ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Comparative efficacy of conventional pap smear and liquid based cytology for screening of cervical cancer in women of reproductive age group in a tertiary care centre in rural Madhya Pradesh

Shambhavi[1], Suresh Kumar Sutrakar[2], Lokesh Tripathi[3], Parul Singh Rajpoot[4], Priyanka Agrawal[5], Uday Raj Singh[6], Jagannath Jatav[7], Deepti Tiwari[8], Pushpkunjika Sharma[9]

[1,4,8,9]Junior Resident, [2]Professor and Head, [3,7]Associate Professor, [5,6]Professor, Department of Pathology, Shyam Shah Medical College, Rewa, Madhya Pradesh, India

Submission: 29-12-2024 Revision: 07-01-2025 Publication: 01-02-2025

ABSTRACT

Background: Cervical cancer poses a significant public health challenge, emphasizing the need for effective screening strategies for early detection. Conventional Pap smear (CPS) has been the standard screening tool for decades, while liquid-based cytology (LBC) was developed to overcome its limitations. This study compares the efficacy of CPS and LBC in detecting cervical neoplastic lesions. **Aims and Objectives:** To determine and compare the efficacy of CPS and LBC as screening tools for early detection of cervical neoplastic lesions in a tertiary care setting. **Materials and Methods:** A prospective observational study was conducted on 240 women aged 18 years and above from August 2022 to August 2023. CPS, LBC (Ezyprep™), and colposcopy-guided biopsies were utilized, with histopathology as the gold standard. Statistical analysis involved sensitivity, specificity, and receiver operating characteristic curves. **Results:** CPS showed a sensitivity of 59.62%, specificity of 94.19%, and sample adequacy of 93.3%, while LBC exhibited higher sensitivity (89.09%), comparable specificity (91.43%), and better sample adequacy (95.8%). The area under the curve for LBC (0.908) was significantly higher than CPS (0.735). LBC identified more true positives (49 vs. 31) and fewer false negatives (6 vs. 21). **Conclusion:** LBC demonstrated superior sensitivity, sample adequacy, and diagnostic accuracy, making it the recommended screening tool for high-risk populations.

Key words: Cervical cancer; Liquid-based cytology; Pap smear; Screening accuracy

Access this article online

Website: https://ajmsjournal.info/index.php/AJMS/index

DOI: 10.71152/ajms.v16i2.4386

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

Cervical cancer remains a leading cause of morbidity and mortality among women worldwide, necessitating effective and accessible screening strategies to facilitate early detection and intervention.[1] Among the most widely used screening methods are the conventional Pap smear (CPS) and liquid-based cytology (LBC), which aim to detect abnormal cervical cells and prevent the progression of precancerous lesions to invasive cancer. The debate over the relative efficacy of these methods persists, given their distinct advantages and limitations.

Routine screening has become a cornerstone of women's healthcare, enabling the detection of precancerous lesions before they progress. The Pap smear, introduced by

Address for Correspondence:
Dr. Shambhavi, Junior Resident, Department of Pathology, Shyam Shah Medical College, Rewa, Madhya Pradesh, India.
Mobile: +91-9439430422. **E-mail:** shambhavisharma004@gamil.com

Dr. George Papanicolaou in the 1940s, has historically been the gold standard for cervical cancer screening.[2] It involves collecting cervical cells using a spatula and endocervical brush, smearing them onto a glass slide, and examining them under a microscope. Despite its widespread use and success in reducing cervical cancer incidence, CPS has notable limitations, including subjective interpretation, low sensitivity for low-grade lesions, and a relatively high rate of unsatisfactory samples.[3]

In response to these drawbacks, LBC emerged in the late 20th century as an alternative approach. In LBC, cervical cells are collected using a specialized brush and suspended in a liquid medium. This technique enables the preparation of a thin, uniform layer of cells for microscopic examination. LBC was designed to improve sample quality, reduce unsatisfactory samples, and enhance the detection of cervical abnormalities. In addition, LBC incorporates automated processing, which reduces human error and allows for expedited results.[3,4]

One of the most scrutinized aspects of cervical cancer screening methods is their accuracy in detecting cervical abnormalities. Diagnostic accuracy is largely determined by the sensitivity and specificity of a test–its ability to correctly identify true positives and true negatives, respectively. Studies have shown conflicting results regarding the relative performance of CPS and LBC. While some research suggests that LBC offers superior sensitivity for high-grade lesions, other studies emphasize the comparable performance of both methods. For instance, LBC often detects more cases of low-grade lesions due to its enhanced sample preparation and processing. However, the specificity of CPS, though slightly higher in some studies, is generally not significantly different from that of LBC.[3,5,6]

CPS benefits from well-established infrastructure and a straightforward methodology, making it a practical option for resource-limited healthcare settings. However, its reliance on manual techniques and higher rates of unsatisfactory samples can impede overall efficiency. In contrast, LBC offers several practical advantages. Automated processing systems streamline sample preparation and reduce variability, while the liquid medium preserves cellular material, allowing for additional testing, such as HPV DNA analysis. These features contribute to LBC's lower rate of inadequate samples and faster turnaround times, enhancing the efficiency of screening programs.[3,5-7]

From a patient perspective, both methods involve similar sample collection procedures, but the quality of results and the likelihood of requiring repeat tests can influence the patient experience. LBC's lower rate of unsatisfactory samples reduces the need for repeat procedures, potentially minimizing patient anxiety and inconvenience. In addition, LBC's improved sensitivity for detecting low-grade lesions ensures that more cases are identified early, which may contribute to better patient outcomes.

In this study we aim to compare the CPS and LBC in the resource limited setting of rural India. This comparative analysis underscores the strengths and limitations of LBC and Pap smear for cervical cancer screening. CPS, with its simplicity and established infrastructure, remains a cost-effective option for many settings. However, LBC offers clear advantages in terms of sample adequacy, sensitivity, and efficiency, making it a valuable tool in resource-adequate healthcare systems. The decision between these methods is not a one-size-fits-all solution and must consider factors such as healthcare infrastructure, population needs, and evolving screening paradigms.

Aims and objectives

Aim

The aim is to determine and compare the efficacy of CPS cytology and LBC as a screening tool for detection of early neoplastic lesions in a tertiary care center.

Objectives

- Primary Objective: To detect the specificity and sensitivity of CPSs and LBC for cervical cytology by comparing the two with cervical biopsies.
- Secondary Objective: To detect the spectrum of cervical lesions in women attending Gynecology OPD of Shyam Shah Medical College, Rewa, MP.

MATERIALS AND METHODS

The study was conducted by the Department of Pathology and Obstetrics and Gynecology at Shyam Shah Medical College, Rewa, from August 2022 to August 2023. This prospective observational study included 240 women aged 18 years and above, presenting with cervical abnormalities. Participants underwent screening with Pap smear, LBC, and colposcopy-guided cervical biopsies. Socioeconomic status was graded using the Revised B. G. Prasad Scale.

Sample collection for cytological and histopathological evaluation followed established procedures. CPSs and Ezyprep™ LBC samples were processed and stained using Papanicolaou and hematoxylin-eosin techniques. Biopsies were preserved in formalin, processed, and embedded in paraffin for microtomy. Histopathology slides were prepared, stained, and analyzed using the Bethesda system.

Ethical clearance was obtained Certificate no. IECBMC/2022/78; Dated August 08, 2022, and data

confidentiality was maintained. Statistical analyses, including Chi-square tests and ANOVA, were conducted using MedCalc software (MedCalc® Statistical Software version 22.021 [MedCalc Software Ltd., Ostend, Belgium; https://www.medcalc.org; 2024]), with a significance threshold of $P<0.05$. This rigorous methodology ensured accurate evaluation of cervical lesions, providing insights into their prevalence and diagnostic efficacy.

Inclusion criteria

Women aged 18 and above presenting with complaints of abnormal vaginal discharge, irregular periods, lower abdomen pain, post coital bleeding, Pelvic Inflammatory Disease (PID), UV prolapse or abnormal cervical findings on per speculum examination were studied randomly.

Exclusion criteria

Women aged <18 years, pregnant women, women who underwent hysterectomy or prior treatment for Cervical Intraepithelial Neoplasia (CIN), and proven cancer cervix cases.

RESULTS

This study evaluated 240 women from a gynecology outpatient department, using Pap smear, LBC, and histopathological examination to screen for cervical pathology.

Demographics and clinical correlations

The majority of participants in this study were in 41–50 years of age group (Table 1), representing 33.33% of the total cases, followed by 31–40 years at 25.42%. Atypical findings were predominantly observed in participants aged 41–50 years, accounting for 24 cases, including 4 cases of squamous cell carcinoma (SCC). In terms of presenting symptoms, utero-vaginal prolapse was the most common, reported in 51.25% of participants. SCC cases were notably linked to post-coital bleeding, with 100% of such cases presenting this symptom. Socioeconomic analysis (Table 2) revealed that most participants belonged to the lower-middle class (42.1%), with the middle-class group showing the highest prevalence of SCC cases (5.7%).

Pap smear results

CPS results showed that most cases were categorized as Negative for Intraepithelial Lesion or Malignancy (NILM), accounting for 75.8% of the participants. This was followed by findings of Atypical Squamous Cells of Undetermined Significance (ASCUS) in 13.3% and Low-grade Squamous Intraepithelial Lesion (LSIL) (Figure 1) in 3.3%. The Pap smear demonstrated a sensitivity of 59.62% and specificity of 94.19%. It had a positive predictive value (PPV) of 75.61% and a negative predictive value (NPV) of 88.53%.

LBC RESULTS

The findings from LBC showed NILM as the predominant result, comprising 69.2% of the cases. This was followed by ASCUS (17.1%), LSIL (5.4%), High-grade Squamous Intraepithelial Lesion, (2.9%), and SCC (1.3%) (Figure 2). LBC exhibited higher sensitivity (89.09%), and specificity (91.43%) compared to the Pap smear. The PPV and NPV for LBC were 75.72% and 96.37%, respectively, demonstrating its superior diagnostic performance.

Comparison of pap smear and LBC

LBC significantly outperformed the Pap smear as a screening tool. The area under the curve for LBC was

Table 1: Age-wise distribution of histopathological diagnoses

Age group (Years)	Normal and benign	Cervical intraepithelial neoplasia 1	Cervical intraepithelial neoplasia 2	Squamous cell carcinoma	Total
21–30	29	0	0	0	29
31–40	54	7	0	0	61
41–50	56	20	0	4	80
51–60	31	14	2	1	48
61–70	13	6	1	1	20
>70	1	1	0	0	2

Table 2: Socioeconomic distribution of histopathological findings

Socioeconomic class	Normal and benign	Cervical intraepithelial neoplasia 1	Cervical intraepithelial neoplasia 2	Squamous cell carcinoma	Total
Upper	3	2	1	0	6
Upper-Middle	43	7	2	0	54
Middle	51	11	1	3	66
Lower-Middle	79	15	4	3	101
Lower	8	3	2	0	13

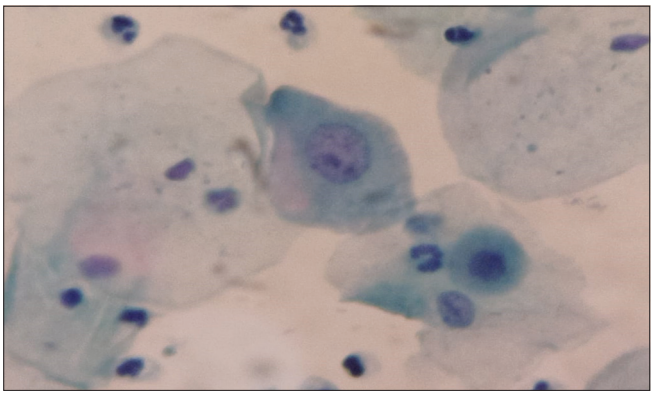

Figure 1: Low grade squamous intraepithelial lesion pap stained (×40)

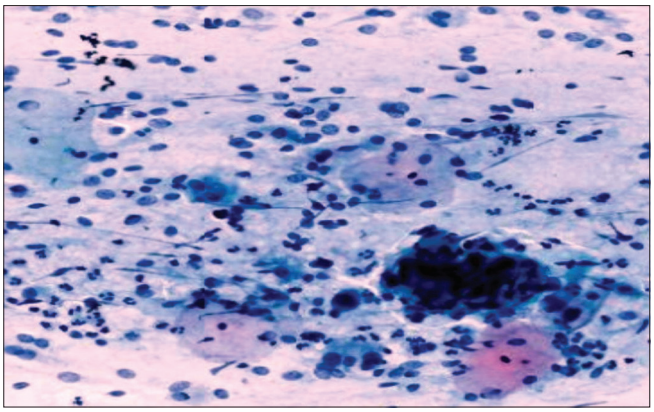

Figure 2: Squamous cell carcinoma. Pap stained (×40)

0.908, indicating excellent diagnostic accuracy, compared to 0.735 for the Pap smear. This difference was statistically significant (P<0.0001), underscoring LBC's enhanced ability to detect cervical abnormalities effectively (Table 3 and Figure 3).

LBC has a significantly higher sensitivity (89.09% vs. 59.62%) and a better NPV (96.37% vs. 88.53%), indicating its superior ability to correctly identify true negatives and avoid missed diagnoses. While Pap smear demonstrates slightly higher specificity (94.19% vs. 91.43%), the overall PPV is comparable for both tests (75.61% for Pap smear vs. 75.72% for LBC). This comparison underscores LBC as a more effective screening tool for detecting cervical abnormalities (Table 4 and Figure 4).

Histopathological examination (Gold standard)

Histopathological examination, the gold standard for cervical pathology, revealed that CIN 1 was the most prevalent atypical diagnosis, identified in 38 cases (15.8%). This was followed by CIN 2 (Figure 5) in 10 cases (4.2%) and SCC (Figure 6) in 8 cases (3.3%). These findings highlight the critical role of histopathology in confirming the presence and severity of cervical abnormalities identified through cytological screening methods.

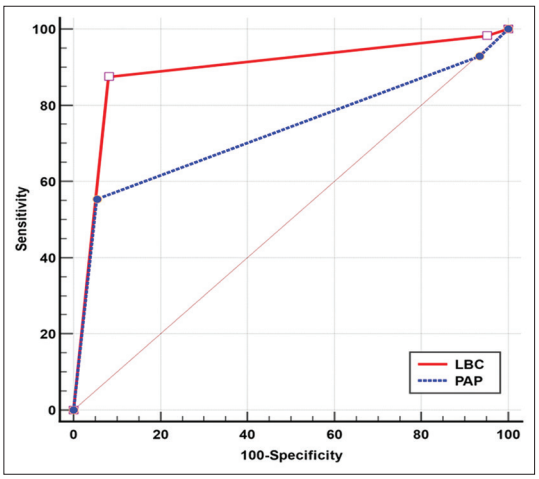

Figure 3: Comparison of receiver operating characteristic curves between liquid-based cytology and Pap smear

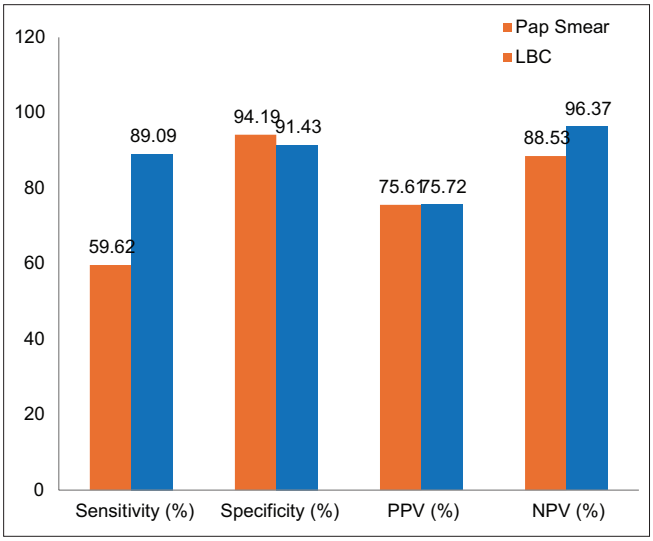

Figure 4: Comparison of pap smear and liquid-based cytology results

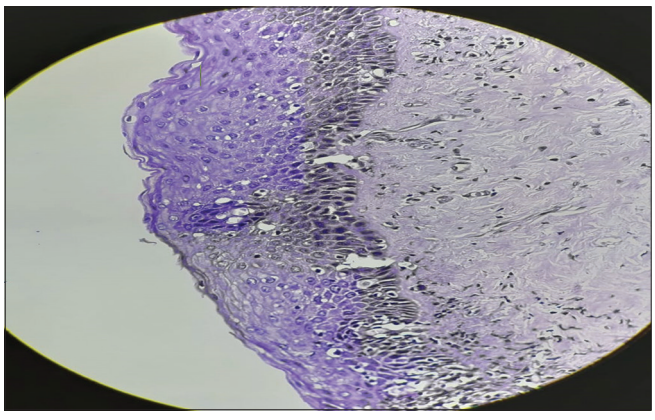

Figure 5: Cervical intraepithelial neoplasm II. H&E stained (×40)

The comparison of Pap smear and LBC against histopathology as the gold standard demonstrates that LBC has superior diagnostic performance. LBC identified more true positive cases (49 vs. 31) and had fewer false

Table 3 : Comparison between ROC curves between LBC and Pap smears

Variable	AUC	SE[a]	95% CI[b]
LBC	0.908	0.0269	0.865–0.942
Pap	0.735	0.0409	0.674–0.789
Pairwise comparison of ROC curves			
LBC~Pap			
Difference between areas			0.174
Standard Error[a]			0.0424
95% Confidence Interval			0.0905–0.257
z statistic			4.096
Significance level			P<0.0001

LBC: Liquid-based cytology, ROC: Receiver operating characteristic, AUC: Area under the curve, [a]DeLong et al., 1988, [b]Binomial exact

Table 4: Comparison of pap smear and LBC results

Cytology Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Pap Smear	59.62	94.19	75.61	88.53
LBC	89.09	91.43	75.72	96.37

PPV: Positive predictive value, NPV: Negative predictive value

negatives (6 vs. 21) compared to Pap smear, highlighting its higher sensitivity. However, LBC exhibited a slightly higher rate of false positives (15 vs. 10), reflecting a marginally reduced specificity compared to Pap smear. Both tests achieved similar true negative results (162 for Pap smear and 160 for LBC). Overall, LBC proved to be more accurate in detecting cervical abnormalities than Pap smear (Table 5).

DISCUSSION

Our study comprehensively analyzed data on cervical health, focusing on key parameters such as age distribution, parity, socio-economic factors, and diagnostic methods. The results were compared with findings from other contemporary studies, providing a contextual understanding of trends in cervical health and diagnostics.

Age distribution

The study observed a peak prevalence of cervical abnormalities in the age group 41–50 years, aligning with findings from Das et al., (2024)[3] and Shobana and Saranya (2019).[5] However, Krishna et al., (2021)[6] reported a younger cohort, emphasizing the role of regional variations and healthcare accessibility in influencing these findings. The concentration of cases in the 41–50 age group highlights the importance of targeting this demographic in cervical cancer screening programs to enable early detection and intervention.

Table 5: Comparison of cytology with histopathology

Cytology test	True positive	True negative	False positive	False negative
Pap Smear	31	162	10	21
LBC	49	160	15	6

LBC: Liquid-based cytology

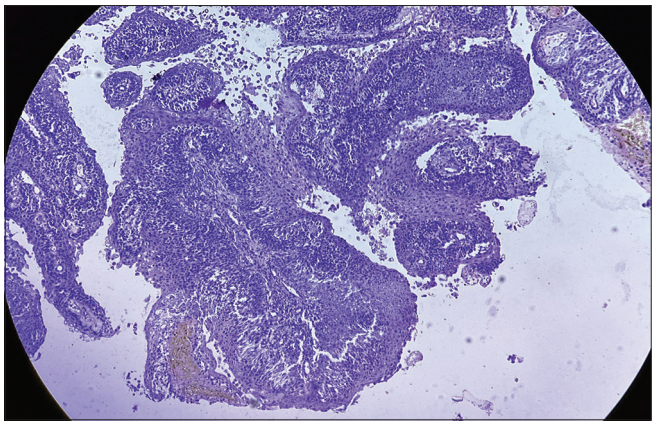

Figure 6: Squamous cell carcinoma cervix. H&E stained (×40)

Parity

Parity played a significant role in the prevalence of cervical abnormalities. The majority of cases were found in women with three or more children, correlating with findings from Jeyakumar and Mohanapu (2019)[8] and Pankaj et al. (2018).[9] Notably, this study reported the highest percentage of atypical findings in patients with parity P4 (44.44%), followed by P5 (42.11%). These findings underscore the need for enhanced family planning measures and education on the risks of high parity, particularly in rural areas where access to healthcare services is limited.

Age at first coitus/marriage

Early sexual activity was associated with an increased risk of cervical abnormalities. This study observed the highest percentage of atypical findings (34.92%) among women who initiated sexual activity between 16 and 18 years of age. These findings corroborate data from Shobana and Saranya (2019),[5] which reported a high prevalence of dysplasia in women with early sexual initiation. This emphasizes the critical need for community-based educational programs on delaying early marriages and promoting reproductive health awareness.

Symptoms and presenting complaints

PID was a prevalent complaint, observed in 34.5% of cases, though lower than the rates reported by Krishna et al. (2021).[6] Unique to this study was the high incidence of uterovaginal prolapse (123 cases), likely due to the rural

background of participants. The association of post-coital bleeding with SCC highlights its importance as a diagnostic indicator.

Diagnostic methods

This study highlighted significant advantages of LBC over Conventional PAP Cytology (CPS). LBC demonstrated a superior sensitivity of 89.09% compared to 59.62% for CPS. These results are consistent with findings from Shobana and Saranya (2019),[5] which reported an 83% sensitivity for LBC versus 55.5% for CPS. The higher sensitivity of LBC is attributed to better sample collection and preparation, reduced obscuring material, and advanced detection methods that enhance abnormality identification.

In addition, LBC showed higher sample adequacy, achieving 95.8% compared to 93.3% for CPS. This trend aligns with the findings of Patel et al., (2023)[7] who reported a 98.6% adequacy for LBC versus 95% for CPS, and Singh et al., (2018)[10] who noted a significant increase in adequacy for LBC (92.55% vs. 78.72%). The consistency in higher sample adequacy across multiple studies highlights the robustness of LBC in providing reliable diagnostic outcomes.

However, specificity varied between methods. While CPS demonstrated a higher specificity in certain studies, including the present study (94.19% for CPS vs. 91.43% for LBC), others reported comparable or higher specificity for LBC. Shanmugapriya et al., (2017)[11] found a specificity of 95.06% for CPS versus 77.16% for LBC, while Krishna et al., (2021)[6] noted equal specificity for both methods (100%). Conversely, Shobana and Saranya (2019)[5] reported a slightly higher specificity for LBC (86.5%) compared to CPS (83.7%). These discrepancies can be attributed to variations in sample size, study populations, diagnostic protocols, and laboratory techniques.

A comprehensive analysis of specificity trends across studies reveals that while LBC generally offers enhanced sensitivity and sample adequacy, CPS may provide slightly better specificity in certain settings. This finding underscores the importance of integrating both methods, leveraging the strengths of each to optimize cervical cancer screening outcomes. Context-specific factors, including population demographics and resource availability, should guide the selection of diagnostic methods.

Limitations of the study

This study's limitations include a small sample size, single-center design, regional focus, and lack of inclusion of HPV testing or cost-benefit analysis. The short study duration and resource-intensive nature of LBC limit its scalability, potentially affecting the generalizability and applicability of findings in diverse healthcare settings.

CONCLUSION

This study highlights LBC as a superior cervical cancer screening method compared to the CPS, demonstrating higher sensitivity, specificity, and sample adequacy. LBC minimizes false negatives, provides clearer results, and reduces errors in sample preparation, making it particularly effective for high-risk populations. It is especially beneficial for women aged 31–50 years or those with risk factors like high parity, early sexual initiation, and post-coital bleeding. LBC is recommended as a reliable and impactful screening tool in both rural and urban healthcare settings.

ACKNOWLEDGEMENTS

The Authors acknowledge Shyam Shah Medical College & Associated SGMH, GMH & SSB hospitals for providing platform for conduct of this study.

REFERENCES

1. Jain MA and Limaiem F. Cervical squamous cell carcinoma. In: StatPearls. Treasure Island, FL: StatPearls Publishing; 2023.
2. Chantziantoniou N, Donnelly AD, Mukherjee M, Boon ME and Austin RM. Inception and development of the papanicolaou stain method. *Acta Cytol. 2017*;61*(4-5):266-280.*
   https://doi.org/10.1159/000457827
3. Das BP, Deka BP, Devi J and Paul R. Conventional PAP smear or liquid-based cytology, the better screening tool for cervical cancer: A comparative study at a tertiary care center in North-East India. Indian J Gynecol Oncol. 2024;22(1):1.
   https://doi.org/10.1007/s40944-023-00766-w
4. Hoda RS, Loukeris K and Abdul-Karim FW. Gynecologic cytology on conventional and liquid-based preparations: A comprehensive review of similarities and differences. Diagn Cytopathol. 2013;41(3):257-278.
   https://doi.org/10.1002/dc.22842
5. Shobana R and Saranya B. Comparison of conventional Papanicolaou smear and liquid-based cytology for cervical cancer screening. Int J Sci Study. 2019;6(12):64-73.
6. Krishna C, Chandraiah S and Krishna C. Comparison of conventional Papanicolaou smear and liquid-based cytology: A study of cervical cancer screening at a tertiary care centre in Bengaluru. Int J Reprod Contracept Obstet Gynecol. 2021;10(8):3106-3112.
7. Patel N, Bavikar R, Buch A, Kulkarni M, Dharwadkar A and Viswanathan V. A comparison of conventional Pap smear and liquid-based cytology for cervical cancer screening. Gynecol Minim Invasive Ther. 2023;12(2):77-82.
   https://doi.org/10.4103/gmit.gmit_118_22
8. Jeyakumar AM and Mohanapu S. A comparison of cervical cancer screening methods: Pap smear, liquid based cytology and VIA VILI. Int J Reprod Contracept Obstet Gynecol. 2019;8(5):1738-1745.
9. Pankaj S, Nazneen S, Kumari S, Kumari A, Kumari A, Kumari J, et al. Comparison of conventional Pap smear and liquid-based cytology: A study of cervical cancer screening at a tertiary care

center in Bihar. Indian J Cancer. 2018;55(1):80-83. https://doi.org/10.4103/ijc.IJC_352_17

10. Singh U, Anjum, Qureshi S, Negi N, Singh N, Goel M, et al. Comparative study between liquid-based cytology & conventional Pap smear for cytological follow up of treated patients of cancer cervix. Indian J Med Res. 2018;147(3):263-267. https://doi.org/10.4103/ijmr.IJMR_854_16
11. Shanmugapriya N and Devika P. Comparing the effectiveness of liquid based cytology with conventional PAP smear and colposcopy in screening for cervical cancer and it's correlation with histopathological examination: A prospective study. Int J Reprod Contracept Obstet Gynecol. 2017;6:5336-5340.

Authors' Contribution:
S- Definition of intellectual content, literature survey, prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article, literature survey and preparation of figures**; SKS-** Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision**; LT-** Design of study, statistical analysis and interpretation, coordination and manuscript revision; **PSR**- Data collection; **PA**- Review manuscript; **URS**- Review manuscript; **JJ**- Review manuscript; **DT**- Data collection; **PS-** Data collection.

Work attributed to:
Shyam Shah Medical College, Rewa, Madhya Pradesh, India.

Orcid ID:
Dr. Shambhavi - https://orcid.org/0000-0002-0317-0991
Dr. Suresh Kumar Sutrakar - https://orcid.org/0000-0002-1892-2770
Dr. Lokesh Tripathi - https://orcid.org/0000-0002-3674-0751
Dr. Parul Singh Rajpoot - https://orcid.org/0009-0009-1054-0143
Dr. Priyanka Agrawal - https://orcid.org/0000-0003-1114-001X
Dr. Uday Raj Singh - https://orcid.org/0000-0003-0551-2024
Dr. Jagannath Jatav- - https://orcid.org/0000-0003-1341-7211
Dr. Deepti Tiwari - https://orcid.org/0009-0007-1903-0372
Dr. Pushpkunjika Sharma - https://orcid.org/0009-0000-7234-9728

Source of Support: Nil, **Conflicts of Interest:** None declared.