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Differences in school factors associated with adolescent HPV vaccination initiation and completion coverage in three Australian states

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ABSTRACT

Background: Schools are the primary setting for the delivery of adolescent HPV vaccination in Australia. Although this strategy has achieved generally high vaccination coverage, gaps persist for reasons that are mostly unknown. This study sought to identify school-level correlates of low vaccination course initiation and completion in New South Wales, Tasmania, and Western Australia to inform initiatives to increase uptake.

Methods: Initiation was defined as the number of first doses given in a school in 2016 divided by vaccine-eligible student enrolments. Completion was the number of third doses given in a school in 2015–2016 divided by the number of first doses. Low initiation and completion were defined as coverage ≤ 25th percentile of all reporting schools. We investigated correlations between covariates using Spearman's rank

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correlation coefficients. Due to multicollinearity, we used univariable logistic regression to investigate associations between school characteristics and low coverage.
Results: Median initiation was 84.7% (IQR: 75.0%-90.4%) across 1,286 schools and median completion was 93.8% (IQR: 86.0%-97.3%) across 1,295 schools. There were strong correlations between a number of school characteristics, particularly higher Indigenous student enrolments and lower attendance, increasing remoteness, higher postcode socioeconomic disadvantage, and smaller school size. Characteristics most strongly associated with low initiation in univariate analyses were small school size, location in Tasmania, and schools catering for special educational needs. Low completion was most strongly associated with schools in Tasmania and Western Australia, remote location, small size, high proportion of Indigenous student enrolments, and low attendance rates.
Conclusion: This study provides indicative evidence that characteristics of schools and school populations are associated with the likelihood of low initiation and completion of the HPV vaccination course. The findings will guide further research and help target initiatives to improve vaccination uptake in schools with profiles associated with lower coverage.

1. Introduction

Human papillomavirus (HPV) infection is the primary cause of cervical cancer and genital warts. HPV is also associated with the development of vulvar, vaginal, penile, anal, and oropharyngeal cancers [1]. Estimates from the pre-vaccination era indicate that up to 79% of women are infected with HPV of any type during their lifetime [2], with incidence highest in young women in the first few years after becoming sexually active [3]. HPV-related cancers and genital warts carry a considerable health and economic burden [4–8].

Australia was the first country globally to implement a fully funded National HPV Vaccination Program, delivered primarily through school-based vaccination programs. From 2007 until its replacement in 2018 by a 2-dose nonavalent vaccine, the 3-dose quadrivalent Gardasil® vaccine (targeting the oncogenic HPV types 16, 18 and the wart-causing types 6, 11) was offered to adolescent girls and, from 2013, to adolescent boys. The HPV school vaccination programs operate at the beginning of secondary school. For the school years covered in this study, the program was delivered in Year 7 at ages 12 to 13 years in all Australian jurisdictions other than South Australia and Western Australia where it was delivered in Year 8 at ages 13–14 years. Program delivery varies between states and territories. The impact of the National HPV Vaccination Program was first observed through rapid and substantial reductions in diagnosis rates of genital warts [9,10] and related hospital admissions [11]. This was followed by a decline in HPV infection prevalence for vaccine-targeted HPV types [12] and substantial reductions in the detection of high-grade cervical abnormalities (precancerous changes) [13]. Similar impacts have been demonstrated internationally, with greater effects in programs with high vaccination coverage for multiple cohorts [14].

At the national level, Australia is under the global elimination threshold of 90% coverage [15] with 3-dose vaccination coverage of 75.9% for males and 80.2% for females turning 15 years of age in 2017 [16,17] with considerable variation between states and territories [16,17] and even greater disparities at smaller geographical levels [18]. Lower coverage for girls has been documented in areas with the lowest socioeconomic status, in remote areas, and in certain school types [19,20]. In other high-income countries with primarily school-based delivery such as Canada and the United Kingdom, studies have shown negative associations between some ethnicities and vaccination initiation, but not course completion, and mixed results regarding associations between area-based socioeconomic status and vaccination coverage [21–25]. These studies also indicate the reasons for not initiating the course may be different to barriers to completing the course [21–25].

To our knowledge, no study has compared school-level correlates of low HPV vaccination initiation and completion coverage in school-based programs in Australia. Internationally, there have other school-level studies conducted in the UK: one of these did not distinguish between correlates of initiation and completion [26], and the second study used vaccination cohorts as the unit of analysis with both school-level and individual-level characteristics included [25]. Schools are the primary setting for the delivery of HPV vaccination in Australia, it is important to identify schools that could benefit from targeted initiatives to improve vaccination initiation and completion coverage and ensure equitability across geographical areas and populations. We aimed to identify school-level factors associated with low initiation and completion of school-based HPV vaccination in three Australian states to help target further research and inform future programming.

2. Methods

2.1. Study design

This study took an exploratory approach to generate hypotheses regarding relationships between school characteristics and vaccination coverage. We undertook an ecological study based on routinely collected administrative data at the school level to investigate associations between school characteristics and HPV vaccination initiation and completion.

2.2. Setting

The study was conducted in three Australian states, New South Wales, Tasmania, and Western Australia, which collectively represent approximately 45% of the Australian population.

2.3. Vaccine delivery

In Australia, health service delivery is the responsibility of state and territory governments and is implemented in a variety of ways. Tasmania operates school vaccination teams primarily through local councils (i.e., municipalities, the lowest level of elected government in Australia), New South Wales uses local health districts (i.e., regional divisions of the jurisdictional health department), and Western Australia uses a combination of local councils and area health services depending on location. The arrangements for catch-up doses for students who missed doses on the scheduled delivery days also differ among states, with New South Wales offering in-school catch-up visits in the following year and the other two states referring students to primary care providers or other external clinics.

2.4. Study population

We included all secondary schools in the three states for which both student enrolment numbers and delivered HPV vaccination doses were available for 2015 and 2016.

2.5. Data sources

From 2007 to 2018, all HPV vaccination doses delivered in Australia under the National Immunisation Program were required to be reported, by name, and the setting in which vaccination took place, to the National HPV Vaccination Program Register (NHPVR). For this study, the NHPVR provided counts of all HPV doses given by school, calendar year of eligibility (coinciding with school year), and sex, aggregated from individual-level records for doses determined by the NHPVR to meet *The Australian Immunisation Handbook* requirements current at the time (i.e., excess doses and doses not meeting minimum intervals where not counted).

Jurisdictional health departments provided 2015 and 2016 school enrolment data for the specific school grade of program administration (Year 7 in two jurisdictions, Year 8 in one jurisdiction), collated from local immunisation providers which collect these data for vaccination program planning.

Data on the school-specific characteristics included in the analyses were obtained from the Australian Curriculum, Assessment and Reporting Authority (ACARA) and the Australian Bureau of Statistics (ABS). ACARA collects information on school location according to the ABS remoteness classification, total school size; special education status (i.e. schools catering for special educational needs or mainstream schools); the percentage of enrolments of students identified as Aboriginal and/or Torres Strait Islander (referred to hereafter respectfully as Indigenous students); the percentage of enrolments of students with a language background other than English; and the school attendance rate defined as actual student days attended over total possible student days. Continuous variables were categorised into tertiles across all schools. We also classified schools based on receiving only government funding or a mix of private and government funding, as well as religious or ideological affiliation using ACARA classifications and school databases in each jurisdiction [27–29]. To maintain anonynimity of affiliation, coverage and correlates by school type and affiliation are not reported publicly but these results were provided confidentially to program managers. Total reported enrolments by sex were used to infer co-educational versus single-sex school status; and the postcode of the school was used to obtain its level of socioeconomic disadvantage as defined by the 2016 Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage [30]. Australian postcodes are not standardised to cover a particular population size or geographical area.

The NHPVR, ACARA, and the three jurisdictions each use different unique school identifiers. For school records from different sources, direct merges based on school name and school postcode were attempted first, followed by probabilistic matching of the remaining records on a combined school name and postcode matching variable using the STATA reclink command [31]. Results were reviewed manually. Records that were unable to be linked probabilistically or appeared to be false matches on manual review were checked. Plausible matches were added to the combined datasets, and implausible ones deleted.

2.6. Study outcomes

We calculated the proportion of adolescents in each school who initiated the HPV vaccination course, and the proportion who completed the course once initiated, for males and females separately. Only doses recorded by the NHPVR as having been delivered in school which could be attributed to a school and year level were included in the analysis. Doses given outside the school setting or in ungraded schools, i.e., schools not organised into year levels, were excluded. To assess completion coverage, schools without dose 1 vaccination records were excluded (see below).

Initiation for a school was the number of dose 1 vaccinations reported to the NHPVR divided by the student enrolment number for the year level of program delivery. Completion was the number of dose 3 vaccinations divided by the number of dose 1 vaccinations. We chose this completion definition, as compared to absolute completion (dose 3 divided by enrolments), to fully differentiate its school-related correlates from those associated with initiation. Both initiation (program year 2016) and completion (program year 2015) were assessed at the end of 2016 to account for catch-up doses. Where the calculation of initiation or completion coverage yielded a figure in excess of 100%, it was set to 100%.

2.7. Statistical analysis

Descriptive analyses of school-level initiation and completion across the three jurisdictions involved calculation of means, standard deviations, medians, ranges and interquartile ranges (IQR). The Wilcoxon rank sum test was used to compare coverage by sex. The 25th percentile across all schools for males and females combined was used as the cut-off for binary categorisation of initiation and completion into high and low coverage. We explored correlations between ordinal covariates using Spearman's rank correlation coefficients. We then conducted univariable logistic regression analyses to determine characteristics associated with low coverage, with the school as unit of analysis. Given strong pairwise correlations between several key covariates (see results section), we do not report multivariable analyses. To assess the sensitivity of our findings to coverage estimates based on small numbers, we repeated the analyses for males and females combined, restricted to schools with vaccine-eligible enrolment numbers $\geq$ 10 students. All analyses were conducted using STATA IC v14.2 (StataCorp, College Station, Texas).

2.8. Ethical approval

Ethical approval was provided by the Human Research Ethics Committees of the University of New South Wales (HC17632), the Australian National University (2017/516), the University of Tasmania (1320/17), the Aboriginal Health & Medical Research Council of New South Wales (1320/17), the Aboriginal Health Council of Western Australia (818), and the Department of Health of Western Australia (RGS0000000456).

3. Results

After exclusions, there were 1,286 schools in the program year 2016 available for analysis of initiation and 1,295 schools in the program year 2015 for completion (see flowcharts in Figs. 1 and 2). Both initiation (program year 2016) and completion (program year 2015) were assessed at the end of 2016 to account for catch-up doses. Overall, 33 schools with 2015 enrolment data and 39 schools with 2016 enrolment data were excluded, two due to their location in an Australian external territory rather than one of the participating jurisdictions, and the remainder because they could not be conclusively matched to a school recoded in the NHPVR. A further 10 schools in the 2015 program year for which the NHPVR reported dose 3 vaccinations did not have any dose 1 vaccinations recorded and were also excluded. Doses given outside the school setting represented 3.9% of dose 1 vaccinations

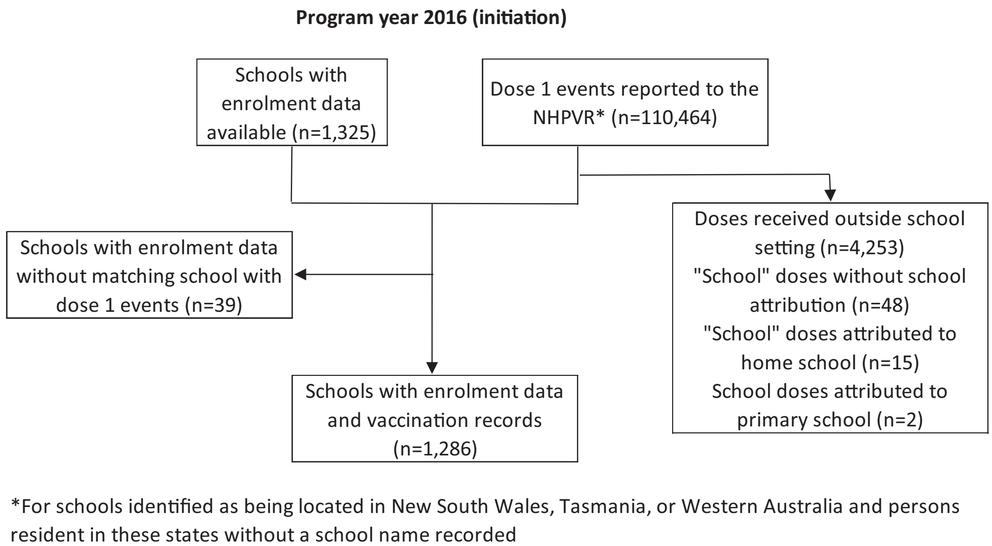

Fig. 1. Flowchart of vaccination and enrolment data by school for program year 2016 to assess HPV vaccination initiation.

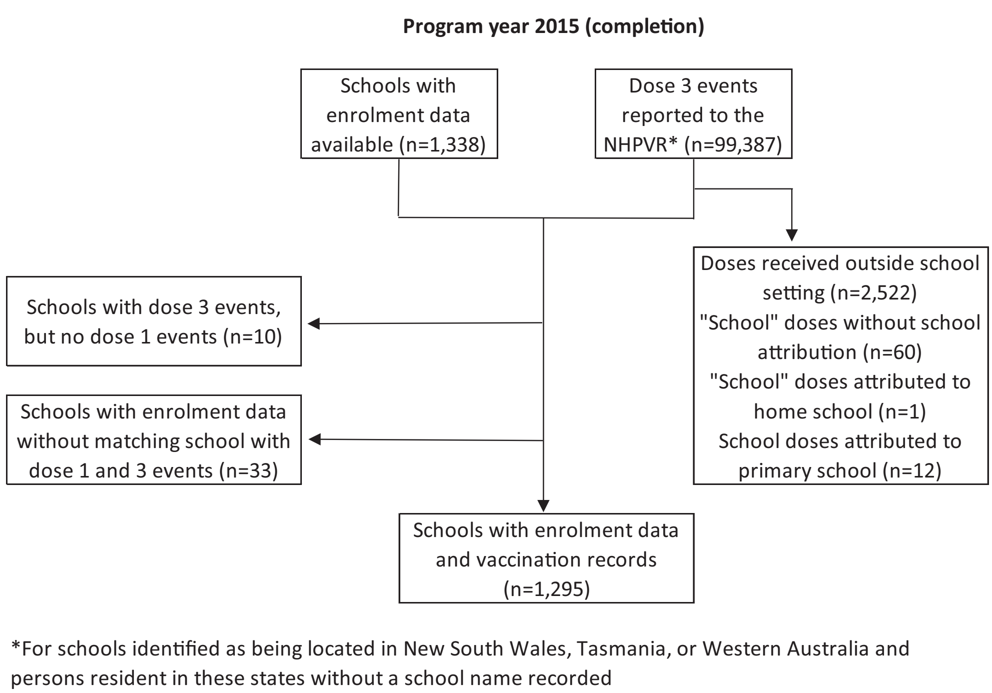

Fig. 2. Flowchart of vaccination and enrolment data by school for program year 2015 to assess HPV vaccination completion following initiation.

in the target age group reported to the NHPVR for 2016 and 2.5% of dose 3 vaccinations for 2015. Doses reported as in-school doses that were given to those in the target group who were home-schooled or whose school name was not recorded accounted for < 0.001% of dose 1 vaccinations for 2016 and a similarly negligible proportion of dose 3 vaccinations for 2015. The HPV coverage was in excess of 100% in 31 schools (2.4%). Of those 31 schools, 71% were small schools with lower enrolment numbers.

Table 1 summarises the characteristics of schools in the 2016 program year by jurisdiction. Note that Tasmania does not have an area classified as a major city. The state also had a higher percentage of schools in disadvantaged areas, and lower percentages of Indigenous students and students with a language background other than English. Western Australia had a higher percentage of schools located in remote and very remote areas. An analysis of correlations between school characteristics (Table 2) showed important overlaps between several of these variables. For continuous variables categorised into groups for this analysis, correlations were stronger when measured on the original continuous scale (see Table 1, supplemental materials). For instance, higher relative Indigenous student enrolments were highly correlated with lower attendance and moderately correlated with increasing remoteness, higher postcode socioeconomic disadvantage, and smaller school size. On the continuous scale, correlation coefficients increased up to ten points (e.g., from – 0.61 to −0.71 for attendance), suggesting that the real-world overlap between

Table 1
Summary of school characteristics by jurisdiction, 2016 program year[1].

	New South Wales (n = 880)		Tasmania (n = 80)		Western Australia (n = 326)		Total (n = 1,286)	
Remoteness area								
Major cities	565	(64%)	0	NA	186	(57%)	751	(58%)
Inner Regional	208	(24%)	45	(56%)	35	(11%)	288	(22%)
Outer Regional	92	(10%)	31	(39%)	46	(14%)	169	(13%)
Remote & very remote	11	(1%)	3	(4%)	59	(18%)	73	(6%)
Missing data	4	(0.5%)	1	(1%)	0	NA	5	(0.4%)
School size (total school enrolments)								
Small (11–383)	255	(29%)	35	(44%)	129	(40%)	419	(33%)
Medium (384–844)	308	(35%)	31	(39%)	81	(25%)	420	(33%)
Large (845–2,735)	297	(34%)	8	(10%)	112	(34%)	417	(32%)
Missing data	20	(2%)	6	(8%)	4	(1%)	30	(2%)
Co-educational status								
Co-educational school	732	(83%)	68	(85%)	305	(94%)	1,105	(86%)
Single sex school	128	(15%)	6	(8%)	17	(5%)	151	(12%)
Missing data	20	(2%)	6	(8%)	4	(1%)	30	(2%)
Special education status								
Mainstream school	801	(91%)	78	(98%)	299	(92%)	1,178	(92%)
Special education school	75	(9%)	1	(1%)	27	(8%)	103	(8%)
Missing data	4	(0.5%)	1	(1%)	0	NA	5	(0.4%)
% Indigenous student enrolments								
Low (0%-2%)	330	(38%)	8	(10%)	114	(35%)	452	(35%)
Medium (3%-8%)	231	(26%)	27	(34%)	85	(26%)	343	(27%)
High (9%-100%)	249	(28%)	38	(48%)	107	(33%)	394	(31%)
Missing data	70	(8%)	7	(9%)	20	(6%)	97	(8%)
% Language-background-other-than-English student enrolments								
Low (0%-6%)	302	(34%)	59	(74%)	94	(29%)	455	(35%)
Medium (7%–22%)	232	(26%)	13	(16%)	135	(41%)	380	(30%)
High (23%-100%)	325	(37%)	2	(3%)	88	(27%)	415	(32%)
Missing data	21	(2%)	6	(8%)	9	(3%)	36	(3%)
School postcode Relative Socioeconomic Disadvantage score								
Most disadvantaged (604–967)	296	(34%)	43	(54%)	89	(27%)	428	(33%)
Less disadvantaged (698–1,016)	293	(33%)	22	(28%)	113	(35%)	428	(33%)
Least disadvantaged (1,017–1,128)	291	(33%)	9	(11%)	124	(38%)	424	(33%)
Missing data	0	NA	6	(8%)	0	NA	6	(0.5%)
Attendance rate (% of all possible school days attended)								
Low (29%-87%)	276	(31%)	29	(36%)	146	(45%)	451	(35%)
Medium (88%-91%)	294	(33%)	30	(38%)	96	(29%)	420	(33%)
High (92%-97%)	203	(23%)	10	(13%)	60	(18%)	273	(21%)
Missing data	107	(12%)	11	(14%)	24	(7%)	142	(11%)

[1] School characteristics are presented for schools in the 2016 program year only. Characteristics and category cut points for continuous variables were similar across years.

Table 2
Correlations between continuous covariates categorised into tertiles and ordinal categorical covariates (Spearman's rank correlation coefficients), schools in 2016 HPV vaccination program year.

	Indigenous student enrolments (1–3)	Language-background-other-than-English student enrolments (1–3)	School postcode SEIFA IRSD score (1–3)	School size (1–3)	Attendance rate (1–3)	Remoteness (1, major cities-4, remote)
Indigenous student enrolments (1–3)						
Language-background-other-than-English student enrolments (1–3)	−0.4455					
School postcode SEIFA IRSD score (1–3)	−0.5036	0.3211				
School size (1–3)	−0.4698	0.312	0.3849			
Attendance rate (1–3)	−0.6125	0.2821	0.3975	0.3458		
Remoteness (1, major cities-4, remote)	0.5629	−0.5686	−0.494	−0.5335	−0.3068	

school characteristics is even more pronounced than reflected in the simplified model used in the analysis to improve interpretability. Of the schools with the highest relative Indigenous student enrolments, 80% had low attendance compared to 12% of schools with the lowest Indigenous student enrolments, 63% were located in the most socioeconomically disadvantaged postcodes compared to 15% of schools with the lowest Indigenous student enrolments, 56% were small schools compared to 14% of schools with the lowest Indigenous student enrolments, and 16% were in remote and very remote areas compared to 0.5% of schools with low Indigenous student enrolments.

3.1. Initiation and completion estimates

Median in-school initiation was 84.7% (IQR: 75.0%-90.4%), with 327 schools classified as having low initiation at $\leq$ 75% coverage. Initiation was lower for males compared to females, with a median of 85.5% (IQR: 75.8%-92.3%) for females and 83.7% (IQR: 73.3%-91.0%) for males ($p = 0.003$). Median completion was 93.8% (IQR: 86.0%-97.3%), with 323 schools classified as having low completion at $\leq$ 86% coverage. Completion was similar for both sexes at 94.0% (IQR: 86.1%-99.0%) for females and 93.8% (IQR: 85.7%-98.9%) for males ($p = 0.888$).

3.2. Associations between school characteristics and low initiation

The percentage of schools classified as having low initiation varied significantly by all school characteristics investigated, for both females and males (Table 3). Low initiation was associated with small schools compared to large schools (females: OR = 8.2, 95% CI = 5.3–12.7; males: OR = 4.1, 95% CI = 2.9–5.8), schools catering for special educational needs compared to mainstream schools (females: OR = 4.1, 95% CI = 2.5–6.6; males: OR = 3.8, 95% CI = 2.5–5.8), and for schools in Tasmania compared to New South Wales (females: OR = 4.5, 95% CI = 2.8–7.2; males: OR = 2.5, 95% CI = 1.5–4.0). In addition, there were strong associations between low initiation and a number of school types and affiliations (highest OR for females: 5.1, 95% CI = 2.9–9.1; highest OR for males 3.8, 95% CI = 2.3–6.4; data not shown in Table 3). Of the socio-demographic variables describing school populations rather than schools, high Indigenous student enrolments were most strongly associated with low initiation (females: OR = 2.4, 95% CI = 1.7–3.4; males: OR = 2.4, 95% CI = 1.7–3.3).

3.3. Associations between school characteristics and low completion

Similar to initiation, all school characteristics included in the analysis showed associations with low completion, with the exception of language background. For both males and females, the following characteristics had some of the strongest associations with low completion: school location in Tasmania (females: OR = 8.4, 95% CI = 5.1–13.7; males: OR = 7.6, 95% CI = 4.7–12.4) and Western Australia (females: OR = 5.3, 95% CI = 3.9–7.2; males: OR = 5.1, 95% CI = 3.8–6.9); small schools (females: OR = 4.9, 95% CI = 3.3–7.2; males: OR = 3.8, 95% CI = 2.7–5.5); school location in remote areas compared to location in major city areas (females: OR = 4.0, 95% CI = 2.5–6.4; males: OR = 5.4, 95% CI = 3.3–9.0); schools with high Indigenous student enrolments compared to those with low Indigenous student enrolments (females: OR = 4.0, 95% CI = 2.8–5.9; males: OR = 4.0, 95% CI = 2.7–5.5); and schools with low attendance rates compared to those with the highest attendance rates (females: OR = 3.2, 95% CI = 2.2–4.6; males: OR = 3.1, 95% CI = 2.1–4.5). In addition, for females in particular, co-educational schools had multiple times the odds of low completion of single-sex schools (females: OR = 9.4, 95% CI = 2.9–30.0; males: OR = 3.2, 95% CI = 1.5–7.4). Some associations seen for initiation were less pronounced for completion, including higher odds of low completion in special schools (females: OR = 2.5, 95% CI = 1.5–4.1; males: OR = 3.1, 95% CI = 2.0–4.7). In addition, the pattern of association between low coverage and certain school types and affiliations remained the same as in the initiation analysis but was less marked in the completion analysis (highest OR for females: 3.0, 95% CI = 1.7–5.3; highest OR for males: 3.6, 95% CI = 2.1–6.2; data not shown in Table 4).

Table 3
Associations between school characteristics and low in-school HPV vaccination initiation by sex, 2016 program year.

	Females			Males		
Variable	Low initiation[1] N (%)	Univariable analysis OR (95% CI)	p-value[2]	Low initiation[1] N (%)	Univariable analysis OR (95% CI)	p-value[2]
State			<0.001			<0.001
New South Wales	171 (22%)	reference		229 (29%)	reference	
Tasmania	42 (55%)	4.5 (2.8–7.2)	<0.001	37 (50%)	2.5 (1.5–4.0)	<0.001
Western Australia	75 (24%)	1.2 (0.8–1.6)	0.367	82 (27%)	0.9 (0.7–1.2)	0.514
Remoteness area			0.001			0.006
Major cities	132 (20%)	reference		170 (27%)	reference	
Inner Regional	81 (29%)	1.7 (1.2–2.3)	0.002	100 (36%)	1.7 (1.2–2.2)	0.001
Outer Regional	49 (30%)	1.7 (1.1–2.5)	0.008	50 (30%)	1.3 (0.9–1.8)	0.226
Remote & very remote	23 (34%)	2.0 (1.2–3.5)	0.009	25 (36%)	1.7 (1.0–2.8)	0.056
School size (total school enrolments)		<0.001			<0.001	
Small (11–383)	150 (40%)	8.2 (5.3–12.7)	<0.001	168 (42%)	4.1 (2.9–5.8)	<0.001
Medium (384–844)	97 (25%)	4.1 (2.6–6.4)	<0.001	114 (29%)	2.3 (1.6–3.3)	<0.001
Large (845–2,735)	28 (7%)	reference		53 (15%)	reference	
Co-educational status						
Co-educational school	267 (25%)	3.1 (1.5–6.6)	0.003	324 (30%)	2.3 (1.2–4.4)	0.014
Single sex school	8 (10%)	reference		11 (16%)	reference	
Special education status						
Mainstream school	244 (22%)	reference		287 (27%)	reference	
Special education school	41 (54%)	4.1 (2.5–6.6)	<0.001	58 (58%)	3.8 (2.5–5.8)	<0.001
% Indigenous student enrolments						
Low (0%-2%)	63 (16%)	reference		81 (21%)	reference	<0.001
Medium (3%-8%)	76 (23%)	1.6 (1.1–2.3)	0.013	79 (24%)	1.2 (0.8–1.7)	0.388
High (9%-100%)	116 (32%)	2.4 (1.7–3.4)	<0.001	152 (39%)	2.4 (1.7–3.3)	<0.001
% Language-background-other-than-English student enrolments	0.014			0.039		
Low (0%-6%)	123 (28%)	1.6 (1.1–2.2)	0.008	145 (33%)	1.3 (0.9–1.7)	0.112
Medium (7%–22%)	76 (22%)	1.1 (0.8–1.6)	0.625	87 (25%)	0.9 (0.6–1.2)	0.381
High (23%-100%)	73 (20%)	reference		101 (28%)	reference	
School postcode Relative Socioeconomic Disadvantage score	0.005			<0.001		
Most disadvantaged (604–967)	110 (27%)	1.7 (1.2–2.3)	0.003	142 (34%)	1.9 (1.4–2.6)	<0.001
Less disadvantaged (698–1,016)	107 (27%)	1.6 (1.2–2.3)	0.004	126 (31%)	1.6 (1.2–2.3)	0.003
Least disadvantaged (1,017–1,128)	69 (18%)	reference		77 (22%)	reference	
Attendance rate (% of all possible school days attended)	0.002			<0.001		
Low (29%-87%)	119 (27%)	1.8 (1.2–2.7)	0.003	157 (36%)	1.9 (1.4–2.6)	<0.001
Medium (88%-91%)	75 (19%)	1.1 (0.8–1.8)	0.515	91 (23%)	1.6 (1.2–2.3)	0.003
High (92%-97%)	41 (17%)	reference		45 (20%)	reference	

[1] Low initiation is defined as initiation (dose 1 events/enrolments at the school level) ≤ 25th percentile of the data distribution for both sexes.
[2] The overall p-value is based on the test for heterogeneity.

Table 4
Associations between school characteristics and low in-school HPV vaccination completion following initiation by sex, 2015 program year.

	Females			Males		
Variable	Low completion[1] N (%)	Univariable analysis OR (95% CI)	p-value[2]	Low completion[1] N (%)	Univariable analysis OR (95% CI)	p-value[2]
State			<0.001			<0.001
New South Wales	55 (13%)	Reference		116 (15%)	reference	
Tasmania	51 (57%)	8.4 (5.1–13.7)	<0.001	45 (57%)	7.6 (4.7–12.4)	<0.001
Western Australia	42 (45%)	5.3 (3.9–7.2)	<0.001	145 (47%)	5.1 (3.8–6.9)	<0.001
Remoteness area			<0.001			<0.001
Major cities	136 (22%)	Reference		149 (23%)	reference	
Inner Regional	55 (20%)	0.9 (0.6–1.3)	0.629	60 (22%)	0.9 (0.7–1.3)	0.696
Outer Regional	51 (30%)	1.6 (1.1–2.3)	0.019	48 (28%)	1.3 (0.9–1.9)	0.192
Remote & very remote	42 (53%)	4.0 (2.5–6.4)	<0.001	46 (62%)	5.4 (3.3–9.0)	<0.001
School size (total school enrolments)		<0.001			<0.001	
Small (7–376)	135 (38%)	4.9 (3.3–7.2)	<0.001	148 (38%)	3.8 (2.7–5.5)	<0.001
Medium (377–838)	101 (26%)	2.8 (1.9–4.1)	<0.001	102 (26%)	2.2 (1.5–3.2)	<0.001
Large (839–2,530)	42 (11%)	Reference		49 (14%)	reference	
Co-educational status						
Co-educational school	275 (27%)	9.4 (2.9–30.0)	<0.001	292 (27%)	3.4 (1.5–7.4)	0.003
Single sex school	3 (4%)	Reference		7 (10%)	reference	
Special education status						
Mainstream school	254 (24%)	Reference		256 (24%)	reference	
Special education school	30 (43%)	2.5 (1.5–4.1)	<0.001	48 (49%)	3.1 (2.0–4.7)	<0.001
% Indigenous student enrolments			<0.001			<0.001
Low (0–2%)	47 (13%)	Reference		49 (14%)	reference	
Medium (3%-9%)	94 (27%)	2.5 (1.7–3.7)	<0.001	102 (28%)	2.4 (1.7–3.5)	<0.001
High (10%-100%)	122 (37%)	4.0 (2.8–5.9)	<0.001	135 (39%)	4.0 (2.7–5.7)	<0.001
% Language-background-other-than-English student enrolments	0.516			0.233		
Low (0–5%)	94 (25%)	1.2 (0.9–1.7)	0.281	109 (28%)	1.3 (0.9–1.8)	0.138
Medium (6%–22%)	91 (25%)	1.2 (0.8–1.7)	0.351	87 (24%)	1.0 (0.7–1.4)	0.911
High (23%-100%)	70 (22%)	Reference		77 (23%)	reference	
School postcode Relative Socioeconomic Disadvantage score	0.009			0.007		
Most disadvantaged (604–965)	115 (29%)	1.7 (1.2–2.4)	0.002	128 (31%)	1.7 (1.2–2.3)	0.002
Less disadvantaged (966–1,016)	102 (26%)	1.5 (1.0–2.1)	0.030	101 (25%)	1.2 (0.9–1.7)	0.228
Least disadvantaged (1,017–1,128)	68 (19%)	Reference		73 (21%)	reference	
Attendance rate (% of all possible school days attended)	<0.001			<0.001		
Low (32%-87%)	156 (35%)	3.2 (2.2–4.6)	<0.001	161 (35%)	3.1 (2.1–4.5)	<0.001
Medium (88%-90%)	61 (21%)	1.6 (1.0–2.4)	0.037	58 (19%)	1.4 (0.9–2.1)	0.134
High (91%-100%)	46 (14%)	reference		44 (15%)	reference	

[1] Low completion is defined as completion following initiation (dose 3 events/dose 1 events at the school level) ≤ 25th percentile of the data distribution for both sexes.
[2] The overall p-value is based on the test for heterogeneity.

3.4. Sensitivity analyses

Sensitivity analyses of results for both sexes combined indicate that the above results are generally robust to the influence of small numbers (see Tables 2-5, supplemental materials). Coverage estimates for very small schools would be disproportionately affected by misattribution of enrolments or doses and student movement after the enrolment census. However, the odds ratios were very similar between the full dataset and a reduced dataset excluding schools with<10 vaccine-eligible students. The odds ratios for small schools decreased slightly and increases were seen in the odds ratio for some of the variables most correlated with school size, including special education status and jurisdiction for initiation and completion, postcode socioeconomic status for initiation, and remoteness and Indigenous student enrolments for completion.

4. Discussion

This analysis demonstrated differences in the initiation and completion of the HPV vaccination course at the school level, with both coverage measures varying by school characteristics. For both sexes, particularly strong associations between school characteristics and low initiation were seen in schools which were smaller, located in Tasmania, had particular school affiliations, and catered for adolescents with special educational needs. Whereas low completion, for both sexes, was most strongly associated with schools in Tasmania and Western Australia, schools located in remote areas, smaller schools, and schools that had high Indigenous student enrolments and low attendance rates. Additionally, schools that were co-educational showed strong associations with low completion for females.

Special education schools, which were very small in size, had much lower initiation and completion than mainstream schools. It is important to note that ungraded special schools were unable to be included in this study due to the unavailability of year-specific enrolment data. As a result, the sub-set of specials schools captured in the analysis is unlikely to reflect the school sector as a whole. A similar association of attendance of non-mainstream schools with lower vaccination coverage was reported among girls in the UK [23], and one study in Australia found low coverage in a small cohort of 375 students from 27 special education schools in Victoria [32]. The study in Victoria found the most frequent reasons for non-vaccination in special school settings to be student absence on immunisation day, missing or declined parental consent, and student behaviour on vaccination day[32]. This study was based on a survey of immunisation providers. Another study from the US, which involved interviews with parents of special needs students found that sexual health, including consideration of HPV vaccination, is a topic that is often neglected in adolescents with disabilities, despite evidence that their sexual health needs are often similar to or greater than those of their typically developing peers[33].

We found school size was associated with lower HPV initiation and completion coverage, similar to the study from the UK [26]. It is currently not known why small schools have lower HPV initiation and completion compared to other schools. It may be that smaller schools have different resource levels or vaccination program organisation systems.

There were a number of specific characteristics of school populations that were more strongly associated with completion than initiation. For example, schools with lower attendance rates were considerably more likely to have low completion rates. Two other Australian studies in recent years have also shown absenteeism to influence HPV vaccination completion rates [19,34]. High absenteeism rates reduce collective opportunities to initiate and complete the vaccination course in school, particularly for completion if subsequent vaccination days are used to catch up dose 1.

Schools with the highest Indigenous student enrolments were also considerably more likely to have low initiation and completion, with the association stronger for completion. Indigenous adolescents continue to experience considerable socioeconomic disadvantage compared to non-Indigenous people [35], and lower school attendance rates [36] which, if combined with a lack of culturally appropriate delivery of vaccination information and services, may present considerable barriers to initiation and completion of school-based HPV vaccination. Addressing these gaps is crucial considering there are important disparities in the burden of disease from cervical cancer in Indigenous women [4,5].

Lower HPV coverage has previously been reported among independent schools in Western Australia, [20] potentially a marker of religious or philosophical beliefs held by the schools or the parents of the adolescents attending the schools, including greater vaccine hesitancy, specific reservations towards vaccination against HPV as a sexually transmissible infection [37], or other factors. In other studies, which were predominately located in the United States, frequent participation in any organised religion and belonging to particular religions or Christian denominations has been shown to be correlated with vaccine acceptability or coverage in some studies [26,38–42].

Unmeasured factors related to vaccination delivery and other organisational differences between jurisdictions are likely to account at least partially for the strong associations with state of school location. In the UK, at least two studies found differences in vaccination coverage between Primary Care Trust areas, suggesting that unmeasured process factors are likely to contribute to vaccination outcomes [22,23]. In our study, the odds ratio was much larger for completion than for initiation which may partially be explained by New South Wales organising regular in-school catch-up vaccination in the second year when most students would have initiated the vaccination course but may not have completed it. As vaccine providers differ across states, it is likely that there is additional process variation between jurisdictions, such as different approaches to obtaining parental consent.

This study had two main strengths. First, it uses a comprehensive dataset built from multiple sources of routine data and comprising all schools in three Australian states for which HPV initiation and completion could be calculated. Second, undertaking the analysis at the school level provided new information about the main setting in which adolescent HPV vaccination in Australia is currently delivered. Knowledge about school characteristics associated with an increased likelihood of low initiation and completion provides an opportunity to prioritise schools with specific profiles for interventions aimed at improving vaccination coverage. This is important as differences in vaccination coverage between geographical areas and population groups could reduce the anticipated population impact if coverage is lower in groups with higher levels of future sexual activity [43]. Also, if coverage is lower in smaller communities with predominantly local sexual contact such as geographically remote or culturally closed communities, this would reduce the vaccination impact within these communities and potentially fail to mitigate relative inequalities in the incidence of cervical and other HPV-related cancers [44,45].

Conversely, there are known limitations of using ecological study designs which should be mentioned, including that associations found at the school level may not hold at the individual level. Also, due to the strong correlations between characteristics of schools and school populations, we were unable to develop multivariable models without introducing bias of unpredictable direction and magnitude due to multicollinearity. We considered using composite variables or a priori elimination of the most highly correlated variables to address the issue of multicollinearity. However, both options would have necessitated a reduction of complex social factors without clear directionality into one indicator and led to a loss of contextual information. We therefore concluded that the presentation of univariate models was more suitable to inform the formulation of potential policy and programmatic interventions. Also, some categories, such as language background, could mask associations between low coverage and specific cultural backgrounds. Consistent with an exploratory approach intended to generate hypothesis in the context of limited prior research at the school level, we chose to focus on understanding potential relationships between school characteristics and vaccination overage, as well as relationships between different school factors. Evidence of associations between multiple school characteristics and the likelihood of low coverage may inform decisions about the prioritisation of resources to schools that fit a certain profile for interventions to increase HPV vaccination coverage.

In conclusion, this study has shown considerable variation in HPV vaccination initiation and completion in the school-based programs, between the three Australian jurisdictions, as well as within subgroups in each jurisdiction. New evidence of associations between key characteristics of schools and school populations and the likelihood of low initiation and completion can help guide programs designed to improve coverage. Further research is needed to investigate the pathways contributing to associations with low coverage. This includes delineation of factors linked to school types and the populations they serve such as lower and completion initiation rates in smaller schools, and investigation of differences specific to course completion such as lower completion rates for girls in co-ed schools. Research approaches may include a review and comparison of organisational factors in schools with particularly high and low coverage, and surveys and qualitative research engaging those involved in program planning and roll-out as well as parents and students as consumers. Future research should be conducted in tandem with the development of targeted interventions to improve initiation and completion of the HPV vaccination course in the school setting.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2021.08.076.

References

[1] Dunne EF IC. Human Papillomavirus Infection. In: Heymann D, editor. Control of Communicable Diseases Manual. Washington, DC: American Public Health Association; 2015.

[2] Syrjänen K, Hakama M, Saarikoski S, Väyrynen M, Yliskoski M, Syrjänen S, et al. Prevalence, incidence, and estimated life-time risk of cervical human papillomavirus infections in a nonselected Finnish female population. Sexually Transmitted Diseases 1990;17(1):15–9.

[3] Tabrizi S, Brotherton J, Stevens M, Condon J, McIntyre P, Smith D, et al. HPV genotype prevalence in Australian women undergoing routine cervical screening by cytology status prior to implementation of an HPV vaccination program. Journal of clinical virology 2014;60(3):250–6.

[4] Australian Institute of Health and Welfare. Australian Cancer Incidence and Mortality (ACIM) books: Cervical cancer. Canberra: AIHW; 2017.

[5] Australian Institute of Health and Welfare. Cancer in Australia Canberra: AIHW; 2017. Contract No.: Cat. No. CAN 100.

[6] Lew JB, Howard K, Gertig D, Smith M, Clements M, Nickson C, et al. Expenditure and resource utilisation for cervical screening in Australia. BMC health Services Res. 2012;12(1). https://doi.org/10.1186/1472-6963-12-446.

[7] Préaud E, Largeron N. Economic burden of non-cervical cancers attributable to human papillomavirus: a European scoping review. Journal of Medical Economics 2013;16(6):763–76.

[8] Pirotta M, Stein AN, Conway EL, Harrison C, Britt H, Garland S. Genital warts incidence and healthcare resource utilisation in Australia. Sexually transmitted infections 2010;86(3):181–6.

[9] Ali H, Donovan B, Wand H, Read TR, Regan DG, Grulich AE, et al. Genital warts in young Australians five years into national human papillomavirus vaccination programme: national surveillance data. BMJ (Clinical research ed). 2013;346:f2032.

[10] Ali H, McManus H, O'Connor C, Callander D, Kong M, Graham S, et al. Human papillomavirus vaccination and genital warts in young Indigenous Australians: national sentinel surveillance data. The Medical journal of Australia. 2017;206 (5):204–9.

[11] Ali H, Guy R, Wand H, Read T, Regan D, Grulich A, et al. Decline in in-patient treatments of genital warts among young Australians following the national HPV vaccination program. BMC Infectious Diseases 2013;13(1). https://doi.org/10.1186/1471-2334-13-140.

[12] Machalek DA, Garland SM, Brotherton JML, Bateson D, McNamee K, Stewart M, et al. Very Low Prevalence of Vaccine Human Papillomavirus Types Among 18- to 35-Year Old Australian Women 9 Years Following Implementation of Vaccination. The Journal of infectious diseases. 2018;217(10):1590-600.

[13] Gertig DM, Brotherton JM, Budd AC, Drennan K, Chappell G, Saville AM. Impact of a population-based HPV vaccination program on cervical abnormalities: a data linkage study. BMC medicine. 2013;11:227.

[14] Drolet M, Bénard É, Pérez N, Brisson M. HPV Vaccination Impact Study Group. Population-level impact and herd effects following the introduction of human papillomavirus vaccination programmes: updated systematic review and meta-analysis. Lancet 2019.

[15] Canfell K. Towards the global elimination of cervical cancer. Papillomavirus research 2019;8:100170.

[16] National HPV Vaccination Program Register. National (Australia) HPV 3 dose vaccination coverage for males turning 15 years of age in 2017. Available from: http://www.hpvregister.org.au/research/coverage-data/HPV-Vaccination-Coverage-2017—Male [last accessed 10 July 2019].

[17] National HPV Vaccination Program Register. National (Australia) HPV 3 dose vaccination coverage for all females turning 15 years of age, 2017. Available from: http://www.hpvregister.org.au/research/coverage-data/hpv-vaccination-coverage-2017only [last accessed 10 July 2019].

[18] Australian Institute of Health and Welfare. Web update: HPV immunisation rates 2015-16. 2018. Available from: https://myhealthy communities.gov.au/our-reports/HPV-rates/march-2018/explore-the-data [last accessed 25 March 2018].

[19] Barbaro B, Brotherton JM. Assessing HPV vaccine coverage in Australia by geography and socioeconomic status: are we protecting those most at risk? Australian and New Zealand journal of public health 2014;38(5):419–23.

[20] Mak DB, Bulsara MK, Wrate MJ, Carcione D, Chantry M, Efller PV. Factors determining vaccine uptake in Western Australian adolescents. Journal of paediatrics and child health 2013;49(11):895–900.

[21] Drolet M, Deeks SL, Kliewer E, Musto G, Lambert P, Brisson M. Can high overall human papillomavirus vaccination coverage hide sociodemographic inequalities? An ecological analysis in Canada. Vaccine. 2016;34(16):1874–80.

[22] Roberts SA, Brabin L, Stretch R, Baxter D, Elton P, Kitchener H, et al. Human papillomavirus vaccination and social inequality: results from a prospective cohort study. Epidemiology and infection. 2011;139(3):400-5.

[23] Fisher H, Audrey S, Mytton JA, Hickman M, Trotter C. Examining inequalities in the uptake of the school-based HPV vaccination programme in England: a retrospective cohort study. Journal of public health (Oxford, England). 2014;36 (1):36-45.

[24] Spencer AM, Roberts SA, Brabin L, Patnick J, Verma A. Sociodemographic factors predicting mother's cervical screening and daughter's HPV vaccination uptake. Journal of Epidemiology and Community Health 2014;68(6):571–7.

[25] Sinka K, Kavanagh K, Gordon R, Love J, Potts A, Donaghy M, et al. Achieving high and equitable coverage of adolescent HPV vaccine in Scotland. Journal of Epidemiology and Community Health 2014;68(1):57–63.

[26] Tiley K, White J, Andrews N, Tessier E, Ramsay M, Edelstein M. What school-level and area-level factors influenced HPV and MenACWY vaccine coverage in England in 2016/2017? An ecological study. BMJ Open. 2019;9(7):e029087. https://doi.org/10.1136/bmjopen-2019-029087.

[27] Association of Independent Schools of NSW. School Finder. Available from: https://archive.aisnsw.edu.au/Pages/SchoolFinder.aspx [last accessed 14 May 2018].

[28] Association of Independent Schools of Western Australia. Search For a School. Available from: https://www.ais.wa.edu.au/search-for-a-school [last accessed 14 May 2018].

[29] Independent Schools Tasmania. Schools. Available from: https://www.independentschools.tas.edu.au/schools/ [last accessed 14 May 2018].

[30] Australian Bureau of Statistics. 2033.0.55.001 - Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016. 2018 Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/2033.0.55.0012016?OpenDocument [last accessed 14 May 2018].

[31] Blasnik, M. 2010. reclink: Stata module to probabilistically match records. Statistical Software Components S456876, Department of Economics, Boston College. https://ideas.repec.org/c/boc/bocode/s456876.html [last accessed 14 May 2018].

[32] O'Neill J, Newall F, Antolovich G, Lima S, Danchin M. The uptake of adolescent vaccinations through the School Immunisation Program in specialist schools in Victoria, Australia. Vaccine. 2019;37(2):272–9.

[33] Rowe M, Pritt AL, Stratton AJ, Yoost JL. HPV Vaccination Among Females with Mental and Physical Limitation.. Marshall Journal of Medicine 2017;3(2). https://doi.org/10.18590/issn.2379-953610.18590/issn.2379-9536/2017v.3issue210.18590/mjm.2017.vol3.iss2.8.

[34] Watson M, Lynch J, D'Onise K, Brotherton J. Barriers to better three-dose coverage with HPV vaccination in school-based programs. Australian and New Zealand Journal of Public Health 2014;38(1):91–2.

[35] Australian Government. Department of Prime Minister and Cabinet. Closing the Gap Report 2019. Available from: https://ctgreport.niaa.gov.au/sites/default/files/ctg-report-20193872.pdf?a=1 [last accessed 16 December 2019].

[36] Australian Government, Department of Prime Minister and Cabinet. Closing the Gap. Chapter Three. Education. School Attendance Target | Literacy & Numeracy Target | Year 12 Attainment Target. Available from: https://www.pmc.gov.au/sites/default/files/reports/closing-the-gap-2018/education.html [last accessed 2 June 2019].

[37] Constantine NA, Jerman P. Acceptance of human papillomavirus vaccination among Californian parents of daughters: a representative statewide analysis. The Journal of adolescent health. 2007;40(2):108–15.

[38] Wilson AR, Hashibe M, Bodson J, Gren LH, Taylor BA, Greenwood J, et al. Factors related to HPV vaccine uptake and 3-dose completion among women in a low vaccination region of the USA: an observational study. BMC Women's Health 2016;16(1). https://doi.org/10.1186/s12905-016-0323-5.

[39] Bodson J, Wilson A, Warner EL, Kepka D. Religion and HPV vaccine-related awareness, knowledge, and receipt among insured women aged 18–26 in Utah. PLoS ONE 2017;12(8):e0183725. https://doi.org/10.1371/journal.pone.018372510.1371/journal.pone.0183725.t001.

[40] Bernat DH, Gerend MA, Chevallier K, Zimmerman MA, Bauermeister JA. Characteristics associated with initiation of the human papillomavirus vaccine among a national sample of male and female young adults. The Journal of adolescent health 2013;53(5):630–6.

[41] Shelton RC, Snavely AC, De Jesus M, Othus MD, Allen JD. HPV vaccine decision-making and acceptance: does religion play a role? Journal of Religion and Health 2013;52(4):1120–30.

[42] Marlow L, Waller J, Evans R, Wardle J. Predictors of interest in HPV vaccination: A study of British adolescents. Vaccine. 2009;27(18):2483–8.

[43] Hughes A, Mesher D, White J, Soldan K. Coverage of the English national human papillomavirus (HPV) immunisation programme among 12 to 17 year-old females by area-level deprivation score, England, 2008 to 2011. Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin. 2014;19(2).
[44] Malagón T, Drolet M, Boily MC, Laprise JF, Brisson M. Changing inequalities in cervical cancer: modeling the impact of vaccine uptake, vaccine herd effects, and cervical cancer screening in the post-vaccination era. Cancer epidemiology, biomarkers & prevention. 2015;24(1):276–85.
[45] Smith MA, Canfell K. Incremental benefits of male HPV vaccination: accounting for inequality in population uptake. PloS one. 2014;9(8): e101048-e.