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ORIGINAL RESEARCH ARTICLE

Cervical human papillomavirus infections in commercial sex workers — risk factors and behaviours

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Summary: We have investigated the prevalence of, and risk factors for, cervical human papillomavirus (HPV) infection in commercial sex workers (CSWs) and controls attending the same sexual health clinics in Sydney. A self-administered 'risk factor' questionnaire was completed and a Pap smear and a specimen for HPV detection and typing were taken. Results from the 288 CSWs and 266 controls were assessed by univariate and multivariate analyses. No significant difference in the rates of cervical HPV infection in CSWs (31.6%) and controls (24.4%) was found but HPV related cytological abnormalities were more common on the CSWs ($P < 0.05$). In both groups, factors independently associated with HPV infection were the use of non-barrier contraception, cytological abnormalities, age under 36 and the number of non-paying sexual partners. A risk factor for CSWs only was sex-work in Japan. A detailed 'work' history from CSWs may be useful to identify unsafe practices or work in countries where safer sex may be less acceptable.

Keywords: human papillomavirus (HPV) infection, commercial sex workers, cervical cancer, risk factors and risk behaviour

Introduction

Cervical cancer is the most important tumour-related cause of death in women under 50 years throughout the world and high-risk human papillomavirus (HPV) genotypes are believed to play a central role in the development of this disease[1,2]. All the HPV types that occur in the genital tract are thought to be acquired predominantly through sexual intercourse and up to 50% of sexually active young women will be infected at some time. However, data regarding the sexual transmissibility of genital HPV infection have produced conflicting results. While some studies have suggested a strong link with sexual activities — for example increased number of partners and frequency of intercourse — some have identified only a moderate link, while others have found no association whatsoever[3–9]. There are several possible explanations for these differences — including the use of viral detection techniques of variable sensitivity and specificity, studies with insufficient data or inadequate sample sizes, and failure to discriminate between infection with different HPV types. The last point may be of some significance, as it appears that 'high-risk' types with recognized oncogenic potential (such as HPV 16, 18, 31 and 45) have a stronger link to sexual activity than the 'low-risk' types rarely implicated in tumorigenesis (such as HPV 6 and 11)[10].

In some communities female commercial sex workers (CSWs) are believed to play an important role in the transmission of sexually transmitted infections (STIs), including HPV. Unfortunately there have only been a relatively small number of published studies that investigated HPV infection in CSWs[11–21]. Some of these had only a small number of participants[11,16,17,20], most did not include controls[11–18,20,21], and some researchers used inappropriate or insensitive virus detection technology[17,18,20]. Many of the more recent studies have concentrated on the links between HIV and HPV[13–16,20,21]. These investigations have produced widely variant data, with the prevalence of cervical HPV infection ranging from a high of 56% (in HIV-positive CSWs in Honduras[21]) — to a low of 14% (in CSWs in Singapore[16]). The two studies that

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included control groups produced conflicting results. In Japan the prevalence of high-risk HPV infection in 546 CSWs was 48%, compared with only 6% in 233 gynaecology controls[18]. On the other hand, in the Cote d'Ivoire the prevalence of HPV in CSWs versus women who had recently delivered was similar, with positivity rates of 38% and 35%, respectively[14]. Whether these discrepancies reflect genuine ethnic disparities in the sexual behaviours and practices of CSWs and non-CSWs in different geographic regions remains a matter for conjecture.

Sydney has a large commercial sex industry that can be divided into two sectors. The first is a well-regulated sector working mostly out of legal parlours (brothels) where most of the CSWs originate from Australia, New Zealand or the United Kingdom. The second sector consists mainly of CSWs from Asia, many of whom are illegal immigrants and are often working in unlawful and/or poorly regulated brothels. A previous study from this centre found that among the first group consistent condom use with clients is almost universal and STIs are uncommon. In the second group condom use with clients is less and STIs are more commonly identified[22].

In this report we present the results of a study that examined a group of CSWs and non-CSW control women attending two inner-city clinics in Sydney. Our main objectives were to compare the prevalence of both high-risk and low-risk HPV cervical infection in the two groups; and to identify any particular risk factors associated with an increased likelihood of infection. To overcome the problems associated with previous studies we used sensitive methods for identifying HPV infection and distinguishing between the individual HPV types.

Methods

Study sites and participants

Ethical approval was obtained from the South-Eastern Sydney Area Health Service Research Ethics Committee. Recruitment took place at the Sydney Sexual Health Centre (SSHC), a public sexual health facility in central Sydney, and at the Kirketon Road Centre (KRC), a primary health care centre for at-risk youth, sex workers and injecting drug users in nearby Kings Cross. All women attending for routine cervical screening between March 1995 and December 1998 were invited to participate in the study (in order to avoid including a disproportionate number of women with high-grade cervical abnormalities, women attending for colposcopic examinations were excluded). Women were classified as CSWs on the basis of self-identification, while controls were those who on direct questioning did not admit to any past or current commercial sex work. Since commercial sex work is legal in New South Wales, and the majority of commercial sex workers who attend SSHC and the Kirketon Road Centre do so for the purposes of screening certificates required by their place of work, self-identification as a CSW or non-CSW was considered a reliable means of discrimination.

Study procedure

After obtaining informed consent each participant completed a self-administered questionnaire (available in English, Thai, Chinese and Indonesian) that elicited information on demographic characteristics (such as ethnicity and country of origin), as well as risk factors for cervical HPV infection (such as numbers of sexual partners, contraceptive practices and smoking). During physical examination two cervical specimens were collected, smeared onto glass slides and fixed with alcohol: the first smear was used for routine cytology, the second for HPV detection. Investigations to identify other sexually transmitted infections (STIs) were performed according to routine clinic procedures.

In order to avoid contamination of the specimen for HPV detection, a separate set of equipment was stored in a closed container outside the clinical rooms. The health care workers used gloves and equipment (glass slides, cervix samplers, fixative etc.) from the box for collecting and processing the second sample. Mid-way through the study the possibility of cross-contamination was investigated by taking multiple samples with moistened swabs from the inside of the container, the equipment itself, and the examination room surfaces. These specimens were analysed by polymerase chain reaction (PCR) assays as described below for the presence of either human cellular (β-globin) or HPV DNA. Since no DNAs were amplified from any of these samples, we concluded that there was negligible likelihood of inadvertent cross-contamination at the clinical sites.

Cervical cytology

Cytology was performed at an accredited commercial diagnostic laboratory. The smears were stained with the Papanicolaou stain and routinely reported by a cytotechnologist according to the criteria currently used in Australia. Diagnosis was only attempted on smears with an adequate number of cells. Abnormal smears were reviewed by a pathologist unaware of the clinical or molecular findings.

HPV detection and typing

Previously described stringent protocols were routinely maintained to minimise contamination of specimens during laboratory processing[23]. The cells of the second smear were scraped into 110 μL

lysis buffer (50 mM Tris-HCl pH 8.5, 1 mM EDTA, 0.5% Tween 80, 100 μg/mL Proteinase K), digested at 37°C for 2–3 hours, heated to 96°C for 10 minutes, and the resultant lysates stored at −20°C. Five μL aliquots were used in separate reactions to amplify a segment of the HPV L1 region (using MY09/MY011 consensus primers)[24], and a 268 bp sequence of the human β-globin gene using GH20 and PC04 primers as previously described[23]. Positive controls comprised 2 ng and 200 pg of nucleic acids extracted from HeLa and Caski cells; and negative controls were lysis buffer and water. Following amplification, 6 μL of PCR products were electrophoresed through 2% Nu-Sieve agarose gels, stained with 1 μg/mL ethidium bromide and examined under UV transillumination for expected amplicons of 460 bp (for HPV) or 268 bp (for β-globin). Confirmation of results was achieved by repeat testing of all extracts on at least one occasion.

For typing of HPV DNA isolates, 50 μL PCR products were purified by polyethylene glycol precipitation then directly sequenced using *Taq*-DyedeoxyTerminator Cycle Sequencing methodology (Applied Biosystems). Comparison of resultant sequences with those of HPV types deposited in Genbank was carried out using *Blast* software: confirmation of HPV type was made on the basis of >90% homology with known HPV DNAs over a minimum of 400 bases. Identified HPVs were classed as 'high-risk' or 'intermediate-low' risk types[25,26] for the later analyses. Typing of some HPVs was also achieved using the Roche Amplicor™ system[27] when the sequencing results were inconclusive (<90% homology) due to the presence of two or more HPV types in the same specimen. Briefly, multiplex PCR amplification of HPV and β-globin was carried out using biotinylated primers in 70 μL reaction volumes. High stringency reverse hybridization of PCR products to 26 type-specific oligonucleotides immobilized as discrete bands on nitrocellulose strips was then performed. Biotin-labelled hybrid oligonucleotides were identified by sequential incubations with streptavidin-HRP and peroxidase substrate: the presence of one or more specific types was identified by comparing the location of bands appearing on the nitrocellulose strip with those of the template.

Compilation of data and statistical analyses

Questionnaire responses, cervical cytology results and HPV results were entered onto a database. Pearson's χ^2 was used for comparison of groups and the *SPSS* computer programme was used to perform univariate and multiple analyses of the association between the presence of HPV and a range of demographic, behavioural and morbidity characteristics. Only P values <0.05 were considered significant.

Results

A total of 587 women were recruited, but 17 were later excluded because of unsatisfactory cervical sampling (no β-globin DNA detectable in the smear), and a further 16 were excluded because of missing or incomplete questionnaire and/or cytological data. Of the 554 women included in the final analysis 288 were CSWs (147 Asian and 141 local sex workers), and 266 were controls (65 Asian and 201 local women). Four hundred and seven of the recruits were from the SSHC and 147 from KRC.

Concurrent STIs were very uncommon in both the CSWs and the controls. Two control women were found to have gonorrhoea, and seven cases of *Chlamydia trachomatis* were identified (five in CSWs and two in controls). Five CSWs had serological evidence of previous syphilitic infection and one was HIV-positive.

A comparison of the demographic and sexual behaviour characteristics of the CSWs and controls is presented in Table 1. The largest ethnic groups in the CSWs were Thai and Australian women; while the control women were more likely to have been born in Australia, New Zealand or the UK. CSWs were slightly older than the controls, but the age distribution of the two groups was not significantly different. CSWs were more likely to be smokers and admitted to fewer non-paying partners in the 12 months prior to the study and in their lifetime ($P<0.001$ for each).

Most CSWs reported consistent use of condoms for vaginal sex with paying partners: 237 always used condoms, 33 were inconsistent users and only one never used condoms (eight did not have vaginal sex). However, the use of condoms for vaginal sex with non-paying partners was more irregular. As shown in Table 1, only 28% of CSWs always used condoms, compared with 20% of the control women and over a quarter of the CSWs never used condoms in these circumstances.

Genital warts, HPV detection and cervical cytology

Data regarding past history or current presence of genital warts, cervical HPV DNA detection rates, and cervical cytology results are shown in Table 2. Controls were more likely to have a history of warts than commercial sex workers (34.5% *vs* 21.6%, $P=0.003$), and to have warts present at the time of examination (8.7% *vs* 3.5%, $P=0.003$).

Cytology results indicated that the CSWs had a higher rate of HPV-associated abnormalities than the control women, with 45/284 (15.8%) *vs* 27/266 (10.1%) showing cytological evidence of HPV infection or mild to severe cervical dysplasia ($\chi^2=3.915$, $P<0.05$). Detection of cervical HPV DNA was more frequent in the CSWs (31.6%) compared with the controls (24.4%), but the difference failed to reach significance ($P=0.08$).

Table 1. Demographic and sexual behaviour characteristics of commercial sex workers *vs* control women

	Controls		Commercial sex workers		*P* value†
Demographic variables					
Country of birth	*n*=266		*n*=288		
Australia	133	50.0%	110	38.2%	
New Zealand	10	3.8%	12	4.2%	
United Kingdom	38	14.3%	8	2.8%	<0.001
Thailand	23	8.6%	121	42.0%	
Malaysia	5	1.9%	6	2.1%	
China	20	7.5%	8	2.8%	
Other	37	13.9%	23	8.0%	
Age (3 missing)	*n*=263		*n*=288		
16–25	104	39.5%	122	42.4%	0.317
26–35	127	48.3%	122	42.4%	
36+	32	12.2%	44	15.3%	
Behavioural variables					
Number of cigarettes smoked (8 missing)	*n*=264		*n*=282		
Never smoked	118	44.7%	96	34.0%	
Ceased	52	19.7%	30	10.6%	
<10/day	38	14.4%	44	15.6%	<0.001
10–20/day	31	11.7%	68	24.1%	
>20/day	25	9.5%	44	15.6%	
Condoms for vaginal sex with non-paying partners in last 12 months (18 missing)*	*n*=245		*n*=214		
Always	48	19.6%	60	28.0%	
Inconsistent	132	53.9%	94	43.9%	<0.05
Never	65	26.5%	60	28.0%	
Number of non-paying partners in the last year (44 missing)	*n*=256		*n*=254		
Nil	14	5.5%	52	20.5%	
One	116	45.3%	116	45.7%	<0.001
Two	52	20.3%	29	11.4%	
Three or more	74	28.9%	57	22.4%	
Number of non-paying partners in a lifetime (81 missing)	*n*=248		*n*=225		
Nil	1	0.4%	6	2.7%	
One	17	6.9%	24	10.7%	
Two	18	7.3%	28	12.4%	0.008
Three to nine	90	36.3%	85	37.8%	
Ten or more	122	49.2%	82	36.4%	
Condoms for contraception (10 missing)	*n*=263		*n*=281		
No	138	52.5%	194	69.0%	<0.001
Yes	125	47.5%	87	31.0%	

†*P* value calculated using Pearson's χ^2
*Excluding women who reported no vaginal sex

There was no evidence of an ethnic difference in the detection rates of HPV among the CSWs: 45/145 (31.0%) of the Asian and 45/141 (31.9%) of the non-Asian sex workers had HPV-positive smears.

By means of either sequencing or reverse hybridization the majority (121/156, 78%) of HPV-positive smears were found to contain a single HPV type. In 28 smears (18%) two or three different HPV types were identified; and in 12 smears (8%) unidentifiable HPVs that had less than 90% homology with known types were present. When the identified HPV types were allocated into either the 'high-risk' or 'low/intermediate-risk' categories (Table 2) the percentage of infections due to high-risk versus low-risk HPV types was identical (38% and 53%, respectively) in both the CSWs and the controls.

Variables associated with cervical HPV infection

In order to determine whether any risk factors associated with cervical HPV DNA detection were different in CSWs and controls, we compared HPV-positive and -negative individuals in these two groups. In CSWs, on univariate analysis several factors were found to be statistically significantly associated with HPV infection, including age under 36; smoking for 5–10 years; using oral contraception; having a private CSW arrangement; and having worked as a CSW in Japan and

Table 2. Presence of genital warts, cervical smear results and HPV detection: comparison of commercial sex workers and control women

Variable	Controls	CSWs	*P* value†
History of genital warts	*n*=264	*n*=283	
Yes	91 (34.5%)	61 (21.6%)	
No	151 (57.2%)	195 (68.9%)	0.003
Unsure	22 (8.3%)	27 (9.5%)	
Genital warts present on examination	*n*=264	*n*=285	
Yes	23 (8.7%)	10 (3.5%)	
No	182 (68.9%)	229 (80.4%)	0.003
Unsure	59 (22.3%)	46 (16.1%)	
HPV detection (PCR)	*n*=266	*n*=288	
No	201 (75.6%)	197 (68.4%)	
Yes	65 (24.4%)	91 (31.6%)	0.079
*Low-intermediate oncogenic risk	35 (53.8%)	49 (53.8%)	
**High oncogenic risk	25 (38.5%)	35 (38.5%)	
***Unknown oncogenic risk	5 (7.7%)	7 (7.7%)	
Pap smear	*n*=266	*n*=284	
Normal	174 (65.4%)	171 (60.2%)	
Inflammatory	45 (16.9%)	42 (14.8%)	
HPV	16 (6.0%)	24 (8.5%)	0.396‡
CIN I±HPV	8 (3.0%)	14 (4.9%)	
CIN II/III±HPV	3 (1.1%)	7 (2.5%)	
Other	20 (7.5%)	26 (9.2%)	

†*P* value calculated using Pearson's χ^2
‡*P* value for all the listed categories
*Low/intermediate-risk HPV types: 6, 11, 34, 42, 43, 44, 53, 54, 55, 61, 62, 66, 70, 72, MM4, MM7, MM8, MM9, CP6108, CP8061, CP8304
**High-risk HPV types: 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 68
***Unknown risk: unidentified HPV types (less than 90% homology to known HPV sequences)

HPV DNA and HPV-related abnormalities detected by cytology. On multivariate analysis the only variables that remained significant were having worked as a CSW in Japan (OR 2.9, 95% CI 1.13–7.57); use of oral contraceptives (OR 3.3, 95% CI 1.77–6.15); and the presence of HPV-related cervical smear abnormalities. The association between HPV DNA detection and cytological findings was strongest for the lower grade abnormalities but remained convincing for the most severe grades of dysplasia: HPV±lower grade lesion (OR 28.4, 95% CI 8.58–93.85); CIN I±HPV (OR 17.7, 95% CI 4.42–71.28); CIN II–III±HPV (OR 7.4, 95% CI 1.48–37.37). Factors that were found to have no significant association with HPV infection included: STIs in the last 12 months; having worked as a CSW in Thailand, Malaysia, Singapore, Hong Kong, Europe or the USA; commercial sex work in a brothel, escort agency or on the street; duration of sex work and number of clients per shift.

As there was no significant difference in the prevalence of cervical HPV DNA between CSWs and controls the data were combined. On univariate analysis a number of variables were found to be significantly associated with the presence of HPV. These included use of the contraceptive sponge or oral contraceptives, failure to use condoms, having an abnormal cervical smear and age under 36. Paradoxically, women with fewer non-paying partners were at increased risk of HPV infection. When this variable was removed from the logistic regression model it had a minimal effect on the Odds Ratios of the other variables. As shown in Table 3, the variables for which an association persisted on multivariate analysis were: use of oral contraceptives, having an abnormal cervical smear, age under 36, and the number of non-paying sexual partners (those with less than three partners were significantly less likely to be HPV-positive).

We then looked at the risks associated with the detection of high-risk HPV types. On univariate analysis several factors were identified, including having an abnormal smear, smoking, being a CSW, HPV detected on previous smears, use of oral contraception and use of the contraceptive sponge. Having one non-paying partner in the last three months compared with none, or being 36 years old or over, were associated with a decreased risk. On multivariate analysis, factors independently associated with high-risk HPV infection were having an abnormal smear (CIN I OR 10.2, 95% CI 4.05–25.55, CIN II/III OR 10.9, 95% CI 2.85–41.29), use of oral

Table 3. Comparison of women (CSWs and controls) who were HPV-positive or HPV-negative

Variable	Crude OR‡ (95% confidence interval)	Adjusted† OR‡ (95% confidence interval)	Percentage of participants HPV DNA positive
Sex workers*	$\chi^2_1=3.44$, $P=0.0636$	$\chi^2_1=0.19$, $P=0.6646$	($n=549$)
No	Reference group	1	64/263 (24.3%)
Yes	1.4 (0.98–2.08)	1.1 (0.68–1.81)	90/286 (31.5%)
Age	$\chi^2_2=7.52$, $P=0.023$	$\chi^2_2=4.62$, $P=0.0994$	($n=546$)
16–25	Reference group	1	72/224 (32.1%)
26–35	0.8 (0.55–1.22)	1.0 (0.63–1.65)	69/246 (28.0%)
36 or greater	0.4 (0.20–0.78)	0.4 (0.17–0.97)	12/76 (15.8%)
Number of non-paying partners lifetime*	$\chi^2_4=7.87$, $P=0.096$	$\chi^2_4=9.60$, $P=0.0477$	($n=469$)
Nil			
One	1.1 (0.21–5.32)	0.7 (0.29–1.92)	3/7 (42.9%)
Two	0.9 (0.39–2.15)	0.8 (0.13–4.83)	16/41 (39.0%)
Three–Nine	Reference group	1	19/46 (41.3%)
Ten or more	0.5 (0.25–0.96)	0.4 (0.18–0.82)	44/173 (25.4%)
	0.5 (0.26–0.98)	0.4 (0.18–0.80)	53/202 (26.2%)
Pap smear result	$\chi^2_5=57.87$, $P<0.001$	$\chi^2_5=48.46$, $P=0.0001$	($n=545$)
Normal	Reference group	1	69/343 (20.1%)
Inflammatory	2.3 (1.39–3.85)	2.5 (1.40–4.45)	32/87 (36.8%)
HPV ± lower grade lesion	5.7 (2.86–11.39)	6.3 (2.88–14.00)	23/39 (59.0%)
CIN I ± HPV	7.9 (3.09–20.43)	10.4 (3.68–29.12)	14/21 (66.7%)
CIN II/III ± HPV	9.2 (2.33–36.76)	14.4 (3.47–59.85)	7/10 (70.00%)
Other	1.0 (0.46–2.16)	1.2 (0.50–3.02)	9/45 (20.00%)
Cytological features of HPV present	$\chi^2_1=43.59$, $P<0.001$	$\chi^2_1=0.01$, $P=0.9676$	($n=545$)
No	Reference group	1	111/475 (23.4%)
Yes	5.2 (3.09–8.84)	1.0 (0.20–5.46)	43/71 (61.4%)
Oral contraceptive use	$\chi^2_1=9.49$, $P=0.002$	$\chi^2_1=13.22$, $P=0.0003$	($n=540$)
No	Reference group	1	68/191 (35.6%)
Yes	1.8 (1.24–2.69)	2.3 (1.48–3.68)	81/349 (23.2%)
Condoms only for contraception	$\chi^2_1=9.14$, $P=0.002$	$\chi^2_1=0.02$, $P=0.8945$	($n=539$)
No	Reference group	1	106/328 (32.3%)
Yes	1.9 (1.24–2.80)	1.0 (0.58–1.82)	43/211 (20.4%)
Sponge contraceptive use	$\chi^2_1=6.93$, $P=0.014$	$\chi^2_1=3.77$, $P=0.0521$	($n=539$)
No	Reference group	1	129/494 (26.1%)
Yes	0.4 (0.24–0.82)	0.5 (0.22–1.01)	20/45 (44.4%)

*Included in logistic regression due to clinical importance
†Adjusted for all the variables listed
‡OR — Odds Ratio, OR reported to 1 decimal place, CI reported to 2 decimal places

contraception (OR 1.8, 95% CI 1.11–2.81), use of the contraceptive sponge (OR 2.6, 95% CI 1.30–5.16) and having one as opposed to no non-paying sexual partners in the last three months (OR 0.5, 95% CI 0.28–0.89).

Discussion

This study has shown that in women attending sexual health services in inner Sydney the prevalence of cervical HPV infection is similar in CSWs and in women not involved in the sex industry. Initially we considered that the lack of difference in HPV prevalence between CSWs and controls could have simply been due to the recruitment of control women who had a larger number of sexual partners than women in the general Sydney community. Almost half the controls in this survey had more than 10 sexual partners in their lifetime and 85% had more than three. In comparison, a concurrent survey carried out on women attending a Family Planning Clinic in suburban Sydney for routine Pap smears identified HPV infection using identical DNA technology in only 8.9% of 412 subjects. These women admitted to far fewer sexual partners than the controls attending the SSHC/KRC clinics, with only 26% stating they had more than three, and 12% more than 10, lifetime sexual partners (unpublished data). Since exposure to increasing numbers of different partners may increase the likelihood of transmission of genital HPVs, selection of a less sexually active control group may have produced very different results.

It was surprising that our analyses indicated that there was an increased risk for detection of all HPV types for those women who had one or two non-paying partners compared with those who had three or more partners. A similar discrepancy was also seen in relation to high-risk HPV infections. This anomaly may be related to the sexual behaviour of the non-paying partners[27,28], or perhaps to the fact that those women who have multiple partners are more likely to use condoms. Unfortunately our data were not sufficiently

detailed to address this issue. Overall, our findings regarding the numbers of partners are in contrast to the majority of previous studies that have shown that the greater the number of lifetime sexual partners the greater the chance of having HPV infection[3–5,8,10,28–30,34–36]. However, these studies are difficult to compare as several different methods of assessing the number of sexual partners were used. In addition, as the CSWs would have been in contact with a large number of clients, our findings on this issue are only applicable to the control women.

When the data from CSWs and controls were combined the factors found to be independently associated with HPV infection were having a low number of non-paying sexual partners, using the oral contraception pill or the sponge, being 36 years old or less, and having an abnormal pap smear. An additional variable independently associated with HPV infection in CSWs only was having worked as a CSW in Japan. The findings in relation to age, oral contraception, the contraceptive sponge, and abnormal cervical cytology are expected and in keeping with previous studies[3,4,10,25,27,28]. However, the observation that HPV infection was independently associated with commercial sex work in Japan was not anticipated but could relate to specific work practices in that country. A recent study from Japan using Hybrid Capture assay showed that high-risk HPV infection was present in 48.4% of 546 CSWs compared with 6% of 233 gynaecology controls ($P < 0.01$), and low-risk HPV infection in 13.7% of CSWs and 2.6% of controls ($P < 0.01$)[18]. These findings, coupled with high detection rates for *Chlamydia* (13%) and gonorrhoea (4.1%), suggest that unsafe sex practices among CSWs in Japan may be more common than in some other countries. A study of commercial sex work in Japan conducted in the late 1990s suggested that 'work establishments' may limit condom use and that clients would pay more for non-condom sex[29]. Further studies will be needed to establish the differences between commercial sex work in Japan and other Asian countries.

Our study assessed condom use in several ways, for contraception, as a barrier against STIs in non-paying partners and as a barrier against STIs by CSWs for vaginal and anal sex. However, the only significant finding related to condoms was 'condom use for contraception', that was shown — on univariate analysis only — to reduce the risk of acquiring cervical HPV. The most likely explanation is that women who rely on condoms for contraception may use condoms more consistently than those who use them to prevent STIs for commercial and non-commercial sex. This partial protection is in keeping with a previous study that demonstrated that consistent condom use reduced the risk of acquiring genital warts[30].

The reported prevalence of HPV in CSWs varies considerably around the world[11–21]. Some of this variation may reflect the prevalence of HIV in the community and several studies have demonstrated that HIV-infected CSWs are more likely to have persistent cervical HPV infection, particularly with high-risk types, than those without HIV infection[33]. In a recent Sydney survey HIV infection in CSWs was found to be uncommon[34] and only one of the women included in this study was known to be HIV-positive. This may partly explain the relatively low rate of HPV infection identified in our cohort.

The strengths of this study are in the large numbers of CSWs we were able to recruit from two separate sites and including two different groups of CSWs, the detailed HPV sequencing we were able to perform and the detailed sexual behaviour we were able to elicit. The main weakness of the study was the lack of follow-up to further elucidate the natural history of HPV in this group of women. Moreover, long-term follow-up would have allowed us to determine whether HPV carriage with high-risk types was persistent.

Strategies for reducing HPV in women attending sexual health services need to be developed. Firstly, despite the ambiguous findings of this study condom use should be encouraged. This may be particularly important in women who are using oral contraception and are at increased risk for HPV infection. Secondly, in CSWs, taking a detailed 'work' history may be useful to identify unsafe practices and work in other countries where safer sex may be less acceptable. Finally, all sexually active women should be encouraged to have regular cervical cytology.

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References

1 Schiffman M, Bauer H, Hoover R, *et al*. Epidemiologic evidence showing that human papillomavirus infection causes most cervical intraepithelial neoplasia. *J Natl Cancer Inst* 1993;**85**:958–64

2 Bosch F, Monos M, Munoz N, *et al*. Prevalence of human papillomavirus in cervical cancer: a worldwide perspective. *J Natl J Cancer* 1995;**87**:796–802

3 Ley C, Bauer HM, Reingold A, *et al*. Determinants of genital human papillomavirus infection in young women. *J Natl Cancer Inst* 1991;**83**:997–1003

4 Bauer HM, Hildesheim A, Schiffman MH, *et al*. Determinants of genital human papillomavirus infection in low-risk women in Portland, Oregon. *Sex Transm Dis* 1993;**20**:274–8

5 Wheeler CM, Parmenter CA, Hunt WC, *et al*. Determinants of genital human papillomavirus infection among cytologically normal women attending the University of New Mexico student health center. *Sex Transm Dis* 1993;**20**:286–9

6 Rohan T, Mann V, McLaughlin J, *et al*. PCR-detected genital papillomavirus infection: prevalence and association with risk factors for cervical cancer. *Int J Cancer* 1991;**49**:1–5

7 Kjaer SK, de Villiers EM, Caglayan H, *et al*. Human papillomavirus, herpes-simplex virus and other potential risk factors for cervical cancer in a high-risk area (Greenland) and a low-risk area (Denmark): a second look. *Br J Cancer* 1993;**67**:830–7

8 Peyton CL, Gravitt PE, Hunt WC, *et al*. Determinants of genital human papillomavirus detection in a US population. *J Infect Dis* 2001;**183**:1554–64

9 Moscicki A-B, Hills N, Shiboski S, *et al*. Risk for incident human papillomavirus infection and low-grade squamous intraepithelial lesion development in young females. *JAMA* 2001;**285**:2995–3002

10 Franco EL, Villa LL, Riuz A, *et al*. Transmission of cervical human papillomavirus infection by sexual activity: differences between low and high oncogenic risk. *J Infect Dis* 1995;**172**:756–63

11 Chan R, Khoo L, Hong HT, *et al*. A comparative study of cervical cytology, colposcopy and PCR for HPV in female sex workers in Singapore. *Int J STD AIDS* 2001;**12**:159–63

12 Juárez-Figueroa LA, Wheeler CM, Uribe-Salas FJ, *et al*. A highly prevalent sexually transmitted disease agent among female sex workers from Mexico City. *Sex Transm Dis* 2001;**28**:125–9

13 Van Doornum GJJ, Van den Hoek JAR, Van den Ameijden EJC, *et al*. Cervical HPV infection among HIV-infected prostitutes addicted to hard drugs. *J Med Virol* 1993;**41**:185–90

14 Piper MA, Severin ST, Wiktor SZ, *et al*. Association of human papillomavirus with HIV and CD4 cell count in women with high or low numbers of sex partners. *Sex Transm Dis* 1999;**75**:253–7

15 Marais DJ, Varda E, Ramjee G, *et al*. The impact of human immunodeficiency virus type 1 status on human papillomavirus (HPV) prevalence and HPV antibodies in serum and cervical secretions. *J Infect Dis* 2000;**182**:1239–42

16 Ferrera A, Belchers WJG, Velema JP, *et al*. Association of infections with human immunodeficiency virus and human papillomavirus in Honduras. *Am J Trop Med Hyg* 1997;**57**:138–41

17 Chatterjee R, Mukhopadhyay D, Murmu N, *et al*. Prevalence of human papillomavirus infection among prostitutes in Calcutta. *J Environ Pathol, Toxicol Oncol* 2001;**20**:113–17

18 Ishi K, Suzuki F, Saito A, *et al*. Prevalence of human papillomavirus, *Chlamydia trachomatis* and *Neisseria gonorrhoeae* in commercial sex workers in Japan. *Infect Dis Obstet Gynecol* 2000;**8**:235–9

19 Thomas DB, Ray RM, Kuypers J, *et al*. Human papillomaviruses and cervical cancer in Bangkok. III. The role of the husbands and commercial sex workers. *Am J Epidemiol* 2001;**153**:740–8

20 Laga M, Icenogle J, Marsella R, *et al*. Genital papillomavirus infection and cervical dysplasia — opportunistic complications of HIV infection. *Int J Cancer* 1992;**50**:45–58

21 Kreiss J, Kiviat N, Plummer FA, *et al*. Human immunodeficiency virus, human papillomavirus, and cervical intraepithelial neoplasia in Nairobi prostitutes. *Sex Transm Dis* 1992;**19**:54–8

22 O'Connor CC, Berry G, Rohrsheim R, Donovan B. Sexual health and the use of condoms among local and international sex workers in Sydney. *Genitourin Med* 1996;**72**:47–51

23 Rose BR, Thompson CH, Chantrill LA, *et al*. Prevalence and distribution of human papillomavirus type 16 DNA in pelvic lymph nodes of patients with cervical cancer and in women with no history of cervical abnormality. *Int J Cancer* 1992;**53**:1–4

24 Ting Y, Manos MM. Detection and typing of genital human papillomaviruses. In: Innes MA, Gelfand DH, Snitsky JJ, *et al*., eds. *PCR Protocols: A Guide to Methods and Applications*. San Diego: Academic Press Inc., 1990:356–67

25 Schiff M, Becker TM, Masuk M, *et al*. Risk factor for cervical intraepithelial neoplasia in southwestern American Indian women. *Am J Epidemiol* 2000;**152**:716–26

26 Nobbenhuis MAE, Meijer CJ, van den Brule AJ, *et al*. Additional of high-risk testing improves the current guidelines on follow-up after treatment for cervical intraepithelial neoplasia. *Br J Cancer* 2001;**84**:796–801

27 Gravitt PE, Apple RJ, Wheeler CM, *et al*. Genotyping of 27 human papillomavirus types by using L1 consensus PCR products by a single-hybridization, reverse line blot detection method. *J Clin Microbiol* 1998;**26**:3020–7

28 Giuliano AR, Papenfuss M, Schneider A, *et al*. Risk factors for high-risk type human papillomavirus infection among Mexican-American women. *Cancer Epidemiol Biomarkers Prev* 1999;**8**:615–20

29 Burk RD, Ho GY, Beardsley L, *et al*. Sexual behaviour and partner characteristics are the predominant risk factors for genital human papillomavirus infection in young women. *J Infect Dis* 1996;**174**:769–89

30 Kimoto K, Hayashi M, Okuni T, *et al*. Changing patterns in the sex industry and sexually transmitted diseases among sex workers in Osaka, Japan. *Sex Transm Dis* 2002;**29**:79–82

31 Wen LM, Estcourt CS, Simpson JM, Mindel A. Risk factors for the acquisition of genital warts: are condoms protective? *Sex Transm Infect* 1999;**75**:312–16

32 Langley CL, Benga-De E, Critchlow CW, *et al*. HIV-1, HIV-2 human papillomavirus infection and cervical neoplasia in high-risk African women. *AIDS* 1996;**10**:413–17

33 National Centre in HIV Epidemiology and Clinical Research. In: *2000 Annual Surveillance Report: HIV/AIDS, hepatitis C and Sexually Transmitted Infections in Australia*. Figure 16: HIV prevalence in people other than homosexually active men seen at metropolitan sexual health clinics by year, sex and HIV exposure category. National Centre in HIV Epidemiology and Clinical Research, Darlinghurst, Sydney, 2000:16

34 Kjaer SK, Chackerian B, van den Brule AJ, *et al*. High-risk human papillomavirus is sexually transmitted: evidence from a follow-up study of virgins starting sexual activity (intercourse). *Cancer Epidemiol Biomarkers Prev* 2001;**10**:101–6

35 Deacon JM, Evans CD, Yule R, *et al*. Sexual behaviour and smoking as determinants of cervical HPV infection and of CIN3 among those infected: a case-control study nested within the Manchester cohort. *Br J Cancer* 2000;**83**:1565–72

36 Richardson H, Franco E, Pintos J, *et al*. Determinants of low-risk and high-risk cervical human papillomavirus infections in Montreal University students. *Sex Transm Dis* 2000;**27**:79–86

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