

# Diagnostic Performance of Liquid-Based Cytology Versus Conventional Pap Smear for Cervical Lesions

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## ABSTRACT

Cervical cancer is still one of the most prevalent cancers in women globally. Early detection of abnormal cells by screening is vital to avoiding the progression to invasive cervical cancer. This systematic review aims to compare the diagnostic ability of Liquid Based Cytology (LBC) with conventional Pap Smear (CPS) in the diagnosis of cervical lesions. The literature search was structured and performed in PubMed, Scopus, Google Scholar, and the Cochrane Library. The studies reviewed were those published from 2019 to 2025 that compared LBC to CPS. The results indicated that the LBC was giving higher sensitivity, better diagnostic accuracy, improved sample sufficiency and the rate of unsatisfactory smears is low when compared with the CPS generally. Also, LBC was shown to offer increased detection of cervical abnormalities and decreased likelihood of false negatives. LBC can also be ordered as HPV testing on the same sample resulting in an increased efficiency in screening. While CPS is a high cost-effective screen test available to virtually all clinical and public health laboratories, it is more sensitive to poor sample quality and interpretation issues. The overall evidence indicates that LBC can be a more effective approach to the detection of cervical lesions and that it will enhance the results of cervical cancer screening.

**Keywords:** Liquid-Based cytology (LBC), conventional pap smear, cervical lesions, cervical cancer screening, diagnostic performance.

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## 1. Introduction

### 1.1 Global Burden of Cervical Cancer

Globally, cervical cancer continues to be a significant health issue of concern, although it can be prevented, to a large extent, by vaccination and routinely performed screening. The World Health Organization (WHO) claims that of the 660,000 new cases of cervical cancer and 350,000 deaths cases of this specific cancer reported globally in 2022, this makes cervical cancer the fourth most prevalent cancer in women. It is estimated that about 90 % of the deaths happen in low- and middle-income countries where screening and treatment are still not readily available (WHO.int, 2025). According to recent world estimates, there were approximately 662,000 new cases of cervical cancer and approximately 349,000 deaths from the disease in 2022. It is also important to treat precancerous lesions in the cervix as soon as they occur, since they may be accessed in the earliest possible stage, thus avoiding the disease turning into an invasive cancer. Thus, successful and proper screening procedures are an essential element of cervical cancer prevention plans in all countries of the world.

### 1.2 Cervical Screening Methods

The screening of the cervix with cytology has greatly reduced the incidence and death rates of cervical cancer within several decades. The traditional Pap smear (CPS) was introduced by Papanicolaou, whereby cervical cells were directly smeared on a glass slide to be observed under a microscope. Despite its high usage and capability to be cost-effective, CPS can be influenced by poor sampling, cell overlap, smear-through, and inflammatory debris, which can decrease the accuracy of diagnosis. In order to overcome these shortcomings, Liquid-Based Cytology (LBC) was proposed in the 1990s. LBC involves the preservation of cervical cells that are collected in a liquid medium, then lived through a laboratory procedure with fewer artefacts, rendering cleaner slides and more uniform. A recent investigation showed that the reversed rates on unsatisfactory samples with LBC (1.3%), opposite to traditional Pap smears (7.3%), are lower (Bray et al., 2024). Additional tests that may be carried out through LBC include the analysis of human papillomavirus (HPV) in the same specimen.

### 1.3 Rationale for the Review

Even though both CPS and LBC screening are commonly employed to screen for cervical cancer,

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some doubts persist regarding their comparative diagnostic efficacies. Recent reports indicate that LBC offers better adequacy of sampling, enhanced sensitivity, and increased ability to identify cervical abnormalities (Andola et al.,2024). But alternative studies have found similar diagnostic results between the two procedures. This conflicting evidence confounds some clinicians, policymakers, and screening programs in choosing the best screening strategy (Ekaterina et al.,2025). Considering the increasing number of publications in recent years, there is a necessity for a systematic review, which would critically analyses and synthesize the existing studies on the comparative diagnostic effectiveness of LBC and conventional Pap smear in recognizing the lesions of the cervix.

## 1.4 Aim and Research Question

### Aim

The systematic review aims to compare the diagnostic capabilities of Liquid-Based Cytology and Conventional Pap Smear in the diagnosis of cervical lesions, as well as to assess their efficacy in screening cervical cancer.

### Review Question

In females receiving cervical cancer screening, does Liquid-Based Cytology have better diagnostic ability in terms of sensitivity, specificity, sufficiency of samples and detection of lesions than Conventional Pap Smear in the detection of lesions in the cervix?

## 2. Methods

### 2.1 Review Design

A systematic review was involved in this study to compare and contrast the levels of diagnostic performance of Liquid-Based Cytology (LBC) and Conventional Pap Smear (CPS) in the diagnosis of cervical lesions. A systematic review method was selected due to the ability of such an approach to collect, evaluate, and synthesize evidence in a structured and transparent way using the results of multiple studies. This approach will minimize bias and give an in-depth picture of the existing studies on cervical cancer screening and cytological diagnosis.

### 2.2 Search Strategy

The four broad electronic databases were used, PubMed, Scopus, Google Scholar, and the MDPI to conduct a comprehensive literature search. The selection of these databases was based on the fact that they include quality peer-reviewed literature in medical and health sciences. Studies published in 2022-24 were searched. Relevant articles were identified with the help of keywords and Boolean operators, such as: liquid-based cytology, conventional Pap smear, cervical lesions, cervical cancer screening, sensitivity, specificity, and diagnostic accuracy. Past reviews have shown that with a combination of multiple databases, database-

driven searches can find more than 90% of eligible studies (Atla, 2021).

### 2.3 Inclusion & Exclusion Criteria

**Inclusion:** The following criteria were used to include the studies: (1) it had to be a publication in the English language, (2) one that involved human subjects, (3) one that compared LBC to Conventional Pap Smear, (4) reports on the diagnostic outcomes such as sensitivity or specificity, (5) it had to be a systematic review, meta-analysis, or comparative study, and (6) it had to be published within the years 2021 to 2026.

**Exclusion:** The studies were not included when they were carried out in other languages (not English), when the articles were based on experiments done on animals, when the articles were editorials and letters and when the articles were based on conference session abstracts, duplicate publications and when the studies did not present comparative data concerning LBC and Conventional Pap Smear. There was also exclusion of studies which lacked outcome information.

### 2.4 Study Selection Process

The procedure of selection of the studies was in three phases. The initial stage is the screening of titles that eliminate obviously irrelevant articles. Second, the responsibility of reviewing the abstracts was to determine the eligibility based on the selection criteria. Lastly, full-text articles were appraised thoroughly. The final review used none other than studies that fit within all the eligibility requirements. To ensure that the process was transparent and reproducible, documentation was made of the selection process (Geetha et al.,2024). Research that compared the diagnostic accuracy of liquid-based cytology to conventional cytology, HPV-based screening, and cervical lesion detection as part of the UK cervical screening programmer.

### 2.5 Data Extraction and Synthesis

The extraction of data was done through a standardized form. Various details such as the name of the author, the year of publication, country, the research design, sample size, sensitivity, specificity, sample adequacy, and key findings were also included. The data that were extracted were summarized and compared between studies. The diagnostic performance of LBC and Conventional Pap Smear shared common findings, differences, and overall trends were identified with the help of a narrative synthesis approach (Connolly et al., 2024).

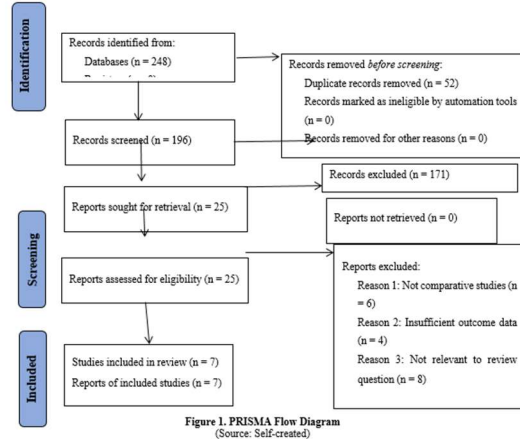
## 3. Results

### 3.1 Study Selection Results

The search of the database revealed 248 records through PubMed, Google Scholar, Scopus, and other academic resources. Following the elimination of 52 records that were similar, 196 articles were left to undergo title and abstract screening. 171 articles were

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discarded as they were not related to the topic subject of the review, or simply failed to compare Liquid-Based Cytology (LBC) and Conventional Pap Smear (CPS). Twenty-five full-text articles were evaluated in terms of eligibility. After evaluation by full text, 13 studies were rejected because they did not have adequate diagnostic data or did not find any comparison outcomes. Lastly, 7 studies were identified as meeting the inclusion criteria and included in the systematic review. The PRISMA flow diagram represents the process of selecting the studies.



(Source: Self-created)

### 3.2 Characteristics of Included Studies

The studies included were published in 2022-2026 and represented various geographical locations, such as the United Kingdom, the United States, Europe, and the population of nations. Three of these were comparative studies, one of which was a large observational study with a sample of more than 1.3 million women, another was a cross-sectional study, and the others were reviews (Rebolj et al., 2022). The majority of the studies determined the diagnostic accuracy, lesion detection, sample adequacy, and screening efficiency. Generally, it was consistently indicated that Liquid-Based Cytology offered better quality of specifications, reduced the unsatisfactory rate of smears and enhanced the capability to identify cervical abnormalities than Conventional Pap Smear.

Author	Year	Country	Study Type	Sample Size	Key Findings
Xue et al.	2023	China/International	Cross-sectional	3514	The LBC with AI demonstrated a high diagnostic

					c accuracy.
Balachandra et al.	2026	USA	Review	N/A	The screening performance was enhanced with the digital cytology.
Rebolj et al.	2022	England	Observational Study	1.3 million+ (1341584 women)	The pathway of HPV-LBC enhanced lesion detection.
Ekaterina et al.	2025	Georgia	Comparative Study	1000	There was increased adequacy and reliability in LBC.
Šečerović	2025	Serbia	Comparative Review	N/A	Fewer unsatisfactory smears were obtained by LBC.
Dasgupta	2023	International	Review	N/A	LBC proved to be more sensitive compared to CPS.
Crifase & Parker	2025	USA	Evidence Review	N/A	There were significant limitations with conventional cytology.

**Table 1: Characteristics of Included Studies**  
(Source: Self-created)

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### 3.3 Diagnostic Performance of Liquid-Based Cytology

The evidence continued to reveal that the Liquid-Based Cytology (LBC) has good diagnostic performance in case of detecting cervical lesions. LBC proved to be highly sensitive and to detect cervical intraepithelial neoplasia (CIN) especially as used with the current technologies in the included studies. According to Xue et al. (2023), AI-assisted LBC demonstrated a sensitivity of 86.49% and a specificity of 96.1% in detecting CIN2+ lesions, which positively reflects that the AI-assisted LBC has a high level of diagnostic precision. Likewise, Rebolj et al. (2022) concluded that incorporation of LBC into HPV-based screening programmes led to successful detection of high-grade cervical abnormalities among more than 1.3 million women who had been screened.

The quality of specimens was also emphasized in the studies. Ekaterina et al. (2025) observed that LBC yielded cleaner and more representative samples, leading to a higher sample adequacy and a better visualization of abnormal cells. This observation is consistent with Balachandra et al. (2026), who suggested that digital cytology combined with artificial intelligence enhances the diagnostic power of LBC by decreasing the role of human error with increasing lesion identification.

The major strength found throughout the studies was the decrease of unsatisfactory smears. Cytological assessment was more reliable due to improved cell preservation and elimination of obscuring materials. Overall, the evidence indicates that LBC has both the beneficial qualities of a high sensitivity, high specificity, better sample adequacy and reduced errors of poor specimen and therefore, LBC is a very effective tool in screening cervical cancer.

### 3.4 Diagnostic Performance of Conventional Pap Smear

The studies provided have indicated that the Conventional Pap Smear (CPS) is a significant test that is used to screen the cervix, but its diagnostic value suffers due to a number of limitations. According to Dasgupta (2023), CPS is usually less sensitive than Liquid-Based Cytology (LBC), which puts cervical abnormalities at risk of being overlooked in more cases. Conversely, CPS tends to have a reasonably high specificity, and it can be used to establish normal results. Equally, the study by Šećerović (2024) has revealed that the presence of coinciding cells, blood, and inflammatory substances in conventional smears was more likely to profile abnormal cells and decrease the accuracy in diagnostics.

One significant issue that was found through the studies was the possibility of false-negative data. Crifase and Parker (2025) emphasized that improper

cell collection, suboptimal slide preparation, and misinterpretation may also be the causes of missed precancerous lesions. These considerations also subtract the number of unsatisfactory samples from the repeat testing. In general, although CPS is a relatively inexpensive and commonly available screening instrument, the findings indicate that its lesser sensitivity and greater risk of false-negative undermine its efficacy in contrast to more modern cytological techniques.

### 3.5 Comparative Findings

The studies included in the review showed a consistent result in multiple diagnostic measures of Liquid-Based Cytology (LBC) outperforming Conventional Pap Smear (CPS). Xue et al. (2023) showed that advanced LBC systems had optimistic sensitivity and specificity, enhancing the detection of clinically relevant cervical lesions. Equally, Ekaterina et al. (2025) and Šećerović (2024) indicated that LBC offered more sample satisfactory and distinct cell presentation, thus boosting detection of cervical abnormalities. By contrast, obscuring blood, inflammation, and cell overlap showed a higher impact on CPS, decreasing diagnostic accuracy and the risk of missed lesions.

Further, Dasgupta (2023) observed that LBC was usually more sensitive and of similar specificity in comparison to CPS. There was also enhancement in the quality of LBC samples which led to low rates of unsatisfactory smear and repetitive tests. On a laboratory scale LBC was more efficient with standardized sample preparation and could be used in conjunction with other HPV assays. The evidence in general indicates that LBC is more discriminating and able to detect lesions compared to other diagnostic solutions, has high specificity, and enhances laboratory workflow.

Parameter	Liquid-Based Cytology	Conventional Pap Smear
Sensitivity	Higher	Lower
Specificity	High	Moderate to High
Diagnostic Accuracy	Higher	Lower
Lesion Detection	Better	More missed lesions
Laboratory Efficiency	Higher	Lower

**Table 2: Comparative summary**  
(Source: Self-created)

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## 4. Discussion

### 4.1 Interpretation of Findings

According to the results from this systematic review, Liquid Based Cytology (LBC) had advantages over Conventional Pap Smear (CPS) for cervical diagnosis. LBC showed increased sensitivity and diagnostic accuracy in all the studies included, as well as increased lesion detection rates. The results furthermore indicated that LBC is more representative and cleaner to obtain cellular samples for cytologists to more easily detect abnormal células (Geetha et al., 2024). On the other hand, CPS was less likely to have overlying cells and inflammation, less likely to have engulfed blood, and more likely to be good. Conversely, CPS was less affected by overlapping cells and inflammation, as well as less likely to have engulfed blood with associated falsely negative results and more likely to be good.

There was also a lesser frequency of unsatisfactory smears with LBC. A higher quality of specimen leads to fewer repeat specimens for testing, hence more efficient overall cervical screening programmes. Another added benefit of HPV testing in today's cervical cancer screening is that testing for LCR or HPV can be done on the same sample. In summary, the study results showed that LBC as a diagnostic approach is more accurate and effective in detecting cervical abnormalities and facilitating the diagnosis at an early stage.

### 4.2 Comparison with Previous Literature

The results of this review are congruent with the previous literature comparing LBC to CPS in screening for cervical cancer. Previous reports have also demonstrated that LBC enhances the quality of the obtained samples, decreases specimen smear failures, and enhances the identification of cervical abnormalities. The studies evaluated in this review yielded similar findings, showing better sensitivity and diagnostic value of LBC as compared to CPS (Khakwani et al., 2022). Past studies have also emphasized that CPS is a beneficial and cost-effective screening tool, especially in the healthcare environment's low resources. Nonetheless, poor sample preparation and false negatives have been identified in many studies. The present review corroborates these, and continues to reinforce LBC's role in cervical cancer prevention and screening programmes as technological progress advances.

### 4.3 Clinical Implications

This review has some significant clinical implications for cervical cancer screening programmes. LBC is more sensitive than conventional PAP tests, and it offers greater sample adequacy, which means it could help detect cervical abnormalities earlier than the conventional test and improve the chances of identifying lesions that may have been missed. The

early detection of changes is crucial because if such changes are caught in time, treatment can be provided before invasive cervical cancer develops. The use of LBC as a preferred screening method, if resources and laboratory facilities are available, could potentially be beneficial for healthcare organizations (Kaur et al., 2024). Also, the testing of HPV with the same specimen enhances the efficiency of screening and helps the current guidance. In some situations, with limited financial resources, equipment or trained staff, CPS can still be an important tool, however. Thus, screening decisions need to take into account diagnostic and local health care requirements.

### 4.4 Strengths and Limitations of the Review

There are a number of strengths to this Systematic Review. It followed a defined, systematic search in several databases and clear inclusion and exclusion criteria. Studies across countries and health care settings were included in the review to gain a broader understanding of the diagnostic performance of LBC and CPS. The analysis of sensitivity, specificity, sample adequacy, and detection of lesions gave a detailed assessment of both screening methods. Although these advantages should be recognized the project had some drawbacks (Varma et al., 2025). Relatively limited number of the studies included in the review; this may affect the generalizability of the findings. Reported outcomes may further have been influenced by differences in the study design, sample size and screening populations. Also, only English-language studies were included which may have resulted in language bias. Finally, limited quantitative data were provided by some studies, limiting direct comparison of diagnostic measures in the other studies included.

## 5. Conclusion

This systematic review compared Liquid-Based Cytology (LBC) with Conventional Pap Smear (CPS) in the diagnosis of cervical lesions. Results suggest that LBC overall has better diagnostic performance in a number of significant respects. LBC proved to be more sensitive, and more accurate and adequate samples and fewest unsatisfactory smears than CPS. The studies examined also revealed that LBC facilitates the detection of cervical abnormalities and decreases the risk of missed lesions and/or missed diagnosis. The CPS is a widely used and cost-effective screening method but can be limited by low quality samples, overlapping cells and obscuring materials. LBC, on the other hand, yields cleaner and representative samples resulting in more accurate cytological evaluation. Another benefit of LBC is that it is compatible with the HPV test which supports the efficiency of the latest cervical cancer screening programmes. In summary, the evidence indicates that LBC may prove to be a more effective screening tool

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for the detection of cervical lesions and for early diagnosis, however CPS remained important in resource limited health care settings.

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