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Supplemental Table 1. HPV vaccine-related questions and responses included in the household interview for female and male participants aged 9-59 years (NHANES, 2011-2016).

Supplemental Table 2. Inadequate responses to the HPV vaccine section of the interview among female and male participants aged 9-26 years (NHANES, 2011-2016).

Supplemental Table 3. Factors associated with inadequate HPV vaccine data among female and male participants aged 9-26 years (NHANES, 2011-2016).

Supplemental Table 4. Age- and race-specific prevalence of inadequate HPV vaccination data over time among males and females aged 9-26 years (NHANES, 2011-2016).

Supplemental Table 5. Prevalence difference in HPV vaccination (≥1 dose) among male and female participants aged 9-26 years between 2011-2012 and 2015-2016 (NHANES).

Supplemental Table 6. Sensitivity analysis: comparison of temporal trends in HPV vaccination (≥1 dose) using complete case and imputation methods for inadequate HPV vaccine data (NHANES, 2011-2016).

Supplemental Table 7. Sensitivity analysis: temporal trends in the percentage of males and females who initiated the HPV vaccine (≥1 dose) prior to their 27th birthday among participants aged 9-59 years (NHANES, 2011-2016).

Supplemental Figure 1. Sensitivity analysis: Comparison of estimates for HPV vaccination (≥1 dose) among participants 13-17 years of age in the NHANES database and the National Immunization Survey—Teen database (2011-2016).

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Supplemental Table 1. **HPV vaccine-related questions and responses included in the household interview for female and male participants aged 9-59 years (NHANES, 2011-2016).**

Variable	Question	Responses
NHANES 2011-2014		
IMQ040 (Females)	Human Papillomavirus (HPV) vaccine is given to prevent cervical cancer in girls and women. There are two HPV vaccines available called Cervarix and Gardasil. It is given in 3 separate doses over a 6-month period. {Have you/Has SP} ever received one or more doses of the HPV vaccine?	1 Yes 2 No 7 Refused 9 Don't know
IMQ070 (Males)	Human Papillomavirus (HPV) vaccine is given to prevent HPV infection and genital warts in boys and men. It is given in 3 separate doses over a 6-month period. {Have you/Has SP} ever received one or more doses of the HPV vaccine? (The brand name for the vaccine is Gardasil.)	1 Yes 2 No 7 Refused 9 Don't know
IMQ090 (Males and Females)	How old {were you/was SP} when {you/SP} received your first dose of {Cervarix/Gardasil/the vaccine}?	(range) 777 Refused 999 Don't know
IMQ045 (Males and Females)	How many doses of {Cervarix/Gardasil/the vaccine} {have you/has SP} received?	1 Dose 2 Doses 3 Doses 7 Refused 9 Don't know
NHANES 2015-2016		
IMQ060 (Females)	Human Papillomavirus (HPV) vaccine is given to prevent cervical cancer in girls and women. The HPV vaccines available are called Cervarix, Gardasil or Gardasil 9. It is given in 3 separate doses over a 6-month period. {Have you/Has SP} ever received one or more doses of the HPV vaccine?	1 Yes 2 No 7 Refused 9 Don't know
IMQ070 (Males)	Human Papillomavirus (HPV) vaccine is given to prevent HPV infection and genital warts in boys and men. It is given in 3 separate doses over a 6-month period. {Have you/Has SP} ever received one or more doses of the HPV vaccine? (The brand name for the vaccine is Gardasil.)	1 Yes 2 No 7 Refused 9 Don't know
IMQ090 (Males and Females)	How old {were you/was SP} when {you/SP} received your first dose of {Cervarix/Gardasil/Gardasil 9/Gardasil or Gardasil 9/the vaccine}?	(range) 777 Refused 999 Don't know
IMQ100 (Males and Females)	How many doses of {Cervarix/Gardasil/Gardasil or Gardasil 9/the vaccine} {have you/has SP} received?	1 Dose 2 Doses 3 Doses 7 Refused 9 Don't know

Supplemental Table 2. Inadequate responses to the HPV vaccine section of the interview among female and male participants aged 9-26 years (NHANES, 2011-2016).

	Overall	2011-2012	2013-2014	2015-2016
Females (IMQ040/IMQ60)	N=4033	N=1304	N=1405	N=1324
Refused to answer	5 (0.1%)	2 (0.2%)	0 (0.0%)	3 (0.2%)
Don't know	246 (6.1%)	69 (5.3%)	72 (5.1%)	105 (7.9%)
No information	2 (0.1%)	0 (0.0%)	2 (0.1%)	0 (0.0%)
Males (IMQ070)	N=4007	N=1320	N=1388	N=1299
Refused to answer	3 (0.1%)	0 (0.0%)	0 (0.0%)	3 (0.2%)
Don't know	413 (10.3%)	105 (8.0%)	138 (9.9%)	170 (13.1%)
No information	3 (0.1%)	1 (0.1%)	2 (0.1%)	0 (0.0%)

Note: Data are unweighted sample sizes (N) and unweighted column percentages (no. [%]). Participants with an inadequate response to the HPV section of the interview were treated as "missing" in the primary analysis.

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Supplemental Table 3. Factors associated with inadequate HPV vaccine data among female and male participants aged 9-26 years (NHANES, 2011-2016).

	Females			Males		
	N	% (95% CI)	*P* value	N	% (95% CI)	*P* value
Survey period			0.208			0.173
2011–2012	1304	4.0 (2.7-5.8)		1320	8.4 (5.1-13.5)	
2013–2014	1405	4.9 (3.4-7.1)		1388	10.7 (9.3-12.3)	
2015–2016	1324	6.0 (4.8-7.6)		1299	12.6 (10.6-15.0)	
Age group, y			0.117			**<0.001**
9-10	638	4.7 (3.2-6.8)		650	6.8 (4.8-9.6)	
11-12	603	5.3 (3.4-8.1)		581	5.4 (3.4-8.4)	
13-17	1273	4.2 (3.0-5.8)		1299	8.6 (6.9-10.8)	
18-21	747	7.0 (5.0-9.6)		750	13.8 (10.0-18.8)	
22-26	772	4.4 (3.0-6.3)		727	13.6 (11.0-16.7)	
Race/ethnicity			**<0.001**			**0.008**
Non-Hispanic white	1085	3.4 (2.4-4.7)		1133	9.9 (7.9-12.3)	
Non-Hispanic Black	1005	5.5 (3.9-7.8)		1017	10.9 (8.2-14.2)	
Non-Hispanic Asian	439	8.6 (5.9-12.5)		488	16.8 (13.3-21.0)	
Mexican American	799	7.7 (5.4-10.9)		745	10.9 (8.1-14.4)	
Other Hispanic	475	8.0 (5.4-11.8)		414	13.6 (9.8-18.6)	
Multiracial/Other	230	5.4 (2.8-10.3)		210	4.6 (2.7-7.5)	
Health insurance			**0.009**			0.113
Yes – Private	1674	3.5 (2.4-4.9)		1706	9.8 (7.8-12.3)	
Yes – Medicaid	1176	6.6 (4.9-8.8)		1051	8.7 (6.6-11.3)	
Yes – Other Public/Gov't	558	6.1 (3.8-9.7)		550	14.6 (9.7-21.5)	
No health insurance	616	6.9 (4.8-9.6)		687	11.8 (9.1-15.1)	
Poverty status			**0.024**			0.701
At or above poverty level	2429	4.0 (3.1-5.3)		2465	10.2 (8.9-11.7)	
Below poverty level	1288	6.1 (4.6-8.0)		1188	11.0 (7.5-15.8)	
Immigration status			**<0.001**			**0.017**
U.S. born	3473	4.5 (3.6-5.5)		3469	10.2 (8.8-11.9)	
Foreign born	559	9.8 (7.0-13.6)		538	14.0 (10.8-18.0)	

Note: N refers to the unweighted sample size. Data are weighted row percentages and 95% confidence intervals (CI) of participants with inadequate HPV vaccine data (i.e., individuals excluded from the primary analysis). *P* values were estimated by Pearson (Rao-Scott) χ^2 tests.

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Supplemental Table 4. **Age- and race-specific prevalence of inadequate HPV vaccination data over time among males and females aged 9-26 years (NHANES, 2011-2016).**

	2011-2012		2013-2014		2015-2016	
	N	% (95%CI)	N	% (95%CI)	N	% (95%CI)
Females						
Age group, y						
9-10	207	4.0 (2.1-7.4)	204	4.8 (2.3-9.6)	227	5.3 (3.0-9.2)
11-12	202	3.7 (1.6-8.7)	202	4.9 (1.9-11.8)	199	7.2 (4.0-12.8)
13-17	398	1.9 (1.0-3.5)	454	5.8 (3.8-9.0)	421	5.0 (2.8-8.7)
18-21	249	6.7 (3.6-12.0)	292	5.7 (3.2-10.0)	206	9.2 (5.5-15.1)
22-26	248	4.4 (2.1-8.7)	253	3.5 (2.0-6.0)	271	5.3 (2.9-9.4)
Race/ethnicity						
NH White	316	2.4 (1.2-4.8)	396	4.4 (2.7-7.3)	373	3.3 (1.9-5.8)
NH Black	397	4.7 (2.9-7.5)	334	3.8 (1.8-8.1)	274	8.3 (4.7-14.4)
NH Asian	172	10.1 (6.0-16.6)	141	2.1 (0.6-6.8)	126	13.4 (8.6-20.2)
Mexican American	195	4.0 (1.9-8.3)	310	7.2 (3.9-12.9)	294	11.5 (6.8-18.7)
Other Hispanic	153	7.4 (3.2-16.3)	143	8.2 (3.9-16.5)	179	8.5 (5.4-13.3)
Multiracial/Other	71	7.9 (2.2-24.5)	81	4.8 (1.8-12.5)	78	4.0 (1.6-9.5)
Males						
Age group, y						
9-10	214	3.8 (2.1-6.8)	232	6.7 (3.4-13.0)	204	9.9 (5.8-16.5)
11-12	178	3.0 (0.9-9.0)	214	6.5 (3.3-12.5)	189	6.6 (3.1-13.5)
13-17	409	7.7 (4.6-12.5)	441	8.3 (6.1-11.3)	449	9.7 (6.8-13.6)
18-21	280	13.7 (6.7-25.8)	258	14.7 (10.2-20.7)	212	12.8 (7.6-20.7)
22-26	239	8.2 (4.1-15.7)	243	13.0 (8.9-18.5)	245	18.2 (13.9-23.6)
Race/ethnicity						
NH White	336	8.3 (4.1-16.1)	420	10.2 (8.2-12.6)	377	11.2 (8.6-14.3)
NH Black	376	9.7 (4.4-19.8)	344	9.1 (6.2-13.2)	297	13.9 (9.7-19.4)
NH Asian	195	13.9 (9.5-19.8)	131	14.0 (7.9-23.6)	162	21.8 (16.1-28.8)
Mexican American	218	6.4 (3.3-12.0)	280	12.0 (7.5-18.7)	247	14.1 (9.2-20.8)
Other Hispanic	129	8.2 (3.6-17.7)	137	16.1 (9.4-26.2)	148	16.5 (11.4-23.4)
Multiracial/Other	66	5.6 (3.0-10.4)	76	4.8 (1.5-14.0)	68	3.4 (1.3-8.6)

Note: N refers to the unweighted sample size. Data are weighted row percentages and 95% confidence intervals (CI) of participants with inadequate HPV vaccine data (i.e., individuals excluded from the primary analysis).

<u>Supplemental Table 5.</u> Prevalence difference in HPV vaccination (≥1 dose) among male and female participants aged 9-26 years between 2011-2012 and 2015-2016 (NHANES).

	PD (95% CI)	P-value	aPD (95% CI)	P-value
<u>Females</u>				
Age group, y				
9-10	0.0 (-4.0, 4.0)	0.890	-0.1 (-4.4, 3.2)	0.748
11-12	5.5 (-7.9, 18.9)	0.411	6.1 (-7.0, 19.2)	0.351
13-17	-2.0 (-13.8, 10.1)	0.757	-4.5 (-17.9, 8.9)	0.503
18-21	13.1 (-0.03, 26.5)	0.054	11.4 (-2.2, 24.9)	0.099
22-26	20.6 (8.5, 32.7)	**0.001**	19.4 (7.8, 31.1)	**0.002**
<u>Males</u>				
Age group, y				
9-10	2.7 (-4.5, 9.9)	0.459	5.5 (0.0, 10.9)	**0.050**
11-12	16.5 (6.1, 27.0)	**0.003**	16.9 (5.3, 28.5)	**0.005**
13-17	29.8 (19.8, 39.7)	**<0.001**	30.3 (20.6, 40.0)	**<0.001**
18-21	23.4 (11.8, 34.9)	**<0.001**	22.1 (11.0, 33.2)	**<0.001**
22-26	14.0 (4.9, 23.1)	**0.003**	10.7 (3.3, 18.1)	**0.005**

Weighted prevalence differences (PD) represent the change in prevalence of HPV vaccination between the 2011-2012 period (reference) and the 2015-2016 period for a given age-group. Each age-stratified multivariable model included study year, race/ethnicity, health insurance status, poverty status, and immigration status.

Supplemental Table 6. Sensitivity analysis: comparison of temporal trends in HPV vaccination (≥1 dose) using complete case and multiple imputation methods for inadequate HPV vaccination data (NHANES, 2011-2016).

	2011-2012		2013-2014		2015-2016		P_{trend}[c]
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)	
Females							
Complete case analysis [a]							
Overall	1233	37.7 (33.8-41.7)	1331	38.7 (33.1-44.6)	1216	45.7 (41.3-50.1)	**0.010**
Age group, y							
9-10	194	5.0 (2.9-8.6)	196	2.6 (1.4-4.6)	213	4.8 (2.7-8.2)	0.909
11-12	191	22.7 (13.5-35.6)	190	22.0 (16.6-28.6)	179	28.2 (21.3-36.3)	0.412
13-17	384	56.4 (46.9-65.6)	432	49.5 (40.5-58.5)	391	54.6 (47.2-61.7)	0.743
18-21	229	40.6 (31.4-50.5)	269	50.6 (41.2-60.0)	181	53.7 (44.4-62.7)	**0.050**
22-26	235	33.6 (24.8-43.7)	244	36.9 (29.3-45.2)	252	54.2 (46.7-61.5)	**0.001**
Multiple imputation [b]							
Overall	1304	38.0 (34.3-41.8)	1405	38.8 (33.2-44.3)	1324	46.0 (41.6-50.5)	**0.009**
Age group, y							
9-10	207	5.3 (2.1-8.6)	204	4.0 (0.8-7.2)	227	6.6 (3.0-10.2)	0.603
11-12	202	23.5 (12.3-34.7)	202	21.9 (15.0-28.8)	199	29.4 (21.4-37.4)	0.394
13-17	387	56.9 (49.0-64.8)	454	48.8 (39.6-57.9)	421	54.3 (47.2-61.4)	0.623
18-21	249	40.2 (31.2-49.3)	292	50.6 (41.2-60.0)	206	51.9 (42.8-61.0)	0.066
22-26	248	34.8 (24.8-44.7)	253	37.9 (30.2-45.6)	271	54.9 (47.6-62.3)	**0.002**
Males							
Complete case analysis [a]							
Overall	1214	7.8 (6.0-10.2)	1248	19.7 (17.5-22.3)	1126	27.4 (23.3-31.9)	**<0.001**
Age group, y							
9-10	202	4.8 (1.6-13.9)	214	4.4 (2.5-7.6)	177	7.5 (3.9-14.0)	0.470
11-12	171	13.6 (9.0-20.0)	198	25.0 (17.5-34.4)	174	30.1 (22.0-39.7)	**0.003**
13-17	377	10.8 (7.1-16.2)	406	29.5 (24.1-35.6)	400	40.6 (32.0-49.7)	**<0.001**
18-21	243	8.2 (4.2-15.2)	219	23.3 (18.0-29.5)	175	31.5 (22.2-42.5)	**<0.001**
22-26	221	2.8 (1.6-4.8)	211	11.7 (8.5-15.8)	200	16.8 (9.6-27.8)	**0.004**
Multiple imputation [b]							
Overall	1320	8.4 (6.3-10.6)	1388	20.0 (17.1-23.0)	1299	27.3 (23.3-31.3)	**<0.001**
Age group, y							
9-10	214	5.4 (0.0-11.3)	232	4.2 (1.1-7.3)	204	9.2 (4.0-14.5)	0.329
11-12	178	14.1 (8.2-19.9)	214	25.3 (16.9-33.7)	189	30.1 (20.9-39.2)	**0.005**
13-17	409	10.9 (6.3-15.5)	441	29.0 (23.2-34.8)	449	39.0 (30.5-47.5)	**<0.001**
18-21	280	8.7 (3.4-14.0)	258	22.9 (16.4-29.4)	212	31.8 (21.7-41.8)	**<0.001**
22-26	239	4.1 (0.9-7.3)	243	13.5 (8.8-18.1)	245	18.7 (10.2-27.1)	**0.004**

Data are unweighted sample sizes (N) and weighted row percentages and 95% confidence intervals (CI).

[a] The complete case analysis is equivalent to the primary analysis that excluded persons with inadequate HPV vaccination data (see Figure 1).

[b] Multiple imputation for missing data (including inadequate HPV vaccination data) was conducted using chained equations (m=20). All variables in the primary analysis were included (age, sex, race/ethnicity, poverty status, health insurance status, immigration status). Additional auxiliary variables were included to improve the stability of the imputation model (i.e., use of a proxy in the family interview, language of the family interview [English/Spanish], receipt of the hepatitis A vaccine, receipt of the hepatitis B dose series, and the number of children aged 6-17 in the household).

[c] Linear test for trend.

SUPPLEMENTAL MATERIAL

Supplemental Table 7. Sensitivity analysis: temporal trends in the percentage of males and females who initiated the HPV vaccine (≥1 dose) prior to their 27th birthday among participants aged 9-59 years (NHANES, 2011-2016).

	2011-2012		2013-2014		2015-2016		P_{trend}
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)	
Females	2744	14.3 (12.0-16.9)	2949	15.4 (13.3-17.7)	2778	18.2 (16.2-20.3)	**0.018**
Males	2622	3.1 (2.3-4.1)	2709	7.2 (6.3-8.4)	2477	9.9 (8.4-11.5)	**<0.001**

The primary analysis excluded participants older than 26 who may have been vaccinated prior to the upper recommended age-limit for HPV vaccination. Thus, a sensitivity analysis was conducted to estimate temporal trends in the percentage of males and females in the U.S. who initiated the HPV vaccine (≥1 dose) prior to their 27th birthday. Similar to the primary analysis, this analysis excluded participants with inadequate HPV vaccination data. Contrary to the primary analysis, this analysis did not have exclusion criteria based on the participant's age at the time of the interview, and included all participants aged 9-59 years at the time of the interview since all members of this age group were eligible to respond to the HPV vaccination questionnaire. Persons were considered to have the outcome if they reported receiving the first dose of the HPV vaccine at an age ≤26 years. In addition, participants who were between 9-26 years of age at the time of the interview and reported previously receiving ≥1 vaccine dose, but had missing data on their age at HPV vaccine initiation, were also considered to have the outcome of interest.

SUPPLEMENTAL MATERIAL

Supplemental Figure 1. **Sensitivity analysis: Comparison of estimates for HPV vaccination (≥1 dose) among participants 13-17 years of age in the NHANES database and the National Immunization Survey—Teen (2011-2016).**
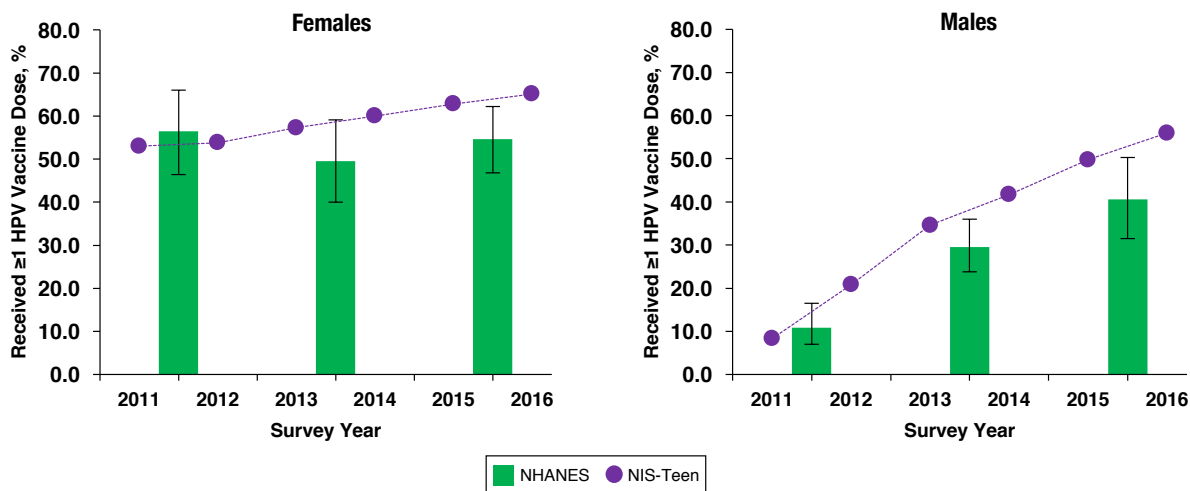
Data shown from NHANES reflect estimates calculated in the primary (complete case) analysis. The NIS-Teen assesses coverage of HPV vaccination using random digit dialing to identify and interview households with children eligible for vaccination. Vaccination histories are verified through a follow-up survey mailed to a medical provider. The NIS-Teen revised their definition for obtaining "adequate provider data" beginning in 2013, so temporal trends before and after this period must be interpreted with caution. See the following report for more information: Walker et al. (2017). National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years—United States, 2016. MMWR. Morbidity and mortality weekly report, 66.