

Evaluation of HPV-Associated Health Indicators between Low, Middle, and High-Income Countries: A Systematic Review

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Abstract

The infection of Human Papillomavirus has remained the major health problem globally, with striking disparities between low-, middle-, and high-income countries in rates of infection, the attendant viral disease impacts, and access to preventive measures. This systematic review has looked into key health indicators in terms of prevalence and incidence of infection, the burden of cervical cancer, vaccination coverage, and screening programs across these economic categories in light of human papillomavirus infection.

Original studies relevant to the research question were systematically searched through electronic databases from 2015 to 2024. The reviewed studies contributed data on infection rates from HPV, incidence and mortality rates related to cervical cancer, vaccination coverage from HPV, and the implementation of screening programs in low-, middle-, and high-income countries. Data extraction, synthesis, and comparison were done to show how these indicators change with economic status.

Results from this review have highlighted health disparities globally that are associated with HPV infection, showing how socioeconomic status influences access to prevention, vaccination, and treatment. These will provide valuable insights to inform targeted strategies toward improving the prevention and control of HPV in different economic contexts.

Keywords: human papillomavirus, HPV, low-income countries, middle-income countries, high-income countries, cervical cancer, vaccination, screening, health indicators.

Introduction

Human papillomavirus (HPV) is an infectious agent; it has been labeled the most common sexually transmitted virus today [1]. Approximately 75–80% of the sexually active population will be exposed to the virus at some point in their lives [2]. For most infected individuals, HPV infection is asymptomatic and typically resolves within 1 to 2 years; however, 70–90% may experience recurrent infections. These recurring infections can lead to significant health issues that may go unnoticed or develop into various cancers. The World Health Organization (WHO) estimated that nearly all cancers of the cervix are attributable to high-risk HPV types, with types 16 and 18 being responsible for over 570,000 new cases and almost 270,000 deaths annually worldwide [3]. Over 90% of such cases occur in LMICs, where effective screening and vaccination programs are lacking [2, 4].

Vaccination for HPV, in addition to the vaccination of high-risk types in both sexes, boys and girls, around 11 or 12 years, has been an acceptable methodology to bring down the incidence of this cancer. These are the high-yielding strategies in high-income countries (HICs), but they are the other way around in low- and middle-income countries (LMICs and MMICs). LMICs and MMICs are still facing this problem because of the cost of the vaccine, living conditions, and facilities for health remaining below the mark [5].

It has been seen through studies that LMICs usually have higher HPV infection and cervical cancer rates, largely due to limited vaccination and screening. On the other hand, HICs have lower rates due to well-succeeded vaccination programs and organized screening efforts. Generally speaking, middle-income countries fall in between, reflecting their transitional status in terms of economy and healthcare systems and their understanding of methods employed in combating the disease compared to other countries [2, 6]. Further, the complications around the health indicators for HPV vaccination uptake, screening participation, and disease incidence do call for a systematic evaluation in an endeavor to elaborate on the global landscape of health outcomes for conditions related to HPV infection.

The following review study has tried to assess various health indicators related to the human papillomavirus in different income group settings, including prevalence and incidence, the burden of cervical cancer, vaccination coverage, and screening programs. The review identifies gaps and differences in HPV-related outcomes between LMICs, MMICs, and HICs to contribute to understanding that can be useful in bettering global efforts in the prevention and control of HPV. Ultimately, such findings will provide a basis for developing better public health strategies to reduce inequalities and improve health outcomes in different groups.

Methodology

This systematic review is set to follow PRISMA guidelines, aiming to improve both transparency and credibility in research reporting. A broad search will be conducted across four primary academic databases—PubMed, Embase, Scopus, and Web of Science. This search is intended to identify relevant peer-reviewed studies published between 2015 and 2024. Carefully selected keywords and MeSH terms, including "HPV," "health indicators," and terms describing economic classifications such as "low-income," "middle-income," and "high-income countries," will be used to target a diverse range of studies. This strategy is crafted to provide a comprehensive view of HPV and associated health indicators across varied economic contexts. A gray literature search, international health organization reports, and conference proceedings were also reviewed to include broad studies.

A study had to be included in the review if it focused on health indicators related to HPV, including the prevalence of the virus, vaccination coverage, and screening program participation, such as cervical cancer. It also has to compare countries that the World Bank groups as LMICs, MMICs, or HICs. Thirdly, the observational studies included systematic reviews, and meta-analyses were included in the review. Studies not providing comparative analysis by different income levels, those not published in

their entirety in English, and those that failed to meet established quality standards were excluded from the review.

Two reviewers carried out data independently using a standardized extraction form. The review collected detailed information about each study, including the author, publication year, country, sample size, types of health indicators assessed, and key findings. If reviewers disagreed on any data, they discussed it or consulted a third expert for input.

To ensure quality, each study was evaluated using the Newcastle-Ottawa Scale (NOS) for observational studies and the AMSTAR tool for systematic reviews. Any study that did not meet a set quality threshold was excluded to maintain the review's rigor.

For the analysis, quantitative data were combined using meta-analysis techniques where appropriate. Differences among studies were measured with the I^2 statistic, which helped determine whether a fixed or random effects model was more suitable. When meta-analysis was impossible, a narrative approach was used to identify key themes and trends.

Sensitivity analyses were conducted to account for potential biases, including checks for publication bias using funnel plots and Egger's test. Since the review used only published data, formal ethical approval wasn't required, but all ethical guidelines for systematic reviews were followed, and all data sources were publicly accessible.

Overall, this careful, multi-step process ensures a thorough synthesis of HPV-related health indicators across various economic contexts, providing meaningful insights for public health policy and global health strategies.

Results

Study Selection and Characteristics

Researchers began to search databases PubMed, Embase, Scopus, and Web of Science for eligible studies reporting health-related outcomes affecting the prevalence of HPV in high-, middle-, and low-income countries. After the removal of duplicates and selection, a set of studies was identified that considered different health indicators regarding HPV, namely, HPV prevalence, vaccination rates, screening participation, and cervical cancer rates.

This approach yielded a diverse dataset on the health outcomes of LMICs, MMICs, and HICs regarding the disease burden. Analyzing these identified studies would enable researchers to examine how the health trends of HPV-related diseases vary across economic settings, hence offering valuable insights into health disparities related to income level.

Global HPV-Related Health Disparities

Cervical cancer is the fourth most common cancer among LMICs. The infections and cancers of HPV occur more predominantly in socioeconomically deprived parts of the world. About 84% of infections with HPV live in LMICs, out of which 80-90% are women. Because of the barrier to screening in these areas, there is high mortality among women due to late-stage diagnosis and a lack of treatment options [7]. For example, cases of cervical cancer in areas such as sub-Saharan Africa and South Asia are disproportionately high compared with other regions worldwide. In addition, access to screening and treatment programs is minimal in these areas, worsening the trends against those in high-income countries where access to medical care is more systematically assured [8].

In MMICs, studies have examined the effectiveness of screening and vaccination programs in reducing HPV-related diseases. HPV infection rates in Brazil and India are considerably higher than in high-income nations. Similarly, in regions like Latin America and Eastern Europe, HPV infections and cervical cancer remain major public health concerns, ranking among the

leading causes of cancer-related deaths in women [9].

Conversely, studies indicate that high-income countries, such as Canada, the United States, and many European nations, have lower HPV infection rates and lower cervical cancer incidence. Improved living standards, better access to healthcare, housing, transportation, nutrition, and effective vaccination and screening programs contribute to these differences [10].

Moreover, vaccine availability problems, low screening rates, and limited access to comprehensive cancer care services have also slowed the progress of cancer treatment in LMICs. In addition to these, cultural and political barriers, combined with public misinformation, ultimately hinder the efforts toward the prevention of HPV infection in these countries [11]. In MMICs, the prevalence is very different, 5% to 25% in some, showing striking urban-rural differences. For instance, a study conducted in Brazil showed that the prevalence was approximately 20%, requiring targeted interventions even in resource-poor settings. Although the rates are relatively lower compared to LMICs, the burden of diseases attributed to HPV remains very high [12].

In HICs, cancers caused by HPV are caught and treated much more promptly than in developing nations, particularly among the younger populations. Due to vigorous screening and general vaccination programs, survival rates and quality of life have improved significantly. Prevalence, in general, is 5-15% in this group; much smaller numbers, in turn, develop related cancers. Extensive vaccination programs have been given notice, leading to significant decreases in infections and cancers related to human papillomavirus (Table 1) [13, 14].

HPV Vaccination Coverage

HPV screening programs are not universally implemented and are generally only available for women, with an overall screening rate of 44% in LMICs and MMICs. This is evident, for example, in the case of broadening programs for HPV vaccination both in Brazil and Thailand, which, under the influence of economic pressure and spotty funding, is hard to continue successfully, thus eventually resulting in lower vaccination coverage over time.

In most high-income countries, such as Europe and North America, HPV vaccination rates remain far higher. About 85% of the eligible populations in all countries put together are covered by the HPV vaccination programs in Europe; in the U.S., it reaches about 77%. This has dramatically reduced not only the infections due to the virus but also the rate of cervical cancer. These high-income countries will benefit from well-organized vaccination efforts, vast public health infrastructure with accessible healthcare systems that include routine screening tests, and spelled-out guidelines for treatment.

In contrast, LMICs face challenges with lower vaccination rates attributed to weak healthcare infrastructure, financial barriers, and generally low public awareness of the virus. In these regions, the lack of resources for consistent screening and treatment has meant high rates of infection with HPV and cervical malignancy. Educational initiatives in these regions are also limited, reducing the effectiveness of HPV prevention strategies (Table 2) [15, 16].

Screening Programs

Screening programs include various things, such as testing asymptomatic people with a detailed screening test to identify patients with HPV. This test aims to prevent deaths, improve quality of life, and provide effective treatment. An accurate and appropriate screening test is an applicable, safe, and non-invasive experiment. Also, sensitivity refers to the ability of a test to identify patients with the disease accurately, and specificity refers to the ability to identify people without the disease (Table 3) [17].

In HICs, HPV screening is routine and widely accessible. Pap smear tests are regularly available, often conducted annually for women, allowing for early detection of HPV and significantly reducing cervical cancer incidence.

The main barriers to effective HPV screening programs in LMICs and MMICs are financial, infrastructural, and personnel-related. In LMICs, HPV infections and cervical cancers have reached such high rates due to tight healthcare budgets and public health education. With the limited resources and public awareness, these regions have been left with a heavy burden of HPV-related health issues, further challenging the efforts on its prevention and treatment.

Healthcare Infrastructure and Resources

The health systems of most of these high-income countries are well-endowed, where the health human resources to population ratios are high, coupled with good access to medical technologies. Facilities in these countries can efficiently deal with conditions arising from HPV, like precancerous lesions and cancers. Hospitals are often well-equipped, and governments invest funds in sufficient health facilities. However, LMICs and MMICs often exhibit several barriers: health facilities are often understaffed, and many lack essential medical equipment and are severely underfunded. These countries are also often characterized by a relatively more minor number of healthcare professionals, hospital beds, and medical technology, which is often outdated or insufficient to manage conditions related to HPV and other conditions effectively. Studies indicate that these resource constraints make it difficult for LMICs to respond effectively to health crises, such as infectious disease outbreaks. Consequently, HPV treatment and prevention services are often inaccessible for many people, and older, less effective methods are still widely used. Public awareness of HPV and its risks is also notably low among young adults in these regions, contributing to a rise in cervical and other HPV-related cancers (Table 4) [18, 19].

People in LMICs and MMICs are generally at higher risk for cervical cancer, partly due to limited access to HPV vaccination programs. Financial constraints, inadequate healthcare infrastructure, and insufficient public awareness often hamper vaccination efforts in these countries. A study covering 29 vaccination programs across 19 LMICs and MMICs identified key obstacles to HPV vaccination, including widespread misconceptions about vaccine safety and efficacy. Additionally, a lack of financial resources, human capital, and efficient vaccine distribution methods remain significant barriers to achieving higher vaccination coverage (Table 4) [20, 21].

Socioeconomic Determinants and Health Outcomes

In high-income countries, studies come from well-developed national health records, cancer registries, and public health surveillance systems. These sources provide detailed data on HPV vaccine coverage, cervical cancer screening rates, and long-term health outcomes, such as reductions in HPV-related cervical cancer frequency. In a country like the United States, about 1.6 million cases of cancer are diagnosed every year; although papilloma immunity has been suppressed with vaccines, still intercourse with other genotypes remains. And the recommendation of this country is to vaccinate males and females aged 11 and 12 [22, 23]. The results of various studies showed that several factors, such as socioeconomic affect geography and poor vaccine immunity [24]. The health outcomes analyzed in the studies include HPV prevalence, cervical cancer incidence, and mortality rates. Studies from LMICs highlight the substantial problem of cervical cancer, often a leading cause of cancer death among women, driven by a lack of screening and limited access to HPV vaccines.

In middle-income countries, there is evidence of decreasing cervical cancer rates where vaccination programs have been more successfully implemented, although rural populations still lag behind urban centers in access to defensive care. In contrast, HICs prove a marked decrease in HPV-related health outcomes, particularly in regions with well-established vaccination programs (Table 5) [25, 26].

Table 1: Table 1 Health Indicators Associated With HPV by Income Level. The following table insults key health indicators of human papillomavirus infection in low-, middle-, and high-income countries, including the prevalence of the virus, cervical cancer incidence, and mortality rates. Furthermore, the indicated disparities in the health outcomes reflect the disparate burden faced by different nations concerning health issues related to the virus, which mainly depend on the nations' incomes.

Country-specific statistics underpin the severity of health problems associated with HPV infection in differing socioeconomic settings.

Low-Income Countries (LMICs)	Middle-Income Countries (MMICs)	High-Income Countries (HICs)	HPV-Associated Health Indicators
Nepal: In women with normal cytology, it is approximately 2%, increasing to 80.3% in more severe lesions. Malawi: Among women with normal cytology, it is approximately 24%, increasing to up to 39% in more severe lesions. Ogando: 10.2-40%	India: Among women with normal cytology, it is approximately 5%, increasing to 83.2% in more severe lesions. Mexico: Among women with normal cytology, it is approximately 4.1%, increasing to up to 65% in more severe lesions. Brazil: 13.7-54.3%	North America: 3.9% Europe: 12%	HPV Prevalence
Nepal: 16.4 in 100,000 Malawi: 72.9 in 100,000 Ogando: 56.2 in 100,000	India: 18 in 100,000 Mexico: 14.3 in 100,000 Brazil: 12.7 3 in 100,000	North America: 8.1 in 100,000 Europe: 2.5%	Cervical Cancer Incidence
Nepal: 11.1 in 100,000 Malawi: 51.5 in 100,000 Ogando: 41.4 in 100,000	India: 11 in 100,000 Mexico: 6.58 in 100,000 Brazil: 7.2 in 100,000	North America: 3.41 in 100,000 Europe: 2.4%	Cervical Cancer Mortality

Table 2: HPV Vaccination Coverage in Various States. The table below summarizes information on HPV vaccination by country and according to income level; it shows when the programs started, current coverage rates for one and two doses, and challenges reported in the implementation process. The obtained data indicate striking differences in vaccination rates based on the need for urgent increases in access and awareness, especially among low- and middle-income countries.

HPV Vaccination Coverage		
<i>Introduction:</i> Vaccination for girls began in 2006 and for boys in 2011. <i>Coverage:</i> Approximately 71% for the first dose and around 48% for the final dose as of 2021. <i>Challenges:</i> Focus on maintaining high coverage and increasing the completion rate for full vaccination.	North America	High-Income Countries (HICs)
<i>Goals:</i> Europe aims to vaccinate 90% of girls by 2030. <i>Coverage:</i> Rates vary widely; countries like Denmark, Sweden, Finland, the U.K., and Ireland have high rates (70-90%), while others, such as Romania and Bulgaria, fall below 10%. <i>Challenges:</i> Wide variation in access and coverage between countries, with specific efforts needed in countries with lower vaccination rates.	Europe	
<i>Introduction:</i> The government budget highlighted vaccination promotion, though specific implementation details are pending. <i>Coverage:</i> HPV vaccination coverage is in the early stages, targeting girls aged 9-14 to prevent cervical cancer, the second most common cancer in Indian women. <i>Challenges:</i> High HPV prevalence due to low public awareness and limited vaccination access.	India	Middle-Income Countries (MMICs)
<i>Coverage:</i> Mexico has made past efforts to promote HPV vaccination, but rates fell significantly during and after the COVID-19 pandemic. In 2021, only around 1% of girls were vaccinated. <i>Challenges:</i> Pandemic-related disruptions impacted coverage, with ongoing efforts to restore program effectiveness.	Mexico	
<i>Introduction:</i> Continued focus on raising awareness and improving access, particularly in rural and underserved areas. <i>Coverage:</i> 70-80% for the first dose among girls aged 9-14; 50-60% for the second dose. <i>Challenges:</i> Lower completion rates for the second dose and reaching underserved populations.	Brazil	
<i>Introduction:</i> From 2017, targeting girls aged 9-14. <i>Coverage:</i> First dose coverage is around 60-70%; second dose completion is between 40-50%. <i>Challenges:</i> Low public awareness, limited healthcare access, and cultural barriers in some regions.	Nepal	Low-Income Countries (LMICs)

<i>Introduction:</i> From 2013, targeting girls aged 9-14. <i>Coverage:</i> The first dose is around 60-70%; the second dose completion rate is lower, around 30-50%. <i>Challenges:</i> Limited healthcare infrastructure, low awareness, and accessibility issues.	Malawi	
<i>Introduction:</i> From 2010, targeting girls aged 9-14. <i>Coverage:</i> First dose around 60-70%; second dose typically 40-50%. <i>Challenges:</i> Cultural concerns, low awareness, and limited healthcare access, especially in certain areas.	Uganda	

Table 3: Programs for Screening HPV. The table below outlines some HPV screening programs developed for the early detection of cancers in some countries worldwide. It gives information on strategies adopted for screening, barriers to implementation, and outreach in diversified socioeconomic settings. This summary illustrates the range of national approaches to reducing HPV-related health risks, reflecting each country's resources and population demands.

Screening Programs		
<i>Programs:</i> include Pap smears and HPV testing for women aged 21 to 65, conducted at intervals of 3 to 5 years. <i>Challenges:</i> Ensuring adherence to recommended intervals and reaching underserved populations.	North America (U.S.)	High-Income Countries (HICs)
<i>Goals:</i> Aim to screen at least 70% of women by 2030. <i>Programs:</i> HPV-DNA testing is preferred for its high accuracy and lower costs. Self-sampling options are also being explored to increase participation. <i>Leading Countries:</i> The Netherlands and others have successful early detection and mortality reduction programs. <i>Challenges:</i> Variability in screening access and participation across different countries.	Europe	
<i>Vaccination Efforts:</i> Efforts to improve HPV vaccination rates accompany screening programs. <i>Programs:</i> Widespread screening initiatives focus on early detection of cervical cancer. The Ministry of Health has introduced free testing and programs to raise awareness and access. <i>Challenges:</i> Low public awareness and cultural barriers limit program effectiveness.	India	Middle-Income Countries (MICs)
<i>Vaccination Efforts:</i> Programs aim to encourage HPV vaccination alongside screening. <i>Programs:</i> Initiatives focus on early detection of HPV-related cancers, with free testing and community education programs. <i>Challenges:</i> Social barriers and low public awareness impact the effectiveness of these efforts.	Mexico	
<i>Vaccination Efforts:</i> Active campaigns promote HPV vaccination among girls. <i>Programs:</i> Screening programs target early detection of HPV-related cancers. The Ministry of Health supports educational campaigns and free testing to increase access. <i>Challenges:</i> Regional disparities, awareness gaps, and access issues in underserved areas affect program reach.	Brazil	
<i>Programs:</i> Gradually expanding screening programs for early detection of HPV-related cancers. Government efforts aim to increase awareness and access to screening services. <i>Challenges:</i> Limited financial resources, inadequate healthcare infrastructure, and high treatment costs prevent many rural women from participating in screening and vaccination programs.	Nepal	Low-Income Countries (LMICs)

<i>Programs:</i> HPV-related cancer screening programs are increasing in scope, though poverty remains a significant barrier. <i>Challenges:</i> Lack of healthcare infrastructure, high costs, and limited public awareness about screening and vaccination restrict program effectiveness.	Malawi	
<i>Programs:</i> Screening programs for early detection of cancer are actively implemented. <i>Challenges:</i> Poverty, high healthcare costs, and limited resources prevent many women from accessing screening and vaccination services.	Uganda	

Table 4: Healthcare Infrastructure for HPV Prevention and Treatment. The following table compares the overall health infrastructure that supports HPV prevention and treatment across countries of varied income levels, detailing vaccination programs, screening and diagnostic services, and educational outreach efforts. It would appear that there is some relationship between each of these countries listed and their economic standing and general proficiency in management regarding HPV infection.

Healthcare Infrastructure	
<i>Vaccination:</i> Comprehensive HPV vaccination programs are routinely conducted in schools and health centers. <i>Screening and Diagnosis:</i> Pap smear and HPV DNA testing are widely available for early detection. <i>Education and Awareness:</i> Educational campaigns increase public awareness about HPV, its transmission, and the importance of prevention and screening.	High-Income Countries (HICs)
<i>Vaccination:</i> HPV vaccination programs have been launched, though coverage is limited. <i>Screening and Diagnosis:</i> Pap smear and HPV tests are available in some health centers, but access in rural areas is limited. <i>Education and Awareness:</i> Awareness campaigns are active, but cultural beliefs and lack of information can reduce effectiveness.	Middle-Income Countries (MICs)
<i>Vaccination:</i> Vaccination efforts are underway but face challenges due to poverty and healthcare access limitations. <i>Screening and Diagnosis:</i> Pap smear and HPV tests are available in some centers, but access in remote areas is challenging. <i>Education and Awareness:</i> Though cultural barriers and limited information impact success, public education programs exist.	Low-Income Countries (LICs)

Table 5: Socioeconomic Determinants Influencing HPV Health Outcome. The following table examines the socioeconomic factors affecting health outcomes caused by the human papillomavirus. It looks at income status, economic conditions, access to education, social and healthcare availability, and environmental concerns. For this reason, these determinants provide a better description of the differences in the burden of HPV and the effectiveness of its prevention; hence, they provide the foundation for health disparities on which strategies may be laid.

Socioeconomic Determinants	
<i>Economic Stability:</i> Stable income and employment improve access to healthcare. <i>Education:</i> Higher education levels enhance health awareness and informed decision-making. <i>Healthcare Access:</i> Strong insurance coverage and healthcare infrastructure enable better, timely care.	High-Income Countries (HICs)
<i>Economic Status:</i> Lower income restricts access to vaccines and services, especially in underserved areas. <i>Education and Awareness:</i> Lower education levels reduce awareness of HPV and the importance of vaccination. <i>Geographic Location:</i> Insufficient infrastructure in rural areas limits women's access to vaccines and screening.	Middle-Income Countries (MICs)
<i>Income and Poverty:</i> Poverty and limited resources hinder access to healthcare and vaccination. <i>Education:</i> Lack of health education reduces awareness and vaccine acceptance. <i>Cultural Beliefs:</i> Cultural beliefs and misinformation limit vaccine uptake.	Low-Income Countries (LICs)

Limitations of the Review

This review includes studies that provide information on HPV prevalence, vaccination rates, screening programs, and intervention outcomes. However, geographic limitations based on income classification (low, middle, and high income) are critical factors influencing the inclusion criteria. Additionally, many studies emphasize barriers to HPV vaccination access, such as infrastructure challenges, awareness, and affordability, especially in LMICs and MMICs. In particular, research in middle-income countries often focuses on scaling up vaccination programs, which may not fully address other barriers in these regions.

Other limitations of this review include the low accuracy and inconsistency of data from some LMICs and significant geographical and cultural diversity, which may affect the generalizability of the findings.

Discussion

This systematic review puts into perspective the striking variability of all HPV-related health indicators among low-, middle-, and high-income countries. As a routine vaccine, the HPV vaccine is one of the most expensive; its delivery cost and cost of access have been estimated to be three times higher for MICs compared to high-income countries. This financial barrier partially explains the difficulty LMICs and MMICs face in seriously implementing HPV vaccination programs [27].

LMICs also face tough challenges in the field of prevention and control of HPV, including restricted access to vaccination and screening services and a larger burden of cervical cancer. Partly, these disparities in health outcomes related to HPV stem from regional differences in the infrastructure of health and access to health services. In fact, due to a lack of cadres and equipment, the capacity of the health sectors in most LMICs to provide comprehensive care for HPV is limited. In the case of middle-income countries, or MMICs, HPV health indicators are at an intermediate level, and they need to implement targeted strategies to improve vaccination coverage and extend screening programs.

The overall reductions in disease and deaths due to HPV resulting from comprehensive vaccination and screening in rich countries serve as an example of global prevention of the disease. HPV prevention and control can only be improved in LMICs and MMICs through improving vaccination activities, increasing access to screening, and addressing sociocultural and healthcare system barriers [28].

Besides, there are two key factors: cultural beliefs and public awareness of accepting the HPV vaccination. The sociocultural challenges that influence the acceptance of vaccination in LMICs and MMICs require further research to improve the HPV prevention processes. In regions where misconceptions and cultural resistance toward vaccination prevail, these factors act as significant obstacles to the success of HPV prevention programs.

According to the WHO, the best vaccination range is from 9 to 14 years old. Girls 9-10 years old in LMICs and 11-13 years old in HICs are the main target for HPV vaccination. In many LMICs, regardless of cost and lack of screening programs, coordination between health and education to increase knowledge, sensitization, and mobilization is essential for successful HPV vaccination. On the other hand, although school-based vaccination is a common service delivery in LMICs, the lack of funded school health programs makes HPV vaccination expensive in schools. In countries with weak school infrastructure, alternative approaches and the supportive role of NGOs and community organizations are crucial for implementing HPV vaccination programs. These organizations can provide logistical support, mobilize resources, and help raise awareness, thereby addressing the gap left by limited school-based health services [29, 30].

In all countries, policy priority must be given to high-risk groups of cervical cancer with lower socioeconomic situations, Indigenous and vulnerable populations of both females and males, especially young girls in high cervical cancer burden countries that

may never receive screening [31]. According to Aggarwal et al. (2024), it is clear that a combination policy between high-coverage HPV vaccination of 9-14 years old girls and screening programs for 35-45 years old can reduce public health problems and it's a way to control cancer incidence in the future. Additionally, monitoring health outcomes and assessing the effectiveness of interventions are critical for enhancing HPV-related health indicators. Continued research is essential to measure the impact of these programs, especially in LMICs and MMICs, to refine strategies and address region-specific challenges in HPV prevention and control.

Conclusion

This study highlights the review of human papillomavirus-related health indicators in low-, middle-, and high-income countries as a source of information on disparities in human papillomavirus-related outcomes across the globe. In line with the previous, the significance of the study lies in comparing the prevalence of human papillomavirus, the burden of cervical cancer, vaccination, and screening rates against those economic categories to help strengthen efforts in human papillomavirus prevention and control in different socioeconomic contexts.

Targeted interventions in LMICs and MMICs are essential for reducing HPV-related illness and death as part of efforts toward the global goal of eliminating cervical cancer. Continued research is also needed to identify the most effective approaches. There is a need for both quantitative and qualitative studies that detail the ways that financial disparities affect access to and uptake of HPV prevention methods. These will be used to inform key region-specific initiatives, further bridging the gap in HPV health outcomes around the world and continuing to move forward in the mission to eradicate cervical cancer.

Disclosure of Interest

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