Prevalence and Genotype Distribution of Genital Human Papillomavirus Infection in Female Sex Workers in the World: a Systematic Review and Meta-Analysis

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Abstract

Background: Female sex workers (FSWs) are amongst the most susceptible groups to acquire Human papillomavirus (HPV) infection and consequently, to develop cervical intraepithelial neoplasia and cervical cancer. This is the first systematic review and meta-analysis to provide estimates of the pooled prevalence of HPV infection and distribution of HPV types among FSWs across the world.

Methods: Five computerized databases were searched for relevant studies published since the inception date of databases to September 2019. The pooled HPV prevalence was calculated by the random effect model described by DerSimonian-Laird. Subgroup analysis was performed to identify the probable source of heterogeneity. The meta-analysis was performed using the “Metaprop” function in the R package Meta.

Results: Sixty-six studies involving 22938 FSWs from 34 countries were included in this meta-analysis, and the pooled HPV prevalence was 41.97% (95% confidence interval (CI): 37.99%-46.05%). HPV-16 (10.42%, 95% CI: 8.61%–12.55%), HPV-52 (7.76%, 95% CI: 5.75%–10.39%), and HPV-53 (6.09%, 95% CI: 4.55%–8.12%) were the most common high-risk HPV types identified among FSWs. Geographically, the highest and the lowest prevalence of HPV were obtained from Hungary (82.35%, 95%CI: 65.90%–91.85%) and Mexico (13.30%, 95%CI: 1.67%–58.06%), respectively.

Conclusion: Due to the high prevalence of HPV infection, particularly with high-risk types, FSWs have a great susceptibility to the development of cervical and vaginal cancers. Furthermore, they can transmit their infection to their clients, which may result in a high prevalence of HPV and incidence of HPV-associated malignancies among the general population.

Background

Human papillomavirus (HPV) is the most frequently sexually transmitted pathogen in humans. There are more than 200 different HPV genotypes recognized to date which are classified into two major groups, high-risk and low-risk genotypes in terms of their malignancy-causing potential [1, 2]. High-risk HPVs are associated with invasive cervical cancer and other genital malignancies; while the low-risk HPVs are associated with benign lesions and genital warts [3–5]. Cervical cancer is the fourth most frequent type of gynecological cancer worldwide, with a high mortality rate. More than 270,000 women annually die from cervical cancer worldwide, which most of them (~85%) are in developing countries [6, 7]. Almost all cases of cervical cancer are caused by persistent HPV infection, which is usually transmitted by sexual intercourse. Accordingly, cervical cancer is more common among females with multiple sex partners [8].

Female sex workers (FSWs) are at greatly elevated risk of acquiring sexually transmitted infections (STIs), including HPV, and their clients can act as a bridging population toward the general population. The major underlying risk factors for this high-risk group include multiple sex partners, unsafe sex behaviors, earlier age of sex work debut, the years of engaging in sex work, and low educational status [9, 10]. It is believed that sexual contact with FSWs contributes to HPV transmission and leads to high prevalence of cervical cancer in this population. In addition, they elevate the risk of penile cancer in males

by the spread of the virus to their male clients [11, 12]. Regarding the important role of viral STIs and their serious health complications among FSWs and their clients which can impose a substantial burden on the public health system, it is worth investigating the prevalence of STIs in this high-risk population. To the best of our knowledge, this is the first meta-analysis that characterizes the global epidemiology of HPV infection and distribution of high-risk and low-risk HPV types among FSWs.

Methods

This systematic review and meta-analysis was based on the items outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline [13].

Search strategy

We conducted an electronic literature search using Web of Science, Scopus, PubMed, Embase, and Google scholar from database inception to September 2019 to identify eligible publications. The details of search terms for each database are presented in Additional file 1. Moreover, reference lists of all articles included were scanned by hand to find additional eligible studies. All identified records were imported to EndNote software version X8 (Thomson Reuters, California, USA) for further management.

Selection criteria

Studies were considered eligible for inclusion if they reported: (1) original data about the prevalence measure for HPV infection among FSWs published in English language in peer-reviewed journals; (2) the prevalence of HPV DNA in different genital specimens, including cervical, endocervical, vaginal, and cervico-vaginal samples; (3) letters to editor, short communications, and English abstracts with sufficient data. Studies meeting any of the following criteria were excluded: (1) studies estimating the incidence of HPV infection among FSWs; (2) studies pertaining to the incidence and the prevalence of HPV infection among transgenders, male sex workers, gays, lesbians, and clients of FSWs; (3) review articles, Case reports, posters, and conference abstracts; (4) articles in languages other than English with non-English abstracts.

Data extraction

Two investigators independently reviewed the eligible articles and extracted data, including first author's last name, publication year, study year, study location, total sample size, type of specimen, diagnostic methods, diagnostic indexes, number of HPV-positive cases, and types of HPV. The extracted data were imported into an Excel spreadsheet (Microsoft Corporation, Redmond, WA, USA), and any discrepancies were resolved by a third investigator.

Statistical analysis

To measure the pooled prevalence of HPV infection among FSWs, a DerSimonian-Laird random-effect meta-analysis using the inverse variance method was performed [14]. In order to stabilize the variance and normalize their distribution, the logit transformation was used, and the Clopper-Pearson method was applied to estimate the 95% exact confidence intervals (CIs) for proportions [15]. To explore the possible sources of heterogeneity, subgroup analyses were performed based on study location, type of specimen, diagnostic method, and diagnostic index. In order to assess the heterogeneity across the included studies, the I^2 statistic was employed, in which the result is expressed as a percentage [16]. The meta-analysis was performed using the "Metaprop" function in the R package "meta" [17] (version 3.5.3 [2019–03–11], R Foundation for Statistical Computing, Vienna, Austria). For all statistical tests, differences with P values of <0.05 were considered statistically significant. Graph of the prevalence and genotype distribution of genital HPV was drawn using GraphPad Prism 7.1 for Windows (GraphPad Software, La Jolla California USA).

Results

Literature search

In initial literature review, 810 articles were identified through searching the five electronic international databases. A total of 402 duplicates was excluded, and then 408 articles were reviewed by title and abstract, which led to the elimination of 269 articles. The remaining 139 articles were checked for eligibility by the full-text review. After full-text screening, 77 articles were excluded based on the inclusion/exclusion criteria. In addition, 4 relevant articles were found and included by a manual search of the reference lists of the identified articles. Overall, 66 articles were included in this systematic review and meta-analysis. Figure 1 shows the process of literature retrieval and screening using a flow diagram.

Study characteristics

The characteristics of eligible studies in this systematic review and meta-analysis are summarized in Table 1. Sixty-six studies with a total of 22938 FSWs were included in this meta-analysis. The studies' publication dates ranged from 1992 to 2019, and they examined the population of 34 countries. The largest study included 2308 and the smallest included 34 FSWs. Most studies investigating the prevalence HPV infection were from Kenya (n = 7) and China (n = 4). Out of 66 studies included, 39 studies assessed the genotype distribution of HPV among FSWs. In one study [39], researchers were investigated the prevalence of only one type of HPV (HPV–16) among FSWs. Therefore, we excluded this study from the main meta-analysis calculating the pooled prevalence to avoid underestimating, and the results of genotype distribution were just included for the analysis.

Prevalence of genital HPV infection among FSWs

The aim of our current study was to determine the pooled prevalence of HPV infection in 22715 FSWs from 33 countries, and the range was from 5.53% to 84.75% of the selected individual studies. Figure 2 shows the prevalence of HPV and 95% CI estimates from individual studies according to the random-effects model. The pooled prevalence of HPV infection among FSWs was 41.97% (95% CI: 37.99–46.05%). The highest and the lowest prevalence of HPV were found in FSWs from the Hungary and the Mexico, respectively (82.35%, 95%CI: 65.90%–91.85% vs 13.30%, 95%CI: 1.67%–58.06%). The HPV prevalence in FSWs was the highest between the years of 2000 and 2004 (49.87%, 95% CI: 37.39%–62.36%); however, the number of HPV-positive cases were decreased from 2005 to 2019. For studies with HPV DNA detection in genital samples of FSWs, there was statistically significant difference between the prevalence of HPV using vaginal (68.41%, 95% CI: 37.70%–88.57%), cervical (42.32%, 95% CI: 38.15%–46.61%), cervico-vaginal (46.22%, 95% CI: 40.28%–52.26%), and endocervical (25.76%, 95% CI: 16.09%–38.57%) specimens (P = 0.02). With respect to HPV detection methods in genital samples of prostitutes, PCR, hybridization, PCR-hybridization, and TMA (transcription-mediated amplification) methods were used. HPV prevalences were 42.21% (95% CI: 36.87%–47.75%), 42.46% (95% CI: 33.97%–51.42%), 40.94% (95% CI: 37.76%–44.20%), and 31.87% (95% CI: 26.63%–37.62%) when PCR-, hybridization-, PCR-hybridization-, and TMA-based methods were used, respectively, and the difference was statistically significant (P = 0.03). Table 2 presents more detailed information on the prevalence of HPV infection among FSWs for subgroups.

Genotype distribution of genital HPV infection in FSWs

Overall, fifty-two HPV types were detected among FSWs across studies. The five most common high-risk HPV types identified were HPV–16 (10.42%, 95% CI: 8.61%–12.55%), HPV–52 (7.76%, 95% CI: 5.75%–10.39%), HPV–53 (6.09%, 95% CI: 4.55%–8.12%), HPV–18 (5.65%, 95% CI: 4.54%–7.03%) and HPV–58 (5.60%, 95% CI: 4.26%–7.32%). HPV–89 (7.04%, 95% CI: 4.21%–11.53%), HPV–50 (4.18%, 95% CI: 2.27%–7.60%), HPV–6 (3.88%, 95% CI: 3.03%–4.95%), HPV–54 (3.42%, 95% CI: 2.58%–4.53%), and HPV–71 (3.20%, 95% CI: 1.89%–5.38%) were also the most common low-risk HPV types identified among FSWs (Figure 3).

Discussion

Sexual intercourse is the main route of transmission of HPV infection, which is known as one of the most common infections around the world. According to this view, FSWs are amongst the most vulnerable group to acquire HPV infection and consequently, to develop precursors of cervical cancer. In part, this arises from the fact that they are constantly being exposed to a large number of risk factors facilitating the spread of sexually transmitted diseases [83]. Previous studies among the general population have reported that the prevalence of HPV ranged from 9% to 13% in the world [84]. As expected, our findings

indicated that the number of HPV-positive cases are significantly higher among FSWs compared to the general population, and the prevalence varied from 13% to 82% across the world.

Concerning the overall prevalence and genotype distribution of cervical HPV infection among FSWs, to date only one meta-analysis has been published by Peng etal. in 2012, which was conducted on 4198 FSWs from nine Asian countries [85]. Their study found a high HPV prevalence in different regions of Asia, so that the overall HPV prevalence in East, South-east, and South Asia were 49.6%, 42.9%, and 29.3%, respectively. Consistent with this, the results of our meta-analysis also indicated that FSWs in most Asian countries, like Bangladesh, China, Cambodia, India, Japan, Philippines, South Korea, and Vietnam had a prevalence of HPV infection greater than 40%.

The wide range variations between the different studies can be attributed to differences in the socio-demographic and behavioral characteristics of FSWs. As an example, we found that Mexican prostitutes exhibit low levels of HPV infection. It may be related to implementation of preventive programs such as primary cervical cancer screening, condom promotion, and HPV vaccination, which were effective to reduce the prevalence of HPV infection [18]. Application of vaccines against HPV infection in 11-year-old girls is a part of the Mexico's national immunization program [24].

There are two available HPV vaccines licensed by the U.S. Food and Drug Administration (FDA): quadrivalent HPV vaccine, including HPV types 6, 11, 16 and 18 (Gardasil®, produced by Merck); and bivalent HPV vaccine, including HPV types 16 and 18 (Cervarix™, produced by GlaxoSmithKline) [86]. HPV types 6 and 11 are known to be responsible for 90% of genital warts, and types 16 and 18 together cause up to 70% of invasive cervical cancer worldwide. Along with cervical cancer, HPV types 16 and 18 are responsible for 40%–50% of invasive vulvar cancer and 70% of vaginal cancer [87]. HPV–16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68, 73 and 82 are considered high risk genotypes, whereas low-risk genotypes include HPV–6, 11, 34, 40, 42, 43, 44, 54, 61, 70, 72, 81, and 89 [88]. Our results showed that HPV–16 and HPV–52 are the most commonly identified genotypes in FSWs. HPV-16 is considered as the most prominent type involved in the development of cervical cancer and other HPV-associated malignancies. HPV-52 is also an oncogenic HPV type, which is closely related phylogenetically to HPV-16. Previous studies have shown that HPV–52 is the sixth most frequently detected HPV high-risk type in cervical intraepithelial neoplasia grade 3 (CIN3) and invasive cervical cancer [89]. According to our findings, FSWs are strongly susceptible to the development of cervical intraepithelial neoplasia and cervical cancer.

Similar to Asian countries, the prevalence of HPV positivity was significantly high among European FSWs. Despite high coverage HPV vaccination among females in Europe, our meta-analysis indicated that HPV infection is very common among FSWs in the Netherlands, Belgium, Bulgaria, Denmark, Hungary, and Spain, with a prevalence of HPV infection between 30% and 80%. Our explanation is that vaccination does not protect against HPV types other than 6, 11, 16, and 18. For instance, the majority of FSWs in the Netherlands was infected with types different than what covered by the current vaccines [31]. To overcome this problem, we recommend the use of a nine-valent vaccine (9vHPV) instead of the

bivalent and quadrivalent vaccines. The 9vHPV vaccine contains type 6, 11, 16, 18, 31, 33, 45, 52 and 58 which was approved by the FDA in December 2014, and by the European Medicines Agency (EMA) in June 2015 [90].

Based on the results of the study, we found that the variations in the prevalence of HPV infection in FSWs across the studies could not be explained by the difference in detection methods. This is due to that the detection rates were similar for HPV using PCR, hybridization, and PCR-hybridization, which were applied in 60 (93.7%) studies. However, sample type may be one of the factors leading to differences in prevalence rates. To confirm this finding, our meta-analysis demonstrated that the detection rate of HPV using vaginal samples was significantly higher than cervical, endocervical, and cervico-vaginal samples. We concluded that the vaginal sample is more sensitive for detecting HPV and has a higher level of HPV DNA than the other genital specimens in FSWs. Furthermore, vaginal sampling is less invasive method, and is easily available for all women at the time of a regular HPV test. Owing to the high prevalence of HPV in vaginal samples, vaginal douching with disinfectants after sex with clients seemed to be an effective practice in reduction of HPV transmission.

In some countries, such as Thailand, Singapore, and Iran, the HPV prevalence is unexpectedly low, and we believe that this is due to several reasons, like limited HPV screening practices, low socioeconomic status, illegality of sex work, severely limited support systems, unsafe workplaces, fear of stigmatization, and lack of education or skills. Thus, it is so likely that the obtained results in our meta-analysis may not be a precise estimate of the HPV prevalence in these regions.

The present study has some limitations that need to be considered during the interpretation of our results. First, a significant part of the studies investigating the HPV prevalence among FSWs did not perform analysis of HPV genotype distribution, and thus we could not include their results in our meta-analysis of genotype distribution of HPV. Second, despite the subgroup analyses, significant heterogeneity still existed, suggesting that it arises from other sources that we could not characterize. Finally, there were no published data on the prevalence of HPV infection among FSWs in so many countries such as the United States, Canada, Russia, France, Germany, Italy, the United Kingdom, Nigeria, South Africa, Cameroon, and Arabian Peninsula.

Conclusions

In summary, FSWs are a neglected population around the world with a high prevalence of HPV infection, deserving greater attention. Our findings showed that high-risk HPV types are common among prostitutes. Persistent infection with high-risk HPV types is the strongest risk factor for the development of cervical intraepithelial neoplasia and cervical or vaginal cancers. In addition, they can transmit their infection to their male sexual partners, which leads to a high HPV prevalence and incidence of HPV-associated malignancies among the general population. Therefore, public health interventions, such as the implementation of national HPV vaccination strategies (particularly by 9vHPV vaccine), regular

screening of female sex workers for HPV, and encouraging safer-sex strategies like condom use are critical.

Declarations

Abbreviations

FSWs: female sex workers; HPV: human papillomavirus; CI: confidence interval; STIs: sexually transmitted Infections; TMA: transcription-mediated amplification; CIN: cervical intraepithelial neoplasia; EMA: European Medicines Agency; 9vHPV: nine-valent HPV vaccine.

Authors' contributions

A.T and M.F designed the study. M.F performed all statistical analysis. A.T wrote, reviewed and edited the manuscript. SH.M and SJ.K performed data interpretation. M.M, and M.T performed search strategy and acquisition of data. All authors read and approved the final draft.

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Availability of data and materials

All data generated or analyzed during this study are included in this article.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

The authors have no conflict of interest.

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Tables

Table 1. The characteristics of all eligible studies in this systematic review and meta-analysis

Author (Ref.)	Publication Year	Study Year	Study location	Total sample size	No. HPV positive
Velazquez-Hernandez [18]	2019	2014-2016	Mexico	217	12
Diop-Ndiaye [19]	2019	2010	Senegal	436	348
Ferre [20]	2019	NR	Togo	310	140
Lockhart [21]	2019	2009-2011	Kenya	344	97
Adams [22]	2019	2016	Ghana	100	26
Shahesmaeili [23]	2018	2015	Iran	1318	552
Muñoz-Ramírez [24]	2018	2011	Mexico	105	6
Lugo [25]	2018	2011	Brazil	67	13
Hooi [26]	2018	2014-2015	Curaçao	76	19
Richards [27]	2018	2015-2016	Dominican Republic	143	62
Bui [28]	2018	2014	Cambodia	200	94
Cameron [29]	2018	2009-2011	Kenya	330	97
Nasirian [30]	2017	2013-2014	Iran	99	7
Marra [31]	2017	2016	Netherlands	304	238
Abdoulaye [32]	2017	2015-2016	Ivory Coast	350	178
Vorsters [33]	2016	2006-2010	Belgium	1334	556
Menon [34]	2016	2010-2016	Kenya	616	357
Singh [35]	2016	2011-2012	India	120	33
Leaungwutiwong [36]	2015	NR	Thailand	100	13
Jia [37]	2015	2013	China	309	191
Gomih-Alakija [38]	2014	2009-2011	Kenya	349	103
Aho [39]	2014	2005-2006	Guinea	223	27
Wang [40]	2013	2008-2009	China	288	192
Patel [41]	2013	2000	Kenya	296	195
Marek [42]	2013	2009-2011	Hungary	34	28
Hoang [43]	2013	2009	Vietnam	281	139
Ersan [11]	2013	NR	Turkey	239	48
Yin [44]	2013	2009	China	802	309
Keten [45]	2013	2007	Turkey	137	53
Li [46]	2012	2009	China	810	315
Huq [47]	2012	2003-2006	Bangladesh	809	147
Ghosh [48]	2012	NR	India	45	35

Couture [49]	2012	2009-2010	Cambodia	220	90
Brown [50]	2012	2009-2010	Peru	199	133
Shikova [51]	2011	NR	Bulgaria	106	46
Montano [52]	2011	NR	Peru	87	44
Matsushita [53]	2011	2007	Japan	196	103
Dal Pogetto [54]	2011	2008-2009	Brazil	102	46
Znazen [55]	2010	2007	Tunisia	188	83
Smith [56]	2010	2004	Madagascar	90	33
Luchters [57]	2010	2005-2006	Kenya	776	429
Rhee [58]	2010	NR	South Korea	2308	939
Valle`s [59]	2009	2004	Guatemala	297	200
Miyashita [60]	2009	2006	Philippines	369	211
del Amo [61]	2009	2003-2004	Spain	549	169
Sultana [62]	2008	2003-2006	Bangladesh	293	222
Sarkar [63]	2008	NR	India	229	58
Hernandez [64]	2008	2003	Vietnam	282	239
Yun [65]	2008	2003	South Korea	188	157
Gazi [66]	2008	2006	Turkey	124	12
Didelot-Rousseau [67]	2006	2003-2004	Burkina Faso	360	238
Chandeying [68]	2006	1997-1998	Thailand	524	120
De Marco [69]	2006	2001-2003	Tunisia	64	28
del Amo [70]	2005	2002	Spain	734	283
Canadas [71]	2004	NR	Spain	187	52
Baay [72]	2004	2001-2003	Belgium	61	19
Mak [73]	2004	1992-2001	Belgium	99	72
Tideman [74]	2003	1995-1998	Australia	288	91
Choi [75]	2003	2001	South Korea	417	194
Juarez-Figueroa [76]	2001	1998	Mexico	495	242
Chan [77]	2001	1995-1996	Singapore	187	27
Kjaer [78]	2000	1992-1993	Denmark	182	59
Ishi [79]	2000	1998-1999	Japan	546	307
Langley [80]	1996	1990-1993	Senegal	681	293
Van Doornum [81]	1993	1991-	Netherlands	121	21

		1992			
Kreiss [82]	1992	1988-1989	Kenya	198	66

NR: Not reported;

Table 2. Subgroup analysis of the prevalence of HPV infection in female sex workers

Characteristics	Categories	No. of Studies	Pooled prevalence (%) (95% CI)	Heterogeneity test I^2 %, *p*-value	Differences between subgroups; χ^2 test (*p*-value)
Overall		65	41.97 (37.99-46.05)	97.0%, *P*<0.0001	
Diagnostic method	PCR	49	42.21 (36.87-47.75)	97.3%, *P*<0.0001	***P*= 0.03†**
	Hybridization	8	42.46 (33.97-51.42)	95.6%, *P*<0.01	
	PCR-Hybridization	3	40.94 (37.76-44.20)	58.4%, *P*= 0.09	
	TMA	4	31.87 (26.63-37.62)	75.0%, *P*<0.01	
Sample type	Cervical	52	42.32 (38.15-46.61)	96.5%, *P*<0.01	***P*= 0.02†**
	Endocervical	6	25.76 (16.09-38.57)	96.5%, *P*<0.01	
	Vaginal	3	68.41 (37.70-88.57)	99.2%, *P*<0.01	
	Cervico-vaginal	2	46.22 (40.28-52.26)	0%, *P*= 0.65	
Diagnostic index	L1 gene	28	44.36 (37.69-51.23)	96.8%, *P*<0.01	***P*<0.01†**
	E6/E7 mRNA transcripts	4	31.87 (26.63-37.62)	75.0%, *P*<0.01	
	E6 gene	2	45.40 (5.86-91.74)	99.6%, *P*<0.01	
	E6/E7 genes	1	26.00 (18.35-35.45)	NA, NA	
Study year	1985-1989	1	33.33 (27.12-40.19)	NA, NA	*P*= 0.07
	1990-1994	3	30.47 (18.65-45.58)	93.2%, *P*<0.01	
	1995-1999	6	39.38 (25.54-55.16)	97.7%, *P*<0.01	
	2000-2004	13	49.87 (37.39-62.36)	98.2%, *P*<0.01	
	2005-2009	17	45.43 (40.10-50.86)	95.3%, *P*<0.01	
	2010-2014	17	38.10 (28.03-49.29)	97.4%, *P*<0.01	
	2015-2019	8	37.46 (26.29-50.15)	96.9%, *P*<0.01	
Study location	Australia	1	31.60 (26.49-37.19)	NA, NA	***P*<0.01†**
	Bangladesh	2	45.40 (5.86-91.74)	99.6%, *P*<0.01	
	Belgium	3	48.81 (28.48-69.54)	94.4%, *P*<0.01	
	Brazil	2	31.27 (12.03-60.21)	91.0%, *P*<0.01	
	Bulgaria	1	43.40 (34.30-52.96)	NA, NA	

Burkina Faso	1	66.11 (61.06-70.82)	NA, NA	
Cambodia	2	43.87 (38.01-49.90)	36.6%, *P*= 0.21	
China	4	51.39 (38.02-64.56)	97.3%, *P*<0.01	
Curaçao	1	25.00 (16.55-35.91)	NA, NA	
Denmark	1	32.42 (26.02-39.55)	NA, NA	
Dominican Republic	1	43.36 (35.48-51.58)	NA, NA	
Ghana	1	26.00 (18.35-35.45)	NA, NA	
Guatemala	1	67.34 (61.80-72.43)	NA, NA	
Hungary	1	82.35 (65.90-91.85)	NA, NA	
India	3	42.11 (19.90-68.05)	94.6%, *P*<0.01	
Iran	2	19.49 (2.61-68.65)	96.9%, *P*<0.01	
Ivory Coast	1	50.86 (45.63-56.07)	NA, NA	
Japan	2	55.25 (51.65-58.80)	0%, *P*= 0.37	
Kenya	7	42.36 (31.15-54.42)	97.4%, *P*<0.01	
Madagascar	1	36.67 (27.38-47.06)	NA, NA	
Mexico	3	13.30 (1.67-58.06)	98.3%, *P*<0.01	
Netherlands	2	46.70 (5.12-93.43)	99.0%, *P*<0.01	
Peru	2	59.36 (42.94-73.93)	85.1%, *P*<0.01	
Philippines	1	57.18 (52.08-62.14)	NA, NA	
Senegal	2	63.29 (25.39-89.73)	99.3%, *P*<0.01	
Singapore	1	14.44 (10.09-20.24)	NA, NA	
South Korea	3	58.40 (39.27-75.30)	98.0%, *P*<0.01	
Spain	3	32.69 (26.60-39.42)	83.8%, *P*<0.01	
Thailand	2	18.23 (10.29-30.22)	79.0%, *P*= 0.03	
Togo	1	45.16 (39.70-50.74)	NA, NA	
Tunisia	2	44.05 (38.04-50.24)	0%, *P*= 0.96	
Turkey	3	20.91 (9.78-39.18)	93.4%, *P*<0.01	
Vietnam	2	69.91 (29.76-92.72)	98.6%, *P*<0.01	

NA: Not applicable; PCR: Polymerase chain reaction; TMA: Transcription-mediated amplification;

† Statistical significant

Figures

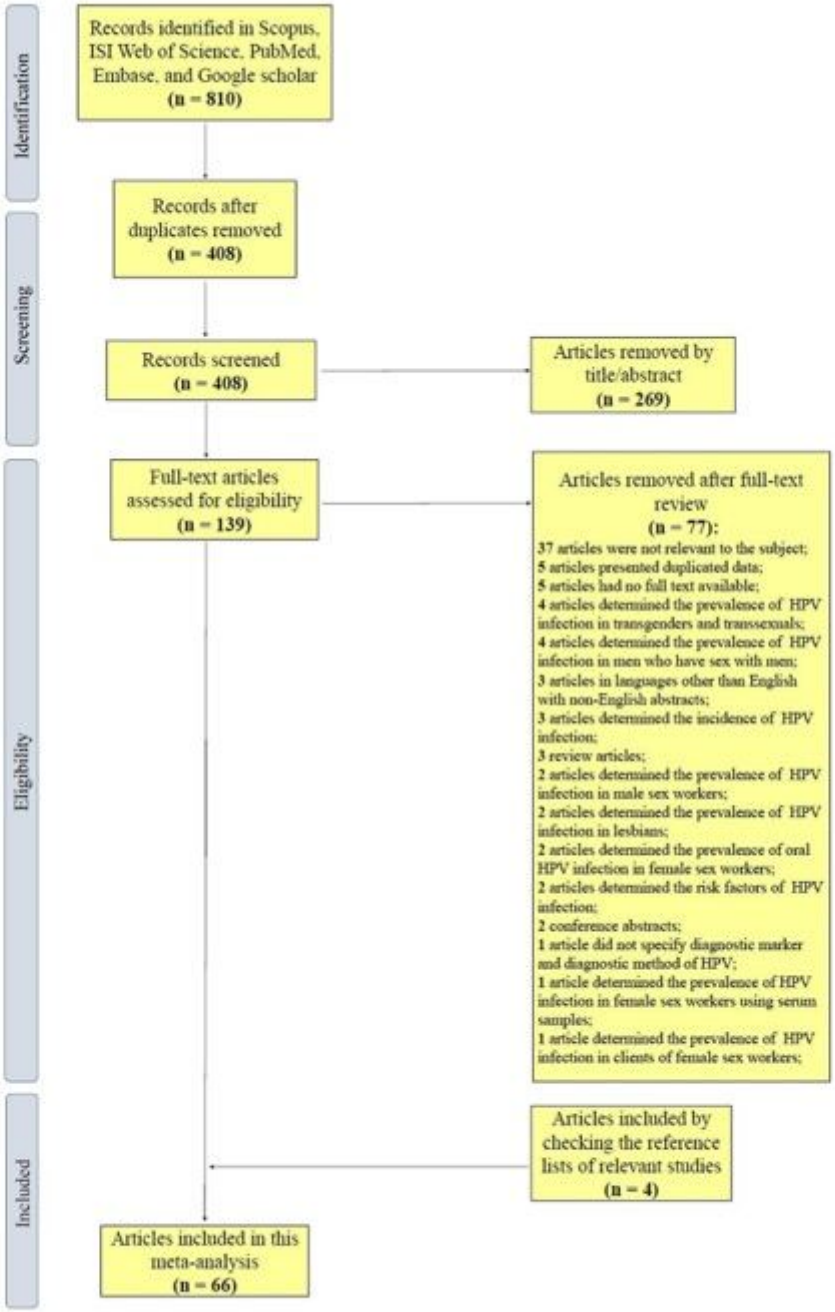

Figure 1.

Figure 1

Flowchart presenting the steps of literature search and selection

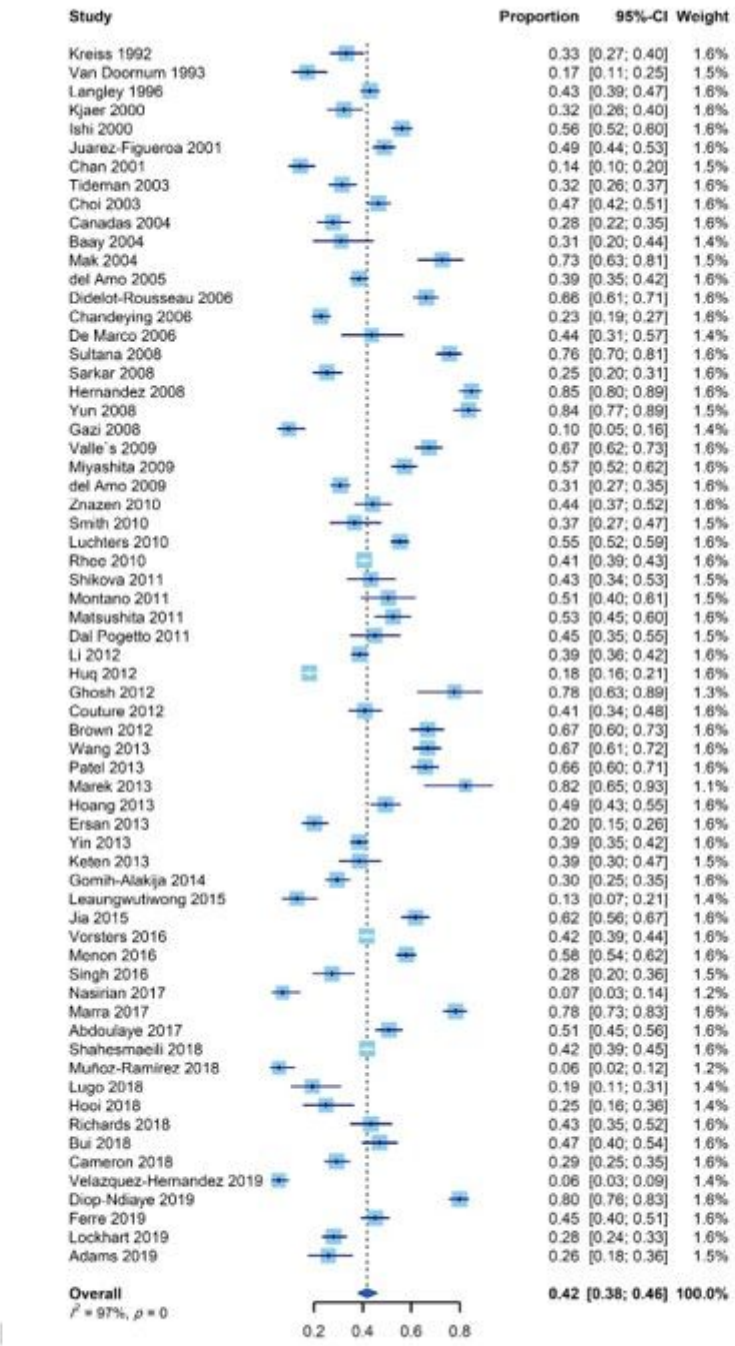

Figure 2.

Figure 2

Forest plot of the prevalence of HPV infection in FSWs

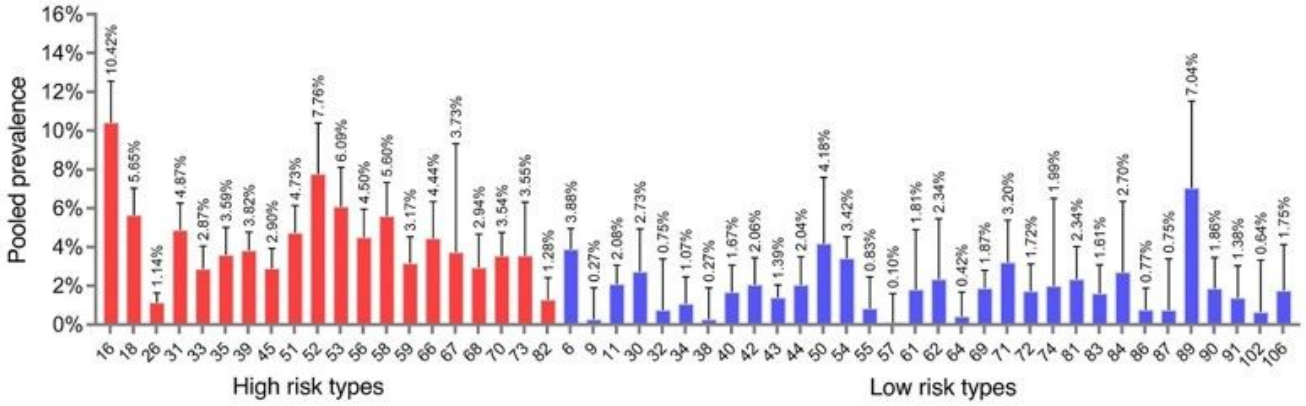

Figure 3.

Figure 3

Prevalence and genotype distribution of genital HPV (high-risk and low-risk) among FSWs.

Supplementary Files

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