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ORIGINAL RESEARCH ARTICLE

Evaluating the Effectiveness of Visual Inspection with Acetic Acid as a Cervical Cancer Screening Tool: A Comparative Study with Pap Smear in Low-Resource Settings

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ABSTRACT

Introduction: Cervical cancer significantly impacts women's health worldwide, especially in low-resource settings where access to preventive screening is limited. Persistent HPV infection, particularly with types 16 and 18, is the primary cause. Pap smear screening has reduced cervical cancer rates in high-income countries but is challenging to implement in low-resource areas due to cost and infrastructure needs. This study aimed to assess the effectiveness of visual inspection with acetic acid (VIA) as an alternative screening tool by evaluating its sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Material and Methods: This prospective observational study was conducted from August 2022 to January 2024 at SRMS Institute of Medical Sciences, Bareilly. Women aged 21 to 65 who met inclusion criteria were screened using VIA and pap smear tests. Data analysis was performed using SPSS, with statistical significance set at $p < 0.05$. Ethical approval and patient consent were obtained.

Results: VIA demonstrated high sensitivity, specificity, PPV, and NPV, showing a statistically significant correlation with pap smear findings. This highlights VIA's reliability for detecting cervical abnormalities.

Conclusion: VIA is a practical and effective alternative to pap smear for cervical cancer screening in low-resource settings. Its affordability and ability to provide immediate results make it a valuable tool for early detection of cervical abnormalities and intervention.

Keywords: Cervical cancer, Visual inspection with acetic acid, Screening, Low-resource settings.

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INTRODUCTION

Cervical cancer remains a critical global health issue, representing approximately 12% of all cancers among women and leading to over 500,000 new cases annually.[1,2] India alone accounts for nearly one-fourth of these cases, positioning cervical cancer as one of the leading causes of cancer-related deaths among women, particularly in low- and middle-income countries.[3,4] The primary cause is persistent infection with high-risk strains of the human papillomavirus (HPV), notably HPV types 16 and 18, which are highly prevalent in India and many other regions with limited access to preventive healthcare.[5,6]

Vaccination against these HPV strains has proven effective in reducing the risk of cervical cancer. [7] However, many low-resource settings face considerable barriers to widespread vaccination and effective screening, including limited infrastructure, funding, and trained personnel.[8] Traditional screening methods like the pap smear, which has drastically reduced cervical cancer rates in high-income countries since its introduction in the 1950s, are often challenging to implement in these regions due to high costs, infrastructure needs, and access issues.[9,10] Additionally, the potential for false negatives in pap smear results underscores the need for simpler, more accessible screening methods.

In response, visual inspection with acetic acid (VIA) has emerged as a promising alternative for cervical cancer screening in resource-limited settings. VIA involves applying acetic acid to the cervix to highlight abnormal lesions, enabling healthcare providers to identify suspicious areas visually.[11] This method is low-cost, delivers immediate results, and requires minimal technical expertise, making it well-suited for low-resource environments where it can be administered by trained paramedical personnel.

The study aimed to evaluate the effectiveness of VIA as a screening tool for cervical cancer by comparing its diagnostic accuracy with the pap smear. Specifically, it

assessed VIA's sensitivity, specificity, positive predictive value, and negative predictive value. By establishing the reliability of VIA, this study seeks to provide critical insights into its potential as a frontline screening method, informing future strategies for cervical cancer prevention and early detection in low-resource settings.

MATERIAL AND METHODS

This prospective observational study was conducted at the Department of Obstetrics and Gynecology, SRMS Institute of Medical Sciences, Bareilly, from August 1, 2022, to January 31, 2024. The study recruited women aged 2 to 65 who visited the Gynecology Outpatient Department (OPD) and met the inclusion criteria. Women eligible for the study were sexually active, provided informed consent, and had no history of cervical cancer, visible cervical growth, active vaginal bleeding, or genital tract infection.

Upon consenting, participants were positioned in a modified lithotomy position. Under aseptic conditions and a halogen light source, a Cusco's bivalve speculum was gently introduced to expose the cervix. After identifying the external os and transformation zone, a pap smear was obtained using an Ayer's spatula and cytobrush, spreading cells on glass slides which were immediately fixed in a Coplin jar containing 95% alcohol.

Following the pap smear, a 3% freshly prepared acetic acid solution was applied to the cervix using a cotton swab, and the cervix was examined after one minute for any acetowhite lesions. VIA results were recorded as positive if acetowhite lesions were present and negative if absent. Women with negative VIA results were advised to follow standard screening guidelines and those with positive findings were advised colposcopy-guided biopsy.

RESULTS

The association between pap smear findings and VIA test outcomes is shown in Table 1 and Figure 1. It shows the distribution of cases based on specific PAP smear categories and the corresponding VIA positive and negative results, highlighting the effectiveness of VIA in detecting abnormalities identified through pap smear testing. The correlation between VIA findings and pap smear is shown in Table 2 and Figure 2. It shows the distribution of abnormal and normal pap smear results within VIA-positive and VIA-negative groups, highlighting the effectiveness of VIA in detecting cases with abnormal pap smear findings. The diagnostic performance of VIA in comparison to the pap smear for cervical cancer screening is in Table 3 and Figure 3. It includes sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, highlighting VIA's reliability in identifying cases with abnormal findings.

The association between high-risk factors (parity, age, occupation, and religion) and VIA outcomes is shown in Table 4 and Figure 4. It shows the distribution of VIA-positive and VIA-negative cases across these high-risk groups, along with *p-values* indicating statistical significance. The association between various high-risk factors, such as parity, age, occupation, and religion, and pap smear findings is shown in Table 5. It shows the distribution of NILM, inflammatory, mixed, and abnormal findings across different risk groups, with p-values indicating statistical significance.

DISCUSSION

In this study of 500 cases, 5.8% of cases in our study were VIA-positive (acetowhite area detected), while 94.2% were VIA-negative. This VIA-positive rate closely mirrors the 10.75% reported by Poli *et al*., with positivity rates across studies ranging from 6.6 to 27.4%. Albert *et al*.[14] observed a 1.7% VIA-positive rate, Vedantham *et al*.[16] found 12.74%, and Goel *et al*.[17] reported 12.5%, all within a comparable range. Studies by Slawson and Megevand[18] noted slightly lower rates, with 4.2 and 3.13% abnormal VIA results, reflecting variations in VIA outcomes across settings.

Of these 500 recruited cases, 51.2% had PAP smear results showing negative for intraepithelial lesion or malignancy (NILM), followed by 32% reporting NILM

Table 1: Distribution of cases based on specific pap smear categories

PAP smear			*No. of cases (n = 500)*	*VIA finding*		*p-value*
				Positive	*Negative*	
NILM			256 (51.2)	5 (2.0)	251 (98.0)	
Inflammatory smear			76 (15.2)	5 (6.6)	71 (93.4)	
Mixed (NILM+ Inflammatory smear)			160 (32.0)	13 (8.1)	147 (91.9)	
Positive (Abnormal cell, Malignancy)	Atypical cells	ASCUS	3 (0.6)	3 (100.0)	0 (0.0)	<0.001
		AGUS	0 (0.0)	0 (0.0)	0 (0.0)	
	LSIL		1 (0.2)	0 (0.0)	1 (100.0)	
	HSIL		3 (0.6)	3 (100.0)	0 (0.0)	
Unsatisfactory smear			1 (0.2)	0 (0.0)	1 (100.0)	

Table 2: Correlation between VIA and pap smear finding

VIA finding	*PAP smear finding*		*Total*	*p-value*
	Positive (Abnormal Cell, premalignant lesion)	*Negative (NILM, inflammatory)*		
Positive	6	23	29	<0.001
Negative	1	470	471	
Total	7	493	500	

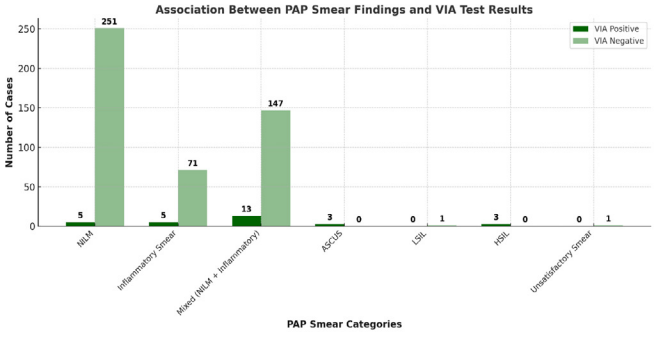

Figure 1: Distribution of cases based on specific pap smear categories

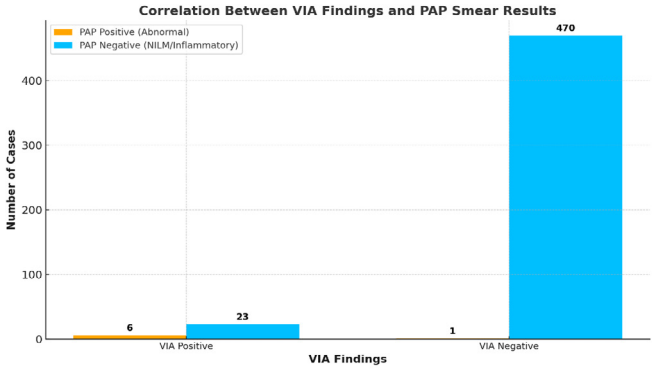

Figure 2: Correlation between VIA and pap smear finding

Table 3: VIA's reliability in identifying cases with abnormal findings

Sensitivity	85.71%
Specificity	95.33%
PPV	20.69%
NPV	99.79%
Accuracy	95.20%

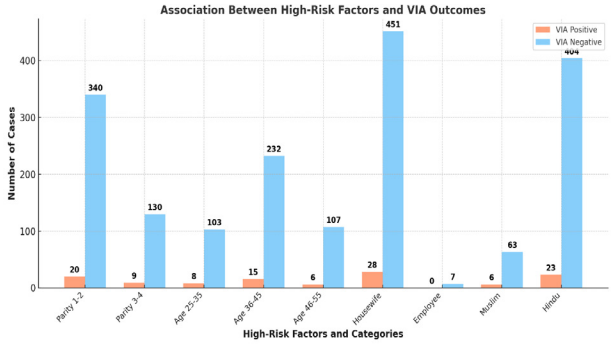

Figure 3: VIA's reliability in identifying cases with abnormal findings

and inflammatory smears. A small number showed abnormalities, with ASCUS in 0.6%, HSIL in 0.6%, and LSIL in 0.2%. No cases of invasive carcinoma were detected. These results align with findings from Verma *et al.*[12] who reported similar distributions, with most cases

Table 4: Association between high-risk factors and VIA outcomes

High-risk factors		*VIA outcome*		*p-value*
		Positive (n = 29)	*Negative (n = 471)*	
Parity	0	0	1	0.974
	1–2	20	340	
	3–4	9	130	
	≥5	0	0	
Age	25–35 years	8	103	0.518
	36–45 years	15	232	
	46–55 years	6	107	
	56–65 years	0	29	
Occupation	Housewife	28	451	0.900
	Employee	0	7	
	House hold helper	1	12	
	Labourer	0	1	
Religion	Hindu	23	404	0.486
	Muslim	6	63	
	Sikh	0	4	
	Others	0	0.0	

Table 5: Association between high-risk factors and pap smear findings

High-risk factors		Pap smear								p-value
		NILM (n = 256)	Inflammatory smear (n = 76)	Mixed (NILM+ Inflammatory smear) (n = 160)	ASCUS (n = 3)	AGUS (n = 0)	LSIL (n = 1)	HSIL (n = 3)	Unsatisfactory smear (n = 1)	
Parity	0	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.080
	1–2	176 (68.8)	52 (68.4)	129 (80.6)	2 (66.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	
	3–4	79 (30.9)	24 (31.6)	31 (19.4)	1 (33.3)	0 (0.0)	1 (100.0)	3 (100.0)	0 (0.0)	
	≥5	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Age (in years)	25–35	35 (13.7)	19 (25.0)	57 (35.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.121
	36–45	136 (53.1)	35 (46.1)	72 (45.0)	1 (33.3)	0 (0.0)	1 (100.0)	1 (33.3)	1 (100.0)	
	46–55	65 (25.4)	18 (23.7)	26 (16.3)	2 (66.7)	0 (0.0)	0 (0.0)	2 (66.7)	0 (0.0)	
	56–65	20 (7.8)	4 (5.3)	5 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Occupation	House wife	245 (95.7)	71 (93.4)	155 (96.9)	3 (100.0)	0 (0.0)	1 (100.0)	3 (100.0)	1 (100.0)	0.957
	Employee	4 (1.6)	1 (1.3)	2 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Household cleaner	6 (2.3)	4 (5.3)	3 (1.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Laborer	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Religion	Hindu	228 (89.1)	67 (88.2)	125 (78.1)	3 (100.0)	0 (0.0)	1 (100.0)	3 (100.0)	0 (0.0)	0.544
	Muslim	26 (10.2)	9 (11.8)	33 (20.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	
	Sikh	2 (0.8)	0 (0.0)	2 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Others	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	

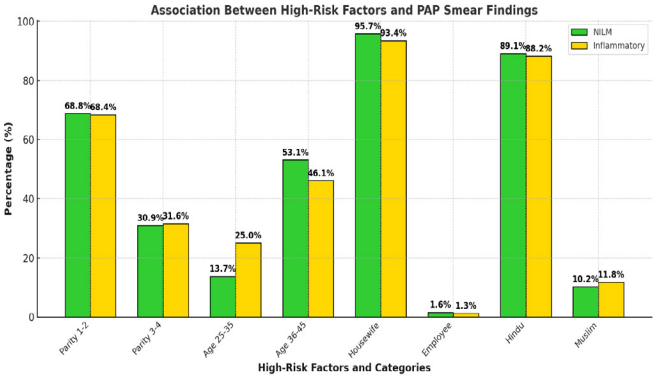

Figure 4: Association between high-risk factors and VIA outcomes

showing normal or inflammatory changes and low rates of LSIL and HSIL. Vahedpoor *et al.*[13] also reported 79.1% normal pap smears and 21% abnormal cases, while Albert *et al.*[14] found 84.9% normal findings with some low-grade abnormalities. In contrast, Gupta *et al.*[15] noted a higher rate of ASCUS (17%) in abnormal smears.

A statistically significant correlation ($p < 0.05$) was observed between pap smear and VIA findings in this study. Among the 29 VIA-positive cases, 6 were also pap smear-positive, suggesting a higher likelihood of abnormal or pre-malignant cells when VIA detects acetowhite areas. Among 471 VIA-negative cases, only one was pap smear-positive, underlining VIA's reliability.

VIA's diagnostic performance in this study was strong, with sensitivity at 85.71%, specificity at 95.33%, PPV at 20.69%, NPV at 99.79%, and accuracy at 95.20%. These figures align with other studies: Vahedpoor *et al.*[13] reported 94.6% sensitivity and 81.6% specificity for VIA, Verma *et al.*[12] found 71.42% sensitivity and 92.0% specificity, and Bhattacharyya *et al.*[19] noted VIA sensitivity and specificity at 89.0 and 87.0%, respectively. While Albert *et al.*[14] reported slightly lower VIA sensitivity (60.0%) and accuracy, their specificity (94.4%) and NPV (99.4%) were comparable to our findings, reinforcing VIA's reliability.

VIA's high sensitivity, especially in studies like Bhattacharyya *et al.*[19] where VIA (89.0%) outperformed pap smear (52.0%), emphasizes its value for real-time screening. Consul *et al.*[20] found VIA's sensitivity comparable to pap smear, recommending it as a viable alternative in low-resource settings. Albert *et al.*[14] demonstrated similar findings, with VIA providing rapid and reliable results despite minor specificity differences. Across studies, VIA's ability to detect pre-invasive lesions promptly allows for quick referrals, addressing a critical gap in low-resource settings where follow-up on pap smear results can be delayed or missed.

In essence, VIA offers an effective, real-time "see-and-treat" approach for cervical cancer screening, making it especially valuable in settings where immediate action is needed to reduce the risk of undiagnosed cases. By providing immediate results, VIA enables healthcare providers to counsel patients on the spot, enhancing compliance and minimizing missed opportunities for intervention.

This study is conducted within a hospital setting, and its sample size is limited. Additionally, the classification of cervix conditions as normal or suspicious is subjective. Further research is necessary to assess the correlation between visual inspection of the cervix with unaided eyes and pap smear results.

CONCLUSION

In conclusion, this study demonstrated that VIA is a highly effective and reliable tool for cervical cancer screening, particularly in low-resource settings. VIA's strong sensitivity, specificity and high negative predictive value confirm its ability to effectively identify and rule out significant abnormalities. The positive correlation between VIA and pap smear findings reinforces VIA's role in the early detection of cervical lesions, highlighting its potential as a practical, cost-effective alternative in areas with limited access to cytology services. Our study suggests that implementing VIA as a primary screening method could substantially enhance cervical cancer prevention and early intervention efforts in underserved populations. VIA should be adopted as a primary screening tool in low-resource settings due to its affordability and immediate results. Expanding VIA training for community health workers will improve accessibility. Further large-scale studies comparing VIA with histopathology could refine its role in cervical cancer screening programs.

CONSENT

Written consent from participants has been obtained and preserved.

ETHICAL APPROVAL

Ethical approval was obtained and documented as per institutional guidelines.

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