



Review Article

Human Papillomavirus (HPV) Vaccination and the Impact of Vaccine Implementation in Kenya: Progress, Challenges, and Future Directions

Maru Kiplimo Adams^{1, 2, *} , Lelei Walter² , Zefaniah Katuah³, Njagi Esther² , Amy Ogot², Rispah Torrorey¹, Simeon Mining¹

¹Department of Pathology, Moi University, Eldoret, Kenya

²Department of Medical Laboratory Sciences, University of Eastern Africa, Baraton, Kenya

³Department of Biomedical Sciences, Kamuzu University of Health Sciences, Zomba, Malawi

Abstract

Human papillomavirus (HPV) is the primary etiological agent of cervical cancer, a disease that remains a major cause of cancer-related morbidity and mortality among women in Kenya despite the availability of highly effective prophylactic vaccines. This review examines the current evidence on HPV virology, vaccine immunology, global vaccine effectiveness, and the implementation of HPV vaccination in Kenya following its introduction into the national immunization program in 2019. It also evaluates progress in vaccine delivery, coverage trends, and the adoption of the single-dose vaccination schedule, while highlighting persistent challenges including vaccine hesitancy, inequitable access, health system constraints, and socioeconomic barriers. Available evidence indicates that HPV vaccination has strengthened cervical cancer prevention efforts and has the potential to substantially reduce the future burden of HPV-related disease. However, vaccine coverage remains below the World Health Organization target for cervical cancer elimination, limiting the full public health impact of the program. Key research priorities include evaluating long-term vaccine effectiveness, monitoring HPV genotype dynamics, assessing vaccine performance among people living with HIV, and strengthening the integration of HPV vaccination with cervical cancer screening programs. Achieving equitable vaccine access, enhancing surveillance systems, improving community engagement, and ensuring sustainable financing will be essential to maximizing the benefits of HPV vaccination and accelerating progress toward the elimination of cervical cancer in Kenya.

Keywords

Human Papillomavirus, Cervical Cancer Prevention, HPV Vaccination, Vaccine Uptake, Kenya

1. Introduction

Cervical cancer represents a major public health challenge globally, with a disproportionate burden borne by low- and

middle-income countries, particularly in sub-Saharan Africa [1]. In Kenya, approximately 5,200 women are diagnosed and

*Correspondence: Maru Kiplimo Adams (Adamsmaru98@gmail.com)

Received: 3 September 2026; Accepted: 17 September 2026; Published: 29 September 2026



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over 3,000 die from the disease each year, making it one of the leading causes of cancer-related morbidity and mortality among women largely attributable to persistent infection with oncogenic human papillomavirus (HPV) genotypes [2, 3]. The natural history of cervical cancer which is characterized by an extended pre-invasive phase, necessitating a critical space for preventive interventions, including vaccination and screening [4, 5].

Prophylactic HPV vaccination has emerged as a cornerstone of primary prevention, with the potential to significantly reduce the incidence of cervical cancer when administered prior to exposure to the virus [6]. Recognizing this, Kenya incorporated the HPV vaccine into its national immunization schedule in 2019, targeting adolescent girls aged approximately 10 years. This policy aligns with the global strategy led by the World Health Organization (WHO) to eliminate cervical cancer as a public health problem [7]. However, the success of vaccination programs depends not only on biological efficacy but also on effective implementation, including vaccine accessibility, public acceptance, and health system readiness. This review provides a comprehensive analysis of HPV vaccination in Kenya, focusing on its scientific basis, implementation outcomes, and the multifactorial challenges influencing its impact.

2. Review Methodology

2.1. Review Design and Scope

This paper presents a narrative review of the current evidence on human papillomavirus (HPV) vaccination, with particular emphasis on vaccine implementation, coverage, effectiveness, challenges, and emerging implications for HPV epidemiology in Kenya. The review integrates Kenya-specific evidence with relevant international and regional literature to provide a broader context for understanding the biological, epidemiological, and programmatic dimensions of HPV vaccination. Particular attention was given to evidence generated within Kenya, including national vaccination program reports, epidemiological studies, clinical trials, and studies evaluating vaccine uptake, effectiveness, and implementation. The evidence was synthesized narratively by comparing findings across studies and identifying areas of convergence, uncertainty, and knowledge gaps. Greater emphasis was placed on studies conducted in Kenya when drawing conclusions about the national program. Evidence from other settings was used to contextualize these findings and to identify potential implications for vaccine delivery, effectiveness, surveillance, and HPV epidemiology.

2.2. Literature Search Strategy

Relevant literature was identified through searches of major scientific and public health information sources, including

PubMed/MEDLINE, Google Scholar, Scopus, and publications from the World Health Organization (WHO), the Kenya Ministry of Health, Gavi, the Vaccine Alliance, and other relevant national and international public health institutions. Search terms were developed around the main themes of the review and included combinations of terms such as “human papillomavirus,” “HPV vaccination,” “HPV vaccine,” “cervical cancer,” “Kenya,” “HPV vaccine coverage,” “vaccine uptake,” “vaccine effectiveness,” “single-dose HPV vaccination,” “HPV genotypes,” “HPV epidemiology,” and “vaccine implementation.” Additional relevant publications were identified by screening the reference lists of key articles and reports.

The search focused primarily on literature published from the introduction of HPV vaccines into national immunization programs to the most recent evidence available at the time of manuscript preparation. Earlier studies were retained where they provided important information on HPV virology, vaccine immunology, vaccine efficacy, the natural history of HPV infection, or the development of HPV vaccination programs. Recent WHO and national program documents were prioritized for information relating to vaccination schedules, program implementation, and coverage estimates.

3. HPV Virology, Immunobiology and Vaccines

Human papillomaviruses (HPVs) are small, non-enveloped viruses with a circular, double-stranded DNA genome belonging to the family *Papillomaviridae* [8]. More than 200 HPV genotypes have been identified, approximately 14 of which are classified as high-risk (oncogenic) because of their association with malignant transformation. Among these, HPV-16 and HPV-18 are the most clinically significant, accounting for nearly 70% of cervical cancer cases globally [9-11].

HPV exhibits a strong tropism for stratified squamous epithelial cells, particularly those of the anogenital tract and oropharyngeal mucosa, and is associated with diseases including cervical, anal, oropharyngeal, and penile cancers [12, 13]. Infection occurs when the virus gains access to basal epithelial cells through microabrasions. Following entry, the viral genome persists as an episome within basal keratinocytes, where early viral genes promote cellular proliferation and viral persistence [8, 10]. The viral life cycle is closely linked to epithelial differentiation: as infected cells migrate toward the epithelial surface, late viral gene expression is activated, resulting in viral genome amplification and assembly of progeny virions in the superficial epithelial layers [14].

In most immunocompetent individuals, HPV infection is transient and cleared within one to two years, primarily through cell-mediated immune responses [15]. However, persistent infection with high-risk HPV genotypes is the principal driver of cervical carcinogenesis [8, 16]. During persistent infection, viral DNA may integrate into the host genome, frequently disrupting the viral E2 regulatory gene and leading to

overexpression of the viral oncogenes E6 and E7 [8, 17]. These oncoproteins promote malignant transformation by inactivating key tumor suppressor pathways. E6 facilitates degradation of the p53 protein, impairing apoptosis and DNA repair, while E7 inactivates the retinoblastoma protein (pRb), resulting in dysregulated cell-cycle progression and uncontrolled cellular proliferation [16, 18]. Over time, these molecular alterations contribute to progression from cervical intraepithelial neoplasia (CIN) to invasive cervical cancer [14].

The burden of HPV-associated disease remains disproportionately high in low- and middle-income countries, including Kenya, where limited cervical cancer screening, delayed healthcare access, and suboptimal vaccine uptake contribute to persistently high incidence and mortality rates [11, 19]. The situation is further exacerbated by high HIV prevalence, which increases susceptibility to persistent HPV infection and accelerates disease progression [20–22].

Prophylactic HPV vaccines represent a major advancement in cancer prevention. These vaccines are based on the HPV major capsid protein L1, which self-assembles into virus-like particles (VLPs) that structurally resemble native virions but lack viral DNA, rendering them non-infectious while maintaining high immunogenicity [23, 24]. Currently licensed vaccines include the bivalent vaccine targeting HPV-16 and HPV-18, the quadrivalent vaccine targeting HPV-6, -11, -16, and -18, and the nonavalent vaccine, which additionally covers HPV-31, -33, -45, -52, and -58, extending protection against cervical cancer to approximately 90% of cases worldwide [25–28].

The protective efficacy of HPV vaccines is primarily mediated through humoral immunity. Following intramuscular administration, VLPs are taken up by antigen-presenting cells, leading to activation of CD4⁺ T-helper cells and subsequent stimulation of B cells to produce high-affinity neutralizing antibodies and long-lived memory responses [29, 30]. These vaccine-induced antibodies prevent infection by blocking the interaction between HPV virions and epithelial basement membrane receptors required for viral entry into basal keratinocytes [23]. Importantly, HPV vaccines are prophylactic rather than therapeutic and are therefore most effective when administered prior to exposure to the virus, typically before sexual debut [26].

Clinical trials and post-licensure studies have consistently demonstrated high efficacy of HPV vaccines against vaccine-type persistent infection and high-grade cervical lesions in HPV-naïve populations [31–33]. More recently, evidence from the Kenyan KEN SHE trial demonstrated that a single-dose HPV vaccination regimen achieved approximately 98% efficacy against persistent infection with vaccine-targeted genotypes over three years of follow-up [34, 35]. These findings have important implications for HPV vaccine implementation programs in low-resource settings, where simplified dosing schedules could improve vaccine accessibility, reduce costs, and enhance coverage.

4. Global Impact of HPV Vaccination

The introduction and scale-up of prophylactic vaccination against human papillomavirus (HPV) infection have produced measurable and, in some settings, transformative public health benefits. Since the first licensure of HPV vaccines in 2006, national immunization programs—particularly in high-income countries with strong delivery systems and high coverage—have demonstrated substantial reductions in HPV prevalence, anogenital warts, and high-grade cervical lesions [33, 36].

Robust epidemiological data from countries such as Australia and the United Kingdom provide some of the clearest evidence of vaccine impact. In Australia, where school-based vaccination programs have achieved high coverage among adolescent girls (and later boys), marked declines in vaccine-type HPV infections and genital warts were observed within a few years of program implementation [33, 37, 38]. Longitudinal analyses have demonstrated significant reductions in high-grade cervical intraepithelial neoplasia (CIN2/3), particularly among women vaccinated before sexual debut [39]. More recently, modelling studies predict that Australia is on course to eliminate cervical cancer problem within the coming decades, positioning Australia on a trajectory toward the potential elimination of cervical cancer as a public health problem [37, 40]. Similarly, in the United Kingdom, population-based studies have shown dramatic reductions in HPV-16/18 prevalence and up to an 80–90% decrease in high-grade cervical lesions among women vaccinated at younger ages, with emerging evidence of reduced cervical cancer incidence in screened populations [36, 41].

The impact of HPV vaccination in Africa, although more recent and less extensively documented than in high-income settings, is increasingly evident [42]. Several African countries, including Rwanda, South Africa, Tanzania, and Uganda, have introduced national HPV vaccination programs with varying levels of success. Rwanda has emerged as a notable example, achieving and sustaining high vaccination coverage through school-based delivery strategies and strong political commitment, resulting in substantial reductions in vaccine-type HPV prevalence among vaccinated cohorts [43–46]. Early evidence from countries such as South Africa, Ghana, among other middle- and low-income countries also suggests improved vaccine uptake and growing public acceptance following national program implementation, although coverage remains heterogeneous across regions and populations [47, 48]. Modeling studies indicate that widespread HPV vaccination across sub-Saharan Africa could avert millions of future cervical cancer cases and deaths, given the region's disproportionately high disease burden [49–52].

Beyond direct protection, HPV vaccination confers important indirect benefits through herd immunity [53, 54]. As vaccine coverage increases, the circulation of oncogenic HPV types declines within the population, thereby reducing transmission even among unvaccinated individuals. This effect has

been clearly demonstrated by declining rates of genital warts and vaccine-type HPV infections in unvaccinated males following the introduction of female-only vaccination programs [33, 38]. The expansion to gender-neutral vaccination strategies in several countries has further amplified these population-level effects, accelerating reductions in HPV transmission and associated disease burden [55, 56].

Despite these successes, the global impact of HPV vaccination remains uneven. Profound disparities persist between high-income countries and low- and middle-income countries (LMICs), where the burden of cervical cancer is disproportionately high [11, 42]. Structural barriers—including limited healthcare infrastructure, vaccine cost, supply constraints, sociocultural factors, and gaps in public awareness—continue to hinder widespread vaccine uptake in many settings. In sub-Saharan Africa, for example, coverage remains suboptimal despite the introduction of national programs in several countries, including Kenya [42, 57]. This inequity is particularly concerning given that LMICs account for the majority of cervical cancer cases and deaths worldwide [11].

World Health Organization (WHO) aims to vaccinate 90% of girls by age 15, screen 70% of women using high-performance tests, and ensure that 90% of women with cervical disease receive appropriate treatment and addressing these disparities is central to achieving the target under the global strategy to eliminate cervical cancer [58].

5. HPV Vaccine Implementation and Uptake in Kenya

The implementation of HPV vaccination in Kenya represents a major milestone in the country's cancer prevention and adolescent health agenda. Following several years of policy deliberation, pilot implementation studies, and stakeholder engagement, Kenya officially introduced the HPV vaccine into its routine national immunization program in October 2019, becoming one of the early adopters of national HPV vaccination programs in sub-Saharan Africa [59, 60]. The program was introduced as part of Kenya's broader National Cancer Control Strategy and aligned with the World Health Organization's global strategy for the elimination of cervical cancer as a public health problem [59, 61].

The implementation process was informed by earlier demonstration projects conducted between 2013 and 2015, particularly in Kitui County and Eldoret, which provided critical operational evidence regarding vaccine acceptability, delivery strategies, stakeholder engagement, and logistical requirements [62, 63]. These pilot experiences demonstrated the feasibility of delivering HPV vaccines through existing health and educational infrastructures and informed the design of the subsequent national rollout strategy [60]. The successful implementation of these demonstration programs highlighted the importance of multisectoral collaboration and evidence-in-

formed policy development in introducing adolescent vaccination programs in low- and middle-income settings.

Kenya adopted a hybrid implementation model combining school-based and facility-based vaccine delivery platforms [60, 61]. The school-based strategy became the primary mechanism for vaccine administration due to its capacity to efficiently reach large numbers of eligible adolescent girls through established educational systems. Concurrently, health facilities were designated as complementary vaccination sites to facilitate access for girls who were absent from school or not enrolled in formal education, thereby supporting broader population coverage [61, 64]. This dual-delivery framework reflected growing recognition that adolescent immunization programs require flexible implementation approaches capable of accommodating diverse educational and sociodemographic contexts.

The implementation of HPV vaccination in Kenya has depended heavily on intersectoral collaboration involving the Ministry of Health, the Ministry of Education, county governments, development partners, healthcare facilities, schools, and community stakeholders [60, 61]. Coordination mechanisms were established at national and county levels to facilitate planning, vaccine distribution, supervision, monitoring, and evaluation activities. The decentralized nature of Kenya's healthcare system enabled county governments to assume substantial responsibility for operational planning and implementation while maintaining alignment with national immunization policies and strategic priorities [64].

A critical component of implementation involved extensive capacity-building activities targeting healthcare workers, teachers, community health volunteers, and other frontline personnel involved in vaccine delivery [61]. Training programs focused on vaccine administration, cold-chain management, adverse event surveillance, communication strategies, data management, and adolescent health service delivery. These preparatory activities were complemented by investments in vaccine logistics systems, cold-chain infrastructure, and monitoring frameworks to support program implementation and sustainability [60, 61].

Community mobilization and public engagement were also integral elements of the implementation strategy [48]. National and subnational communication campaigns involved religious leaders, teachers, healthcare workers, civil society organizations, and community health volunteers to promote awareness of cervical cancer prevention and HPV vaccination [61]. These initiatives aimed to increase public understanding of HPV infection, vaccine effectiveness, and the broader public health importance of cervical cancer prevention. The incorporation of trusted community actors into implementation activities reflected lessons learned from previous immunization programs and emphasized the importance of social engagement in adolescent vaccination programs [61, 69].

The implementation trajectory of HPV vaccination in Kenya has continued to evolve in response to emerging scien-

tific evidence and global policy recommendations. A particularly significant development has been the country's transition from a two-dose to a single-dose HPV vaccination schedule following recommendations from the World Health Organization Strategic Advisory Group of Experts on Immunization (SAGE) [65, 66]. This policy transition was informed by accumulating evidence demonstrating that a single vaccine dose provides substantial and durable protection against persistent HPV infection, including evidence generated through studies conducted in Kenya itself, such as the KEN SHE trial [34]. The adoption of the single-dose schedule in November 2025 represents an important example of evidence-based policy adaptation and offers opportunities to simplify program implementation, optimize resource utilization, and improve population-level vaccine coverage.

Furthermore, HPV vaccination implementation in Kenya has increasingly been positioned within a broader framework of cervical cancer prevention and control. National policy frameworks have emphasized the importance of integrating vaccination programs with cervical cancer screening, early diagnosis, treatment services, and health promotion activities. This integrated approach reflects the recognition that HPV vaccination constitutes one component of a comprehensive cervical cancer prevention strategy and aligns with global targets for cervical cancer elimination [66].

Despite strong political commitment and support from international partners, HPV vaccination coverage in Kenya has remained below the levels required to achieve the WHO cervical cancer elimination targets. Following program introduction in 2019, first-dose coverage was approximately 25%, while final-dose coverage was considerably lower, at about 16%, highlighting early challenges in completing the recommended two-dose schedule. First-dose coverage increased to approximately 33% in 2020 but subsequently remained relatively low, at about 29% in both 2021 and 2022. Coverage by

age 15 showed a similar pattern of limited program reach and incomplete vaccination. In 2019, approximately 25% of the target population had received the first and final recommended doses by age 15, while from 2020 to 2022, first-dose coverage by age 15 remained around 29% and final-dose coverage around 17%. These findings indicate a substantial gap between initiation and completion of the two-dose schedule among girls reaching the age of 15 [42, 67, 68]. More recent program estimates indicate improvement in overall vaccine uptake, with first-dose program coverage increasing to approximately 62% in 2023 and 79% in 2024, while final-dose program coverage increased from approximately 36% to 69% over the same period. This improvement suggests recovery and strengthening of program delivery following the disruptions associated with the COVID-19 pandemic, although coverage remained below the WHO target of 90% [68].

In November 2025, Kenya transitioned from the two-dose to a single-dose HPV vaccination schedule, representing an important policy change intended to simplify vaccine delivery and improve completion. Program coverage was approximately 69% in 2025, although the available data also report a first-dose coverage estimate of 12.39%, which may reflect differences in reporting or denominator definitions and should therefore be interpreted cautiously. Consequently, vaccination estimates before and after the 2025 schedule change should not be directly compared as equivalent measures of dose completion. Overall, the available data demonstrate gradual improvement in HPV vaccination program reach and completion, but persistent variation between first-dose uptake, age-specific coverage, and final-dose coverage underscores the continuing need to strengthen timely vaccination, follow-up, and monitoring of coverage among the target population. Table 1 summarizes the reported HPV vaccination coverage trends in Kenya from 2019 to 2025.

Table 1. National HPV Vaccination Coverage Trends and Programmatic Milestones in Kenya, 2019–2026.

Year	Schedule	1st Dose Coverage (%)	Coverage by Age 15 (1st Dose, %)	Coverage by Age 15 (Final Dose, %)	Program Coverage (1st Dose, %)	Program Coverage (Final Dose, %)	HPV Final Dose Coverage (%)
2019	Two-dose	25	25	25	25	16	16
2020	Two-dose	33	29	17	33	44	25
2021	Two-dose	29	29	17	29	17	42.1
2022	Two-dose	29	29	17	25	32	42
2023	Two-dose	55	–	–	62	36	45
2024	Two-dose	31	–	–	79	69	16
2025	Transition to single-dose (Nov 2025)	12.39	–	–	69	69	6

Year	Schedule	1st Dose Coverage (%)	Coverage by Age 15 (1st Dose, %)	Coverage by Age 15 (Final Dose, %)	Program Coverage (1st Dose, %)	Program Coverage (Final Dose, %)	HPV Final Dose Coverage (%)
2026	Single dose	*Not yet available	–	–			*Not applicable

Source: WHO Immunization Data Portal, Kenya HPV Vaccination Coverage. Female 1st Dose and Female Final Dose represent the official national estimates of HPV vaccination coverage. Coverage by Age 15 refers to the proportion of girls vaccinated by their 15th birthday. Program Coverage represents vaccination coverage among the target population during the implementation year. "–" indicates that no official estimate was reported for that indicator in the available dataset. *Nationally validated WHO/UNICEF estimates for completed vaccination were not yet available at the time of writing.

6. Impact of HPV Vaccination in Kenya

The full impact of HPV vaccination on cervical cancer incidence and mortality in Kenya will only become evident over several decades, but early indicators suggest both important progress and persistent challenges. Current evaluations therefore rely on intermediate outcomes, including vaccine uptake, public awareness, health system adaptation, and projected epidemiological effects [50, 66]. One notable achievement of HPV vaccine introduction has been the increased visibility of cervical cancer prevention within public health discourse [69]. Health education and vaccine rollout activities have improved awareness of the relationship between HPV infection and cervical cancer among parents, adolescents, teachers, and healthcare workers. However, awareness remains uneven, with substantial gaps in understanding of HPV transmission, vaccine effectiveness, and the role of vaccination in cancer prevention. Moreover, persistent misinformation, sociocultural concerns, and vaccine hesitancy continue to influence vaccine acceptance, highlighting the limitations of awareness campaigns that emphasize biomedical messaging without sufficiently addressing local social and cultural contexts [63, 70].

The introduction of HPV vaccination has also created opportunities to strengthen adolescent health services in Kenya. As one of the few national immunization programs targeting adolescents, the HPV vaccine platform has the potential to support broader adolescent-centered health interventions, including reproductive health education and preventive healthcare services [42, 66]. Nevertheless, this potential remains only partially realized. In practice, HPV vaccination in Kenya has largely operated as a vertical intervention, with limited integration between immunization services, schools, reproductive health programs, and community health systems. Furthermore, the heavy reliance on school-based delivery strategies has contributed to inequities in access, particularly among out-of-school girls and populations in underserved and pastoralist regions [61, 71]. These challenges underscore the need for stronger intersectoral coordination and more inclusive delivery strategies to maximize the broader health system benefits of HPV vaccination.

Mathematical modeling studies project that achieving and

sustaining high HPV vaccine coverage in Kenya could substantially reduce the prevalence of high-risk HPV infections, cervical precancerous lesions, invasive cervical cancer, and cervical cancer mortality over the coming decades [50, 52]. Similarly, economic evaluations suggest that HPV vaccination represents a cost-effective intervention with the potential to reduce the long-term financial burden associated with cervical cancer diagnosis and treatment [40, 72]. However, these projected epidemiological and economic benefits depend heavily on assumptions regarding vaccine coverage, durability of protection, healthcare access, and integration with cervical cancer screening programs. Persistent challenges in Kenya, including regional disparities in vaccine uptake, healthcare access inequities, vaccine hesitancy, and dependence on external funding sources, may limit the realization of these anticipated benefits. In addition, the long-term impact of HPV vaccination in populations affected by HIV and other contextual epidemiological factors remains insufficiently characterized.

A major limitation in assessing the impact of HPV vaccination in Kenya is the lack of robust long-term surveillance systems [70]. Effective evaluation requires comprehensive data on HPV genotype prevalence, vaccine effectiveness, precancerous lesions, and cervical cancer incidence, yet cancer registries, laboratory infrastructure, and longitudinal monitoring systems remain underdeveloped in many settings. The recent transition to a single-dose HPV vaccination schedule introduces additional considerations regarding long-term effectiveness and durability of protection, particularly within African populations where long-term real-world data remain limited [34, 73]. Importantly, HPV vaccination alone is insufficient to eliminate cervical cancer. Its success will ultimately depend on effective integration with cervical cancer screening, early diagnosis, and treatment services, which remain inadequately accessible in many parts of Kenya. Consequently, while HPV vaccination has demonstrated considerable promise as a cervical cancer prevention strategy, its long-term impact will depend on sustained investments in equitable vaccine delivery, surveillance infrastructure, health system strengthening, and comprehensive cancer prevention programs.

7. Challenges to HPV Vaccination Implementation

The implementation of vaccination programs against HPV infection in Kenya is influenced by a complex interaction of sociocultural, economic, political, and health system factors. Although the incorporation of HPV vaccination into the national immunization schedule represented a major milestone in cervical cancer prevention, the Kenyan experience demonstrates that vaccine introduction alone does not guarantee successful implementation or equitable uptake [70, 74]. Persistent structural inequalities, weak health systems, sociocultural resistance, and policy-level challenges continue to shape the effectiveness and sustainability of the program [61, 70].

One of the most significant barriers to HPV vaccine implementation in Kenya is vaccine hesitancy. However, vaccine hesitancy in the Kenyan context is more complex than simple refusal or ignorance. It reflects a broader crisis of trust involving healthcare systems, government institutions, and external health interventions. While misinformation regarding infertility, vaccine safety, and adverse effects is widespread, these fears often emerge within historical and sociocultural contexts shaped by unequal access to healthcare, inconsistent public communication, and skepticism toward externally driven health programs [42, 71, 75].

The sexual transmission nature of HPV further complicates vaccine acceptance. In many Kenyan communities, sexuality among adolescents remains a culturally sensitive subject, and interventions associated with sexually transmitted infections are often interpreted through moral and religious frameworks. As a result, some parents and religious leaders perceive HPV vaccination as potentially encouraging premarital sexual activity [76, 77]. Critically, these concerns are not simply based on scientific misunderstanding but are tied to broader societal anxieties regarding changing gender norms, adolescent autonomy, and reproductive health education. Public health messaging that focuses exclusively on biomedical evidence without engaging with these deeper cultural concerns may therefore fail to achieve meaningful community trust [78].

Additionally, the role of social media and informal communication networks has significantly influenced vaccine perceptions in Kenya. Unverified claims regarding infertility, hidden political agendas, or experimental use of African populations have circulated widely through online platforms and community discussions. Importantly, misinformation spreads rapidly in contexts where institutional trust is fragile and where official communication channels may be inconsistent or inaccessible [79, 80]. This highlights a critical weakness in the implementation strategy: reactive rather than proactive communication approaches. In many cases, health authorities have focused on responding to misinformation after resistance has already emerged rather than building sustained public engagement and trust before rollout [81].

Another major challenge concerns structural weaknesses within Kenya's healthcare system. Although national HPV

vaccination policy reflects strong political commitment, implementation capacity at county and community levels remains highly variable. Devolution of healthcare services in Kenya has created significant disparities in resource allocation, infrastructure, and administrative efficiency across counties [82]. Consequently, vaccine availability and service quality are often determined by local governance capacity rather than national policy intentions.

In rural and underserved regions, inadequate cold-chain infrastructure, transportation limitations, and shortages of healthcare personnel continue to undermine vaccine delivery. These logistical challenges are especially problematic for out-reach-based and school-based campaigns, which require substantial coordination, mobility, and workforce capacity. Some peripheral facilities struggle to maintain reliable vaccine storage conditions, while healthcare workers frequently operate under high workloads with limited training and supervision [83, 84]. This reveals an important contradiction within the Kenyan HPV vaccination strategy: ambitious national targets are often implemented within chronically under-resourced local health systems.

The healthcare workforce itself represents another critical factor influencing program implementation. Frontline healthcare workers play a central role in vaccine advocacy, community sensitization, and administration [85, 86]. However, Kenyan studies suggest that some healthcare providers lack adequate knowledge or confidence regarding HPV vaccine communication, particularly when addressing concerns related to fertility, safety, and adolescent sexuality. Inconsistent messaging from healthcare providers can reinforce public uncertainty and reduce vaccine confidence. Moreover, healthcare workers in many settings are already burdened by competing responsibilities related to maternal health, infectious diseases, childhood immunization, and routine clinical care [70]. HPV vaccination therefore becomes an additional task within an already strained workforce rather than part of a well-integrated adolescent health strategy.

The exclusion of out-of-school girls remains one of the most critical equity concerns in Kenya's HPV vaccination program. School-based delivery strategies are often praised for their efficiency and cost-effectiveness; however, they inherently privilege populations already connected to formal educational systems. Girls who are out of school due to poverty, early marriage, pregnancy, disability, migration, or social marginalization are significantly less likely to access vaccination services. Ironically, these populations may also face increased vulnerability to poor reproductive health outcomes, including cervical cancer risk factors associated with limited healthcare access and socioeconomic disadvantage [87, 88].

This reveals a deeper structural issue within the implementation framework: efficiency is often prioritized over equity. While school-based campaigns maximize coverage among accessible populations, they may unintentionally widen disparities by failing to adequately reach socially marginalized groups. Community-based and mobile outreach strategies

have been proposed as alternatives, but their implementation remains inconsistent due to funding, logistical, and workforce constraints [89, 90].

Weaknesses in health information systems also pose significant barriers to effective implementation and evaluation. Reliable vaccination data are essential for tracking coverage, identifying missed populations, monitoring dropout rates, and evaluating long-term program effectiveness. However, Kenya's immunization information systems continue to face challenges related to fragmented reporting structures, inconsistent data quality, and limited interoperability between county and national databases. In some settings, vaccine coverage estimates may be inaccurate due to incomplete reporting or poor denominator estimates for eligible populations [59, 61, 82].

Economic constraints further complicate implementation sustainability. Although HPV vaccine procurement has been substantially supported through international partnerships such as Gavi, the Vaccine Alliance, successful implementation requires far more than vaccine acquisition alone. Financial resources are needed for transportation, cold-chain maintenance, healthcare worker training, social mobilization, monitoring systems, and outreach activities. In a resource-constrained healthcare environment characterized by competing priorities such as HIV/AIDS, malaria, tuberculosis, maternal health, and emerging infectious diseases, HPV vaccination programs may struggle to secure sustained domestic financing [72, 91, 92].

Dependence on donor support and funding also raises broader concerns regarding sustainability and national ownership. While external funding has enabled rapid program introduction, long-term continuation may become vulnerable if donor priorities shift or financial support decreases. This dependence reflects a broader challenge within many African public health programs, where implementation success often relies heavily on international financing and technical guidance rather than fully self-sustaining national systems [93].

Overall, the implementation of HPV vaccination programs in Kenya is shaped by interconnected sociocultural, structural, and economic factors that extend far beyond vaccine availability itself. Vaccine hesitancy, healthcare infrastructure limitations, workforce shortages, inequities affecting out-of-school girls, weak surveillance systems, and financial sustainability concerns continue to undermine optimal program performance. Addressing these challenges will require more than technical vaccination strategies alone. Sustainable progress will depend on community-centered engagement, culturally responsive communication, stronger health systems, equitable outreach mechanisms, robust surveillance infrastructure, and long-term domestic investment in adolescent health services. Ultimately, the Kenyan experience demonstrates that successful HPV vaccine implementation requires not only biomedical innovation but also social trust, institutional resilience, and health equity.

8. Opportunities and Strategies for Improvement

Overcoming the persistent barriers to effective vaccination against HPV infection in Kenya requires a multifaceted and coordinated approach that integrates community engagement, health system strengthening, and policy innovation. While significant challenges remain, there are clear opportunities to enhance vaccine uptake, improve equity, and maximize long-term public health impact.

A central priority is the strengthening of community engagement through culturally sensitive and evidence-based health education. Misinformation and vaccine hesitancy can be effectively addressed by leveraging trusted community structures, including religious leaders, teachers, and community health volunteers. Tailored communication strategies that clearly explain the link between HPV and cervical cancer—while addressing concerns about vaccine safety and fertility—are essential for building public trust [75, 76, 94]. Engaging adolescents themselves as active participants in health promotion can further improve acceptance and demand for vaccination services [95].

Optimizing delivery platforms is equally critical. School-based vaccination programs remain one of the most efficient strategies for reaching large numbers of eligible girls and should be strengthened through improved coordination between the health and education sectors. This includes better planning of vaccination schedules, enhanced tracking of eligible students, and minimizing disruptions during academic calendars [96, 97]. At the same time, targeted outreach strategies are needed to reach out-of-school girls, who are often underserved. Community-based approaches, mobile clinics, and integration with existing child and adolescent health outreach programs can help bridge this gap and ensure more equitable coverage [75, 95].

The transition to a single-dose vaccination schedule represents a particularly promising opportunity. By simplifying the immunization regimen, a single-dose approach reduces logistical complexity, lowers program costs, and minimizes the risk of dropout associated with multi-dose schedules [98]. This strategy is especially advantageous in resource-limited settings, where follow-up for subsequent doses can be challenging. If effectively implemented, it has the potential to significantly accelerate coverage and enhance the overall efficiency of the vaccination program [73].

Integration of HPV vaccination with broader adolescent health services offers another strategic advantage [99, 100]. Delivering the vaccine alongside other interventions—such as routine immunizations, sexual and reproductive health education, deworming programs, and nutritional services—can improve service uptake and create a more holistic approach to adolescent health. This integration not only enhances efficiency but also normalizes HPV vaccination as part of standard preventive healthcare [59].

Investments in digital health systems and data infrastructure

are also essential to strengthen program performance [101, 102]. Robust data systems can facilitate real-time tracking of vaccine coverage, identification of missed populations, and monitoring of program outcomes. Digital registries, mobile health (mHealth) tools, and integrated health information systems can improve data accuracy, support decision-making, and enhance accountability at both national and subnational levels [103].

Sustained political commitment and adequate financing remain foundational to the long-term success of HPV vaccination efforts [104]. Strong leadership from the Ministry of Health Kenya, in collaboration with global partners such as the World Health Organization (WHO) and Gavi, the Vaccine Alliance, is crucial for ensuring consistent vaccine supply, program expansion, and system strengthening. Long-term investment will also be needed to support community engagement, workforce development, and surveillance systems [59].

9. Research Gaps and Future Directions

Despite notable progress in the implementation of vaccination against HPV infection in Kenya, several critical research gaps remain that must be addressed to optimize program effectiveness and inform long-term policy decisions. Given the relatively recent introduction of the vaccine, much of the existing evidence is based on short-term outcomes or extrapolated from studies conducted in high-income settings. There is therefore a pressing need for context-specific, longitudinal research within the Kenyan population [42].

One of the most important priorities is the establishment of long-term cohort studies to evaluate the real-world effectiveness of HPV vaccination [33, 105]. Such studies should assess trends in HPV genotype prevalence, the incidence of persistent infection, and progression to cervical intraepithelial neoplasia and invasive cervical cancer over time. These data will be essential for validating model-based projections and for quantifying the true population-level impact of vaccination in a sub-Saharan African context.

A particularly important area of investigation in Kenya is vaccine immunogenicity and durability in populations with a high burden of human immunodeficiency virus (HIV). Immunocompromised individuals, including those living with HIV, may exhibit altered immune responses to vaccination, potentially affecting both the magnitude and longevity of protective immunity. Understanding how HIV infection—and factors such as antiretroviral therapy, immune status, and viral suppression—modulates HPV vaccine responses will be critical for tailoring vaccination strategies in these populations [106]. This aligns closely with broader questions in immunology regarding vaccine-induced memory and immune durability in diverse host environments.

Further research is also needed to evaluate the effectiveness and feasibility of emerging vaccination strategies. The transition to single-dose HPV vaccination schedules, while promis-

ing, requires continued monitoring to confirm long-term protection, especially in real-world programmatic settings [73, 107]. In addition, the potential benefits of gender-neutral vaccination strategies—targeting both girls and boys—warrant careful evaluation. Such approaches could enhance herd immunity, reduce transmission, and address HPV-associated diseases in males, including anal, oropharyngeal, and penile cancers [33, 56].

Another critical gap lies in the strengthening of surveillance systems. High-quality, population-based data on HPV infection, genotype distribution, and cervical cancer incidence are still limited in many parts of Kenya [108]. Enhanced surveillance infrastructure, including cancer registries and HPV monitoring programs, will be essential for tracking vaccine impact, detecting potential shifts in genotype prevalence (e.g., type replacement), and guiding evidence-based policy adjustments.

Implementation research also represents a key priority area. Understanding the contextual factors that influence vaccine uptake—including sociocultural dynamics, health system constraints, and behavioral determinants—can inform the design of more effective and locally appropriate interventions. Evaluations of different delivery strategies, communication approaches, and integration models will help identify best practices for improving coverage and equity [70, 109].

Finally, there is a growing need for interdisciplinary research that integrates epidemiology, immunology, health economics, and social sciences. Such approaches can provide a more comprehensive understanding of HPV vaccination outcomes, including cost-effectiveness, health system impact, and community perceptions [72].

10. Conclusion

Vaccination against HPV infection represents a highly effective strategy for reducing the burden of cervical cancer in Kenya, and its integration into the national immunization program marks a significant public health achievement. However, persistent challenges related to vaccine uptake, health system capacity, and equitable access continue to limit its full impact. Addressing these barriers through sustained community engagement, culturally appropriate health education, strengthened delivery systems, and strategic innovations such as single-dose schedules will be critical to improving coverage and program efficiency.

With continued leadership from the Ministry of Health Kenya and support from global partners including the World Health Organization (WHO), Kenya is well-positioned to accelerate progress toward cervical cancer prevention. Sustained investment in vaccination programs, surveillance systems, adolescent health services, and implementation research will be essential to ensure long-term success. Through coordinated national and international efforts, Kenya can move closer to achieving the WHO target of cervical cancer elimination as a public health threat.

Abbreviations

HPV	Human Papillomavirus
WHO	World Health Organization
NVP	National Vaccination Program
CIN	Cervical Intraepithelial Neoplasia

Author Contributions

Maru Kiplimo Adams: Conceptualization, Data curation, Writing – original draft, Writing – review & editing

Lelei Walter: Writing – review & editing

Zefaniah Katuah: Writing – review & editing

Njagi Esther: Writing – review & editing

Amy Ogot: Writing – review & editing

Rispah Torrorey: Writing – review & editing

Simeon Mining: Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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