

## RESEARCH ARTICLE

# Community-Based Prevalence of Genital Human Papilloma Virus (HPV) Infection: a Systematic Review and Meta-Analysis

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### Abstract

**Introduction:** Cervical cancer probably represents the best-studied human cancer caused by a viral infection and the causal association of this preventable cancer with human papilloma virus (HPV) is well established. Worldwide there is a scarcity of data regarding HPV prevalence with vast differences existing among populations. **Objective:** The aim of this meta-analysis was to determine the community-based HPV prevalence estimates among asymptomatic women from urban and rural set ups and in participants of cancer screening clinics. **Study design:** Systematic review and meta-analysis. **Methods:** PubMed-Medline, CINAHL, Scopus, and Google scholar were systematically searched for studies providing prevalence data for HPV infection among asymptomatic women between 1986 and 2016. **Results:** The final analysis included 32 studies comprising a population of 224,320 asymptomatic women. The overall pooled HPV prevalence was 11% (95% confidence interval (CI), 9%-12%). The pooled HPV prevalence of 11% (95% CI, 9%-11%) was observed among women attending cervical cancer screening clinics. The pooled HPV prevalences were 10% (95% CI 8%-12%) and 11% (95% CI 4%-18%) from urban and rural areas respectively, indicating higher infection rates among the rural women with the least access to cancer screening and cancer care. **Conclusion:** The prevalence rates in this systematic quantitative review provide a reliable estimate of the burden of HPV infection among asymptomatic women from developed as well as developing nations. Rural women and women attending cervical cancer screening programmes feature higher genital HPV prevalences compared to their urban counterparts.

**Keywords:** Cancer screening- cervical cancer- community- Human Papilloma Virus- HPV- prevalence

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### Introduction

Globally cancers are one of the leading causes of mortality and morbidity and the number of cancer cases is expected to rise by 70% over the next two decades due to population growth, an increase in life expectancy and tobacco exposure (Stewart et al., 2016). Cancer is known as the second leading cause of death after cardiovascular disease worldwide (Naghavi et al., 2015). A recent estimate from IARC predicted the occurrence of 16 million new cancer cases by the year 2020 surpassing the mortality burden due to cardiovascular diseases (Varughese et al., 2010).

In low and middle-income countries viral infections, such as Hepatitis B, C, and Human Papilloma Virus (HPV) are responsible for 20% of cancer deaths (de Martel et al., 2012), (Forman et al., 2012). There is a strong evidence for a causal association of HPV in cancers of the cervix, vulva, vagina, penis and oropharynx (Forman et al., 2012). Amongst these, infection with certain Human Papillomaviruses classified as high-risk types are known

to cause cervical and anogenital cancers. Cervical cancer is the fourth most common cancer among women after breast, colorectal and lung cancer. However, cervical cancer is the most common cause of cancer death among women in Eastern, Middle and Western Africa, Central America, South Central Asia, and Melanesia (Arbyn et al., 2011).

The incidence of cervical cancer cases can be correlated with high-risk HPV prevalence in a community and the age-specific prevalence of HPV among women above 35 years is a better predictor of cervical cancer incidence (Maucort-Boulch et al., 2008), (M. Sharma et al., 2013). The estimated prevalence rates vary vastly both at inter and intra-national levels (Vinodhini et al., 2012). As per IARC surveys, the HPV prevalence shows nearly 20 times variation in different regions (Clifford et al., 2005). The HPV prevalence of 8-9% was reported from Central Asia, Western Asia, and Europe whereas more than 20% prevalence rate was found in Africa, Oceania, North America, South and Central America (Guan et al., 2012). Globally, HPV crude prevalence estimate of 31%

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was reported among women with the highest estimate of 57% in Eastern Asia including China and Korea, and the lowest prevalence estimate of 3.7% from Europe. The observed HPV prevalence was higher in the developing countries (42.2%) compared to the developed countries (22.6%) (Vinodhini et al., 2012).

Numerous factors such as young age, high-risk sexual behavior, illiteracy, low socioeconomic status and impaired immunity can influence the prevalence of sexually transmitted infections (STIs) like HPV. Healthy people have a low high-risk HPV prevalence and a higher prevalence rate is seen among at-risk population like sex workers, men having sex with men and women with gynecological symptoms. Further, the prevalence of STIs in a community mainly depends on the type of genital specimens collected and the methods employed for testing.

Statistically significant higher HPV prevalence estimates were reported from studies that employed Hybrid Capture assay (HC II assay) as compared to those that used PCR (Polymerase chain Reaction) testing (de Sanjosé et al., 2007). The higher prevalence of 12.0-13.0% was found in the studies using cervicovaginal washings for HPV testing whereas a lower prevalence of 10.5% was reported when cervical samples collected with spatula were employed (de Sanjosé et al., 2007).

#### *Description of the condition*

The term prevalence indicates all the current cases (old and new) existing at a given point in time or over a period of time in a given population (K.Park., 2014). The HPV prevalence data among women from a region measures the risk of the participants developing cervical cancer.

#### *Why it is important to do this review*

Cervical cancer is the most common cause of cancer death among rural women from developing countries. In resource-poor settings, the single largest cause of years of life lost (YLL) among women due to cancer is attributed to cervical cancer as it affects relatively younger age groups. The screening for genital HPV infection is one of the best modalities to assess the risk of developing cervical cancer and appropriate preventive measures have to be undertaken in areas having a higher prevalence. The epidemiological data from every subpopulation is required before implementing preventive options, especially vaccination (Nigam et al., 2014). The present review aims to systematically examine the available literature reporting the overall HPV prevalence among urban women, rural women, and women attending cancer screening centres. The review also aims to analyse the variations in the HPV prevalence among asymptomatic women from different study sites.

## **Materials and Methods**

For this systematic review, we followed the standard systematic review guidelines prescribed by major agencies namely Cochrane Collaboration ([www.cochrane.org](http://www.cochrane.org)) and Campbell Collaboration ([www.campbellcollaboration.org](http://www.campbellcollaboration.org)). We further modified the meta-analysis component suited for the synthesis of prevalence study results.

#### *Type of studies, participants, settings, measurements, and outcome measurements*

All the accessible, cross-sectional studies on the concerned topic carried out during the time period between 1986 and 2016 were included in this review. Our initial search also tried to include the meta-analysis studies that have the potential to give the prevalence information. Community-based studies conducted among asymptomatic women at home and cancer screening centres were considered for the systematic review. The studies, reporting HPV prevalence estimates by confirming the presence of HPV DNA in cervical, vaginal or urine samples through Hybrid Capture (HCII) or Polymerase Chain Reaction (PCR) were included. The articles focused on the prevalence of genital HPV infection among immunocompromised women, women with cervical cancer, and gynecological symptoms were excluded. The studies with no information on specific sample size, the studies carried out among women less than 25 years of age, and the studies presented in meetings and congresses without full texts were also excluded.

#### *Search methods for identification of studies*

A comprehensive literature search to identify all the published studies between 1986 and 2016 April regarding "Genital Human Papillomavirus prevalence among asymptomatic women" in English was carried out. The electronic databases included in the search were PubMed Medline, CINAHL, Scopus and Google Scholar. The relevant articles in English involving human subjects were identified using the search terms such as "Human Papilloma Virus" OR HPV AND prevalence AND genital AND women NOT men". A manual library search for articles published in the peer-reviewed journals was done. The search builders were checked for their reproducibility before the final search. The references cited in the retrieved articles were also reviewed to increase the search sensitivity. The last date of the search was May 31st, 2016.

#### *Data collection and analysis*

##### *Selection of studies*

We followed a three-stage selection process for the final inclusion of the studies in the systematic review. In the first stage, one reviewer assessed each title from 4812 titles (records) for the appropriateness for inclusion in the review. If found inappropriate, the articles were rejected (n=4,472) and all the other articles were moved to the second stage of selection. In the second stage abstract of 340 titles were obtained and two reviewers independently scrutinised all such abstracts. All the non-relevant and duplicate studies were rejected (n=152) and the remaining 188 studies were moved to the third stage. In the third stage, full-text articles of 188 studies were obtained and were reviewed by two authors independently. The studies chosen by both the reviewers were included and in the case of disagreement between reviewers, a third reviewer arbitrated the selection process. Including one unpublished study, a total of 35 articles were included in the systematic review. However, 32 studies were included in the quantitative synthesis (meta-analysis). Study selection process is shown in the PRISMA chart (Figure 1).

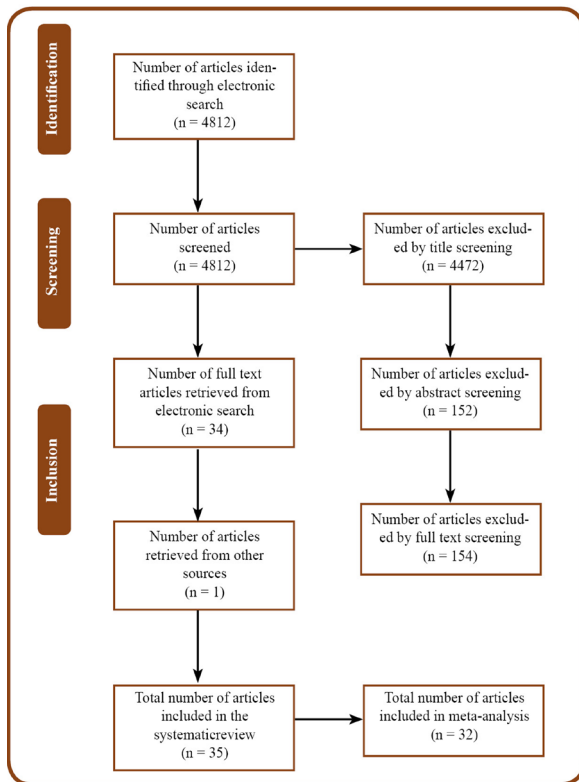


Figure 1. PRISMA Chart Detailing Study Selection for the Review

The flow diagram detailing the number of studies identified, records screened, full-text articles assessed for the eligibility and studies included in the systematic review and meta-analysis.

#### Quality assessment

A checklist was applied to assess the quality of the studies selected after the abstract and content review. This checklist included 14 questions using the NIH (National Heart, Lung and Blood Institute) checklist for observational cohort and cross-sectional studies (Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies - NHLBI, NIH.pdf (Song and Chung., 2010). Out of these fourteen questions, question numbers 1,2,3,4,5,11 were applicable to our study and all the aspects of the methodology like study objectives, defined study population, the participation rate of eligible subjects, sample size estimation, and the statistical adjustment of confounding variables were evaluated. The remaining 8 questions were applicable to cohort studies and the response to these questions was marked as not applicable (NA). Each question was graded as Yes, No, Others- CD (can not determine) / NA (not applicable) / NR (not reported). The studies with 6 Yes responses, were considered good and studies with 4-5 Yes responses were considered fair and less than 4 Yes responses were considered to be of poor quality.

#### Data-analysis

Meta-analysis was performed in STATA version 13.0 (College Station, Texas 77,845 USA). The forest plots were constructed using metan package in STATA. As we included only cross-sectional studies in this review which

are not methodologically as robust as experimental studies, we anticipated a considerable presence of methodological heterogeneity (differences in the method of conduct) as well as statistical heterogeneity (variability in the effect sizes) across the studies. Therefore we adopted a random effects model for meta-analysis rather than a fixed effect model. The pooled prevalence with 95% CI was reported along with  $I^2$  Statistic to quantify the heterogeneity between the studies.

#### Data extraction and Management

The pre-designed and pre-tested proforma was employed to extract the data. The proforma focused on the year of publication, study setting, country, sampling method, mode of HPV testing, HPV prevalence, and age groups. From the full-text articles, data was extracted by one reviewer and was reviewed by a second reviewer. The disagreements were discussed with a third reviewer, who was an expert and consensus was drawn.

## Results

Through electronic database search, 4,812 articles were identified and screened for eligibility and 4,472 titles were excluded. Abstracts of 340 titles were reviewed and 188 abstracts were found to be eligible for the full-text review and the remaining 152 articles were excluded. Full-text articles were retrieved for 188 studies.

Forty-one population-based studies employing Polymerase Chain Reaction (PCR) or Hybrid capture assays (HCII) for the detection of HPV infection were retrieved. Among the forty-one studies, three studies dealing with the prevalence of genital HPV infection among young women below 25 years of age (Datta et al., 2012),(Manhart et al., 2006), (K. Sharma et al., 2015) and three population-based studies with no reporting of overall HPV prevalence were excluded (Giorgi Rossi et al., 2010), (Asiimwe et al., 2008), (F. Zhao et al., 2006) as shown in Figure 1.

For the systematic review, 35 studies were selected. Two studies dealing with HPV prevalence in aboriginal

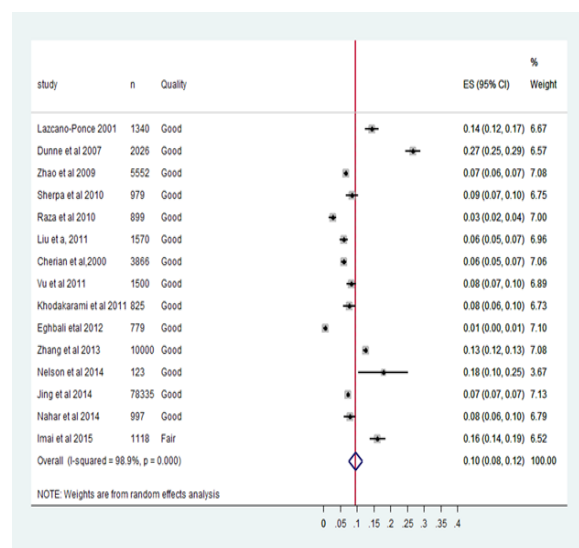


Figure 2. The Forest Plot of Pooled HPV Prevalence among Urban Women

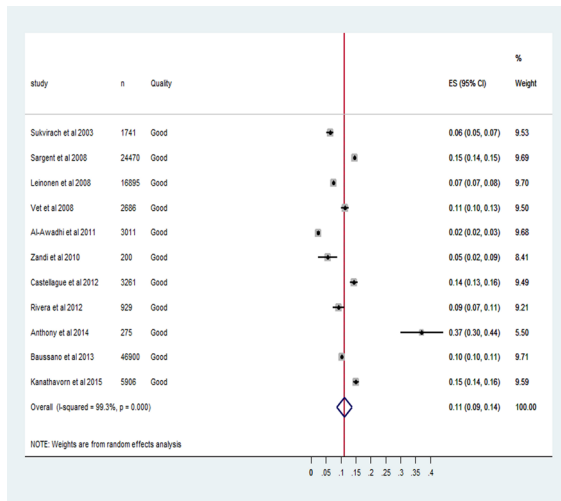


Figure 3. The Forest Plot of HPV Prevalence among Women Attending Cancer Screening Centres

communities from Argentina and Australia were not considered for the meta-analysis as these indigenous subgroups often practice specific sexual habits and the prevalence data is not representative of the general population (Deluca et al., 2012),(Tabrizi et al., 2014). Another study carried out among young women with higher sexual risk profile compared to the general population was also not included for the final meta-analysis (Mollers et al., 2013).

For the final meta-analysis, 32 articles dealing with the prevalence of genital HPV infection among asymptomatic women were considered. Two studies from North America, two studies from Central America (Mexico), three studies from Europe, eight studies from South Asia, seven studies from South East Asia, four studies from East Asia, four studies from the Middle East and one each from West Africa and South America were qualified. There were no population-based studies available from New Zealand and one study from Australia, carried out among indigenous population was included for the systematic review (Tabrizi et al., 2014).

There were 32 studies totaling to a population of 2,

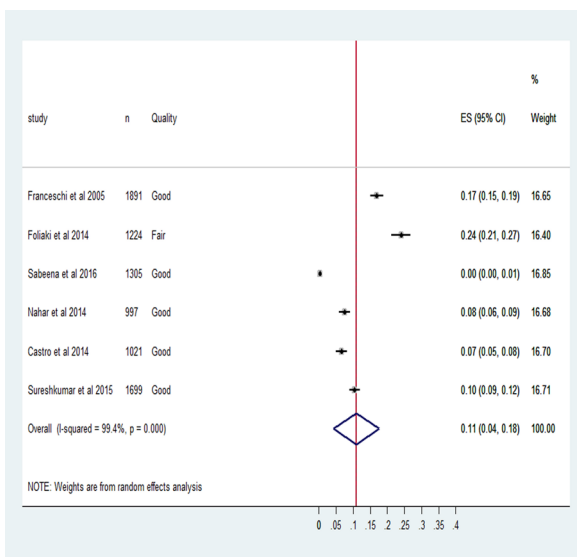


Figure 4. The Forest Plot of Pooled HPV Prevalence among Rural Women

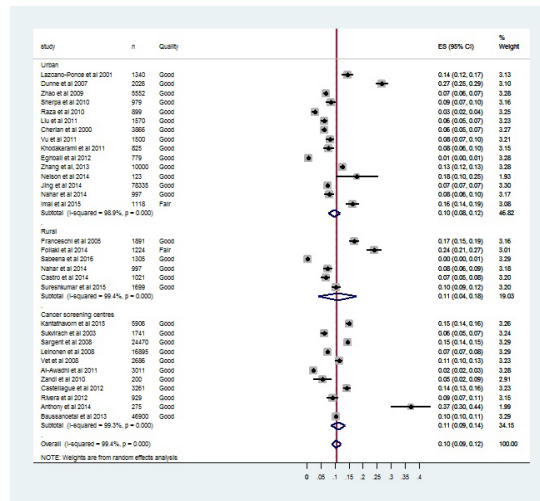


Figure 5. The Forest Plot Showing Overall Pooled HPV Prevalence among Asymptomatic Women From Different Study Sites

24,320 qualified for the meta-analysis. These studies were conducted globally between the year 2000 and 2016 April. The overall pooled HPV prevalence with 95% confidence interval was 11 % (9%, 12%). The Figure 2 shows overall HPV prevalence from study areas. The characteristics of each study included in the meta-analysis are presented in Table 1.

HPV prevalence in urban areas

Two studies from the United States (Dunne et al., 2007), (Nelson et al., 2015), three studies from China (R. Zhao et al., 2009), (Zhang et al., 2013), (Jing et al., 2014) two studies from Iran (Khodakarami et al., 2012), (Eghbali et al., 2012), one each from India, Mexico, Nepal, Pakistan, Japan, Hong Kong, Vietnam (Cherian Varghese., 2000), (Lazcano-Ponce et al., 2001), (Sherpa et al., 2010), (Raza et al., 2010), (Imai et al., 2015), (Liu et al., 2011), (Vu and Le., 2011) were reviewed. Only one study from Bangladesh reported HPV prevalence data among both the urban and rural women with no statistically significant difference in the prevalence between the two localities

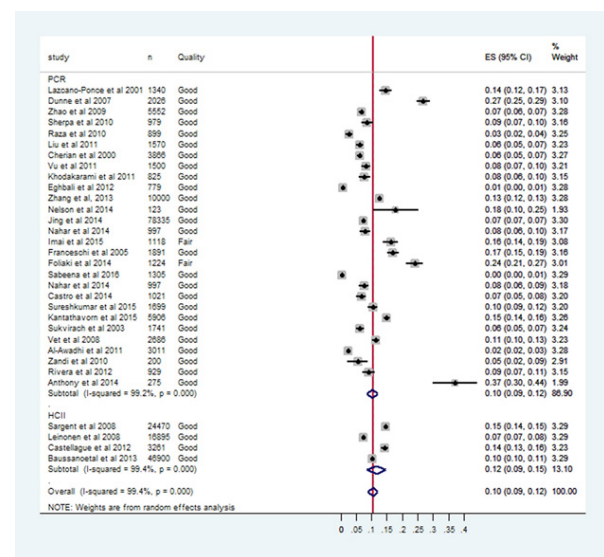


Figure 6. The Forest Plot Showing the Overall Pooled HPV Prevalence Based on PCR and HCII Assay

Table 1. Characteristics of the Studies Included in the Review

Study area	study setting	number	References	Samples	HPV testing	HPV	Age (years)	Quality assessment
Mexico	Urban	1,340	Lazcano-Ponce 2001	Cervical sample	PCR	14.50%	20-70	Good
United States	Urban	2,026	Dunne et al 2007	Self-collected vaginal sample	PCR	26.80%	14-59	Good
Beijing, China	Urban	5,552	Zhao et al 2009	Cervical sample	PCR	6.70%	25-54	Good
Nepal	Urban	979	Sherpa et al 2010	Cervical sample	PCR	8.60%	15-59	Good
Karachi, Pakistan	Urban	899	Raza et al 2010	Cervical sample	PCR	2.80%	15-59	Good
Hong Kong	Urban	1,570	Liu et al 2011	Cervical sample	PCR	6.20%	20-65	Good
Guangzhou		1,369				10%		
2Cities, Vietnam HCM Hanoi	Urban	1,500	Vu et al 2011	Cervical sample	PCR	HCM-8.3% Hanoi 6.10%	15-69	Good
Tehran, Iran	Urban	825	Khodakarami et al 2011	Cervical sample	PCR	7.80%	18-59	Good
Southern Iran	Urban	779	Eghbali et al 2012	Cervical sample	PCR	0.60%	21-50	Good
Shanghai	Urban	10,000	Zhang et al 2013	Cervical sample	PCR	12.60%	17-89	Good
Minnesota	Urban	123	Nelson et al 2014	Self-collected vaginal sample	PCR	17.80%	21-30	Good
Guangdong Province, China	Urban	78,335	Jing et al 2014	Cervical sample	PCR	7.30%	18-75	Good
Urban area, Bangladesh	Urban	997	Nahar et al 2014	Cervical sample	PCR	7.90%	13-64	Good
Miyazaki city	Urban	1,118	Imai et al 2015	Self-collected vaginal samples	HC II	16.20%	mean age 20 years	Fair
India	Urban	3,866	Cherian et al 2000	Cervical sample	PCR	6.10%	15-65	Good
Thailand	Cancer screening centre	1,741	Sukvirach et al 2003	Cervical sample	PCR	6.30%	15-65	Good
Manchester	Cancer screening centre	24,470	Sargent et al 2008	Cervical sample	HC II	14.60%	20-64	Good
Finland	Cancer screening centre	16,895	Leinonen et al 2008	Cervical sample	HC II	7.50%	25-65	Good
Indonesia	Cancer screening centre	2,686	Vet et al 2008	Cervical sample	PCR	11.40%	15-70	Good
Bushehr city Iran	Cancer screening centre	200	Zandi et al 2007	Cervical sample	PCR	5.50%	20-45	Good
Kuwait	Cancer screening centre	3,011	Al-Awadhi et al 2011	Cervical sample	PCR	2.40%	18-81	Good
Spain (CLEOPATRE study)	Cancer screening centre	3,261	Castellague et al 2012	Cervical sample	HCII	14.30%	18-65	Good
Mexico	Cancer screening centre	929	Rivera et al 2012	Cervical sample	PCR	9.10%	18-76	Good
Abuja Nigeria	Cancer screening centre	275	Anthony et al 2014	Cervical sample	PCR	37%	mean age 38 years	Good

Table 1. Continued

Study area	study setting	number	References	Samples	HPV testing	HPV	Age (years)	Quality assessment
Italy (NTCC trial) 9 areas	Cancer screening centre	46,900	Baussano et al 2013	Cervical sample	HC II	5.7-10.3%	25-60	Good
Thailand	Cancer screening centre	5,906	Kantathavorn 2015	Cervical sample	PCR	15.10%	20-70 years	Good
Fiji	Rural	1,224	Foliaki et al 2014	Cervical sample	PCR	24%	16-63	Fair
Bangladesh (rural)	Rural	997	Nahar et al 2014	Cervical sample	PCR	7.50%	13-64	Good
Chile	Rural	1,021	Castro et al 2014	Cervical sample	PCR	6.70%	15-85	Good
Dindigul	Rural	1,891	Franceschi et al 2005	Cervical sample	PCR	16.90%	16-59	Good
Tamil nadu	Rural	1,699	Suresh kumar et al 2015	Urine sample	PCR	10.50%	20-70	Good
Udupi Karnataka	Rural	1305	Sabeena et al 2016	Urine sample	PCR	0.40%	18-65	Good

(Nahar et al., 2014). The HPV prevalence varied from 0.6% in Iran to 26.8% in the US (Eghbali et al., 2012), (Dunne et al., 2007). The pooled prevalence with 95% confidence interval was found to be 10% (8%, 12%) as shown in Figure 2.

#### HPV prevalence in cancer screening centres

Total of eleven studies were qualified for the meta-analysis of HPV prevalence in cancer screening clinics. There were two studies from Thailand (Sukvirach et al., 2003), (Kantathavorn et al., 2015) and one study each from Manchester, Finland, Indonesia, Iran, Kuwait, Spain (CLEOPATRE study), Mexico, Abuja Nigeria, and Italy (Sargent et al., 2008), (Leinonen et al., 2008), (Vet et al., 2008), (Zandi et al., 2010), (Al-Awadhi et al., 2011), (Castellsagué et al., 2012), (pez Rivera et al., 2012), (Akarolo-Anthony et al., 2014), (Baussano et al., 2013). Asymptomatic women were recruited from the community and along with HPV testing, cervical smears were collected for cytology in most of the studies. Only one qualified study from Kuwait enrolled women with normal cytology reports (Al-Awadhi et al., 2011). Other studies reported abnormal cytological findings ranging from 1.1% to 35.1% among the enrolled women (pez Rivera et al., 2012), (Sargent et al., 2008). Indonesian study by Vu et al was conducted among the general population as part of a cervical cancer screening programme and 91% of the participants were never screened before. Among the 2686 samples tested, 13 women were found to be having histologically confirmed cervical cancer (0.5%) (Vet et al., 2008).

The prevalence rates varied from 2.4% in Kuwait to 37% in Nigeria (Al-Awadhi et al., 2011), (Akarolo-Anthony et al., 2014). The overall pooled prevalence was 11% with 95% confidence interval of 9% to 14% as shown in Figure 3.

#### HPV prevalence in rural areas

Altogether, six rural studies were qualified for the

meta-analysis. A thorough literature search revealed less number of studies carried out in the rural setups compared to urban or suburban areas. Three studies from India (Franceschi et al., 2005), (Sureshkumar et al., 2015), (Sabeena et al., 2016), and one each from Fiji and Chile were qualified for the current study (Foliaki et al., 2014), (Castro et al., 2015). We also included the prevalence data among rural women from Bangladesh as per the study by Nahar et al for the meta-analysis. The prevalence rates varied from 0.4% in rural India to 24% in Fiji (Sabeena et al., 2016), (Foliaki et al., 2014). The forest plot is shown in Figure 4. The pooled prevalence among the rural women was found to be 11% with 95% confidence interval of 4% to 18%.

#### HPV prevalence based on PCR and HCII assay

We observed that the studies reporting HPV prevalence based on HCII assays had a higher pooled prevalence of 12% (10%-15%) compared to the studies using PCR assays with a pooled prevalence of 10% (confidence interval 8%-12%) as shown in Figure 6.

## Discussion

A meta-analysis enables summarisation of the results of the relevant studies from different study areas with enhanced precision. The meta-analysis presented here includes 32 published studies regarding genital HPV infection among 2, 24, 320 asymptomatic women from different study locations. Of these studies 66% were population based and 34% were from cancer screening clinics. We observed an increase in the population-based studies from Asia during the last six years, whereas more European studies from cancer screening clinics were qualified for the meta-analysis.

Previous meta-analyses in HPV included women with normal cervical cytology (Clifford et al., 2005), (de Sanjosé et al., 2007), (Bruni et al., 2010). In the present

quantitative analysis, most of the studies from developing countries enrolled women with no prior exposure to cervical cancer screening. The estimate of HPV prevalence in women with normal cytology might not precisely represent HPV prevalence in the general asymptomatic population. Cytology has limited sensitivity and poor reproducibility, mainly attributed to the subjective nature of the cytological interpretation (Kitchener et al., 2006). The compliance of asymptomatic women for regular cancer screening mainly depends on socioeconomic status, literacy, and health seeking behavior.

We observed a higher prevalence of HPV infection among rural women and women attending cervical cancer screening clinics. HPV detection rate was higher among rural women compared to their urban counterparts. Globally less number of studies were conducted among the rural women despite these women being at a higher risk of cervical cancer. We observed the absence of community-based studies among the general population from Australia, where a National HPV vaccination Programme provides HPV vaccine free of cost to all the girls and boys aged 12-13 years since 2007. One important observation made was that only one study from Africa was qualified for the present meta-analysis. The main explanation for this dearth of information from Africa is the enormous burden of infectious diseases like AIDS and malnutrition. International and national research aids and supports are directed towards these issues which claim millions of lives every year.

The important challenges for implementing cervical cancer screening programmes in developing countries are the resource constraints, invasive method of sampling, and the lack of awareness regarding the asymptomatic nature of HPV infection, especially among the indigenous populations. Often health-conscious women are more likely to participate in these programmes, compared to the general population resulting in "healthy effect" bias (Castellague et al., 2012).

Most of the studies qualified for the present meta-analysis used cervical samples, whereas three studies from urban centres and two studies from rural India detected HPV infection in self-collected vaginal and urine samples respectively. Urine-based detection of high-risk HPV is lower (58.3%) than cervical (73.6%) and vulvar (72.1%) detection (Sahasrabudhe et al., 2014). Sowjanya et al have reported 25%-42% lower HPV DNA detection rate and lower viral load in self-collected vaginal samples when compared to clinician-collected samples (Sowjanya et al., 2009). However self-collected samples were preferred in these studies to facilitate the participation of hard-to reach participants. The main reasons for low screening rate among healthy women from developing countries were observed to be economical, geographical, cultural and social barriers to clinic attendance.

At a population level, the only intervention ever known to reduce the cancer mortality is prevention. The primary prevention of cervical cancer is the health education about safe sexual practices and HPV vaccination (CDC 2016). Most of the developing countries lack uniform cancer prevention strategy and awareness programmes have been undertaken in urban and suburban areas. Health education

should focus on the risk factors, the early warning signs, various preventive options and the management of premalignant and malignant lesions. International health organisations and resource-rich countries have the moral obligations to provide the capital resources and training to help the low-income countries in various control measures (Kerr and Kerr., 2006).

The rural population, having limited access to the cancer screening centres and presenting at advanced stages of malignancy demonstrate the lowest survival rates. One of the 17 sustainable development goals by WHO is to reduce the inequalities in all aspects of life. Even developed countries like Australia having a well-equipped health system for early detection and management of cancers, report inequalities in cancer care and survival among the people from rural and remote areas (Baade et al., 2011). Ensuring affordable, accessible, and appropriate preventive care to women from remote areas is a matter of social justice and prevention becomes the cure for cancers like cervical cancer which has a long pre-invasive stage.

#### *Quality of evidence*

A large proportion of heterogeneity was observed in this meta-analysis and the I-squared value was high. There was considerable variation between the studies, mainly in terms of the number of study participants and the samples used for HPV detection. An attempt was made to minimise the heterogeneity by excluding the studies carried out among women attending colposcopy centres and women having high-risk sexual behaviour. Vast heterogeneity in overall and type-specific HPV prevalence rates have been reported in earlier meta-analyses (Clifford et al., 2005), (de Sanjosé et al., 2007), (Bruni et al., 2010). An important goal of the meta-analysis is to identify the sources of heterogeneity (Higgins et al., 2003). We observed vast differences in the study settings, samples used, testing methods, and HPV molecular assays like MY09/11, PGMY09/11, and GP5+/6+.

In the present meta-analysis, studies employing HCII assay were found to report higher pooled prevalence than studies using molecular assays. de Sanjose et al reported higher prevalence rate in studies using HC II assay for HPV detection. A population study carried out in the slums of Delhi, India also observed higher HPV prevalence when tested by HC II assay (8.4%) compared to PCR-based detection (7%) (Datta et al., 2012).

#### *Strengths of the study*

Studies with high quality, published in indexed journals were included in the final analysis. To the best of our knowledge, this is the first meta-analysis dealing with the community-based HPV prevalence estimates among asymptomatic women from rural areas, urban settings, and cancer screening centres. We could perform a quantitative estimation of the HPV prevalence in the community, based on study settings and tests employed for detecting the infection. The present review will be helpful for policy makers in planning affordable, accessible, and appropriate preventive strategies for cervical cancer prevention in low-resource settings.

### Limitations

We included studies published only in English language and could not include relevant articles published in other languages. The low response rate may bias the results in population-based surveys. The cross-sectional studies estimate the HPV prevalence at a single point in time. Only persistent high-risk HPV infections lead to cancer and most of the HPV infections undergo complete resolution. Another limitation is the absence of pooled prevalence data on high-risk HPV types from different study areas. With increasing severity of lesions, HPV-16 is the most dominant type globally and we observed a fewer number of HPV type-specific prevalence studies from low-income countries.

Our review included studies carried out within a wide time span of thirty years between 1986 and 2016. The present meta-analysis observed higher HPV prevalence among rural women and women attending cervical cancer screening programmes compared to their urban counterparts.

The first step in achieving cancer control in a population is the appropriate application of the knowledge derived from years of successful research. In developing countries, in addition to cancers being diagnosed at advanced stages, cancer-related deaths are higher among women from rural and remote areas compared to their urban counterparts. Whilst multicentric HPV prevalence studies have to be carried out among the rural and indigenous population, the adoption of appropriate preventive measures can definitely lead to a decline in the cancer incidence and cancer-related deaths.

### Recommendations

1. Policymakers from both the developing as well as developed countries should ensure equity in cancer prevention, screening, and cancer care.

2. Multicentric community-based HPV prevalence studies among rural women have to be carried out before implementing vaccination to all the pre-adolescents in low-income countries.

3. Preventive measures have to be undertaken including vaccination in communities with higher HPV prevalence with the massive burden of cervical cancer.

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### Author contribution

Conception and design-SS, PB, VK, SB, AK  
Developing search strategy specific to each database-SS, RS  
Acquisition of data- SS, VK, RS, KB, AK  
Data analysis and interpretation of data-SS, PB, VK, SB, RS, SN  
Statistical interpretation-SN, RS  
Drafting the article-SS, PB, VK, SB, AK, RS

*Conflict of interest:* NIL

*Ethical considerations:* Not Applicable

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