Vaccine 53 (2025) 127089

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Human papillomavirus awareness, vaccination rate, and sociodemographic covariates of vaccination status in a low-income country: A cross-sectional study in the rural Busoga region of Uganda

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ARTICLE INFO

Keywords:
Good health and well-being
Vaccination
Human papillomavirus
Uganda
Rural
Awareness

ABSTRACT

We aimed to describe Human Papillomavirus (HPV) and HPV vaccine awareness. Moreover, we estimated a vaccination rate for the accumulated target group of 10 to 18-year-old girls based on a maternal approach. Finally, we evaluated sociodemographic covariates of HPV vaccination status in rural Uganda. Via questionnaires filled by instructed research assistants, women above 18 years were included via randomisation schemes in the rural Busoga Region in Eastern Uganda.

In total, 585 participants were included. One out of eight (12.6 %) had heard about HPV before. More than one-third (36.5 %) had heard about the HPV vaccine. Almost all (94.9 %) would vaccinate their daughter against HPV if they had one. Most participants (61.9 %) believed the vaccine prevents cervical cancer, although more than one-third (34.9 %) did not know this. Altogether, 213 mothers to 388 daughters aged 10 to 18 years were registered. Of these, 49 to 63 (12.6 % - 16.2 %) daughters were single-dose HPV vaccinated, and 79 (20.4 %) daughters were double-dose vaccinated, yielding an any-dose HPV vaccination rate of 33.0 % - 36.6 %. Lastly, 51 (13.1 %) of the daughters had a vaccination card confirming the vaccine. Living in a peri-urban district was a significant covariate of having a double-vaccinated daughter compared to rural districts.

We found low awareness levels of HPV and the HPV vaccine, but indications of a favourable attitude toward the vaccine. The any-dose vaccination rate was 33 % - 36,6 % with indications that a future HPV awareness- and vaccine campaign should focus on the most peripheral districts of rural Uganda.

1. Introduction

1.1. The key to eliminating cervical cancer and other HPV-related cancers

Rapid and effective distribution of the Human Papillomavirus (HPV) vaccine in Sub-Saharan Africa (SSA) is important for the global elimination of HPV-related cancers. [1] The incidence- and mortality rates of HPV-related cancers are inversely proportional to the income level and development of a country. [2] Cervical cancer (CC) makes up 4/5 cases of HPV-related cancers [3], but may also cause anogenital, head, neck, breast, and oesophageal cancers. [4] CC is the second most common cancer in Africa. [5] The predominant etiological factor for CC development is infection with the high-risk HPV genotypes (HR-HPV), accounting for approximately 99.7 % of all CC cases. [6] Six prophylactic HPV vaccines have been licensed covering the most common HR-HPV genotypes [7], and are considered the most efficient and cost-effective measure to prevent HPV-related cancers. [8]

World Health Organisation (WHO) predicts increasing incidence and mortality of CC by 2030 [9] and launched a global campaign in 2020 to eliminate cervical cancer as a public health issue. A key aspect of the plan is 90 % coverage of HPV vaccination among 15-year-old girls by 2030. [1] In SSA, 259.8 million girls below 15 years of age constitute 20.4 % of the total SSA population; a number predicted to increase and accumulate future generations' risk of CC. [10] The SSA population has

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https://doi.org/10.1016/j.vaccine.2025.127089
Received 25 June 2024; Received in revised form 27 December 2024; Accepted 30 March 2025
Available online 11 April 2025

the highest cervical HPV infection prevalence globally [11], therefore, extensive distribution of the HPV vaccine before the current and future generations of girls are exposed to HPV is key to preventing a backlog of CC for the generations to come.

By following the WHO strategy, it is estimated that by HPV vaccination alone low- and lower-middle-income countries (LLMIC) will see an 89.4 % (95 % confidence interval (CI) 86.2–90.1) reduction in CC incidence over the next century. Using the WHO goal of 4 CC cases per 100.000 women years as an elimination threshold, this means the elimination of CC in 60 % (95 % CI 58–65) of all LLMICs. [12]

1.2. HPV vaccination and awareness in Uganda

In 2024, an estimated 10.9 million girls in Uganda aged 0–14 years make up 21.8 % of the total population. [10] HR-HPV is highly prevalent in the general population [13], resulting in a high burden of HPV-related cancers including CC as the predominant cancer in Uganda. [14]

Following a gradual introduction of the vaccine in two districts in 2008 and 12 districts in 2012 at a triple-dose regimen, the HPV vaccine was introduced nationally by the Ugandan Ministry of Health (MOH) on the 23rd of November 2015 for all 10-year-old girls at a double-dose regimen. [15] In 2017, the HPV vaccine was introduced in the Child Health Days, a biannual school-based health campaign to increase vaccination uptake. [16] The vaccine is part of a compulsory child immunisation programme that waives parental consent to participate but obliges parents to ensure the child's immunisation and to hold their vaccination card for a minimum of 15 years. [17]

A systematic literature review across PubMed, Scopus, and Embase using MeSH Terms for studies presenting HPV vaccination rates in Uganda after 2015 yielded 7 different studies (see Table 1). Any-dose rates varied between 19.6 % - and 50.4 %. The higher-yielding studies took place in districts included in the early HPV vaccination intervention at a triple-dose regimen. The full search string and results are available upon request from the corresponding author.

WHO Uganda has published yearly HPV vaccination rates for the target group from 2016 to 2021. These ranged from 30 % double-dose coverage in 2016 to 44 % in 2021 with a peak of 74 % coverage in 2018. [18] The MOH has released similar vaccination rates in a 2020 report. [19] Gavi, the Vaccine Alliance released a report in 2016 including a double-dose coverage of 22.8 % in December 2016. [15] In 'The National Cervical Cancer Prevention and Control Strategic Plan 2021 - 2026', the MOH presents a 57 % double-dose coverage and a 96 % single-dose coverage in 2021 as the latest information. [20] An accumulated HPV vaccination rate for the target group is not available from these sources. Recent coverage information is scarce and none of the above sources stratify for urbanisation. In 2024, approximately 72.6 % of the Ugandan population live in a rural setting. Learning from other researchers [21], certain settings demand extra attention as the HPV vaccine distribution poses logistical challenges in a rural setting.

Table 1
Systematic literature search results for Human Papillomavirus vaccination rates in Uganda after 2015.

Author (publication year)	Survey year	Target group	Single-dose rate	Double-dose rate	Any-dose rate
Odongo Ojok I, et al. (2023) [49]	2021	9–13 year olds	NA	NA	35 %
Aruho C, et al. (2022) [50]	2020	15–18 year olds	NA	22 %	NA
Bitariho GK, et al. (2023) [31]	2021	10–14 year olds	18.9 %	8.6 %	27.5 %
Isabirye A, et al. (2020) [51]	2016	10–14 year olds	NA	NA	22 %
Nakayita RM, et al. (2023) [52]*	2022	9–14 year olds	3.7 %	15.1 %	19.6 %
Kisaakye E, et al. (2018) [53]*	2016	12–17 year olds	18.0 %	32.4 %	50.4 %
Nabirye J, et al. (2020) [22]*	2017	9–15 year olds	35.2 %	13.5 %	48.7 %

NA = Not available.
*Conducted in a 2012 release district with a triple-dose regimen. The double-dose rate includes triple-dose participants.

WHO recommends accompanying vaccination interventions with information campaigns. [1] Moreover, having a basic knowledge of HPV and the vaccine shows an association with higher HPV vaccination uptake in Uganda. [22] Local communities have also requested local, targeted awareness campaigns to raise knowledge of the HPV vaccine before it is introduced. [23]

Assessing the rate of HPV vaccination and the awareness of the vaccine in rural Uganda is essential for expanding sustainable awareness- and vaccination campaigns in the future.

2. Methods

2.1. Design

In November 2023, we conducted a cross-sectional study on HPV vaccination awareness among rural women in the Busoga Region of Uganda. Questionnaires were verbally administered to participants via instructed research assistants (RA). Based on the mothers' accounts, we estimated vaccination rates for girls aged 10 to 18.

2.2. Setting

The Busoga Region consists of 11 districts in Eastern Uganda. [24] The region's population's wealth is largely similar to Uganda's average wealth. [25] The regional urbanisation rate is 12.4 % living in urban areas compared to Uganda's general urbanisation rate of 22.0 % measured in 2016. [26]

The collaborative partner of this study, Rays of Hope Hospice Jinja (RHHJ) [27], is a holistic palliative care, diagnostic, and treatment non-governmental organisation. Among many activities, RHHJ advocates, educates and informs about HPV vaccination and CC awareness in the rural Busoga Region. The RAs were selected from the organisation's network of local community volunteers.

2.3. Sample size calculation

The single population proportion formula was used to calculate the sample size. We used 95 % confidence, 5 % margin of error and a sample proportion of 45.8 % derived from a similar study in the Busoga Region. [28] Due to our study's exploratory nature, an additional 50 % was added to increase overall statistical strength. This yielded a sample size of 573 participants, rounding up to 585 because of the sampling guideline structure.

2.4. Sampling guideline

Nine RAs planned their route through 15 subcounties of five districts in the Busoga Region. These five districts were chosen according to the home district of the RAs. Each RA went through their home subcounty, and additionally six RAs included the neighbouring subcounty. Thirteen villages (<1000 inhabitants) spaced a minimum of two kilometres apart were included in each subcounty. Three households spaced a minimum of four houses apart were included in each village. If more than one woman was present in the household, the Kish method [29] by age would be applied. If the household was not eligible for inclusion, the RA would proceed to the neighbouring household.

2.5. Inclusion criteria

Women above 18 years were included following the sampling

guidelines. Households of previous cancer or RHHJ patients were excluded, as we expected their cancer and HPV awareness levels to be higher than that of the background population.

2.6. Ethical statement

The study received ethical approval from Hospice Africa Uganda Research and Ethical Committee (HAU-2023-72). Verbal and written information on all aspects of the study was given before the participant gave informed consent to proceed with the interview.

2.7. Research assistant instructions and supervision

The RAs received general and group-based instructions to administer the recruitment guideline and the questionnaire including instructions to maintain a formal and professional environment during participant interaction. Each RA was individually supervised in their home sub-county during a test interview. A random selection of participants was called to ensure correct information was given and alignment with ethical procedures was kept. A second round of supervision was introduced randomly to oversee recruitment and interview procedures.

2.8. Questionnaire development

The questionnaire was developed in English and later translated by two pairs of translators into Luganda and Lusoga, respectively the predominant written and spoken languages in the Busoga Region. A pilot study of four women with additional, elaborating questions was conducted to ensure preciseness in understanding the questionnaire. We applied the free-listing method with no answers prompted.

2.9. Data definitions and analysis

Luganda and Lusoga responses were translated into English and similar answers were grouped. HPV was explained correctly if identified as any pathogen and incorrectly if described as a vaccine or other explanation. Correct HPV transmission was defined as sexual contact. WHO guidelines were used to set the recommended vaccination group in Uganda, targeting those aged 9 to 14 or before sexual debut. [7] A correct answer was noted for ages within this span of years, any answer noting anything like “before sexual debut”, or answers that could not be excluded to involve the relevant age group. Two researchers independently reviewed and marked responses for accuracy and consistency, and incongruity cases were referred to an oncologist from Odense University Hospital, Denmark.

Districts Jinja and Iganga were defined as peri-urban as their urban population rate is 36.6 % and 18.4 % respectively. Buyende, Mayuge, and Namutumba were defined as rural with urban population rates between 7.1 % and 7.4 %. [30]

Results are presented in descriptive statistics using proportions and mean values. Fisher’s exact test was used to estimate associations between knowledge and awareness questions (those answered by all participants) of mothers to daughters aged 10 to 18 years of age and vaccination status (double-dose and any-dose). Logistic regression assessed variables associated with whether the daughter has received two doses of HPV vaccine at a significance level of $p = 0.05$.

3. Results

3.1. Sociodemographic results and model adjustments

In total, 585 participants were included. Five missing responses were registered in four different questions. Two participants were Rwandan, one Kenyan, and the rest Ugandan. The mean age (standard deviation (SD)) was 36.3 (13.4). The mean number of children (SD) was 4.6 (2.9).

3.2. HPV vaccination awareness

The awareness level of HPV and the HPV vaccine was low, but we found indications of a favourable disposition for the HPV vaccine (see Table 2). 74 participants (12.6 %) had heard about HPV, and of these, 19 knew it was a pathogen, and 27 knew it was sexually transmitted. However, more than 1/3 had heard about the HPV vaccine, and half of these knew the correct vaccination target group. Moreover, almost 95 % would vaccinate their daughter against HPV, and the primary reason for not wanting to vaccinate was a lack of knowledge of the vaccine. About 2/3 agreed the HPV vaccine prevents CC, and 1/3 did not know if this was true. Overall, low knowledge of HPV and the HPV vaccine, but favourable attitudes.

3.3. HPV vaccination rate

The rural vaccination rate for 10 to 18-year-old girls was estimated by asking the participant after the knowledge section if the participant had a daughter between 10 and 18 years of age, and then how many daughters within that age span they had. We then asked these mothers how many daughters had one dose and two doses of vaccine. Finally, we asked if they had vaccination cards to prove the vaccine, and then registered the number of confirmed vaccinated daughters at any dose. Altogether, 388 daughters aged 10 to 18 years were registered among 213 participating mothers to daughters aged 10 to 18 years. Sixty-three (16.2 %) out of the 388 daughters were single-dose vaccinated and 79 (20.4 %) were double-dose vaccinated. Thus, 142 (36.6 %) had received any dose of the HPV vaccine, and 246 daughters had not received any dose according to their mothers. The 79 double-vaccinated daughters were registered among 54 mothers. Thirty-eight of the 213 participating mothers could show the HPV vaccination card on behalf of 51 daughters, yielding a 13.1 % confirmed HPV vaccination rate. However, evaluating data presented some ambiguity regarding the single-dose question.

The single-dose question was intended to capture the daughter who had received one dose only but was in some cases misunderstood to include both single and double doses.

To clarify, we compared the number of daughters registered to the registered single- and double-dose numbers to determine if there was any duplication in the responses. For example, if a participant listed having two daughters but also registered two single-dose and two double-dose cases, we concluded that the question had been misinterpreted, and corrected the single-dose count to zero. However, if the same participant registered one single-dose and one double-dose case, it was unclear whether there was a misinterpretation, requiring us to employ an approach to estimate a range for the results.

This analysis yielded two distinct single-dose estimates. The lower estimate, which assumes duplication in responses, was 49 daughters (12.6 %), while the higher estimate, assuming no duplication, was 63 daughters (16.2 %). Combined with the double-dose this leaves an estimated any-dose rate of 33.0 % - 36.6 %.

3.4. Maternal associations and covariates of vaccination status

For Fisher’s exact test results, having heard about HPV before was significantly associated with having a daughter with any-dose vaccination with an odds ratio = 2.30 (95 % CI: 1.26–4.25. No other questions showed significant associations with either vaccination status tested. Three variables had some significant associations, though with varying statistical strength (see Table 3). Working status level ‘Not working’ compared to ‘Farmer’ had weak statistical power while marital status level ‘Not married’ versus ‘Married’ indicated a higher likelihood of having a double-vaccinated daughter, despite the small sample size of 39 participants. Both effects turned insignificant after adjusting for urbanisation, which strongly correlated with vaccination status. Participants from peri-urban districts had a 2.24 (95 % CI 1.19–4.26) higher likelihood of having double-vaccinated daughters compared with those

Table 2
Numbers and proportions of knowledge question responses and association with having a vaccinated daughter using Fisher's exact test (only including participants with a daughter in the selected age group ($n = 213$)).

Question	Number	Percentage	OR (95 %CI) of having a double-dose daughter	OR (95 % CI) of having an any-dose daughter
Have you heard about Human Papillomavirus (HPV)? ($n = 585$)			1.33 (0.67–2.60)	2.30 (1.26–4.25)
Yes	74	12.6		
No	439	75.0		
Do not know	72	12.3		
Explain what Human Papillomavirus (HPV) is ($n = 74$)				
Correct explanation	19	25.7		
Incorrect explanation	26	35.1		
Cannot explain	27	36.5		
Missing	2	2.7		
Can you explain how HPV is transmitted? (n = 74)				
Correct explanation	27	36.5		
Incorrect explanation	5	6.8		
Cannot explain	42	56.8		
Have you ever heard about the vaccine that may prevent HPV infection and cervical cancer? (n = 585)			0.78 (0.29–1.91)	1.54 (0.71–3.34)
Yes	213	36.4		
No	319	54.5		
Do not know	53	9.1		
Who should get vaccinated against HPV in Uganda? (n = 213)				
Correct answer	109	51.2		
Incorrect answer	104	48.8		
If you had a daughter, would you vaccinate her against HPV? (n = 585)			2.45 (0.30–112.74)	4.77 (0.60–218.75)
Yes	555	94.9		
No	16	2.7		
Do not know	13	2.2		
Missing	1	0.2		
Why would you not vaccinate her against HPV? ($n = 16$) *				
Did not know the vaccine existed/was available	8	38.1		
Do not know	4	19.0		
My husband will not allow it	4	19.0		
Afraid of side effects	2	9.5		
Other	2	9.5		
Missing	1	4.8		
Vaccination with the HPV vaccine prevents cervical cancer. (n = 585)			0.82 (0.39–1.67)	0.70 (0.37–1.32)
Agree	362	61.9		
Do not care	2	0.3		
Disagree	13	2.2		
Do not know	204	34.9		
Do not want to answer	4	0.7		

* Multiple choice questions. % out of the total of responses (n = 21). OR = Odds ratio. CI = confidence interval.

from rural districts.

4. Discussion

4.1. Knowledge of HPV and the HPV vaccine

We found low awareness of HPV and the HPV vaccine in rural Uganda, which aligns with previous findings. In a study from central Uganda, researchers found adolescent girls from rural settings had lower knowledge of HPV and the HPV vaccine compared with urban participants. [31] However, in a study from Eastern Uganda including largely rural and peri-urban participants that prompted response options for the participants, 84.4 % recognised HPV infection as a CC risk factor. [28] This raises a discussion on response bias and methods to present the true awareness level. The same study found that 64.2 % agreed that someone can get vaccinated against CC, like our finding of 61.9 %. [28] However, over a third of participants did not agree, indicating low knowledge of the HPV vaccine purpose.

Like our findings, other researchers present indications of favourable dispositions for the HPV vaccine, although with some misconceptions. From the same cross-sectional data above, 90.4 % of participants would allow their daughters to be vaccinated against HPV. [32] High acceptability and low awareness of HPV and the HPV vaccine are similarly found in a systematic review from 2014 across several SSA countries. [33]

4.2. Vaccination rates in Uganda

We estimate the double dose rate to be 20.4 %. This is below any published yearly rate from the Ugandan MOH and WHO Uganda. [18,19] It is similar to the Gavi vaccination rate in 2016, indicating slow vaccine distribution since the roll-out campaigns. For districts where the vaccine was introduced in 2015, we identified a double-dose vaccination coverage between 8.6 % and 22 % (see Table 1). Another article identified after the systematic search was performed, based on 2020 data, suggested even lower coverage in some areas with an any-dose rate of 10.6 % with 7/10 being only single-dose vaccinated. [34] Our finding corresponds to the higher estimates of the identified 2015-release areas' double-dose rates. With a single-dose rate between 12.6 % and 16.2 % yielding an any-dose rate between 33.0 % and 36.6 %, we could not reproduce the published single-dose rate of the Ugandan MOH of 96 % in 2021. [20] The literature search identified any-dose rates in 2015-release areas ranging from 19,6–35 % (not including the 10,6 % previously mentioned), where our findings are at the high end of this range. One study by Nabirye J. et al. (2020) [22] was similarly conducted in 2017 in a rural setting in Eastern Uganda but in a 2012 release district.

Table 3
Sociodemographic covariates of being a mother with one or more double-vaccinated daughter(s).

Variable	Mother with one or more double-vaccinated daughter(s)		Crude model (95 % CI)	Age-adjusted model (95 % CI)	Age and urbanisation adjusted model (95 % CI)
	Yes	**No**			
Urbanisation					
Rural	26	109	1	1	–
Peri-urban	28	50	2.35 (1.25–4.43)*	2.24 (1.19–4.26)*	–
Age					
18–29	4	14	1	–	–
30–49	34	115	1.03 (0.34–3.83)	–	–
50–69	16	30	1.87 (0.56–7.43)	–	–
Educational level					
Primary or lower	43	127	1	1	1
Secondary or higher	11	32	1.02 (0.46–2.14)	1.06 (0.47–2.25)	0.98 (0.43–2.10)
Working status					
Farmer	49	143	1	1	1
Employed	1	14	0.21 (0.01–1.08)	0.23 (0.01–1.20)	0.19 (0.01–1.02)
Not working	4	2	5.84 (1.10–43.05)*	6.22 (1.16–46.42)*	4.94 (0.90–37.18)
Marital status					
Married	38	136	1	1	1
Not married	16	23	2.49 (1.18–5.17)*	2.23 (1.02–4.79)*	1.89 (0.84–4.15)
Family structure (n = 175)					
Monogamous	19	80	1	1	1
Polygamous	19	57	1.40 (0.68–2.90)	1.57 (0.73–3.43)	1.61 (0.75–3.53)
Children					
1–3	8	22	1	1	1
4 or more	46	137	0.92 (0.40–2.34)	0.93 (0.40–2.38)	1.06 (0.44–2.77)
Ethnic group					
Basoga	49	131	1	1	1
Baganda	1	7	0.38 (0.02–2.22)	0.40 (0.02–2.37)	0.45 (0.02–2.69)
Iteso	1	6	0.45 (0.02–2.70)	0.43 (0.02–2.64)	0.61 (0.03–3.87)
Other	3	15	0.53 (0.12–1.71)	0.59 (0.13–1.92)	0.70 (0.15–2.33)
Religion					
Church of Uganda	18	59	1	1	1
Islam	18	42	1.40 (0.65–3.03)	1.47 (0.68–3.21)	1.45 (0.66–3.20)
Catholic	10	29	1.13 (0.45–2.72)	1.22 (0.48–2.97)	1.34 (0.52–3.33)
Born Again	7	24	0.96 (0.34–2.51)	0.96 (0.33–2.53)	1.04 (0.36–2.81)
Other	1	5	0.66 (0.03–4.42)	0.78 (0.04–5.38)	0.80 (0.04–5.67)

n = 213, unless otherwise specified. CI = confidence interval.

They found a higher single-dose rate, but a lower double-dose rate than ours. This could likely be due to the study's earlier data collection and the release area being introduced to the vaccine earlier, allowing vaccination campaigns to reach more 9–13-year-olds. Overall, this indicates that our findings are plausible representations of HPV vaccination rates in rural Uganda, but also indicate major issues in vaccine distribution.

Using observed vaccination cards to confirm HPV vaccination should be discussed. The method gave rise to representability issues for several reasons. Some participating women kept the vaccination card at their daughter's school, had lost it, or were never handed one. On the other hand, the card is the most certain proof of vaccination status available and less prone to recall bias, such as for vaccination rate by mother's account. Nonetheless, the observed vaccination cards confirmed that the vaccination rate questions were correctly understood, as participants provided the correct card when available. In the Busoga Region, the HPV vaccine is commonly referred to as "HPV" (pronounced in English) in all languages. Therefore, RAs read out both the full name of the virus and its abbreviation to ensure correct understanding, supporting the trustworthiness of our findings.

4.3. Vaccination rate in a regional perspective

Our estimated double-dose vaccination rate is below the regional mean rates. In East Africa, the estimated mean HPV vaccination rate is 35 % (95 % CI: 26–45) for the target group [35], and for SSA it is estimated at 28.53 (95 % CI: 5.25–51.81) [36]. These estimates are not from a specific rural setting, which may obscure comparability. Nonetheless, all estimates are far below the WHO 2030 target of 90 % underlining an urgent need for increased effective vaccination dispersal in Uganda and SSA in general.

4.4. Maternal associations to daughter's vaccination status

We found a significantly lower vaccination uptake among the daughters of participants in rural districts than in peri-urban districts. Ndejjo R. et al. (2017) [32] found rural residency as a risk factor for low willingness to vaccinate their daughter compared with semi-urban/urban participants. We included only participants from villages excluding urban participants, preventing a comparison of vaccination rates between rural and urban settings. However, the district-based participant division reveals a greater need for HPV awareness and vaccination interventions in more remote districts of the Busoga Region.

Other sociodemographic factors, such as the mother's educational level and family size, were not reproduced in our study. [35] This may be due to local variations in vaccine distribution or this study's relatively small sample size.

In other studies, researchers have commonly suggested HPV and CC awareness as a predicting factor of HPV vaccine uptake. [22] This was indicated by our association test where a significant, positive association was found between knowledge of HPV and having an any-dose daughter. However, no significant association was established for having a double-dose daughter and the same question or other questions. Thus, these results merely indicate a positive association between maternal knowledge of HPV and the daughter's vaccination status.

4.5. Strategies to alleviate the HPV burden

Rural Uganda is a low-resource setting, where healthcare interventions should be prioritised carefully. The 2015 HPV vaccine introduction has been criticised for lack of transparency and representation from the district communities. [37] However, the release has been a part of a larger policy change across the continent to battle HPV-related cancers [38] with a projected significant impact on future cancer incidence [12] and considerable health-economy advantages. [39] Nonetheless, proposals to improve the current strategy further have been made.

Along with regular healthcare facilities, the MOH introduced the HPV vaccine in outreach school-based campaigns to improve vaccination uptake. [16] It has been proposed to strengthen this intervention by recruiting vaccine candidates based on school grade instead of age. [40] This allows a simplified recruitment guide in a setting where age may be uncertain.

In a 2022 position paper on HPV vaccines, the WHO added a single-dose regimen as an off-label alternative to HPV vaccine coverage in less resourceful settings. [7] The Ugandan MOH and WHO Uganda HPV vaccination rates suggest a large gap between the one- and two-dose receivers. Researchers studying the immunogenicity of partially vaccinated girls in Uganda showed significantly lower antibody levels of single-dose girls. Nonetheless, researchers presented efficacious results of a single-dose regimen for the general population in neighbouring countries [41,42] and in long-term studies in other countries. [43,44] Delivering in a single-dose regimen may avail resources for more extensive out-reaches and raise coverage further. The positive cost-effectiveness of an exclusive single-dose regimen depends on reallocating these resources purposefully.

One strategy could be to vaccinate men and women equally to reduce HPV-related cancer incidence and to impede a natural reservoir. As of 2022, 125 (64 %) countries have introduced the HPV vaccine nationally, but only 47 (24 %) have introduced it to both sexes. [7] Although not as common as for females, males also have disease-reducing effects from HPV vaccination. Moreover, the immunisation of men will eliminate a virus reservoir and induce herd immunity at an earlier point. [45] This strategy also allows for more passive immunity in individuals who cannot receive the vaccine. [46] The cost-effectiveness of male vaccination depends on factors like price and coverage. [47] Concerning herd immunity, vaccination of males is imperative as they compose half the population and commonly facilitate HPV transmission. An alternative approach is to expand the female vaccination program to include men who have sex with men, which has proven cost-effective. [47] However, this strategy may face implementational issues in Uganda specifically. [48]

4.6. Limitations

The study's representativeness may be questioned due to the lack of subsampling. Ideally, participants should have been recruited based on updated sociodemographic data to match the rural female population of Busoga. The most recent census was from 2014, and the required design would have had high costs in the rural setting of the Busoga Region. Instead, randomisation schemes were used to reduce selection bias. Cultural bias was minimised by consulting local clinical experts, conducting a pilot study, and supervising research assistants (RAs) during interviews and recruitment. Local RAs were employed to reduce researcher and courtesy bias, and responses were written verbatim in the participant's preferred language to address translation issues. Although RAs primarily read Luganda and participants spoke Lusoga, this mainly concerns the awareness questions, as vaccination-rate questions were quantitative and less subject to translation variations. However, the awareness findings are generally like other studies' findings, indicating a low effect of this source of uncertainty.

As vaccination rates are based on the mother's account, this may induce recall bias. The daughter's previous vaccines may get mixed up in the mother's memory or she may simply forget the daughter got vaccinated. However, the mother is the primary carer for the adolescent daughters thus responsible for their healthcare. Therefore, mothers constitute a reliable source of information on adolescent girls' vaccination status. Asking the target group of girls directly would yield direct results but also have concerns of bias on its own. However, a similar study to this including the vaccine target group girls directly would substantially contribute to the scientific understanding of this topic and should be considered in future research projects.

Excluding households of cancer patients may have reduced the representability of our HPV vaccination rate estimate. One may assume that adolescent girls in households of previous cancer- or RHHJ-patients would be aware of the HPV vaccine and more likely to get vaccinated. In this case, our vaccination rate would be an underestimation. However, the number of these households also including a girl of 10 to 18 years of age is not likely to be very high, which diminishes the effect of this selection bias to a low level.

5. Conclusion

In conclusion, our findings underscore the need to increase HPV vaccination awareness and coverage in rural Uganda. Despite efforts to introduce the HPV vaccine nationally in 2015, our findings reveal persistent challenges in achieving optimal vaccination rates in this setting. Low awareness of HPV and the vaccine is associated with suboptimal vaccination rates. The disparity is more pronounced in the peripheral districts compared with those closer to urban centres. By prioritising HPV vaccination as a public health intervention, we can make significant strides toward reducing the burden of cervical cancer and achieving the WHO's target of 90 % HPV vaccination coverage by 2030, ultimately preventing HPV-related cancers in the future.

Credit authorship contribution statement

Troels Alnor Einarson: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Emmanuel Musana:** Validation, Supervision, Resources, Project administration, Methodology, Data curation. **Joseph Balonde:** Writing – review & editing, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Katinka Bolette Lorentzen:** Writing – review & editing, Visualization, Software, Funding acquisition, Formal analysis, Conceptualization. **Rasmus Kallestrup:** Writing – review & editing, Validation, Software, Project administration, Funding acquisition, Formal analysis, Conceptualization. **Margrethe Juncker:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Data curation, Conceptualization. **Sylvia Nakami:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Data curation, Conceptualization. **Per Kallestrup:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization.

Funding

This work was supported by Eva & Henry Frænkels Mindefond under Grant 10-09-2023; Knud Højgaards Fond [grant number 23-01-2180]; William Demant Fonden [grant number 23–2018]; Aase & Ulrik Alfred Hansens Fond [grant number 33049]; and Dagmar Marshalls Fond [grant number 07-05-2024].

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgements

The authors thank all participants for their candid contributions and the research assistants for their dedicated work. Special thanks to Claus Høstrup Vestergaard for statistical support, Jan Blaakær for consultation and feedback, and the Rays of Hope Hospice Jinja team for their exceptional support and guidance.

Data availability

Data will be made available on request.

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