

# High-Risk Human Papillomavirus (HPV) Infection and Cervical Cancer Prevention in Britain: Evidence of Differential Uptake of Interventions from a Probability Survey

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## Abstract

**Background:** The third British National Survey of Sexual Attitudes and Lifestyles (Natsal-3) provides an opportunity to explore high-risk human papillomavirus (HR-HPV) and uptake of cervical screening and HPV vaccination in the general population.

**Methods:** Natsal-3, a probability sample survey of men and women ages 16 to 74, resident in Britain, interviewed 8,869 women in 2010 to 2012. We explored risk factors for HR-HPV (in urine from 2,569 sexually experienced women ages 16 to 44), nonattendance for cervical screening in the past 5 years, and noncompletion of HPV catch-up vaccination.

**Results:** HR-HPV was associated with increasing numbers of lifetime partners, younger age, increasing area-level deprivation, and smoking. Screening nonattendance was associated with younger and older age, increasing area-level deprivation (age-adjusted OR 1.91, 95% confidence interval, 1.48–2.47 for living in most vs. least deprived two quintiles), Asian/Asian British

ethnicity (1.96, 1.32–2.90), smoking (1.97, 1.57–2.47), and reporting no partner in the past 5 years (2.45, 1.67–3.61 vs. 1 partner) but not with HR-HPV (1.35, 0.79–2.31). Lower uptake of HPV catch-up vaccination was associated with increasing area-level deprivation, non-white ethnicity, smoking, and increasing lifetime partners.

**Conclusions:** Socioeconomic markers and smoking were associated with HR-HPV positivity, nonattendance for cervical screening, and noncompletion of catch-up HPV vaccination.

**Impact:** The cervical screening program needs to engage those missing HPV catch-up vaccination to avoid a potential widening of cervical cancer disparities in these cohorts. As some screening nonattenders are at low risk for HR-HPV, tailored approaches may be appropriate to increase screening among higher-risk women. *Cancer Epidemiol Biomarkers Prev*; 24(5); 842–53. ©2015 AACR.

## Introduction

In over 99% of cases, cervical cancer is associated with persistent infection with one or more high-risk human papilloma virus (HR-

HPV) genotypes (1). Every year in Britain approximately 2,900 women are diagnosed with cervical cancer (2), and it is the most common cancer in women under 35 years (3). Worldwide, the burden of cervical cancer varies substantially, and 85% of cases occur in low-to-middle income countries (4). In many high-income countries, including Britain, incidence and mortality have decreased over the past few decades, since the introduction of cervical cancer screening programs (5). In Britain, cervical screening uptake is high (around 80%; ref. 6), but cervical cancer incidence and mortality are higher in more deprived areas (7, 8). The two recent Cancer Reform Strategies (2011 and 2007; refs. 9, 10) have highlighted the need to reduce these inequalities. Understanding the burden of HR-HPV prevalence and uptake of cervical cancer prevention programs (HPV immunization and cervical screening) will help address this aim.

In Britain, there have been two recent notable changes in cervical cancer control. First, since 1996, increases in cervical cancer incidence have been seen in women ages 20 to 29 years (11), among whom screening uptake is lower and declining (12). Changes in both smoking and sexual behavior may be contributing to the upward trend (11). Second, in September 2008, the UK introduced a school-based HPV immunization program against HPV-16/18 (the types associated with over 70% of cervical cancers) for girls aged 12 years, which has achieved a fairly uniformly high uptake (>80% from 2008–2012; ref. 13). A catch-up program was

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implemented in schools and general practice over the first few years for girls aged up to 18 years. Coverage in these catch-up cohorts was lower and more variable (13) and showed some tendency to be lower in more deprived areas (14, 15, 16). We have already reported that Britain's third National Survey of Sexual Attitudes and Lifestyles (Natsal-3) found that women with more partners and those living in more deprived areas were less likely to complete the catch-up immunization schedule (17).

If nonparticipation in cervical screening and HPV immunization is not independent or participation is lower amongst individuals at risk of HR-HPV infection, their effectiveness may be limited. Natsal-3 provides an opportunity, unique in Britain, to explore individual-level data on participation in cervical screening and HPV immunization in relation to detailed demographic characteristics, sexual behaviors, and the presence of HR-HPV and to explore overlap between risk factors for HR-HPV infection and participation in prevention programs and thus to inform the provision of future services.

## Materials and Methods

### Participants and procedure

Natsal-3 is a stratified probability sample survey of 8,869 women and 6,293 men ages 16 to 74 years, resident in Britain. The overall response rate was 57.7%. Interviews were carried out between September 2010 and August 2012. Participants were interviewed using computer-assisted personal interviewing with computer-assisted self-interview (CASI) for the more sensitive questions. Details of the methods have been published previously (18, 19).

Natsal-3 included questions on sociodemographic characteristics, including educational level and occupation, allowing derivation of the National Statistics Socio-economic Classification (NS-SEC). Area-level deprivation was determined from postcodes using the Index of Multiple Deprivation (IMD; ref. 20), a multidimensional measure of deprivation.

Women who reported some sexual experience (although not necessarily a sexual partner) were routed into the CASI section of the questionnaire ( $N = 8,538$ ) where cervical screening and HPV immunization questions were asked. Women aged 26 years and over at interview ( $N = 5,614$ ) were asked "When did you last have a cervical smear test?" with the following five answer options: (i) I have never had one, (ii) less than 3 years ago, (iii) between 3 and 5 years ago, (iv) between 5 and 10 years ago, and (v) more than 10 years ago (adapted from ref. 21).

Women eligible for the HPV immunization program (those born on or after September 01, 1990, up to 21 years by the end of the interview period,  $N = 1,094$ ) were asked "Have you ever been vaccinated against cervical cancer (received HPV vaccination)?" with the following three answer options: (i) Yes—I have completed three doses of the vaccine, (ii) Yes—I have had one or two doses of the vaccine, but not all three doses, and (iii) No. Women who had not been vaccinated and those who had only received one or two doses were defined as not having completed the recommended 3-dose vaccination course. Women who reported not having been vaccinated were asked whether they had been offered the vaccination.

### Urine collection and testing

Briefly, at the end of the interview, a subsample of 16 to 44 year olds who reported at least one lifetime sexual partner was invited

to provide a urine sample to be tested for STIs and 60% agreed (17). Written consent was provided for testing without return of results (22). Full details of the urine collection methods have been described previously (17, 18).

Urine samples from 2,569 women were tested for HPV (17). An in-house Luminex-based genotyping assay was used for the detection of HPV types (23). HPV types 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, and 68 were defined as HR-HPV according to the WHO International Agency for Research on Cancer definition (24).

### Ethics

The Natsal-3 study was approved by the Oxfordshire Research Ethics Committee A (Ref: 10/H0604/27; ref. 22).

### Statistical analysis

Analyses were carried out using Stata (version 13) accounting for the stratification, clustering, and weighting of the sample. To account for differences in the probability of selection for and response to providing a urine sample, an additional weight was applied to the urine data (17, 18).

Logistic regression models were used to explore the factors associated with HR-HPV detection ( $N = 2,569$ ), nonattendance for cervical screening in the past 5 years ( $N = 5,012$ ), and noncompletion of HPV catch-up vaccination ( $N = 1,050$ ). Limited results have been presented previously (17) but are expanded here to present a more comprehensive picture of factors associated with HR-HPV and HPV catch-up vaccination in the general British female population.

Women under 26 or over 64 (60 in Scotland), women reporting having had a hysterectomy ( $N = 365$ ; who would not be invited for screening), and women reporting no lifetime sexual partners ( $N = 39$ ; who are advised that they might decline their screening invitation) were excluded from analyses of cervical screening. Factors associated with noncompletion of HPV catch-up vaccination are presented for eligible women [born before September 01, 1995 (England and Wales), or March 01, 1995 (Scotland)].

We hypothesized that cervical screening nonattenders may have differing risk of HR-HPV and cervical cancer based on sociodemographics (e.g., ethnicity) and sexual behavior (e.g., partner numbers). We explored the characteristics of women not attending for cervical screening, to examine how the prevalence of other cofactors for cervical cancer (25) differed by HR-HPV risk.

We explore the overlap between factors associated with HR-HPV and participation in cervical screening and HPV catch-up vaccination.

## Results

### HR-HPV prevalence

HR-HPV was detected in urine from 15.9% [95% confidence interval (CI), 14.4–17.5] of women ages 16 to 44 years reporting at least one lifetime partner. HR-HPV prevalence declined above age 24 and was associated with a number of sociodemographic characteristics (Table 1). Prevalence was higher in women not living with a partner, in women of lower socioeconomic status, as measured by markers including area-level deprivation [age-adjusted OR (AOR) 1.37; 1.05–1.80 for those living in the most deprived vs. least deprived two quintiles] and NS-SEC, and in those of mixed versus white ethnicity (AOR, 2.00; 1.09–3.67). Prevalence was lower in women of Asian/Asian-British ethnicity (AOR 0.40; 0.17–0.97). Prevalence did not vary significantly by

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**Table 1.** Factors associated with high-risk HPV in urine in sexually experienced women ages 16 to 44 years

	% (95% CI)	OR (95% CI)	Age-adjusted OR (95% CI)	Denominator (unwt, wt) <sup>a</sup>
<b>All</b>	15.9% (14.4–17.5)	–		2,569, 2,189
Socio-demographic characteristics				
Age (years)		<i>P</i> < 0.0001		
16–19	24.4% (20.0–29.3)	1 (–)		377, 203
20–24	26.6% (22.8–30.8)	1.13 (0.82–1.56)		580, 370
25–34	15.6% (13.4–18.2)	0.58 (0.42–0.79)		1,108, 779
35–44	9.3% (7.1–12.2)	0.32 (0.22–0.47)		504, 837
Relationship status at interview		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
Living with a partner	11.2% (9.5–13.1)	1 (–)	1 (–)	1,256, 1,357
In a steady relationship (but not living with a partner)	26.0% (22.2–30.1)	2.79 (2.13–3.66)	1.95 (1.44–2.65)	602, 360
Previously in a live-in partnership	19.9% (15.3–25.4)	1.97 (1.37–2.84)	1.92 (1.34–2.76)	353, 240
Not in a steady relationship (never lived with partner)	23.9% (18.8–29.8)	2.49 (1.76–3.54)	1.65 (1.13–2.42)	355, 229
IMD (quintiles) <sup>b</sup>		<i>P</i> = 0.0238	<i>P</i> = 0.0578	
1–2 (least deprived)	13.5% (11.2–16.1)	1 (–)	1 (–)	873, 778
3	15.0% (11.8–18.7)	1.13 (0.80–1.58)	1.12 (0.80–1.57)	502, 439
4–5 (most deprived)	18.3% (15.9–20.9)	1.43 (1.10–1.87)	1.37 (1.05–1.80)	1,194, 973
Academic qualifications <sup>c</sup>		<i>P</i> = 0.6717	<i>P</i> = 0.1250	
No academic qualifications	15.1% (10.5–21.4)	0.99 (0.63–1.56)	1.13 (0.72–1.77)	215, 191
Academic qualifications typically gained at age 16	16.7% (14.1–19.6)	1.12 (0.87–1.44)	1.3 (1.01–1.68)	877, 748
Studying for/attained further academic qualifications	15.2% (13.3–17.4)	1 (–)	1 (–)	1,348, 1,157
Housing tenure		<i>P</i> < 0.0001	<i>P</i> = 0.0011	
Own outright	14.3% (10.0–19.9)	1.38 (0.88–2.16)	1.15 (0.72–1.81)	218, 201
Buying with a mortgage or loan <sup>d</sup>	10.8% (8.9–13.0)	1 (–)	1 (–)	911, 912
Rent it	20.5% (18.0–23.1)	2.13 (1.64–2.78)	1.71 (1.30–2.26)	1,325, 996
Lives rent free	24.1% (16.6–33.8)	2.64 (1.59–4.38)	1.53 (0.91–2.56)	106, 74
Respondent's NS-SEC		<i>P</i> < 0.0001	<i>P</i> = 0.0009	
Managerial and professional occupations	10.3% (8.3–12.7)	1 (–)	1 (–)	709, 714
Intermediate occupations	16.6% (13.0–21.1)	1.74 (1.21–2.52)	1.60 (1.11–2.30)	464, 423
Semiroutine/routine occupations	18.5% (15.6–21.7)	1.98 (1.45–2.69)	1.57 (1.14–2.17)	780, 617
No job (10+ hours/week) or not in last 10 years	22.5% (16.6–29.8)	2.53 (1.62–3.96)	2.08 (1.31–3.31)	210, 173
Student in full-time education	19.8% (15.8–24.6)	2.16 (1.50–3.11)	2.01 (0.66–1.55)	398, 256
Ethnic group <sup>e</sup>		<i>P</i> = 0.0061	<i>P</i> = 0.0150	
White	16.2% (14.6–18.0)	1 (–)	1 (–)	2,312, 1,914
Mixed	29.7% (19.4–42.7)	2.18 (1.24–3.85)	2.00 (1.09–3.67)	74, 58
Asian/Asian British	7.0% (2.9–15.5)	0.39 (0.16–0.95)	0.40 (0.17–0.97)	82, 114
Black/Black British	12.6% (6.8–22.0)	0.74 (0.38–1.46)	0.69 (0.36–1.32)	77, 77
Religion		<i>P</i> = 0.0286	<i>P</i> = 0.2671	
None	17.7% (15.7–20.0)	1 (–)	1 (–)	1,509, 1,189
Christian—Church of England/Anglican	9.8% (6.2–15.2)	0.51 (0.30–0.85)	0.70 (0.42–1.19)	220, 235
Christian—Roman Catholic	14.2% (10.3–19.3)	0.77 (0.52–1.14)	0.84 (0.57–1.25)	261, 226
Christian—other	17.0% (13.4–21.5)	0.96 (0.69–1.32)	1.01 (0.73–1.39)	457, 396
Non-Christian	10.4% (5.9–17.7)	0.54 (0.29–1.01)	0.57 (0.31–1.05)	122, 142
Sexual identity		<i>P</i> = 0.2447	<i>P</i> = 0.1893	
Heterosexual/straight	16.1% (14.5–17.8)	1 (–)	1 (–)	2,457, 2,108
Gay/lesbian/bisexual	11.4% (6.1–20.1)	0.67 (0.34–1.32)	0.62 (0.31–1.26)	107, 79
Health behaviors				
Smoking status		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
Non/ex-smoker	12.9% (11.4–14.7)	1 (–)	1 (–)	1,702, 1,568
Current smoker	23.4% (20.1–26.9)	2.05 (1.61–2.60)	1.91 (1.49–2.43)	867, 622
Frequency of binge drinking <sup>f</sup>		<i>P</i> = 0.0001	<i>P</i> = 0.0011	
Never/less than monthly	13.9% (12.2–15.7)	1 (–)	1 (–)	1,730, 1,573
Monthly	19.1% (15.6–23.2)	1.47 (1.10–1.96)	1.31 (0.98–1.75)	484, 355
Weekly or more often	23.8% (19.1–29.3)	1.94 (1.42–2.66)	1.80 (1.31–2.47)	355, 261
Sexual behaviors				
Age at first heterosexual sex (years)		<i>P</i> < 0.0001	<i>P</i> = 0.0059	
18+	11.0% (8.5–14.0)	1 (–)	1 (–)	577, 642
17	12.9% (9.8–16.7)	1.20 (0.79–1.82)	1.18 (0.78–1.80)	432, 419
16	20.5% (17.2–24.3)	2.10 (1.48–2.97)	1.78 (1.24–2.56)	659, 517
<16	20.2% (17.4–23.4)	2.06 (1.47–2.89)	1.65 (1.17–2.34)	859, 577
Number of sexual partners, lifetime <sup>g</sup>		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
1	4.2% (2.4–7.2)	1 (–)	1 (–)	342, 361
2	11.3% (7.5–16.5)	2.89 (1.40–5.96)	2.74 (1.32–5.69)	234, 213
3–4	13.7% (10.6–17.5)	3.60 (1.91–6.81)	3.71 (1.97–7.01)	441, 388
5–9	17.2% (14.3–20.6)	4.74 (2.55–8.79)	5.67 (3.07–10.46)	709, 593
10+	24.0% (20.9–27.4)	7.19 (3.94–13.10)	9.35 (5.14–17.02)	822, 614

(Continued on the following page)

**Table 1.** Factors associated with high-risk HPV in urine in sexually experienced women ages 16 to 44 years (Cont'd)

	% (95% CI)	OR (95% CI)	Age-adjusted OR (95% CI)	Denominator (unwt, wt) <sup>a</sup>
Number of sexual partners, past 5 years <sup>g</sup>		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
0/1	7.1% (5.7–8.9)	1 (–)	1 (–)	1,162, 1,258
2	21.9% (17.5–26.9)	3.64 (2.52–5.25)	3.34 (2.29–4.86)	425, 316
3–4	23.0% (19.0–27.4)	3.88 (2.77–5.42)	3.43 (2.45–4.79)	424, 290
5+	37.5% (32.7–42.7)	7.82 (5.63–10.86)	6.62 (4.68–9.38)	544, 313
Number of sexual partners without a condom, past year <sup>g</sup>		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
0	11.3% (8.5–14.8)	1 (–)	1 (–)	449, 405
1	14.0% (12.3–15.9)	1.28 (0.91–1.80)	1.35 (0.96–1.90)	1,741, 1,566
2+	40.1% (33.9–46.5)	5.27 (3.49–7.95)	4.35 (2.87–6.60)	347, 193
Sexual health and services				
Used hormonal contraception <sup>h</sup> , past year		<i>P</i> = 0.0001	<i>P</i> = 0.1711	
No	13.1% (11.1–15.5)	1 (–)	1 (–)	1,172, 1,137
Yes	19.7% (17.5–22.1)	1.63 (1.28–2.07)	1.20 (0.92–1.55)	982, 1,388
Attended a sexual health (GUM) clinic, past 5 years		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
No	11.7% (10.2–13.4)	1 (–)	1 (–)	1,779, 1,686
Yes	30.4% (26.8–34.2)	3.29 (2.62–4.14)	2.54 (2.00–3.23)	765, 484
STI diagnosis <sup>i</sup> , past 5 years		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
No	14.7% (13.2–16.4)	1 (–)	1 (–)	2,316, 2,038
Yes	35.3% (29.2–41.9)	3.16 (2.33–4.28)	2.36 (1.76–3.16)	237, 134
Genital warts diagnosis, ever		<i>P</i> = 0.2095	<i>P</i> = 0.0891	
No	15.8% (14.3–17.5)	1 (–)	1 (–)	2,436, 2,085
Yes	20.2% (13.9–28.3)	1.35 (0.85–2.14)	1.47 (0.94–2.30)	117, 86

<sup>a</sup>Participants who reported at least one lifetime sexual partner, with urine test results [unweighted (unwt), weighted (wt)].

<sup>b</sup>IMD is a multidimensional measure of area (neighborhood)-level deprivation based on the participant's postcode. IMD scores for England, Scotland, and Wales were adjusted before being combined and assigned to quintiles, using a method by Payne and Abel (20).

<sup>c</sup>Participants aged  $\geq 17$  years.

<sup>d</sup>Includes 29 women paying part mortgage and part rent (shared ownership).

<sup>e</sup>Those of Chinese/other ethnicity are excluded from the denominator due to small numbers.

<sup>f</sup>Binge drinking defined as having six units on one occasion.

<sup>g</sup>Includes both opposite-sex and same-sex partners.

<sup>h</sup>Defined as having used the oral contraceptive pill, hormonal IUD, injections, or implants.

<sup>i</sup>Defined as having been diagnosed with one of chlamydia, gonorrhoea, syphilis, genital herpes, genital warts, trichomonas, nonspecific urethritis/non-gonococcal urethritis.

sexual identity. Prevalence was higher in women who smoked (AOR 1.91; 1.49–2.43) or reported binge drinking regularly (AOR 1.80; 1.31–2.47).

HR-HPV was strongly associated with markers of more risky sexual behavior including a younger age ( $\leq 16$  years) at first heterosexual intercourse, increasing numbers of partners over the lifetime and in the past 5 years, as well as reporting two or more partners without a condom in the past year (AOR 4.31; 2.83–6.55). Prevalence was also higher in women who reported attending a sexual health (GUM) clinic (AOR 2.54; 2.00–3.23) or sexually transmitted infection (STI) diagnosis/es (AOR 2.36; 1.76–3.16) in the past 5 years.

### Cervical screening uptake

Figure 1A shows the time since last cervical screen in women ages 26 to 74 years. Overall, 96.8% of women ages 26 to 74 years reported ever having had a cervical screen. Over 70% of women ages 26 to 49 reported having attended screening within the last 3 years. Around 90% of women ages 50 to 64 years reported having attended for screening within the last 5 years. A notable proportion of 26 to 29 and 30 to 34 year olds reported never having had a cervical screen (12.1% and 5.9%, respectively).

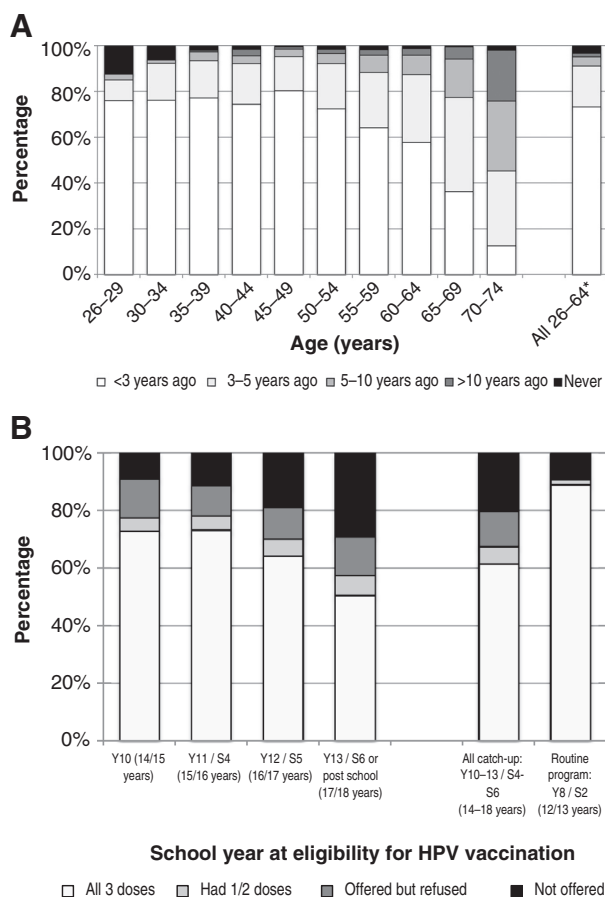
Table 2 shows factors associated with nonattendance for cervical screening in the past 5 years in women ages 26 to 64 (those eligible for screening), of which 8.9% (8.0–9.8) were nonattenders. Nonattendance was associated with a number of sociodemographic characteristics including younger (<30 years) or older (60+ years) age (OR 2.28, 1.72–3.00 and 2.01, 1.32–3.05, respectively, com-

pared with those ages 30 to 39), lower socioeconomic status, including area-level deprivation (AOR 1.91; 1.48–2.47 for most vs. least deprived two quintiles) and having no educational qualifications (AOR 1.95; 1.43–2.66), and being of Asian/Asian British ethnicity (AOR 1.96; 1.32–2.90). Women self-identifying as lesbian were more likely to be nonattenders (AOR 2.94; 1.36–6.38). Nonattendance was also strongly associated with being a current smoker (AOR 1.97; 1.57–2.47). The relationship with markers of risky sexual behavior was not consistent. Overall, there was no association with age at first heterosexual intercourse or number of lifetime partners, although nonattendance was highest in those with one lifetime partner (11.4%). Women reporting no partners in the past 5 years (AOR 2.45; 1.67–3.61 vs. 1 partner), or no partners without a condom in the past year were more likely to be nonattenders. Nonattendance was lower in women who reported using hormonal contraceptives in the past year (AOR 0.53; 0.41–0.69) and in those who had ever attended a sexual health (GUM) clinic (AOR 0.53; 0.40–0.69) or had an STI diagnosis (AOR 0.49; 0.33–0.71). There was no difference in attendance by HR-HPV status overall (AOR 1.35; 0.79–2.31). Stratification of these analyses by age (<50 and 50+ years) and lifetime partners (1 and 2+) returned similar associations (data not shown).

There were two distinct groups of nonattending women (Table 3). Overall, a quarter of nonattenders reported only 1 lifetime partner. A high proportion of these women were of Asian/Asian British ethnicity (25.5%, 17.2%–36.1%), few smoked (20.3%, 12.6%–31.1%), less than 1% reported first heterosexual intercourse before 16 years, and 20.3% (12.6%–31.1%) reported no



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**Figure 1.**

Uptake of cervical cancer interventions. A, time since last cervical smear test by age group among women ages 26 to 74 years. B, HPV vaccination uptake by school year at eligibility for vaccination in either the routine (Year 8/S2) or catch-up programs. A, women are eligible for cervical screening every 3 to 5 years depending on regional protocols (3 yearly to age 49 in England then 5 yearly to age 64; 3 yearly to age 64 in Wales and 3 yearly to age 60 in Scotland). Denominators exclude women who report having had a hysterectomy and those with no lifetime sexual partners. \*, All women in eligible age range for screening. Denominators (unwt., wt.) are as follows: 26-29 (1,121, 547), 30-34 (1,025, 648), 35-39 (580, 664), 40-44 (571, 710), 45-49 (536, 694), 50-54 (427, 553), 55-59 (399, 505), 60-64 (381, 444), 65-69 (349, 387), 70-74 (225, 226), all eligible (5,012, 4,731). Percentage screened in past 5 years when women reporting a hysterectomy are included in the denominator ( $N = 5,372$ , 5,164) is 86.2%. B, denominators (unwt., wt.) are as follows: Y10 (153, 78), Y11 (244, 123), Y12 (238, 117), Y13 (415, 243), all catch-up (1,050, 562), routine (44, 21).

sexual partner in the past 5 years. Prevalence of HR-HPV in those providing a urine sample was 5.2% (1.4%–17.2%). In contrast, among the three quarters of nonattenders reporting 2 or more lifetime partners, 89.6% (85.3%–92.7%) were of White ethnicity, 39.8% (34.4%–45.4%) were smokers, and 21.7% (17.3%–26.8%) reported first heterosexual intercourse before 16 years. However, a similar proportion reported no partner in the past 5 years (14.5%, 10.6%–19.4%). Prevalence of HR-HPV in nonattenders providing a urine sample with 2 or more lifetime partners was 20.3% (12.9%–30.5%). This was nonsignificantly higher than the prevalence in attenders with 2 or more lifetime partners (13.3%, 11.3%–15.7%;  $P = 0.079$ ).

We looked at the reported recent use of healthcare services among nonattenders. Overall, 6.1% (4.3%–8.5%) of nonattenders had been to a sexual health (GUM) clinic in the past 5 years, 14.3% (11.2%–18.0%) had attended an ante-natal clinic in the past 5 years, and 19.2% (15.8%–23.1%) had obtained family planning from a clinical source in the past year. In total, 31.7% (27.1%–36.7%) of nonattending women had used one or more of these services. Use of healthcare services did not vary by lifetime partners.

#### HPV vaccine uptake

HPV catch-up vaccine uptake varied substantially by school year at eligibility (Fig. 1B) with 72.9% of women eligible at 14 years reporting having received all 3 doses, compared with only 50.6% of women eligible at 17 years. In contrast, 89.0% of women in the routine program reported having received all 3 doses (but denominators are small). Few women had received only one or two doses. The proportion of women who reported not having been offered the vaccine was higher in the older catch-up cohorts.

Of women eligible for the HPV catch-up immunization program, 38.5% reported not having completed the vaccination course. This was strongly associated with markers of lower socioeconomic status (Table 4), non-white ethnicity (AOR 2.01; 1.29–3.13), and smoking (AOR 2.61; 1.93–3.55). Noncompletion was also associated with reporting larger numbers of lifetime partners (AOR 1.70; 1.09–2.63 for 5+ vs. 1 lifetime partner). Among those with at least one lifetime partner, noncompletion was higher in women reporting first heterosexual intercourse before 16 (AOR 1.68; 1.22–2.30) and unprotected sex with two or more partners in the past year (AOR 1.81; 1.15–2.84). Those using hormonal contraception were less likely to be noncompleters (AOR 0.47; 0.34–0.67), whereas those attending sexual health (GUM) clinics (AOR 1.49; 1.10–2.02) and ever having been pregnant (AOR 2.94; 2.04–4.23) were more likely to report noncompletion. Noncompletion was higher in women who were HR-HPV positive (AOR 2.33; 1.45–3.74).

Associations with having had no doses of the vaccine were similar (data not shown), although a stronger association was seen with area-level deprivation and slightly weaker associations with sexual behaviors, GUM clinic attendance, and ever having been pregnant.

#### Overlap between factors associated with HR-HPV infection and uptake of cervical screening and HPV vaccination

Figure 2 shows factors associated with HR-HPV infection (vertical axes) plotted against factors associated with nonattendance for cervical screening (Fig. 2A) and noncompletion of HPV vaccination (Fig. 2B). The top right hand quadrant for each figure indicates increased risk of HR-HPV infection and lower uptake of the cervical cancer prevention program. The area of the bubble represents the size of the group as a proportion of those eligible for screening. There was evidence of overlap of HR-HPV infection risk and cervical screening uptake for some factors (Fig. 2A). Living in more deprived areas and smoking were associated with both HR-HPV infection and nonattendance for cervical screening. These factors were also associated with noncompletion of HPV vaccination (Fig. 2B). Associations between smoking and HR-HPV infection, and uptake of cervical screening and HPV vaccination persisted after adjustment for area-level deprivation (data not shown). In contrast, HR-HPV prevalence was lower in women of Asian/Asian British ethnicity, another group less likely to attend for screening (Fig. 2A). Women with 5 or more lifetime partners

**Table 2.** Factors associated with nonattendance at cervical screening in the past 5 years in women ages 26 to 64 years

	Not in past 5 years % (95% CI)	Not screened versus screened in past 5 years		Denominator (unwt, wt) <sup>a</sup>
		OR (95% CI)	Age-adjusted OR (95% CI)	
<b>All ages</b>	8.9% (8.0–9.8)			5,012, 4,731
Sociodemographic characteristics				
Age, years				
<i>P</i> < 0.0001				
26–29	14.9% (12.7–17.4)	2.28 (1.72–3.00)		1,121, 547
30–39	7.1% (5.9–8.7)	1 (–)		1,605, 1,312
40–49	6.2% (4.9–8.0)	0.86 (0.61–1.21)		1,107, 1,404
50–59	9.6% (7.8–11.9)	1.38 (1.01–1.90)		826, 1,058
60–64	13.4% (9.7–18.2)	2.01 (1.32–3.05)		353, 411
Relationship status at interview				
<i>P</i> < 0.0001				
<i>P</i> = 0.0004				
Living with a partner	8.0% (7.0–9.1)	1 (–)		3,151, 3,476
In a steady relationship (but not living with a partner)	8.4% (6.3–11.2)	1.06 (0.75–1.50)	1.04 (0.73–1.46)	585, 373
Previously in a live-in partnership	11.5% (9.4–14.0)	1.50 (1.14–1.96)	1.43 (1.09–1.87)	1,015, 717
Not in a steady relationship (never lived with partner)	18.5% (13.1–25.4)	2.61 (1.71–3.99)	2.31 (1.49–3.57)	234, 145
IMD (quintiles) <sup>b</sup>				
<i>P</i> < 0.0001				
<i>P</i> < 0.0001				
1–2 (least deprived)	6.3% (5.2–7.6)	1 (–)	1 (–)	1,885, 1,938
3	8.9% (7.1–11.2)	1.46 (1.06–2.00)	1.44 (1.05–1.98)	1,003, 943
4–5 (most deprived)	11.5% (10.1–13.2)	1.95 (1.52–2.50)	1.91 (1.48–2.47)	2,124, 1,850
Academic qualifications				
<i>P</i> < 0.0001				
<i>P</i> = 0.0001				
No academic qualifications	14.1% (11.5–17.1)	2.04 (1.53–2.73)	1.95 (1.43–2.66)	751, 764
Academic qualifications typically gained at age 16	8.1% (6.8–9.5)	1.09 (0.84–1.42)	1.16 (0.88–1.52)	1,828, 1,730
Studying for/attained further academic qualifications	7.4% (6.3–8.7)	1 (–)	1 (–)	2,278, 2,102
Housing tenure				
<i>P</i> < 0.0001				
<i>P</i> < 0.0001				
Own outright	9.6% (7.7–12.0)	1.77 (1.28–2.46)	1.34 (0.93–1.92)	868, 1,034
Buying with a mortgage or loan <sup>c</sup>	5.7% (4.7–6.9)	1 (–)	1 (–)	2,092, 2,118
Rent it	12.6% (11.0–14.3)	2.40 (1.86–3.08)	2.14 (1.65–2.78)	1,967, 1,505
Lives rent free	17.3% (9.4–29.8)	3.49 (1.70–7.19)	2.88 (1.44–5.77)	71, 59
Respondent's NS-SEC				
<i>P</i> < 0.0001				
<i>P</i> < 0.0001				
Managerial & professional occupations	6.4% (5.3–7.7)	1 (–)	1 (–)	1,868, 1,810
Intermediate occupations	7.0% (5.5–8.8)	1.10 (0.80–1.53)	1.07 (0.77–1.49)	1,160, 1,081
Semiroutine/routine occupations	11.8% (10.0–13.9)	1.96 (1.49–2.59)	1.88 (1.42–2.49)	1,361, 1,249
No job (10+ hours/week) or not in last 10 years	14.8% (11.4–18.9)	2.54 (1.77–3.65)	2.40 (1.66–3.47)	475, 474
Student in full-time education	9.5% (5.1–17.1)	1.55 (0.77–3.11)	1.32 (0.67–2.62)	124, 95
Ethnic group				
<i>P</i> = 0.0066				
<i>P</i> = 0.0052				
White	8.3% (7.4–9.2)	1 (–)	1 (–)	4,415, 4,155
Mixed	11.7% (5.7–22.4)	1.46 (0.68–3.17)	1.49 (0.68–3.25)	89, 72
Asian/Asian British	15.1% (10.9–20.6)	1.97 (1.32–2.93)	1.96 (1.32–2.90)	254, 256
Black/Black British	11.8% (6.8–19.6)	1.48 (0.81–2.71)	1.62 (0.88–2.97)	174, 176
Other	12.5% (6.5–22.7)	1.58 (0.78–3.24)	1.52 (0.73–3.16)	69, 63
Religion				
<i>P</i> = 0.0076				
<i>P</i> = 0.0049				
None	9.4% (8.2–10.9)	1 (–)	1 (–)	2,330, 2,052
Christian—Church of England/Anglican	6.3% (4.8–8.4)	0.65 (0.46–0.92)	0.60 (0.42–0.86)	832, 906
Christian—Roman Catholic	7.9% (5.9–10.6)	0.83 (0.58–1.19)	0.80 (0.55–1.16)	582, 558
Christian—other	9.2% (7.2–11.7)	0.97 (0.72–1.32)	0.93 (0.68–1.28)	930, 903
Muslim	13.9% (8.8–21.1)	1.55 (0.91–2.63)	1.50 (0.88–2.56)	160, 152
Hindu	19.6% (11.2–32.1)	2.34 (1.20–4.57)	2.21 (1.13–4.32)	68, 57
Other	8.6% (3.8–18.5)	0.91 (0.38–2.18)	0.91 (0.40–2.08)	102, 94
Sexual identity				
<i>P</i> = 0.0271				
<i>P</i> = 0.0234				
Heterosexual/straight	8.7% (7.9–9.7)	1 (–)	1 (–)	4,849, 4,599
Gay/lesbian	20.9% (11.1–35.7)	2.76 (1.31–5.78)	2.94 (1.36–6.38)	63, 56
Bisexual	8.3% (3.9–16.5)	0.94 (0.43–2.05)	0.93 (0.44–1.98)	75, 53
Health behaviors				
Smoking status				
<i>P</i> < 0.0001				
<i>P</i> < 0.0001				
Non/ex-smoker	7.5% (6.6–8.5)	1 (–)	1 (–)	3,700, 3,646
Current smoker	13.5% (11.5–15.7)	1.92 (1.54–2.40)	1.97 (1.57–2.47)	1,312, 1,085
Frequency of binge drinking <sup>d</sup>				
<i>P</i> = 0.0277				
<i>P</i> = 0.0473				
Never/less than monthly	9.5% (8.5–10.6)	1 (–)	1 (–)	3,769, 3,636
Monthly	6.7% (5.0–9.0)	0.69 (0.49–0.96)	0.69 (0.49–0.97)	664, 568
Weekly or more often	7.1% (5.3–9.4)	0.73 (0.52–1.02)	0.77 (0.55–1.09)	578, 527
Sexual behaviors				
Age at first heterosexual sex (years)				
<i>P</i> = 0.3000				
<i>P</i> = 0.5485				
18+	9.7% (8.3–11.2)	1 (–)	1 (–)	1,971, 2,033
16/17	8.2% (6.9–9.7)	0.83 (0.65–1.06)	0.89 (0.69–1.14)	1,943, 1,825
<16	8.4% (6.7–10.5)	0.86 (0.64–1.15)	0.87 (0.64–1.18)	1,040, 812

(Continued on the following page)

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**Table 2.** Factors associated with nonattendance at cervical screening in the past 5 years in women ages 26 to 64 years (Cont'd)

	Not in past 5 years % (95% CI)	Not screened versus screened in past 5 years		Denominator (unwt, wt) <sup>a</sup>
		OR (95% CI)	Age-adjusted OR (95% CI)	
Number of sexual partners, lifetime <sup>e</sup>		<i>P</i> = 0.0612	<i>P</i> = 0.2391	
1	11.4% (9.3–13.9)	1 (–)	1 (–)	832, 923
2	9.4% (7.0–12.4)	0.80 (0.54–1.19)	0.81 (0.55–1.21)	468, 478
3–4	8.5% (6.8–10.6)	0.72 (0.51–1.02)	0.77 (0.54–1.09)	920, 890
5–9	8.0% (6.5–9.9)	0.68 (0.49–0.94)	0.74 (0.54–1.03)	1,338, 1,246
10+	7.5% (6.0–9.3)	0.63 (0.45–0.87)	0.68 (0.48–0.96)	1,367, 1,105
Number of sexual partners, past 5 years <sup>e</sup>		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
0	19.3% (15.0–24.5)	2.72 (1.94–3.82)	2.45 (1.67–3.61)	358, 342
1	8.1% (7.1–9.2)	1 (–)	1 (–)	3,133, 3,311
2	8.2% (6.1–10.9)	1.02 (0.72–1.45)	0.94 (0.66–1.34)	625, 471
3–4	7.1% (5.1–9.8)	0.87 (0.60–1.25)	0.73 (0.50–1.05)	489, 328
5+	8.2% (5.6–12.0)	1.02 (0.66–1.58)	0.77 (0.49–1.22)	349, 216
Number of sexual partners without a condom, past year <sup>e</sup>		<i>P</i> < 0.0001	<i>P</i> < 0.0001	
0	14.1% (12.0–16.6)	1 (–)	1 (–)	1,263, 1,136
1	7.1% (6.2–8.1)	0.46 (0.37–0.59)	0.48 (0.38–0.62)	3,420, 3,358
2+	8.2% (5.0–12.9)	0.54 (0.31–0.93)	0.50 (0.28–0.89)	259, 163
Health-related factors				
Used hormonal contraception <sup>f</sup> , past year		<i>P</i> = 0.0001	<i>P</i> < 0.0001	
No	9.8% (8.7–10.9)	1 (–)	1 (–)	3,369, 3,489
Yes	6.3% (5.1–7.6)	0.62 (0.48–0.79)	0.53 (0.41–0.69)	1,573, 1,168
Ever attended a sexual health (GUM) clinic		<i>P</i> = 0.0002	<i>P</i> < 0.0001	
No	9.7% (8.7–10.8)	1 (–)	1 (–)	3,611, 3,636
Yes	6.0% (4.8–7.5)	0.60 (0.46–0.78)	0.53 (0.40–0.69)	1,353, 1,041
Ever diagnosed with a STI <sup>g</sup>		<i>P</i> = 0.0004	<i>P</i> = 0.0002	
No (or only thrush)	9.5% (8.6–10.6)	1 (–)	1 (–)	4,080, 3,958
Yes (excluding thrush)	5.1% (3.7–7.1)	0.51 (0.35–0.74)	0.49 (0.33–0.71)	882, 717
STI risk: to self		<i>P</i> = 0.0377	<i>P</i> = 0.0200	
Greatly at risk/quite a lot	5.5% (2.9–10.0)	1 (–)	1 (–)	130, 97
Not very much	7.1% (5.6–9.1)	1.33 (0.65–2.71)	1.34 (0.67–2.67)	903, 715
Not at all at risk	9.3% (8.3–10.3)	1.78 (0.92–3.44)	1.83 (0.97–3.48)	3,958, 3,900
<b>All women ages 26 to 44 who have not had a hysterectomy and who provided a urine sample</b>	10.6% (8.7–12.8)			1,474, 1,512 <sup>h</sup>
1+ high-risk HPV type(s)		<i>P</i> = 0.2062	<i>P</i> = 0.2775	
Negative	10.1% (8.1–12.5)	1 (–)	1 (–)	1,243, 1,329
Positive	13.7% (9.0–20.5)	1.42 (0.83–2.44)	1.35 (0.79–2.31)	231, 184

<sup>a</sup>Participants who have not had a hysterectomy and who reported at least 1 lifetime sexual partner (unweighted, weighted).

<sup>b</sup>IMD is a multidimensional measure of area (neighborhood)-level deprivation based on the participant's postcode. IMD scores for England, Scotland, and Wales were adjusted before being combined and assigned to quintiles, using a method by Payne and Abel (20).

<sup>c</sup>Includes 46 women paying part mortgage and part rent (shared ownership).

<sup>d</sup>Binge drinking defined as having six units on one occasion.

<sup>e</sup>Includes both opposite-sex and same-sex partners.

<sup>f</sup>Defined as having used the oral contraceptive pill, hormonal IUD, injections, or implants.

<sup>g</sup>Defined as having been diagnosed with one of chlamydia, gonorrhea, syphilis, genital herpes, genital warts, trichomonas, nonspecific urethritis/non-gonococcal urethritis.

<sup>h</sup>Participants ages 26 to 44 years who have not had a hysterectomy, who reported at least 1 lifetime sexual partner and who provided a urine sample.

and those who reported attending a sexual health (GUM) clinic had a higher prevalence of HR-HPV infection, and were more likely to have attended for cervical screening but less likely to have completed HPV vaccination.

## Discussion

In this cross-sectional probability sample survey of the British general population, we found markers of lower socioeconomic status and smoking to be common risk factors for HR-HPV infection and nonuptake of both cervical screening and HPV catch-up vaccination. Overall, cervical screening attendance was not lower in women reporting more risky sexual behaviors, and there was no difference in attendance by HR-HPV status. However, our analysis suggests that there are two distinct groups of nonattenders, one of which would be considered at higher risk of

developing cervical cancer due to high prevalence of other lifestyle risk factors such as smoking and early age at first sex, whose nonattendance might augment their overall risk of cervical cancer, and one of which would be considered lower risk, whose nonattendance might negate their lower lifestyle risk.

The major strength of this study is that it is a population-based survey with individual-level data from a nationally representative sample. We were able to link behavioral and biologic data and look at risk factors for different outcomes in the same survey. One limitation is the accuracy of self-reporting, especially of cervical screening (26,27). Our estimates of cervical screening uptake are higher than official figures, which estimate 5-year coverage in 2011–2012 as 78.6% (6), and one other study (28), which asked for year and month of last cervical screen. We believe that social desirability bias is unlikely to have had a substantial effect since this question was asked in the self-completion part of the

**Table 3.** Key characteristics of women who have not attended for cervical screening in the past 5 years, by number of lifetime partners

	Not attended for screening in past 5 years		
	All not attended (100%) % (95% CI)	1 lifetime partner <sup>a</sup> (25%) % (95% CI)	2+ lifetime partners <sup>a</sup> (75%) % (95% CI)
Denominator (unweighted, weighted)	496, 420	111, 105	385, 314
Age, years			
26-29	19.4% (16.3-22.9)	18.4% (12.6-26.0)	19.8% (16.3-23.8)
30-39	22.3% (18.5-26.7)	26.5% (18.3-36.6)	21.0% (16.8-25.9)
40-49	20.8% (16.6-25.8)	14.3% (7.2-26.3)	23.0% (18.2-28.7)
50-59	24.3% (19.9-29.3)	20.3% (12.4-31.5)	25.6% (20.5-31.5)
60-64	13.1% (9.6-17.6)	20.6% (12.5-31.9)	10.6% (7.1-15.5)
IMD (quintiles) <sup>b</sup>		<i>P</i> = 0.4394 <sup>c</sup>	
1-2 (least deprived)	29.1% (24.4-34.2)	28.8% (20.3-39.2)	29.1% (23.8-35.1)
3	20.0% (16.0-24.7)	15.7% (10.0-23.9)	21.5% (16.7-27.2)
4-5 (most deprived)	50.9% (45.7-56.1)	55.5% (44.9-65.6)	49.4% (43.4-55.4)
Academic qualifications		<i>P</i> = 0.1289 <sup>c</sup>	
No academic qualifications	26.7% (22.1-31.8)	34.7% (24.2-46.9)	24.1% (19.4-29.7)
Academic qualifications typically gained at age 16	34.6% (29.6-39.9)	26.4% (17.4-38.0)	37.2% (31.5-43.2)
Studying for/attained further academic qualifications	38.7% (33.6-44.1)	38.9% (28.4-50.6)	38.7% (32.9-44.8)
Ethnic group		<i>P</i> < 0.0001 <sup>c</sup>	
White	82.0% (77.5-85.8)	59.3% (47.9-69.8)	89.6% (85.3-92.7)
Mixed	2.0% (1.0-4.1)	1.4% (0.3-5.8)	2.2% (1.0-4.9)
Asian/Asian British	9.2% (6.5-12.8)	25.5% (17.2-36.1)	3.7% (2.1-6.6)
Black/Black British	4.9% (2.8-8.5)	9.4% (3.8-21.2)	3.5% (1.7-6.9)
Other	1.9% (1.0-3.5)	4.5% (1.9-9.9)	1.0% (0.4-2.7)
Smoking status		<i>P</i> = 0.0022 <sup>c</sup>	
Non/ex-smoker	65.1% (60.2-69.7)	79.7% (68.9-87.4)	60.2% (54.6-65.6)
Current smoker	34.9% (30.3-39.8)	20.3% (12.6-31.1)	39.8% (34.4-45.4)
Age at first heterosexual sex (years)		<i>P</i> < 0.0001 <sup>c</sup>	
18+	47.4% (42.4-52.6)	81.6% (71.3-88.8)	36.1% (30.6-41.9)
16/17	36.1% (31.2-41.2)	17.5% (10.4-27.9)	42.3% (36.5-48.3)
<16	16.5% (13.1-20.5)	0.9% (0.3-2.9)	21.7% (17.3-26.8)
Sexual partner, past 5 years <sup>a</sup>		<i>P</i> = 0.2239 <sup>c</sup>	
No	15.9% (12.2-20.3)	20.3% (12.5-31.4)	14.4% (10.6-19.2)
Yes	84.1% (79.7-87.8)	79.7% (68.6-87.5)	85.6% (80.8-89.4)
Denominator (unwt, wt) <sup>d</sup>	148, 160	31, 47	117, 112
1+ high-risk HPV type(s)		<i>P</i> = 0.0216 <sup>c</sup>	
Negative	84.2% (76.2-89.8)	94.8% (82.8-98.6)	79.7% (69.5-87.1)
Positive	15.8% (10.2-23.8)	5.2% (1.4-17.2)	20.3% (12.9-30.5)

<sup>a</sup>Includes both opposite-sex and same-sex partners.

<sup>b</sup>IMD is a multidimensional measure of area (neighborhood)-level deprivation based on the participant's postcode. IMD scores for England, Scotland, and Wales were adjusted before being combined and assigned to quintiles, using a method by Payne and Abel (20).

<sup>c</sup>*P* values for comparison between nonattenders with 1 and 2+ lifetime partners.

<sup>d</sup>Nonattenders ages 26 to 44 years who provided a urine sample.

questionnaire. However, "telescoping," where an event is remembered as occurring more recently than it did, is a strong possibility both for us and other studies (27,29). Any variation in such a bias by the sociodemographic or behavioral variables that we report could mean that we have over- or underestimated associations, for example, if telescoping errors were greater among more educated women, the association between attendance and education would be overestimated. Women may also not be able to accurately report their vaccination status (30), and accurate reporting may vary by other variables. Uptake estimates may be affected by biases in the women who agreed to participate in Natsal-3. The Natsal-3 response rate was 57.7%, which is comparable with other population-based surveys completed around the same time (31,32). After weighting our data to match the British population for age, gender, and geographic region, the sample was comparable with the 2011 census data on other key demographic characteristics (18). However, women who do not attend for screening may be less likely to participate in research studies or engage more generally (33).

Another limitation is that urine is a suboptimum specimen for HPV detection (34) with recent estimates of 77% sensitivity of

cervical HR-HPV (35) and therefore a likely underestimate of HR-HPV prevalence, although this would weaken, not bias, our identification of risk factors. Finally, due to the years the Natsal-3 fieldwork was carried out, our study could only focus on the catch-up program, and the factors we describe as associated with vaccination uptake in the catch-up cohorts may not be generalizable to routine vaccination at 12 years of age.

To our knowledge, no population-based studies have examined the associations between cervical screening and sexual behavior or HR-HPV infection. We found lower screening uptake among women with lower levels of education and of non-White ethnicity as in other British population studies (21,28). Other studies have shown lower uptake of HPV catch-up vaccination in women of Black/Black British and Asian/Asian British ethnicity (36, 37). Our sample of women of these ethnic minorities was too small to examine associations between vaccination and each ethnic group, but completion of catch-up vaccination was lower in women of non-White ethnicity.

It is a reasonable expectation that herd immunity should lead to a reduction in cervical cancer incidence among unvaccinated women in the catch-up vaccination cohorts (38). However, the



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**Table 4.** Factors associated with noncompletion of HPV catch-up vaccination

	Not completed % (95% CI)	Not completed versus completed		Denominator (unwt, wt)
		OR (95% CI)	Age-adjusted OR (95% CI)	
<b>All eligible for HPV catch-up vaccination program</b>	38.5% (35.3–41.9)			1,050, 562
Socio-demographic factors				
Age at interview (years)				
16–17	28.0% (23.2–33.4)	1 (–)		394, 195
18–19	41.7% (36.7–47.0)	1.84 (1.33–2.56)		449, 241
20–21	48.7% (41.3–56.1)	2.44 (1.64–3.63)		207, 125
School year at eligibility for HPV vaccination program				
14 (Y10/S3)	27.1% (20.1–35.3)	1 (–)	<i>P</i> = 0.0060	153, 78
15 (Y11/S4)	26.8% (21.1–33.3)	0.99 (0.61–1.59)	1.01 (0.62–1.65)	244, 123
16 (Y12/S5)	35.8% (29.5–42.6)	1.50 (0.94–2.39)	1.57 (0.90–2.74)	238, 117
17 (Y13/S6 or post school)	49.4% (44.1–54.8)	2.64 (1.69–4.10)	2.87 (1.39–5.95)	415, 243
Grouped government office region				
Rest of England	36.4% (32.7–40.2)	1 (–)	1 (–)	803, 421
London	62.4% (52.3–71.5)	2.90 (1.87–4.50)	2.76 (1.77–4.30)	100, 66
Scotland	19.8% (13.1–28.8)	0.43 (0.26–0.72)	0.41 (0.24–0.70)	89, 46
Wales	44.4% (31.0–58.6)	1.40 (0.78–2.48)	1.31 (0.74–2.35)	58, 29
IMD (quintiles) <sup>a</sup>				
1–2 (least deprived)	30.1% (25.3–35.4)	1 (–)	1 (–)	393, 210
3	36.7% (29.4–44.7)	1.34 (0.90–2.01)	1.35 (0.90–2.04)	209, 116
4–5 (most deprived)	46.9% (42.0–51.9)	2.05 (1.50–2.81)	1.99 (1.44–2.74)	448, 236
Parents' social class				
I/II/III	35.1% (31.2–39.2)	1 (–)	1 (–)	714, 385
IV/V	44.9% (37.0–53.1)	1.51 (1.04–2.19)	1.52 (1.05–2.21)	196, 103
Academic qualifications <sup>b</sup>				
No academic qualifications	75.2% (55.9–87.9)	6.04 (2.63–13.85)	5.84 (2.50–13.62)	39, 18
Academic qualifications typically gained at age 16	57.2% (49.3–64.7)	2.66 (1.85–3.83)	2.52 (1.75–3.65)	188, 92
Studying for/attained further academic qualifications	33.4% (29.5–37.6)	1 (–)	1 (–)	650, 361
Ethnic group				
White	36.3% (32.9–39.7)	1 (–)	1 (–)	937, 491
Non-white	54.1% (43.5–64.5)	2.07 (1.32–3.25)	2.01 (1.29–3.13)	113, 71
Health behaviors				
Smoking status				
Non/ex-smoker	31.8% (28.3–35.7)	1 (–)	1 (–)	737, 400
Current smoker	55.0% (48.9–61.0)	2.62 (1.95–3.53)	2.61 (1.93–3.55)	313, 162
Frequency of binge drinking <sup>c</sup>				
Never/less than monthly	36.8% (32.9–41.0)	1 (–)	1 (–)	712, 376
Monthly	36.9% (30.0–44.5)	1.00 (0.71–1.43)	0.90 (0.62–1.30)	200, 107
Weekly or more often	48.4% (39.4–57.6)	1.61 (1.07–2.42)	1.41 (0.92–2.15)	137, 78
Sexual behaviors (all eligible for catch-up vaccination)				
Number of sexual partners, lifetime <sup>d</sup>				
0	24.5% (18.4–31.7)	0.62 (0.38–1.01)	0.72 (0.43–1.18)	205, 109
1	34.4% (27.1–42.5)	1 (–)	1 (–)	203, 113
2	37.6% (29.1–46.8)	1.15 (0.69–1.89)	1.12 (0.68–1.84)	147, 77
3–4	39.6% (31.6–48.2)	1.25 (0.77–2.03)	1.22 (0.75–2.00)	171, 93
5+	49.9% (43.6–56.1)	1.89 (1.23–2.91)	1.70 (1.09–2.63)	317, 167
<b>All eligible for HPV catch-up vaccination program with 1+ lifetime partner<sup>d</sup></b>	41.9% (38.3–45.6)			843, 451
Sexual behaviors (those with 1+ lifetime partner)				
Had heterosexual sex before 16				
No	37.5% (32.7–42.6)	1 (–)	1 (–)	456, 252
Yes	47.7% (42.0–53.4)	1.52 (1.11–2.07)	1.68 (1.22–2.30)	355, 181
Number of sexual partners, past year <sup>d</sup>				
0/1	39.7% (35.0–44.6)	1 (–)	1 (–)	475, 260
2	44.8% (36.2–53.6)	1.23 (0.82–1.84)	1.28 (0.85–1.93)	156, 78
3+	45.7% (38.2–53.3)	1.28 (0.89–1.84)	1.30 (0.90–1.88)	203, 108
Number of sexual partners without a condom, past year <sup>d</sup>				
0	38.8% (31.0–47.2)	1 (–)	1 (–)	196, 106
1	39.6% (34.7–44.7)	1.03 (0.68–1.56)	1.03 (0.69–1.55)	443, 238
2+	53.1% (45.1–60.9)	1.79 (1.13–2.83)	1.83 (1.16–2.88)	185, 98
Health-related factors				
Used hormonal contraception, past year <sup>e</sup>				
No	54.3% (47.1–61.4)	1 (–)	1 (–)	235, 131
Yes	36.4% (32.4–40.7)	0.48 (0.34–0.68)	0.47 (0.34–0.67)	570, 299

(Continued on the following page)

**Table 4.** Factors associated with noncompletion of HPV catch-up vaccination (Cont'd)

	Not completed % (95% CI)	Not completed versus completed		Denominator (unwt, wt)
		OR (95% CI)	Age-adjusted OR (95% CI)	
Ever attended a sexual health (GUM) clinic		$P = 0.0044$	$P = 0.0100$	
No	37.2% (32.6–42.1)	1 (–)	1 (–)	462, 251
Yes	47.8% (42.3–53.3)	1.54 (1.15–2.08)	1.49 (1.10–2.02)	377, 199
Ever diagnosed with an STI (excluding thrush) <sup>f</sup>		$P = 0.1735$	$P = 0.4147$	
No (or only thrush)	41.0% (37.1–45.0)	1 (–)	1 (–)	730, 395
Yes	48.5% (38.3–58.8)	1.36 (0.87–2.10)	1.20 (0.77–1.88)	109, 55
Ever been pregnant		$P < 0.0001$	$P < 0.0001$	
No	35.4% (31.4–39.8)	1 (–)	1 (–)	633, 346
Yes	63.4% (55.9–70.2)	3.15 (2.21–4.49)	2.94 (2.04–4.23)	210, 105
<b>All eligible for HPV catch-up vaccination program with 1+ lifetime partner<sup>d</sup> who provided a urine sample</b>	41.0% (36.1–46.1)			481, 273
HPV markers in urine				
Any HPV type(s)		$P = 0.0302$	$P = 0.0383$	
HPV negative	36.0% (29.3–43.2)	1 (–)	1 (–)	253, 152
HPV positive	47.2% (40.0–54.6)	1.60 (1.04–2.44)	1.57 (1.02–2.40)	228, 121
1+ high-risk HPV type(s)		$P = 0.0003$	$P = 0.0005$	
Negative	35.3% (29.6–41.4)	1 (–)	1 (–)	347, 200
Positive	56.6% (46.8–65.9)	2.39 (1.49–3.83)	2.33 (1.45–3.74)	134, 73

<sup>a</sup>IMD is a multidimensional measure of area (neighborhood)-level deprivation based on the participant's postcode. IMD scores for England, Scotland, and Wales were adjusted before being combined and assigned to quintiles, using a method by Payne and Abel (20).

<sup>b</sup>Participants aged  $\geq 17$  years.

<sup>c</sup>Binge drinking defined as having six units on one occasion.

<sup>d</sup>Includes both opposite-sex and same-sex partners.

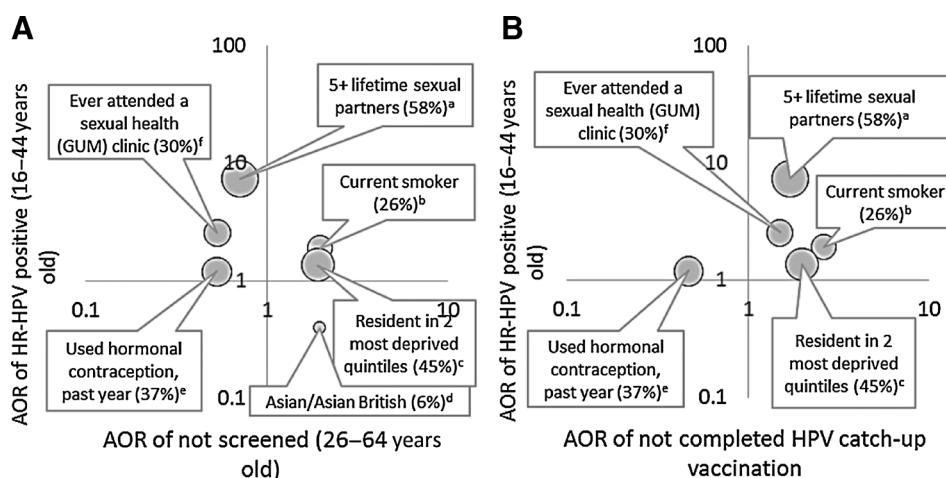
<sup>e</sup>Defined as having used the oral contraceptive pill, hormonal IUD, injections, or implants.

<sup>f</sup>Defined as having been diagnosed with one of chlamydia, gonorrhea, syphilis, genital herpes, genital warts, trichomonas, nonspecific urethritis/non-gonococcal urethritis.

effect of multiple risks in some groups of women has the potential to widen inequalities in cervical cancer incidence. Women who live in more deprived areas and who smoke were less likely to complete catch-up vaccination. These women were also at higher risk of HR-HPV, and their cervical cancer risk is compounded by smoking, which is itself a cofactor in cervical cancer development (39). In addition, these women were less likely to attend for cervical screening, thereby losing the opportunity for early detec-

tion and treatment of cancer abnormalities. Special efforts may be warranted to ensure women who missed vaccination are engaged by the cervical screening program, especially since girls with low intentions to attend for cervical screening may be less likely to be fully vaccinated (40). Good linkage between vaccination and screening records will be important to target those not vaccinated.

As some nonattenders for cervical screening seem to be at low risk for HR-HPV, tailored approaches may be appropriate to

**Figure 2.**

Relationship between risk factors for HR-HPV and uptake of cervical cancer programs: (A) cervical screening and (B) HPV catch-up vaccination. All ORs adjusted for age. 95% CIs for AORs exclude 1 with the exception of the association between hormonal contraception use and HR-HPV (see Tables 1, 2, and 4).

Top right quadrant for each graph indicates increased risk of HR-HPV and lower uptake of cervical cancer prevention program. The area of the bubble represents the size of the group as a proportion of those eligible for screening. Letters indicate reference groups: (a) 1 lifetime sexual partner; (b) non/ex-smoker; (c) resident in 2 least deprived quintiles; (d) white/white British; (e) not used hormonal contraception, past year; (f) never attended a sexual health (GUM) clinic.

increase screening among higher risk women. On the other hand, there is evidence of lower uptake of cervical screening among women who may be considered at lower risk for cervical cancer or may perceive themselves to be. For example, as in other studies, we found lower uptake in women self-identifying as lesbian (41, 42). Previous studies have also found that women who are not sexually active are less likely to attend for screening (33). Cervical screening prevents approximately 75% of cervical cancers by detecting and treating cervical abnormalities in women who attend regularly (5, 43). The odds of cervical cancer are approximately six times higher in women with no adequate screens at age 50 to 64 compared with those with adequate negative screening (44) so despite being at lower relative risk for cervical cancer, by missing the prevention opportunity offered by cervical screening these women may end up at increased risk. Although they have a lower incidence of cervical cancer overall, Asian/Asian British women aged 65 and over have a higher incidence than do women of White ethnicity (45). Because these women are unlikely to access sexual health services, engaging them in screening through general practice (family doctor) is important. The cervical screening program also needs to counter this risk-based tendency for nonparticipation. This will be particularly important in the era of vaccination, where careful messaging will be needed to promote uptake of screening among those who may perceive themselves at less risk.

Overall, those at increased risk of HR-HPV were no more or less likely to attend for screening. We found markers of engagement with healthcare, such as sexual health (GUM) clinic attendance and using hormonal contraception, were associated with higher cervical screening attendance. In 2011–2012, 17% of women having a cervical screen in England had a test that was outside the invitation system of the cervical screening program, i.e., opportunistic tests which were initiated by the person taking the sample or by the woman (46). This underlines the importance of maintaining integrated sexual health services to ensure that screening levels remain high in those at highest risk. However, around 30% of women who had not attended cervical screening in the past 5 years reported attending ante-natal or sexual health (GUM) clinics in the past 5 years or obtaining contraceptives from clinical sources in the past year, suggesting missed opportunities to engage these women with cervical screening.

Changes to the cervical screening program are likely in coming years, due both to HPV immunization effects on HPV epidemiology and the use of HPV testing in screening algorithms. HPV testing has already been introduced to help manage women with borderline and mildly abnormal cytology results. A pilot of HPV testing as the primary screening test (in place of cytology) is currently under way (46). It is unclear how changes will impact cervical screening uptake.

To date, there are few data relating to HPV vaccination uptake in the routine cohorts by the variables we have explored. It will be important to study factors associated with routine HPV vaccination uptake in the same way. Uptake of cervical screening among women who have not received HPV vaccination should be studied as these women reach screening age.

As some nonattenders for cervical screening seem to be at low risk for HR-HPV, tailored approaches may be appropriate to increase screening among higher-risk women. Socioeconomic markers and smoking were associated with HR-HPV positivity, noncompletion of catch-up HPV vaccination, and nonatten-

dance for cervical screening. This highlights the importance of general practice considering all aspects of the cervical cancer prevention pathway: vaccination, healthy lifestyle advice, and cervical screening. To avoid a potential widening of cervical cancer disparities in the catch-up age cohorts, special efforts may be warranted to ensure that those who missed catch-up HPV vaccination are engaged by the cervical screening program.

### Disclosure of Potential Conflicts of Interest

A.M. Johnson is Governor at the Wellcome Trust. No potential conflicts of interest were disclosed by the other authors.

### Disclaimer

The sponsors of the study had no role in study design and the collection, analysis and interpretation of data, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

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# Cancer Epidemiology, Biomarkers & Prevention

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Clare Tanton, Kate Soldan, Simon Beddows, et al.

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