set of coefficient estimates for each of our outcome variables.

The interpretation of our estimates rests on the assumption that trends in outcomes did not differ between 19-25 year olds and 18 or 26 year olds *prior* to policy implementation. To test whether this criterion was met, we used data before October 1, 2010 to estimate each outcome as a function of a binary variable equal to one for 19-25 year olds and zero otherwise, year fixed effects, and interactions between the year variables and the variable indicating that an individual was age 19-25. We conducted an F-test of the joint significance these interactions, which implied there were no significant differences in outcome trends between 19-25-year-olds and 18 or 26 year-olds prior to policy implementation. Analogous tests comparing 19-25-year-olds with 18-year-olds, or alternatively, 26-year-olds were also insignificant.

Exhibit A.1.1: Percentage point change in HPV awareness and vaccination: Full regression results[a]

	Outcome			
	Knowledge		Vaccination Status	
Explanatory Variables	Heard of HPV	Heard of HPV Vaccine	Vaccine Initiation	Vaccine Completion
Post	0.48	0.64	-0.85	-1.51
	(-5.24, 6.20)	(-5.75, 7.03)	(-8.01, 6.30)	(-7.59, 4.57)
Age_{19-25}	0.84	1.20	-2.94	-2.22
	(-3.35, 5.02)	(-3.11, 5.51)	(-6.90, 1.01)	(-5.13, 0.70)
Age_{19-25} x Post	-0.12	1.75	7.69***	5.83**
	(-4.63, 4.40)	(-3.08, 6.59)	(2.26, 13.11)	(1.02, 10.63)
Age 18	-5.80***	0.00	20.41***	13.37***
	(-9.87, -1.37)	(-4.37, 4.37)	(15.26, 25.56)	(8.73, 18.01)
Age 19	-5.80***	-3.59	16.02***	9.18***
	(-10.09, -1.51)	(-8.03, 0.85)	(11.50, 20.53)	(5.29, 13.06)
Age 20	-4.55**	-3.37	13.65***	8.31***
	(-8.68, -0.42)	(-7.72, 0.97)	(9.00, 18.30)	(4.40, 12.22)
Age 21	-2.22	-2.55	6.74***	3.90***
	(-6.35, 1.90)	(-6.92, 1.81)	(2.98, 10.51)	(0.92, 6.88)
Age 22	-1.81	-1.80	3.41*	2.35
	(-5.37, 1.75)	(-5.76, 2.15)	(-0.51, 7.33)	(-0.79, 5.48)
Age 23	-0.41	-3.68*	0.36	0.49
	(-3.93, 3.11)	(-7.67, 0.31)	(-3.36, 4.09)	(-2.46, 3.43)
Age 24	-3.53*	-5.07**	-0.12	0.39
	(-7.47, 0.40)	(-9.13, -1.00)	(-3.56, 3.31)	(-2.18, 2.96)
Married	-6.50***	-5.82***	-9.57***	-8.49***
	(-9.08, -3.92)	(-8.64, -3.00)	(-11.91, -7.23)	(-10.07, -6.92)
Black	-14.11***	-15.51***	-8.96***	-11.18***
	(-17.13, -11.09)	(-18.68, -12.34)	(-11.79, -6.13)	(-13.39, -8.96)
Hispanic	-21.86***	-27.41***	-13.18***	-10.50***
	(-24.76, -18.97)	(-30.54, -24.29)	(-15.87, -10.48)	(-12.59, -8.41)
Asian/Other	-27.08***	-28.08***	-10.64***	-8.29***
	(-32.20, -21.96)	(-33.06, -23.09)	(-14.27, -7.02)	(-11.18, -5.40)
West	-2.32	-1.97	3.27*	1.27
	(-5.15, 0.52)	(-5.12, 1.18)	(-0.32 6.86)	(-1.66, 4.20)
Northeast	-5.09***	-4.63**	6.04***	3.63**
	(-8.58, -1.59)	(-8.29, -0.96)	(2.22, 9.87)	(0.19, 7.07)
South	-2.92**	-2.19	-1.94	-0.89
	(-5.49, -0.34)	(-5.04, 0.67)	(-4.91, 1.03)	(-3.38, 1.61)
Urban	2.91*	2.94*	5.97***	3.77***
	(-0.16, 5.99)	(-0.27, 6.15)	(2.77, 9.17)	(1.10, 6.45)
Excellent Health	0.50	3.30**	2.80**	4.05***
	(-2.07, 3.06)	(0.51, 6.09)	(0.29, 5.31)	(1.95, 6.15)
Very Good Health	2.43*	5.17***	-0.17	1.72
	(-0.08, 4.94)	(2.48, 7.86)	(-2.78, 2.45)	(-0.45, 3.88)
Year 2008	-6.66**	-2.32	-17.86***	-12.17***
	(-12.48, -0.84)	(-9.03, 4.38)	(-24.58, -11.13)	(-17.63, -6.71)
Year 2009	0.05	6.59**	-10.82***	-6.84**
	(-5.62, 5.73)	(0.15, 13.03)	(-17.72, -3.92)	(-12.45, -1.23)
Year 2010	-1.22	0.18	-7.95***	-5.22*
	(-5.74, 3.30)	(-5.11, 5.47)	(-13.74, -2.16)	(-10.81, 0.38)
Year 2011	1.33	-0.65	-4.97***	-4.24***
	(-1.45, 4.11)	(-3.84, 2.54)	(-8.35, -1.60)	(-7.47, -1.02)

[a] Source: Authors' analysis of the National Health Interview Survey 2008-2012. Percentage point changes were estimated using linear probability models. Sample size included 10,010 women aged 18-26. Controls included age fixed effects, race/ethnicity, marital status, health status, region of residence, an urban area indicator, and year fixed effects. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Technical Appendix A.2: Difference-in-difference estimates by insurance status

Exhibit A.2.1: Difference-in-difference estimates by insurance status: age 19-25 vs. 18 or 26[a]

	Vaccination Status	
	Vaccine initiation	Vaccine completion[b]
Insured	8.62***	5.93**
	(2.25, 14.99)	(0.08, 11.79)
Uninsured	0.62	1.83
	(-7.03, 8.27)	(-3.08, 6.73)

[a] Source: Authors' analysis of the National Health Interview Survey 2008-2012. Percentage point changes were estimated using linear probability models. Insured sample included 5,954 insured 19-25-year-old women and 1,588 18 or 26 year-old insured women. Uninsured sample included 2,025 19-25-year-old uninsured women and 448 18 or 26 year-old uninsured women. Controls included fixed effects for single years of age, race/ethnicity, marital status, health status, region of residence, an urban area indicator and year fixed effects. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are in parentheses below each estimate. The difference-in-difference estimate is the coefficient on the interaction between the binary variable indicating an interview date after policy implementation and the binary variable indicating that an individual was in the 19-25 year age group.

[b] In regressions with vaccine completion as an outcome variable, the binary explanatory variable indicating an interview date after policy implementation was equal to one for interview dates after April 1, 2011 instead of October 1, 2010. An individual was considered to have completed the three dose vaccine series if she reported receipt of three or more doses of the vaccine.

Technical Appendix A.3: Computation of the Effect of Changes in Coverage Generosity vs. Increases in the Percentage with Any Insurance Coverage

The following will describe the computation for vaccine initiation, but the computation is analogous for vaccine completion. The difference-in-difference estimate of the increase in vaccine initiation due to changes in insurance coverage generosity that we would like to estimate can be written as follows:

$$DD^{PI} = [PI^{Post} - PI^{Pre}] - [Control^{Post} - Control^{Pre}]$$

Where PI denotes vaccine initiation among 19-25 year olds insured in the post-period that would have been insured even in the absence of the policy (previously insured), Control denotes vaccine initiation among the control group of 18 or 26 year-olds, Post denotes the post-policy period, and Pre denotes the pre-policy period. This difference-in-difference estimate represents the effect of the increase in coverage generosity on the previously insured.

However, because we do not know which individuals insured in the post-policy period were previously insured, it is not possible to estimate DD^{PI} directly. Instead, we estimate the regression above including all insured individuals and estimate an effect of 8.6 percentage points (see Exhibit 4, Panel A), which can be expressed as follows:

$$8.6 = DD^{I} = [I^{Post} - I^{Pre}] - [Control^{Post} - Control^{Pre}]$$

Where I stands for vaccine initiation among all insured 19-25 year-olds. Since 73.7% of individuals aged 19-25 were insured in the pre-period (Exhibit 1) and 77.9% were insured in the post-period based on our calculations from NHIS, approximately 94.6% (=73.7/77.9) of individuals aged 19-25 insured in the post-period would have been insured in the absence of the policy. This implies that:

$$I^{Post} = 0.946PI^{Post} + 0.054NI^{Post}$$

where NI represents 19-25 year olds insured in the post-implementation period who would not have been insured in the absence of the policy (i.e., newly insured). (As before, PI represents 19-25 year olds insured in the post-implementation period who would have been insured even in the absence of the policy.) Using this relationship and the fact that $I^{Pre} = PI^{Pre}$ since the insured in the pre-period are only comprised of the "previously insured," the above estimated effect (DD^{I}) can be expressed as follows:

$$DD^{I} = [(0.946PI^{Post} + 0.054NI^{Post}) - PI^{Pre}] - [Control^{Post} - Control^{Pre}]$$

Adding and subtracting $0.054PI^{Post}$ and rearranging terms yields:

$$= [PI^{Post} - PI^{Pre}] - [Control^{Post} - Control^{Pre}] + 0.054[NI^{Post} - PI^{Post}]$$

$$= DD^{PI} + 0.054[NI - PI]^{Post}$$

It can be seen from the above expression that if the newly insured and previously insured had the same vaccine uptake in the post-implementation period (i.e., $NI^{Post} = PI^{Post}$), then $DD^{I} = DD^{PI}$. If the newly and previously insured have different vaccine uptake in the post-implementation period, it is possible to solve for DD^{PI} if an assumption is made about the size of vaccine initiation among the newly insured relative to the previously insured in the post-implementation period. We compute bounds on the effect of coverage generosity on vaccine uptake by first assuming that $NI^{Post} = 2 \times PI^{Post}$ and then assuming that $NI^{Post} = 1/2 \times PI^{Post}$.

We will use the following two expressions along with our assumption about the size of vaccine initiation among the newly insured relative to the previously insured:

$$DD^{I} = DD^{PI} + 0.054[NI - PI]^{Post} \qquad (1)$$

$$I^{Post} = 0.054NI^{Post} + 0.946PI^{Post} \qquad (2)$$

Where expressions (1) and (2) were derived above. Note that vaccine initiation among the total insured population post-policy is observed while vaccine initiation among the newly and previously insured post-policy are unobserved

Case 1: $NI^{Post} = 2 \times PI^{Post}$

Under the given assumption, expression (1) can be written as follows:

$$DD^{I} = DD^{PI} + 0.054PI^{Post}$$

Expression (2) can be written as:

$$I^{Post} = 1.054PI^{Post}$$

Vaccine initiation among the total insured 19-25 year-old population post-policy (i.e., I^{Post}) is observed. We estimate that approximately 36.7% of insured 19-25 year-olds had initiated the vaccine post-policy, which allows us to solve for PI^{Post} = 34.9 percent. Plugging PI^{Post} = 34.9 percent and DD^{I} = 8.6 into expression (1) allows us to solve for DD^{PI} = 6.8 percentage points. Because approximately 73.8% of women aged 19-25 were insured pre-policy, this estimate would imply that 5.0 percentage points (0.738 x 6.8) of the effect of the policy on vaccine initiation was due to the increase in coverage generosity among the previously insured. Compared with the estimated effect of the policy on the full sample (7.7 percentage points, Exhibit 3), this estimate implies a 2.7 percentage point effect of the policy due to the increase in the percentage with any source of insurance coverage.

Case 2: $NI^{Post} = 1/2 \times PI^{Post}$

Under the given assumption, expression (1) can be written as follows:

$$DD^{I} = DD^{PI} - 0.027PI^{Post}$$

Expression (2) can be written as:

$$I^{Post} = 0.973PI^{Post}$$

Vaccine initiation among the total insured 19-25 year-old population post-policy (i.e., I^{Post}) is observed. We estimate that approximately 36.7% of insured 19-25 year-olds had initiated the vaccine post-policy, which allows us to solve for PI^{Post} = 37.7 percent. Plugging PI^{Post} = 37.7 percent and DD^{I} = 8.6 into expression (1) allows us to solve for DD^{PI} = 9.6 percentage points. Because approximately 73.8% of women aged 19-25 were insured pre-policy, this estimate would imply that 7.1 percentage points (0.738 x 9.6) of the effect of the policy on vaccine initiation was due to the increase in coverage generosity among the previously insured. Compared with the estimated effect of the policy on the full sample (7.7 percentage points, Exhibit 3), this estimate implies a 0.6 percentage point effect of the policy due to the increase in the percentage with any insurance coverage.