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Sub-Regional Assessment of HPV Vaccination Among Female Adolescents in the Intermountain West and Implications for Intervention Opportunities

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Abstract *Objectives* We investigated the similarities and differences in the factors related to human papillomavirus (HPV) vaccination of female adolescents in three sub-regions of the Intermountain West (IW). *Methods* We analyzed 2011–2012 National Immunization Survey-Teen data. Respondents (parents) who were living in the IW and who had daughters aged 13–17 years old with provider-verified immunization records were included in our analyses. East, Central, and West sub-regions were defined based on geographic contiguity and similarity in HPV vaccination rates and sociodemographic characteristics. Survey-weighted Chi square tests and multivariable Poisson regressions were performed. *Results* In all three sub-regions, older teen age and receipt of other recommended adolescent vaccinations were significantly associated with HPV vaccination. In the East sub-region, providers' facility type and source of vaccines were significantly related to HPV vaccination. In the Central sub-region, teens with married parents were significantly less likely to be vaccinated than were those with unmarried parents. In the West sub-region, non-Hispanic teens were significantly less likely to be vaccinated than were Hispanic teens. *Conclusionsfor Practice* In order to improve HPV vaccine coverage in the IW, region-wide efforts to target younger teens and to promote the HPV vaccine with other recommended adolescent vaccinations should be supplemented with sub-regional attention to the health care system (East sub-region), to married parents (Central sub-region), and to non-Hispanic teens (West sub-region).

Keywords Human papillomavirus · Cancer · Prevention · Adolescent · Female · Vaccine

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Significance

What is already known on this subject: HPV vaccine coverage of female adolescents in the IW is poor. A recent regional assessment demonstrated that older teen age, younger parent age, and receipt of other recommended vaccinations were significantly associated with HPV vaccination. This assessment informed regional intervention strategies.

What this study adds: This study demonstrates sub-regional differences in factors associated with HPV vaccination: health care system level factors are significant in the East sub-region; family structure is significant in the Central sub-region; and race/ethnicity is significant in

the West-sub-region. Regional HPV vaccination interventions could be improved by considering these sub-regional findings.

Introduction

In 2006, the Centers for Disease Control and Prevention (CDC) recommended a 3-dose human papillomavirus (HPV) vaccine as a cancer prevention strategy for women aged 11–26 years old (Markowitz et al. 2007). A half-decade later, HPV vaccination rates remain low ("National and state vaccination coverage," 2011; "National and state vaccination coverage," 2012). Uptake has been particularly poor in the Intermountain West (IW), a region comprised of Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. Among adolescent females, in both 2011 and 2012, three of the eight IW states had HPV vaccine initiation rates below the national average, and five had completion rates below the national average ("National and state vaccination coverage," 2011; "National and state vaccination coverage," 2012).

The sociodemographic characteristics of the IW region may contribute to these low vaccination rates. Several of the IW states are among the most rural in the US (US Census Bureau 2015a), so individuals may have limited access to health care due to the greater geographic distance from providers (Arcury et al. 2005). Additionally, the IW features a large religious population—specifically a high density of Mormons (Pew Research Center 2014)—and religious beliefs regulating the sexual activity of unmarried women may pose challenges to HPV vaccination (Constantine and Jerman 2007; Zimet et al. 2008). Finally, the IW also has a rapidly growing minority and immigrant population that may lack well-established community and institutional support necessary for navigating the health care system (Grieco et al. 2012).

In spite of their shared characteristics when compared to other regions of the US, the IW states also feature notable within-region variation. For example, the rural population ranges from 5.8% in Nevada to 44.11% in Montana (US Census Bureau 2015a); the Mormon population ranges from 2% in Colorado and New Mexico to 55% in Utah (Pew Research Center 2014); and the Hispanic population ranges from 3.5% in Montana to 47.7% in New Mexico (US Census Bureau 2015b). Furthermore, though the HPV vaccination rates in the IW states are among the lowest in the nation, they too vary considerably. In 2011, HPV vaccine initiation among adolescent females ranged from 45.5% in Idaho to 60.9% in Wyoming, and completion ranged from 25.3% in Colorado to 40.9% in Wyoming ("National and state vaccination coverage," 2011). In 2012, initiation ranged from 44.3% in Utah to 62.5% in Nevada, and completion ranged from 39.0% in Utah to 46.5% in Montana ("National and state vaccination coverage," 2012).

This substantial within-region variation suggests that efforts to improve HPV vaccination in the IW region may be improved by considering sub-regional differences. Therefore, building on an assessment of the entire IW region (Lai et al. 2016), we use national survey data to clarify similarities and tease apart differences in the factors related to adolescent females' HPV vaccine initiation and completion in three sub-regions of the IW.

Methods

Data from the 2011 and 2012 National Immunization Survey-Teen (NIS-Teen) was used. The 2011 and 2012 NIS-Teen surveys occurred January 2011-April 2012 and January 2012-April 2013, respectively (NORC at the University of Chicago [NORC] 2012, 2013). Analysis of the NIS-Teen data was conducted September 2014-March 2015. Analysis of publicly available data is considered exempt by the University of Utah Institutional Review Board.

Participants

The NIS-Teen is a national survey that monitors adolescent vaccination coverage. It consists of a phone survey of parents and legal guardians to collect immunization information about adolescents, followed by a mailed survey of providers to validate the adolescents' vaccination records (NORC 2012, 2013). For the present analyses, we included respondents (hereafter referred to as parents) to the 2011 and 2012 NIS-Teen surveys who were living in the IW and who had daughters aged 13–17 years old with provider-verified immunization records.

Sub-regions

We defined three sub-regions of the IW based on geographical contiguity, similarity in HPV vaccine initiation and completion rates in the 2011 and 2012 NIS-Teen surveys, and similarity in sociodemographic characteristic (e.g., having large religious populations). The East sub-region includes Colorado, Montana, and Wyoming; the Central sub-region includes Idaho and Utah; and the West sub-region includes Arizona, New Mexico, and Nevada.

Measures

The outcomes of interest were HPV vaccine initiation and completion, defined by provider-verified receipt of at least one dose or of three doses of the HPV vaccine, respectively. Independent variables were chosen a priori

Table 1 Factors associated with HPV vaccine initiation among female adolescents in three sub-regions of the Intermountain West

	East sub-region: CO, MT, & WY (N = 1058)			Central sub-region: ID & UT (N = 682)			West sub-region: AZ, NM, & NV (N = 1085)		
	Initiated HPV vaccine series			Initiated HPV vaccine series			Initiated HPV vaccine series		
	Yes	No	p value	Yes	No	p value	Yes	No	p value
	n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]	
Total	566 (54.0)	492 (46.0)		318 (48.7)	364 (51.3)		578 (55.7)	509 (44.3)	
Teen age			**0.012**			0.421			0.411
13 years	78 (35.9)	116 (64.1)		57 (42.9)	81 (57.1)		114 (48.0)	119 (52.0)	
14 years	100 (48.3)	100 (51.7)		73 (53.3)	74 (46.7)		105 (56.0)	101 (44.0)	
15 years	119 (61.8)	110 (38.2)		75 (50.4)	69 (49.6)		133 (55.3)	114 (44.7)	
16 years	133 (56.9)	89 (43.1)		59 (41.9)	83 (58.1)		126 (59.3)	97 (40.7)	
17 years	136 (65.8)	77 (34.2)		54 (56.0)	57 (44.0)		98 (61.5)	78 (38.5)	
Teen race/ethnicity			0.828			0.053			**0.014**
Hispanic	55 (57.2)	42 (42.8)		43 (65.0)	22 (35.0)		220 (62.4)	150 (37.6)	
Non-Hispanic White	445 (52.9)	403 (47.1)		248 (45.2)	329 (54.8)		274 (47.5)	297 (52.5)	
Other	66 (54.0)	47 (46.0)		27 (59.0)	13 (41.0)		82 (57.5)	62 (42.5)	
Teen receipt of influenza vaccination			**<0.001**			**<0.001**			**<0.001**
No	298 (43.2)	380 (56.8)		169 (36.3)	300 (63.7)		293 (46.4)	395 (53.6)	
Yes	268 (71.2)	112 (28.8)		149 (76.7)	64 (23.3)		283 (71.4)	114 (28.6)	
Teen receipt of TDAP vaccination			**0.038**			**<0.001**			**0.007**
No	113 (43.6)	147 (56.4)		90 (29.5)	185 (70.5)		130 (45.9)	179 (54.1)	
Yes	453 (58.1)	345 (41.9)		228 (59.3)	179 (40.7)		446 (60.3)	330 (39.7)	
Teen receipt of meningitis vaccination			**<0.001**			**<0.001**			**<0.001**
No	125 (29.0)	291 (71.0)		54 (20.2)	231 (79.8)		98 (31.5)	226 (68.5)	
Yes	441 (67.0)	201 (33.0)		264 (69.9)	133 (30.1)		478 (63.7)	283 (36.3)	
Parent age			**0.014**			0.061			**0.002**
≤34 years	48 (80.0)	25 (20.0)		31 (66.3)	18 (33.7)		57 (77.1)	29 (22.9)	
35–44 years	229 (50.8)	201 (49.2)		157 (50.2)	169 (49.8)		249 (53.5)	226 (46.5)	
≥45 years	289 (52.0)	266 (48.0)		130 (42.0)	177 (58.0)		270 (52.8)	254 (47.2)	
Parent marital status			0.510			**0.002**			0.290
Married	439 (55.6)	388 (44.4)		243 (43.9)	322 (56.1)		402 (53.8)	395 (46.2)	
Other	127 (50.8)	104 (49.2)		75 (65.1)	42 (34.9)		174 (59.2)	114 (40.8)	
Parent educational attainment			0.100			0.146			0.055
<12 years	36 (71.1)	29 (28.9)		38 (61.4)	24 (38.6)		106 (67.4)	56 (32.6)	
12 years	111 (43.9)	85 (56.1)		56 (47.5)	68 (52.5)		108 (55.9)	98 (44.1)	
>12 years (some years)	175 (53.1)	159 (46.9)		133 (52.6)	137 (47.4)		148 (48.4)	159 (51.6)	
College graduate	244 (53.0)	219 (47.0)		91 (39.8)	135 (60.2)		214 (53.2)	196 (46.8)	
Parent poverty status			0.166			0.076			**0.049**
Above poverty (>$75K)	267 (58.8)	207 (41.2)		119 (46.8)	145 (53.2)		201 (46.5)	210 (53.5)	
Above poverty (≤$75K)	227 (47.5)	230 (52.5)		135 (44.6)	179 (55.4)		213 (57.0)	207 (43.0)	
Below poverty	60 (61.4)	46 (38.6)		58 (62.2)	31 (37.8)		138 (61.7)	67 (38.3)	
Source of health insurance			0.494			0.324			0.092
Provided through employment or union	362 (52.1)	327 (47.9)		220 (46.6)	257 (53.4)		313 (51.7)	319 (48.3)	
Not provided through employment or union	201 (56.4)	159 (43.6)		96 (52.8)	104 (47.2)		260 (59.7)	188 (40.3)	
Provider facility type			0.062			0.158			0.470
All public facilities	132 (60.5)	97 (39.5)		41 (37.6)	94 (62.4)		117 (54.4)	91 (45.6)	
All hospital facilities	36 (25.1)	29 (74.9)		25 (62.1)	19 (37.9)		30 (65.6)	14 (34.4)	
All private facilities	178 (55.4)	165 (44.6)		117 (46.5)	107 (53.5)		223 (52.9)	207 (47.1)	

Table 1 (continued)

	East sub-region: CO, MT, & WY (N = 1058)			Central sub-region: ID & UT (N = 682)			West sub-region: AZ, NM, & NV (N = 1085)		
	Initiated HPV vaccine series			Initiated HPV vaccine series			Initiated HPV vaccine series		
	Yes	No	p value	Yes	No	p value	Yes	No	p value
	n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]	
Mixed/other	194 (54.3)	169 (45.7)		126 (52.6)	127 (47.4)		176 (60.8)	153 (39.2)	
Providers order vaccination from states/ local health department			0.095			0.266			0.243
All providers	395 (59.6)	299 (40.4)		224 (45.9)	256 (54.1)		426 (55.4)	359 (44.6)	
Some but possibly not all	87 (47.5)	84 (52.5)		66 (49.4)	74 (50.6)		94 (59.2)	82 (40.8)	
No providers	47 (52.9)	52 (47.1)		10 (66.8)	13 (33.2)		23 (40.9)	26 (59.1)	
Don't know	37 (38.7)	50 (61.3)		18 (63.9)	18 (36.1)		33 (65.9)	37 (34.1)	

For details about variable operationalization, see Datasets and Related Documentation for the National Immunization Survey—Teen, 2008–2014, available at https://www.cdc.gov/nchs/nis/data_files_teen.htm

[a]Survey weighted percentage

based on existing literature on the correlates of HPV vaccine initiation and completion among adolescent females in the US. Independent variables related to teens included age, race/ethnicity, and receipt of other recommended adolescent vaccinations (influenza, TDAP, and meningitis). Independent variables related to parents included age, marital status, educational attainment, and poverty status. Independent variables related to the health care system included source of health insurance, type of provider practice, and providers' use of state or local health departments to obtain vaccines.

Statistical Analyses

To combine NIS-Teen data from 2011 to 2012, we used the survey weighting methodology provided by the CDC (NORC 2013). Actual frequency and survey-weighted percentages were reported for categorical variables, and comparisons between teens who did and did not initiate or complete the HPV vaccine were evaluated using a survey-weighted Pearson Chi square test. Multivariable weighted Poisson regression models with robust standard errors were used to estimate adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) for selected factors. For all tests, the null hypothesis was that no significant differences existed between groups, and statistical significance was defined as $p < 0.05$; all p values represent two-sided comparisons. Data management was done with SAS Statistical Software version 9.3, and statistical analyses were performed using Stata version 13.1.

Results

HPV Vaccine Initiation

Bivariate analyses (Table 1) revealed that receipt of other recommended adolescent vaccinations was associated with HPV vaccine initiation in all three sub-regions (all $p < 0.05$). In the East sub-region, parent and teen age were both related to HPV vaccine initiation (both $p < 0.02$). In the Central sub-region, parents' marital status was associated with HPV vaccine initiation ($p = 0.002$). In the West sub-region, parent age ($p = 0.002$), poverty status ($p = 0.049$), and teen race/ethnicity ($p = 0.014$) were all associated with HPV vaccine initiation.

Poisson regression analyses (Table 2) showed that when adjusting for other variables, older teen age and receipt of other recommended adolescent vaccinations were significantly associated with higher HPV vaccine initiation in all three sub-regions (see Table 2). In the East sub-region, providers' facility type and providers' use of state or local health departments to obtain vaccines were significantly related to HPV vaccine initiation (see Table 2). In the Central sub-region, non-Hispanic White teens and teens with married parents were significantly less likely to have initiated the HPV vaccination series compared to Hispanic teens and teens with unmarried parents, respectively (see Table 2). In both the East and West sub-regions, younger parent age and lower educational attainment were significantly associated with HPV vaccine initiation (see Table 2). In both of these sub-regions, poverty status was also significantly associated with HPV vaccine initiation, though the direction of the effect was different for each (see Table 2).

Table 2 Multivariable analyses for HPV vaccine initiation among female adolescents in three sub-regions of the Intermountain West

Characteristic	East sub-region: CO, MT, & WY (N = 973)			Central sub-region: ID & UT (N = 631)			West sub-region: AZ, NM, & NV (N = 963)		
	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value
Teen age									
13 years	29.3 (19.5, 39.2)	Reference		41.8 (31.3, 52.4)	Reference		46.2 (38.3, 54.2)	Reference	
14 years	46.9 (34.8, 59.0)	1.60 (1.08, 2.37)	**0.019**	44.6 (36.7, 52.5)	1.07 (0.80, 1.42)	0.664	49.6 (39.7, 59.6)	1.07 (0.84, 1.38)	0.573
15 years	60.1 (49.4, 70.8)	2.05 (1.43, 2.93)	**<0.001**	50.8 (40.4, 61.1)	1.21 (0.91, 1.62)	0.189	55.9 (45.6, 66.2)	1.21 (0.95, 1.54)	0.119
16 years	65.9 (54.1, 77.7)	2.25 (1.57, 3.21)	**<0.001**	46.1 (34.1, 58.1)	1.10 (0.77, 1.57)	0.589	65.9 (55.0, 76.9)	1.43 (1.13, 1.80)	**0.003**
17 years	72.1 (59.7, 84.5)	2.46 (1.71, 3.53)	**<0.001**	62.9 (48.3, 77.5)	1.50 (1.08, 2.09)	**0.015**	65.7 (53.7, 77.6)	1.42 (1.11, 1.82)	**0.005**
Teen race/ethnicity									
Hispanic	47.9 (34.3, 61.5)	Reference		64.1 (45.2, 83.0)	Reference		59.3 (52.1, 66.4)	Reference	
Non-Hispanic White	56.2 (48.5, 63.8)	1.17 (0.86, 1.60)	0.311	44.8 (39.0, 50.6)	0.70 (0.51, 0.97)	**0.030**	52.3 (44.6, 59.9)	0.88 (0.73, 1.07)	0.202
Other	57.7 (42.5, 72.9)	1.21 (0.84, 1.74)	0.318	62.4 (41.2, 83.7)	0.97 (0.62, 1.53)	0.908	55.3 (43.7, 67.0)	0.93 (0.73, 1.19)	0.582
Teen receipt of influenza vaccination									
No	45.9 (38.1, 53.8)	Reference		39.9 (33.4, 46.4)	Reference		48.2 (42.2, 54.2)	Reference	
Yes	64.7 (56.8, 72.5)	1.41 (1.17, 1.69)	**<0.001**	63.1 (55.0, 71.2)	1.58 (1.31, 1.91)	**<0.001**	69.1 (61.9, 76.4)	1.43 (1.22, 1.68)	**<0.001**
Teen receipt of TDAP vaccination									
No	44.6 (34.6, 54.6)	Reference		39.3 (30.6, 48.1)	Reference		47.8 (38.2, 57.3)	Reference	
Yes	58.0 (50.9, 65.2)	1.30 (1.04, 1.63)	**0.024**	51.8 (45.1, 58.6)	1.32 (1.02, 1.70)	**0.034**	59.7 (53.8, 65.6)	1.25 (1.00, 1.57)	0.054
Teen receipt of meningitis vaccination									
No	34.8 (25.5, 44.1)	Reference		24.3 (16.4, 32.1)	Reference		40.3 (30.4, 50.1)	Reference	
Yes	63.0 (55.8, 70.1)	1.81 (1.37, 2.39)	**<0.001**	62.6 (55.8, 69.4)	2.58 (1.83, 3.63)	**<0.001**	60.1 (54.5, 65.7)	1.49 (1.14, 1.95)	**0.003**
Parent age									
≤34 years	83.0 (63.0, 102.9)	Reference		57.0 (39.6, 74.5)	Reference		74.7 (62.6, 86.8)	Reference	
35–44 years	53.9 (45.1, 62.7)	0.65 (0.49, 0.86)	**0.003**	49.2 (42.0, 56.4)	0.86 (0.61, 1.22)	0.398	54.1 (47.2, 61.0)	0.72 (0.59, 0.89)	**0.002**
≥45 years	49.3 (41.0, 57.6)	0.59 (0.44,0.81)	**0.001**	44.4 (36.0, 52.8)	0.78 (0.54, 1.12)	0.176	53.7 (46.9, 60.5)	0.72 (0.58, 0.89)	**0.002**
Parent marital status									
Married	55.1 (47.9, 62.3)	Reference		44.7 (38.5, 50.9)	Reference		57.1 (50.9, 63.2)	Reference	
Other	52.5 (40.6, 64.5)	0.95 (0.74, 1.23)	0.710	59.3 (46.8, 71.9)	1.33 (1.02, 1.72)	**0.032**	54.4 (46.2, 62.6)	0.95 (0.79, 1.15)	0.620
Parent educational attainment									
<12 years	70.4 (50.5, 90.4)	Reference		48.4 (31.9, 64.9)	Reference		64.7 (53.2, 76.2)	Reference	

Table 2 (continued)

Characteristic	East sub-region: CO, MT, & WY (N = 973)			Central sub-region: ID & UT (N = 631)			West sub-region: AZ, NM, & NV (N = 963)		
	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value
12 years	56.0 (42.8, 69.2)	0.80 (0.57, 1.12)	0.187	45.9 (33.2, 58.7)	0.95 (0.60, 1.50)	0.824	52.7 (43.1, 62.4)	0.81 (0.63, 1.05)	0.116
>12 years (some years)	50.2 (41.2, 59.2)	0.71 (0.51, 0.99)	**0.043**	56.9 (48.5, 65.3)	1.18 (0.80, 1.72)	0.405	48.9 (40.5, 57.4)	0.76 (0.59, 0.98)	**0.032**
College graduate	50.5 (41.3, 59.7)	0.72 (0.50, 1.03)	0.073	39.1 (31.4, 46.8)	0.81 (0.53, 1.23)	0.315	59.5 (50.1, 68.9)	0.92 (0.71, 1.20)	0.531
Parent poverty status									
Above poverty (>$75K)	66.7 (53.7, 79.6)	Reference		50.3 (41.2, 59.5)	Reference		48.1(39.3, 57.0)	Reference	
Above poverty (≤$75K)	50.3 (41.2, 59.5)	0.75 (0.60, 0.95)	**0.019**	45.2 (38.2, 52.3)	0.90 (0.72, 1.13)	0.353	60.3 (53.1, 67.4)	1.25 (1.02, 1.54)	**0.033**
Below poverty	44.8 (32.2, 57.3)	0.67 (0.46, 0.98)	**0.037**	51.9 (37.9, 65.8)	1.03 (0.73, 1.46)	0.868	56.6 (46.6, 66.7)	1.18 (0.88, 1.57)	0.271
Source of health insurance									
Provided through employment or union	50.2 (42.5, 57.8)	Reference		46.8 (40.2, 53.4)	Reference		54.9 (47.6, 62.1)	Reference	
Not provided through employment or union	59.9 (50.2, 69.5)	1.19 (0.97, 1.47)	0.097	51.7 (42.5, 60.9)	1.10 (0.88, 1.38)	0.383	57.1 (50.3, 64.0)	1.04 (0.87, 1.25)	0.664
Provider facility type									
All public facilities	63.9 (52.2, 75.5)	Reference		42.4 (30.6, 54.2)	Reference		52.5 (42.1, 62.9)	Reference	
All hospital facilities	35.9 (18.3, 53.4)	0.56 (0.34, 0.92)	**0.023**	50.5 (31.7, 69.4)	1.19 (0.74, 1.91)	0.465	56.8 (39.2, 74.4)	1.08 (0.75, 1.56)	0.671
All private facilities	50.1 (41.7, 58.5)	0.78 (0.62, 0.99)	**0.037**	50.0 (41.6, 58.1)	1.18 (0.87, 1.59)	0.295	56.5 (48.9, 64.1)	1.08 (0.85,1.36)	0.546
Mixed/other	58.4 (47.6, 69.2)	0.91 (0.71, 1.18)	0.496	49.0 (41.1, 56.8)	1.15 (0.85, 1.58)	0.366	58.1 (50.3, 66.0)	1.11 (0.87, 1.41)	0.417
Providers order vaccination from states/local health department									
All providers	57.8 (50.7, 64.8)	Reference		46.0 (39.9, 52.0)	Reference		54.5 (49.2, 59.9)	Reference	
Some but possibly not all	51.1 (36.0, 66.2)	0.89 (0.66, 1.19)	0.420	54.1 (42.0, 66.3)	1.18 (0.93, 1.50)	0.184	63.7 (51.2, 76.1)	1.17 (0.95, 1.44)	0.148
No providers	55.2 (38.6, 71.7)	0.96 (0.70, 1.31)	0.777	49.5 (29.7, 69.2)	1.08 (0.72, 1.62)	0.723	48.3 (30.5, 66.0)	0.89 (0.61, 1.29)	0.528
Don't know	24.7 (12.5, 36.9)	0.43 (0.26, 0.71)	**0.001**	60.4 (33.4, 87.3)	1.31 (0.83, 2.08)	0.247	71.8 (51.2, 92.4)	1.32 (0.97, 1.79)	0.077

For details about variable operationalization, see Datasets and Related Documentation for the National Immunization Survey—Teen, 2008–2014, available at https://www.cdc.gov/nchs/nis/data_files_teen.htm

[a]Multivariable Poisson regression

[b]Predictive marginal prevalence

Table 3 Factors associated with HPV vaccine completion among female adolescents in three sub-regions of the Intermountain West

	East sub-region: CO, MT, & WY (N = 1058)			Central sub-region: ID & UT (N = 682)			West sub-region: AZ, NM, & NV (N = 1085)		
	Completed HPV vaccine series			Completed HPV vaccine series			Completed HPV vaccine series		
	Yes	No	p value	Yes	No	p value	Yes	No	p value
	n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]	
Total	384 (33.3)	674 (66.7)		179 (24.6)	503 (75.5)		366 (34.5)	719 (65.1)	
Teen age			**<0.001**			0.623			**0.012**
13 years	41 (18.3)	153 (81.7)		29 (20.9)	109 (79.1)		184 (80.0)	49 (20.0)	
14 years	61 (23.5)	139 (76.5)		31 (23.6)	116 (76.4)		133 (63.0)	73 (37.0)	
15 years	80 (28.4)	149 (71.6)		51 (30.8)	93 (69.2)		154 (60.5)	93 (39.5)	
16 years	100 (46.0)	122 (54.0)		40 (23.8)	102 (76.2)		135 (59.5)	88 (40.5)	
17 years	102 (51.9)	111 (48.1)		28 (22.6)	83 (77.4)		113 (61.0)	63 (39.0)	
Teen race/ethnicity			0.105			0.146			**0.011**
Hispanic	31 (22.8)	66 (77.2)		24 (32.0)	41 (68.0)		133 (41.8)	237 (58.2)	
Non-Hispanic White	309 (36.2)	539 (63.8)		138 (22.4)	439 (77.6)		181 (29.0)	390 (71.0)	
Other	44 (38.2)	69 (61.8)		17 (37.0)	23 (63.0)		52 (29.3)	92 (70.7)	
Teen receipt of influenza vaccination			**<0.001**			**<0.001**			**<0.001**
No	179 (23.8)	499 (76.2)		86 (15.9)	383 (84.1)		176 (26.6)	512 (73.4)	
Yes	205 (48.4)	175 (51.6)		93 (44.2)	120 (55.8)		190 (48.8)	207 (51.2)	
Teen receipt of TDAP vaccination			0.148			**<0.001**			**0.006**
No	73 (26.6)	187 (73.4)		45 (14.6)	230 (85.4)		72 (24.8)	237 (75.2)	
Yes	311 (35.9)	487 (64.1)		134 (30.1)	273 (69.9)		294 (39.7)	482 (60.3)	
Teen receipt of meningitis vaccination			**<0.001**			**<0.001**			**<0.001**
No	67 (16.7)	349 (83.3)		25 (7.2)	260 (92.8)		48 (16.6)	276 (83.4)	
Yes	317 (42.0)	325 (58.0)		154 (37.5)	243 (62.5)		318 (40.9)	443 (59.1)	
Parent age			**0.044**			0.369			0.993
≤34 years	23 (13.7)	50 (86.3)		15 (30.7)	34 (69.3)		29 (34.3)	57 (65.7)	
35–44 years	161 (33.5)	269 (66.5)		90 (26.0)	236 (74.0)		155 (34.8)	320 (65.2)	
≥45 years	200 (36.8)	355 (63.2)		74 (20.9)	233 (79.1)		182 (35.1)	342 (64.9)	
Parent marital status			**0.025**			**0.003**			0.794
Married	301 (37.7)	526 (62.3)		136 (20.8)	429 (79.2)		269 (35.3)	528 (64.7)	
Other	83 (24.4)	148 (75.6)		43 (37.5)	74 (62.5)		97 (34.0)	191 (66.0)	
Parent educational attainment			0.056			0.730			0.382
<12 years	17 (22.5)	48 (77.5)		22 (29.2)	40 (70.8)		54 (36.4)	108 (63.6)	
12 years	76 (28.0)	120 (72.0)		30 (21.7)	94 (78.3)		71 (40.2)	135 (59.8)	
>12 years (some years)	112 (29.7)	222 (70.3)		68 (23.1)	202 (76.9)		96 (29.3)	211 (70.7)	
College graduate	179 (43.3)	284 (56.7)		59 (26.9)	167 (73.1)		145 (34.6)	265 (65.4)	
Parent poverty status			**0.005**			0.453			0.495
Above poverty (>$75K)	190 (45.7)	284 (54.3)		71 (28.6)	193 (71.4)		135 (31.9)	276 (68.1)	
Above poverty (≤$75K)	149 (26.1)	308 (73.9)		76 (22.0)	238 (78.0)		137 (37.1)	283 (62.9)	
Below poverty	36 (26.5)	70 (73.5)		28 (25.1)	61 (74.9)		84 (38.4)	121 (61.6)	
Source of health insurance			0.153			0.582			0.520
Provided through employment or union	258 (37.2)	431 (62.8)		126 (25.6)	351 (74.4)		209 (36.4)	423 (63.6)	
Not provided through employment or union	124 (28.7)	236 (71.3)		53 (22.9)	147 (77.1)		155 (33.5)	293 (66.5)	
Provider facility type			0.101			**0.015**			0.837
All public facilities	84 (26.0)	145 (74.0)		16 (10.5)	119 (89.5)		67 (32.4)	141 (67.6)	
All hospital facilities	22 (16.4)	43 (83.6)		15 (35.3)	29 (64.7)		21 (42.5)	23 (57.5)	
All private facilities	124 (35.7)	219 (64.3)		68 (25.4)	156 (74.6)		153 (34.9)	277 (65.1)	

Table 3 (continued)

	East sub-region: CO, MT, & WY (N = 1058)			Central sub-region: ID & UT (N = 682)			West sub-region: AZ, NM, & NV (N = 1085)		
	Completed HPV vaccine series			Completed HPV vaccine series			Completed HPV vaccine series		
	Yes	No	p value	Yes	No	p value	Yes	No	p value
	n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]		n (%)[a]	n (%)[a]	
Mixed/other	137 (39.0)	226 (61.0)		76 (29.4)	177 (70.6)		104 (36.6)	225 (63.4)	
Providers order vaccination from states/ local health department			0.342			0.948			0.582
All providers	267 (33.2)	427 (66.8)		130 (24.3)	350 (75.7)		267 (34.4)	518 (65.6)	
Some but possibly not all	64 (39.9)	107 (60.1)		39 (24.6)	101 (75.4)		60 (41.2)	116 (58.8)	
No providers	31 (37.8)	68 (62.2)		3 (20.0)	20 (80.0)		15 (29.1)	34 (70.9)	
Don't know	22 (21.8)	65 (78.2)		7 (28.4)	29 (71.6)		24 (31.4)	46 (68.6)	

For details about variable operationalization, see Datasets and Related Documentation for the National Immunization Survey—Teen, 2008–2014, available at https://www.cdc.gov/nchs/nis/data_files_teen.htm

[a]Survey weighted percentage

HPV Vaccine Completion

In bivariate analyses (Table 3), receipt of influenza or meningitis vaccination was associated with HPV vaccine completion in all three sub-regions (all $p < 0.05$). In the Central and West sub-regions, receipt of the TDAP vaccination was associated with HPV vaccine completion (both $p < 0.01$). In the East sub-region, parent and teen age (both $p < 0.05$), poverty status ($p = 0.005$), and parents' marital status ($p = 0.025$) were related to HPV vaccine completion. In the Central sub-region, parents' marital status ($p = 0.003$) and provider facility type ($p = 0.015$) were related to HPV vaccine completion. In the West sub-region, teen race/ethnicity ($p = 0.011$) and age ($p = 0.012$) were associated with HPV vaccine completion.

Poisson regression analyses (Table 4) demonstrated that when adjusting for other variables, receiving other recommended adolescent vaccinations was significantly associated with HPV vaccine completion in all three sub-regions (see Table 4). In both the East and West sub-regions, older teen age was significantly associated with higher HPV vaccine completion (see Table 4). In the Central sub-region, teens with unmarried parents were significantly more likely to complete the HPV vaccination series than were teens with married parents (see Table 4). In the West sub-region, Hispanic teens were significantly more likely to complete the HPV vaccination series than were non-Hispanic teens (see Table 4). Certain health care system-level factors were significantly related to HPV vaccine completion: in the East sub-region, providers' use of state or local health departments to obtain vaccines; in the Central sub-region, providers' facility type (see Table 4).

Discussion

Low HPV vaccination rates in the IW present a serious public health challenge for the region ("National and state vaccination coverage," 2011; "National and state vaccination coverage," 2012). Identifying factors that influence HPV vaccination practices regionally and sub-regionally is critical to improving HPV vaccine coverage in the IW. This study builds on an earlier assessment of the entire IW region (Lai et al. 2016) to assess the factors related to female adolescents' HPV vaccine initiation and completion in three sub-regions of the IW. Results highlight opportunities for improvement and will inform intervention strategies for the region. Although from the time of data collection, the vaccination schedule for younger adolescents has changed to require only two doses of the HPV vaccine (Meites et al. 2016), the variables related to both initiation and completion that are discussed in this paper continue to be relevant.

Our analyses yielded two findings that support the results of the region-wide examination (Lai et al. 2016). First, in all three sub-regions, receipt of other recommended adolescent vaccinations was significantly associated with HPV vaccine initiation and completion. This finding underscores the importance of reducing missed opportunities for HPV vaccination by administering the HPV vaccine along with other adolescent vaccinations. It also highlights the opportunity to improve HPV vaccination rates through promotion of the HPV vaccine along with other adolescent vaccinations via parental education and provider training and reminders (e.g., Mayne et al. 2014). Second, older teen age was significantly related to HPV vaccine initiation and completion in all three sub-regions. This finding

Table 4 Multivariable analyses for HPV vaccine completion among female adolescents in three sub-regions of the Intermountain West

Characteristic	East sub-region: CO, MT, & WY (N = 973)			Central sub-region: ID & UT (N = 631)			West sub-region: AZ, NM, & NV (N = 963)		
	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value
Teen age									
13 years	13.7 (4.9, 22.5)	Reference		19.3 (11.9, 26.7)	Reference		18.3 (12.2, 24.5)	Reference	
14 years	22.9 (13.8, 32.0)	1.67 (0.82, 3.40)	0.158	19.4 (12.4, 26.3)	1.00 (0.61, 1.65)	0.988	31.1 (22.2, 39.9)	1.69 (1.10, 2.61)	**0.016**
15 years	30.1 (20.5, 39.8)	2.19 (1.08, 4.45)	**0.029**	30.1 (21.4, 38.9)	1.56 (0.98, 2.49)	0.059	44.2 (33.4, 54.9)	2.41 (1.62, 3.59)	**<0.001**
16 years	45.8 (35.0, 56.6)	3.34 (1.71, 6.52)	**<0.001**	27.2 (18.1, 36.3)	1.41 (0.87, 2.28)	0.159	48.9 (37.6, 60.3)	2.67 (1.80, 3.95)	**<0.001**
17 years	53.5 (41.3, 65.7)	3.90 (1.99, 7.64)	**<0.001**	30.6 (20.0, 41.2)	1.59 (0.98, 2.58)	0.063	44.1 (32.5, 55.7)	2.41 (1.59, 3.64)	**<0.001**
Teen race/ethnicity									
Hispanic	24.1 (9.9, 38.2)	Reference		35.1 (19.6, 50.6)	Reference		44.9 (37.0, 52.8)	Reference	
Non-Hispanic White	34.5 (27.5, 41.5)	1.43 (0.76, 2.68)	0.264	22.8 (18.4, 27.2)	0.65 (0.41, 1.04)	0.071	30.2 (24.1, 36.3)	0.67 (0.51, 0.88)	**0.005**
Other	41.7 (28.0, 55.4)	1.73 (0.87, 3.44)	0.117	37.7 (19.8, 55.6)	1.07 (0.56, 2.04)	0.831	27.7 (18.9, 36.5)	0.62 (0.43, 0.88)	**0.009**
Teen receipt of influenza vaccination									
No	25.2 (18.9, 31.5)	Reference		17.4 (12.8, 21.9)	Reference		27.8 (22.3, 33.3)	Reference	
Yes	43.1 (34.6, 51.7)	1.71 (1.28, 2.29)	**<0.001**	37.0 (29.4, 44.7)	2.13 (1.55, 2.94)	**<0.001**	51.9 (44.2, 59.5)	1.87 (1.48, 2.36)	**<0.001**
Teen receipt of TDAP vaccination									
No	24.9 (16.6, 33.2)	Reference		23.4 (16.2, 30.6)	Reference		25.6 (17.5, 33.6)	Reference	
Yes	37.2 (29.9, 44.5)	1.49 (1.05, 2.13)	**0.020**	25.5 (20.5, 30.5)	1.09 (0.77, 1.55)	0.629	41.8 (35.6, 48.1)	1.64 (1.16, 2.32)	**0.005**
Teen receipt of meningitis vaccination									
No	20.2 (12.6, 27.8)	Reference		9.2 (4.6, 13.8)	Reference		22.6 (13.4, 31.8)	Reference	
Yes	39.0 (31.9, 46.1)	1.93 (1.32, 2.83)	**0.002**	33.4 (27.3, 39.5)	3.63 (2.08, 6.31)	**<0.001**	39.6 (34.1, 45.1)	1.75 (1.14, 2.71)	**0.011**
Parent age									
≤34 years	19.1 (1.5, 36.6)	Reference		33.7 (17.6, 49.9)	Reference		36.4 (23.7, 49.0)	Reference	
35–44 years	39.1 (29.7, 48.5)	2.05 (0.79, 5.30)	0.138	26.2 (20.5, 32.0)	0.78 (0.46, 1.31)	0.345	35.4 (28.8, 41.9)	0.97 (0.66, 1.42)	0.884
≥45 years	31.2 (24.0, 38.4)	1.64 (0.62, 4.30)	0.318	21.2 (15.3, 27.1)	0.63 (0.36, 1.10)	0.101	38.0 (31.5, 44.5)	1.05 (0.71, 1.54)	0.824
Parent marital status									
Married	34.7 (27.9, 41.6)	Reference		21.7 (17.3, 26.0)	Reference		36.9 (31.0, 42.8)	Reference	
Other	39.5 (18.1, 41.0)	0.85 (0.55, 1.32)	0.468	36.2 (24.6, 47.7)	1.67 (1.14, 2.44)	**0.008**	35.4 (27.5, 43.3)	0.96 (0.73, 1.26)	0.764
Parent educational attainment									
<12 years	27.0 (8.4, 45.6)	Reference		27.2(12.8, 41.6)	Reference		35.1 (24.7, 45.4)	Reference	

Table 4 (continued)

Characteristic	East sub-region: CO, MT, & WY (N = 973)			Central sub-region: ID & UT (N = 631)			West sub-region: AZ, NM, & NV (N = 963)		
	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value	Adjusted vaccination coverage[a] % (95%CI)	Prevalence ratio[b] (95%CI)	p value
12 years	36.4 (24.8, 47.9)	1.35 (0.65, 2.81)	0.428	23.4 (14.5, 32.3)	0.86 (0.45, 1.66)	0.658	38.1 (28.6, 47.6)	1.09 (0.74, 1.61)	0.673
>12 years (some years)	27.9 (18.7, 37.2)	1.04 (0.47, 2.20)	0.989	26.3 (19.6, 33.0)	0.97 (0.55, 1.71)	0.912	33.3 (25.4, 41.2)	0.95 (0.65, 1.39)	0.789
College graduate	37.8 (29.0, 46.5)	1.40 (0.67, 2.98)	0.384	23.6 (16.8, 30.3)	0.87 (0.46, 1.63)	0.659	38.8 (29.5, 48.1)	1.11 (0.73, 1.67)	0.627
Parent poverty status									
Above poverty (>$75K)	38.8 (28.1, 49.5)	Reference		31.4 (22.0, 40.7)	Reference		29.6 (21.9, 37.2)	Reference	
Above poverty (≤$75K)	27.7 (19.9, 35.4)	0.71 (0.49, 1.04)	0.083	23.5 (17.8, 29.3)	0.75 (0.52, 1.07)	0.116	38.5 (31.4, 45.7)	1.30 (0.97, 1.75)	0.078
Below poverty	33.3 (17.5, 49.2)	0.86 (0.46, 1.59)	0.630	19.8 (10.5, 29.0)	0.63 (0.34, 1.16)	0.138	39.0 (29.1, 48.8)	1.32 (0.88, 1.97)	0.180
Source of health insurance									
Provided through employment or union	31.1 (24.5, 37.8)	Reference		24.5 (19.5, 29.5)	Reference		39.1 (31.7, 41.4)	Reference	
Not provided through employment or union	37.4 (26.6, 48.1)	1.20 (0.84, 1.70)	0.310	26.2 (18.1, 34.3)	1.07 (0.74, 1.55)	0.711	34.0 (27.5, 40.5)	0.87 (0.66, 1.14)	0.322
Provider facility type									
All public facilities	35.2 (22.5, 47.9)	Reference		13.9 (6.0, 21.7)	Reference		35.8 (25.6, 46.0)	Reference	
All hospital facilities	26.9 (12.6, 41.2)	0.76 (0.41, 1.41)	0.310	27.9 (11.9, 43.9)	2.01 (0.89, 4.55)	0.093	41.6 (21.9, 61.2)	1.16 (0.67, 2.01)	0.594
All private facilities	31.2 (23.7, 38.7)	0.88 (0.58, 1.34)	0.564	26.6 (20.2, 33.0)	1.92 (1.07, 3.43)	**0.028**	38.1 (30.4, 45.9)	1.06 (0.74, 1.52)	0.732
Mixed/Other	37.0 (26.6, 47.4)	1.05 (0.65, 1.69)	0.841	26.8 (19.9, 33.7)	1.93 (1.04, 3.60)	**0.038**	34.1 (26.8, 41.5)	0.95 (0.67, 1.34)	0.795
Providers order vaccination from states/local health department									
All providers	35.0 (28.0, 42.0)	Reference		25.1 (20.3, 31.2)	Reference		35.2 (30.1, 40.4)	Reference	
Some but possibly not all	36.5 (23.8, 49.3)	1.04 (0.71, 1.53)	0.824	25.0 (16.2, 28.9)	1.00 (0.67, 1.47)	0.982	45.6 (32.5, 58.8)	1.30 (0.95, 1.76)	0.098
No providers	33.0 (19.0, 46.9)	0.94 (0.60, 1.47)	0.793	16.1 (0, 33.3)	0.64 (0.22, 1.86)	0.415	35.3 (18.4, 52.2)	1.00 (0.61, 1.64)	0.992
Don't know	11.2 (3.2, 19.2)	0.32 (0.15, 0.66)	**0.002**	31.1 (9.2, 52.9)	1.24 (0.61, 2.51)	0.556	33.3 (14.6, 51.9)	0.94 (0.53, 1.67)	0.845

For details about variable operationalization, see Datasets and Related Documentation for the National Immunization Survey—Teen, 2008–2014, available at https://www.cdc.gov/nchs/nis/data_files_teen.htm

[a]Multivariable Poisson regression

[b]Predictive marginal prevalence

may reflect parent and/or provider reluctance to vaccinate younger adolescents against a sexually transmitted virus. Interventions should therefore work to educate parents and providers about the rationale for vaccinating younger adolescents (e.g., Mayne et al. 2014; PATH 2008), to leverage the school system to reach younger adolescents (e.g., Eldred et al. 2015), and to use HPV vaccine delivery as the basis for comprehensive adolescent reproductive health services (e.g., Pollack et al. 2007).

Supplementing these all-region findings, four important sub-regional differences emerged in our analyses. First, whereas the region-wide investigation indicated that teens with older parents were less likely to be vaccinated than teens with younger parents (Lai et al. 2016), our study showed this finding to hold for the East and West sub-regions only, and with regards to HPV vaccine initiation only. Therefore, the recommendation to focus educational and persuasive messaging to older parents (Lai et al. 2016) may be less effective in the Central sub-region and should be employed only in the East and West sub-regions. Second, health care system-level factors were associated with HPV vaccine initiation and completion predominantly in the East sub-region. Though the processes underlying this finding merit further investigation, it is clear that intervention efforts in the East sub-region should operate on the health care system level in addition to the patient level (e.g., CDC 2015; Perkins et al. 2015). Third, in the Central sub-region, parents' marital status was significantly related to HPV vaccine initiation and completion, with teens with married parents less likely to be vaccinated than teens whose parents were unmarried. Although our data cannot unequivocally establish the causes of this finding, it may be that unmarried couples are more understanding of the vagaries of sexual activity, and thus more inclined to vaccinate their daughters against a sexually transmitted virus. This finding suggests that interventions must be sensitive to family structure in this sub-region in order to reach married parents (e.g., Gerend et al. 2013). Finally, teen race/ethnicity was significantly associated with HPV vaccine initiation and completion in the West sub-region, with Hispanic teens more likely to have completed the vaccine than non-Hispanic teens. This finding may reflect different levels of support for vaccines among various racial/ethnic groups, and underscores the need to target non-Hispanic racial/ethnic groups—particularly whites—with HPV vaccine intervention materials in this sub-region (e.g., Lechuga et al. 2011).

In addition to highlighting these opportunities for improvement, this study also contributes to a large body of literature concerning HPV vaccination in the US (Fisher et al. 2013; Holman et al. 2014; Kessels et al. 2012; Rambout et al. 2014), and to research using data from the NIS-Teen (Rahman et al. 2014). To the best of our knowledge, this is the first study to use national survey data to study sub-regional similarities and differences related to HPV vaccination in the US.

Limitations

This study is limited by the methodology of the NIS-Teen. Bias related to the exclusion of households with non-response or without any phones is a possibility. Additionally, adequate provider-verified vaccination data was available for only 54.6 and 56.38% of cellular and 61.5 and 61.97% of landline respondents in 2011 and 2012, respectively (NORC 2012, 2013). Also, this study does not address geographical, political, or sociodemographic variations among individual states within the sub-regions studied. Moreover, comparisons drawn between this study and the prior regional examination are limited by differences in their samples: the regional investigation assesses data from the 2012 NIS-Teen, whereas this investigation relies on NIS-Teen data from 2011, as well.

Conclusions

Identifying the regional and sub-regional factors that influence HPV vaccination is critical to improving HPV vaccine coverage among female adolescents in the IW. This study presents region-wide intervention opportunities and highlights a number of strategies for tailoring efforts to address unique sub-regional needs. Regionally, interventions should promote the HPV vaccine along with other recommended adolescent vaccinations and should focus efforts to vaccinate younger girls. Sub-regionally, interventions should work on the health care system level in the East sub-region, reach out to married couples in the Central sub-region, and focus on non-Hispanics in the West sub-region.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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