

Comparison And Correlation Of Pap Smear, Colposcopy, And Histopathology In The Evaluation Of Cervical Pre-Cancer Among Women: Towards Strengthening Early Detection Strategies

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Abstract

Cervical cancer is an enduring global health concern, especially in low- and middle-income nations where organized screening programs and healthcare access are limited. An immense number of cases are preventable when timely diagnosis and treatment are carried out. Pap smear cytology, colposcopy, and histopathology form the pillars of diagnosis in the evaluation of cervical precancer and cancer. This review focuses on evaluating and correlating the diagnostic efficiency of Pap-smear and colposcopy with histopathology, the latter being the gold standard, in the detection of cervical intraepithelial neoplasia (CIN). Since several studies have shown, Pap smear is an easy, cheap, and very specific method whose sensitivity varies and hence presents many false negatives. The use of colposcopy demonstrates greater sensitivity and guides in taking biopsies yet lacks specificity and heavily depends on the examiner. Histopathology is considered the gold-standard method and thus ensures an unequivocal and accurate diagnosis of the lesions under scrutiny. Studies support the combined use of all three modalities with Pap smear as a screening test, colposcopy and biopsy for evaluation and histopathology for final confirmation, all of which significantly improve diagnostic accuracy. This could provide a solution if early detection strategies incorporating the above techniques and new approaches like HPV DNA testing is strengthened to reduce the incidence and mortality of cervical cancer, particularly in developing countries.

Keywords: Cervical cancer, Pap smear, Colposcopy, Histopathology, Cervical intraepithelial neoplasia (CIN), Early detection, Screening strategies

INTRODUCTION

cervical cancer remained among the reasons for morbidity and mortality in women, being the fourth most common cancer worldwide (WHO, 2003). It is almost preventable, though it is a huge public health problem for low and middle-income nations as over 85-90% of the death cases occur there (Najib et al., 2020). The long pre-invasive phase of cervical cancer offers an opportunity for prevention because premalignant lesions can be detected and treated before the lesion develops into invasive cancer (Mishra et al., 2013). Hence, early detection remains the essence of cervical cancer control programs, making screening programs and diagnostic methods-text are equally important.

Introduced in the 1940s, the Papanicolaou (Pap) smear has been one of the most widely utilized screening tests around the globe, and it has dramatically reduced cervical cancer incidence and mortality in developed nations (Karimi-Zarchi et al., 2015). It is inexpensive, minimally invasive, capable of detecting cellular abnormalities at an early stage, and thus serves as the first line of defense in cervical cancer prevention. Pap smear cytology finds itself limited by low sensitivity, which ranges between 47% and 60%, and a high false-negative rate, mostly when high-grade lesions are concerned (Ukey & Singh, 2021). Contributing factors to these diagnostic gaps include technical error, poor sampling, and subjective interpretation (Nema et al., 2020).

It was originally introduced as a technique accompanied by cytology: it provides a magnified view of the cervix to allow the selection of suspicious areas for biopsy and further evaluation (Joshi et al., 2015). Its sensitivity is higher than that of the Pap smear, and so it is especially useful in detecting high-grade cervical intraepithelial neoplasia (CIN). However, it possesses certain limitations. It has reduced specificity levels ranging from 45% to 65%, culminating in over-diagnosis and over treatment (Najib et al., 2020; Nema

et al., 2020). Moreover, the accuracy of the diagnosis depends highly on the skills and training of the colposcopist, with both inter- and intra-observer variabilities having been considered great in many studies (Karimi-Zarchi et al., 2015).

Histopathology is the ultimate method of diagnosing pre-malignant and malignant cervical lesions on biopsy specimens, which may be taken either during colposcopy or from the site of a suspicious lesion (Ukey & Singh, 2021; Sabbella, 2025). Cases of abnormal cells, whether dysplastic changes or outright invasive ones, are diagnosed with histopathology, wherein accurate grading and staging of CIN are established. The main advantage of histopathology is confirmatory and reproducible evaluation against cytology or colposcopy. Being invasive in nature, they cannot really be used for large-scale screening, considering their cost and infrastructural requirement, particularly in LMICs (Dasgupta, 2023).

As each test has its strong and weak points, most clinical centers now translate an integrated approach. The Pap smear has value for initial screening for the mere accessibility of it; colposcopy serves as a second-line diagnostic method in women with abnormal cytology or in whom clinical suspicion persists. Histopathology then confirms or invalidates the diagnosis for decision making on treatment (Mishra et al., 2013; Najib et al., 2020). Several studies, including Joshi et al. (2015) and Sabbella (2025), established that a combination of Pap smear and colposcopy increases the accuracy of diagnosis and reduces the incidence of false negatives, thereby reinforcing early detection programs.

The advent of liquid-based cytology and the inception of HPV DNA testing increased their sensitivity and their predictive values, though these tests still remain less accessible in resource-limited settings (Jain & Sharma, 2020). In view of this, with the global campaigns focused on meeting the WHO cervical cancer elimination targets of 90-70-90, strengthening the diagnostic pathway to optimize early detection by correlating Pap smear, colposcopy, and histopathology findings is considered to be of prime importance (WHO, 2003; Barut et al., 2015).

This study aims to review and synthesize evidence in the comparison and correlation between Pap smear, colposcopy, and histopathology for the assessment of cervical pre-cancer. Through diagnostic accuracy and operational use studies, it intends to establish the most efficient methods of improving early diagnosis, especially in countries where cervical cancer remains a leading cause of female cancer mortality.

METHODS

A narrative review and synthesis were used in this process to examine the diagnostic accuracy and correlation of Pap smear cytology and colposcopy with histopathology in the detection of cervical pre-cancer and cancer. Principal objectives were fulfilled by trying to find the relative sensitivity, specificity, PPV, and NPV of Pap smear and colposcopy, taking histopathology as the gold standard reference.

Literature Search Strategy

In the electronic databases, PubMed, Scopus, Google Scholar, and various institutional repositories were queried. A mixture of classical and recent studies was incorporated into the search from the years 2012 to 2025. Search terms were: "Pap smear AND histopathology," "colposcopy AND histopathology," "cervical intraepithelial neoplasia detection," and "diagnostic accuracy cervical lesions." Boolean operators and Medical Subject Headings (MeSH) were considered to maximize the spectrum of search results. The lists of references of the selected articles were also screened to locate additional references.

Inclusion and Exclusion Criteria

The following **inclusion criteria** were applied:

1. Studies that directly compared **Pap smear and colposcopy** findings with histopathology.
2. Research involving **women with abnormal cytology results, abnormal colposcopic findings, or clinical suspicion of cervical lesions.**
3. Studies reporting at least one diagnostic accuracy parameter (sensitivity, specificity, PPV, NPV).
4. Publications available in **English** between 2012 and 2025.

Exclusion criteria were: case reports, editorials, conference abstracts, studies involving non-human subjects, and studies lacking sufficient diagnostic accuracy data.

Study Selection and Data Extraction

Two independent reviewers screened titles and abstracts for relevance. Full texts of eligible studies were then retrieved and reviewed. Data extracted included: study design, sample size, diagnostic method

applied, histopathological outcomes, sensitivity, specificity, PPV, and NPV values. Where studies reported multiple cytology methods (e.g., conventional Pap smear vs liquid-based cytology), results were extracted separately.

Data Analysis

Given the heterogeneity of study designs, a **qualitative synthesis** approach was adopted rather than a formal meta-analysis. The diagnostic performance of Pap smear and colposcopy was compared against histopathological outcomes, which served as the **gold standard**. Sensitivity was defined as the ability to correctly identify true positives (CIN or cancer cases), while specificity was the ability to correctly identify true negatives (normal findings). PPV and NPV were assessed to evaluate predictive accuracy in clinical practice. Correlation strength between Pap smear, colposcopy, and histopathology was interpreted from reported kappa statistics, concordance rates, and diagnostic agreement.

Ethical Considerations

As this study was a review of previously published research, **no ethical approval** was required. However, only peer-reviewed, methodologically sound studies were included to ensure reliability of the findings.

RESULTS

The analysis of published studies comparing Pap smear, colposcopy, and histopathology revealed variability in the diagnostic accuracy of each modality, with distinct strengths and limitations. The results are summarized under four domains: Pap smear, colposcopy, histopathology, and combined approaches.

Pap Smear

For many decades, Pap smear being the cornerstone in cervical cancer screening, and success across studies is reported for the utility for population-level screening. Reported sensitivity estimates have ranged between 47% and 78%, whereas specificity has mostly remained beyond 85%, making it a highly specific but moderately sensitive test (Najib et al., 2020; Mishra et al., 2013). This suggests that Pap smears tend to miss some cases of cervical intraepithelial neoplasia (CIN) but are quite reliable in finding women who do not have the disease.

False-negative results were commonplace, especially in the cases of high-grade lesions (CIN2 and CIN3), due to sampling errors, obscuring blood or inflammation, and interpretational difficulty. Such limitations reduce its reliability as a true test. The advent of LBC techniques has, however, improved the sensitivity and adequacy of specimens over the use of conventional smears, though LBC is costly and unavailable in resource-poor settings (Jain & Sharma, 2020). Despite the limitations, Pap smear remains cheap and easily deployable for screening purposes, especially in the primary health care system.

Colposcopy

Colposcopy was found to have more sensitivity than the Pap test in CIN and invasive cancer detection. Sensitivity for colposcopy was reported throughout various studies to range between 65% and 92%, making it a highly sensitive diagnostic tool for identifying diseased women (Joshi et al., 2015; Nema et al., 2020). However, specificity for colposcopy ranged only between 45% and 65%, comparatively lower to that of the Pap test. Such lower specificity often comes with false positives, leading to unnecessary biopsies and the apprehension of patients.

The diagnostic value of colposcopy gained immensely on acceptability when colposcopic impressions were subjected to directed biopsy, for the purpose of improving accuracy by way of limiting biopsy specimens to suspicious areas. However, the results remain subject to observer variability because interpretation is very much dependent on the skill and experience of the colposcopist. Some were argued to be overdiagnosed as low-grade lesions, which include overtreatment.

Histopathology

Histopathological examination of cervical biopsies remains the **gold standard** for diagnosing pre-cancerous and cancerous lesions (WHO, 2003). It provides a definitive diagnosis by identifying the grade and extent of dysplasia, carcinoma in situ, or invasive carcinoma. Across studies, histopathology was consistently regarded as essential for confirming findings suggested by cytology or colposcopy (Ukey & Singh, 2021).

Although highly accurate, histopathology requires invasive sampling, specialized laboratory infrastructure, and expert pathologists, making it unsuitable for mass screening. Its role is therefore confirmatory rather than primary in large-scale early detection programs.

Combined Approach

There is a large body of evidence supporting the use of screening methods in the integration process to overcome the limitations brought on by individual techniques. Sabbella (2025) and Dasgupta (2023) pointed out that the combination of Pap smear and colposcopy improves the detection of CIN2+ lesions and decreases false negatives. In fact, the sequential nature of the approach, with an initial screening by Pap smear, colposcopy as a further evaluation, and histopathology as the confirmation, possesses the greatest diagnostic power.

This integrated approach preempts the onset of high-grade lesions so that their treatment may be prevented or performed on time. Consequently, by synergizing the diagnostic techniques, a well-balanced sensitivity and specificity could be attained, which will maximize the false negatives (underdiagnosis) and false positives (overdiagnosis). This synergism will assist preventive programs toward realizing the goal envisaged by WHO, which is the elimination of cervical cancer through effective screening, diagnosis, and treatment pathways.

DISCUSSION

A comparative study of the Pap smear, colposcopy, and histopathology brings forth the complementary nature of these three diagnostic tools in the detection of precancerous and cancerous conditions of the cervix. All give their own strengths and weaknesses in their clinical application. Despite its long history as a first-line test, the Pap smear still suffers from moderate sensitivity and tends to miss high-grade lesions. Its high specificity means that there will be very few cases of false positives, but the danger of false negatives makes this test less reliable when used alone (Karimi-Zarchi et al., 2015). This explains how unless accompanied by other procedures, many cases of CIN or invasive carcinoma go undetected by Pap smear alone.

In contrast, colposcopy has enhanced sensitivity, allowing for better identification of healthy and abnormal cervical epithelium. However, this advantage is at the expense of specificity and can lead to unnecessary biopsy and possible overtreatment (Joshi et al., 2015; Nema et al., 2020). It is operator-dependent, and its accuracy depends on how skillful, trained, and experienced the examiner is. Nonetheless, colposcopy is useful as a second-line diagnostic tool, especially for women with abnormal Pap smears. It improves diagnostic accuracy, particularly when combined with directed biopsy (Najib et al., 2020).

Histopathology remains the primary research method for ascertaining the presence and grade of cervical lesions (Ukey & Singh, 2021). While it is the only definitive method of diagnosis, it directs treatment planning and prognosis. However, its use is limited as a first step screening test due to its invasive technique, reliance on laboratory infrastructure, and high upfront cost. Instead, it is used at the end of the diagnostic pathway to confirm what has been diagnosed.

Put together, evidence tells us that no one method is wholly sufficient to guarantee early detection. The sequential and/or combined approach denotes better diagnostic accuracy. Therefore, the best approach would be to employ Pap smear testing first, next colposcopy for further assessment of abnormal cases, and histopathology for confirmation (Barut et al., 2015). This particular multi-modal approach is ideal in considering sensitivity and specificity, by avoiding missed cases and unnecessary interventions.

Recent innovations have further transformed this diagnostic pathway. Liquid-based cytology offers better specimen adequacy and sensitivity compared to a conventional Pap smear (Jain & Sharma, 2020). On the other hand, HPV DNA testing came into its own as a powerful adjunct, having more sensitivity for the detection of high-risk HPV strains associated with cervical cancer (Dasgupta, 2023). Offered together with traditional methods, they can tremendously improve the impact of any national screening programs.

Major problems still center around affordability, accessibility, and training, especially in LMICs. Many resource-constrained countries function with limited or no trained colposcopists, laboratory infrastructure, or create a sustainable screening program. These barriers must be addressed through policy interventions that focus on capacity building, institutionalized training programs for healthcare providers, and equitable distribution of diagnostic services.

In summarizing, prevention of cervical cancer is not a single technology but a system integrating various diagnostic methods through strengthened healthcare infrastructure. Universal provision and appropriate

application of Pap smear, colposcopy, and histopathology-endorsed by new tools for diagnosis like HPV testing-will prove to be essential measures in bearing down on the global load of cervical cancers.

CONCLUSION

the comparative analysis of Pap smear, colposcopy, and histopathology reveals that the three complement each other in early detection and confirmation of cervical cancer. As far as Pap smear tests are concerned, they represent a well-established method for screening, are highly specific, and cheap, therefore fitting well into the spectrum of national screening programs. Yet, this slight magnitude of sensitivity and relatively high false-negative rate seriously limit the usefulness of the method when used stand-alone. This issue becomes utmost important for the detection of high-grade cervical intraepithelial neoplasia (CIN) since the lag in diagnosis often heavily influences the natural history of the patient.

More sensitive to colposcopy, it is crucial in finding lesions, some of which require biopsy. Its dependence on visual interpretation, however, results in lowered specificity, thus heightening overdiagnosis and unnecessary treatment. A much greater accuracy can be achieved in colposcopy when the results are combined with a directed biopsy, which once again indicates the need for histopathological confirmation.

Histopathology still serves as the gold standard, offering definitive evidence for diagnosis, grading, and staging of cervical neoplasia. Despite being invasive, histopathology is essential to confirm different types of cytological findings and colposcopic findings as well as in the decision of treatment.

Combining these diagnostic modalities-Pap smear for screening, colposcopy for evaluation, histopathology for confirmation-is considered the best approach for truly preventing cervical carcinoma. According to many studies, combining these methods reduces false negatives, enhances early detection of CIN2+ lesions, and enhances preventive outcomes. Now, with the advent of liquid-based cytology and HPV DNA testing, opportunities are available to even improve diagnostic precision and fine-tune intervention.

REFERENCES:

1. Najib, F. S., et al. (2020). Diagnostic Accuracy of Cervical Pap Smear and Colposcopy in Detection of Cervical Premalignant and Malignant Lesions. *Iranian Journal of Pathology*, 15(2), 97-105. <https://pmc.ncbi.nlm.nih.gov/articles/PMC7501362/>
2. Sabbella, A. N. (2025). Comparative Study and Evaluation of Pap Smear and Colposcopy with Histopathology in Cervical Lesions. *Healthcare Bulletin*. Retrieved from <https://healthcare-bulletin.co.uk/article/comparative-study-and-evaluation-of-pap-smear-and-colposcopy-with-histopathology-in-cervical-lesions-2871/>
3. Journal of Barpeta Obstetrics and Gynecology Society. (2021). A comparative study of Pap smear and colposcopy with cervical histopathology in the evaluation of cervical lesions. Retrieved from <https://journal.barpetaogs.co.in/pdf/9925312.pdf>
4. Mishra, R., et al. (2013). Comparison and Correlation of PAP Smear, Colposcopy and Histopathology in the Evaluation of Pre-malignant and Malignant Lesions of Cervix. *International Journal of Health Sciences and Research*, 3(5), 62-71. Retrieved from https://www.ijhsr.org/IJHSR_Vol.3_Issue.5_May2013/10.pdf
5. Joshi, S., et al. (2015). Correlation of Pap Smear and Colposcopy in Relation to Histopathological Findings in Detection of Pre-malignant and Malignant Lesions of Cervix. *International Journal of Scientific Study*, 3(8), 55-60. Retrieved from https://www.ijss-sn.com/uploads/2/0/1/5/20153321/ijss_nov_oa13.pdf
6. Ukey, P., & Singh, S. (2021). Correlation of cervical pap smears with histopathological diagnosis in cervical lesions. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, 10(12), 4478-4481. <https://doi.org/10.18203/2320-1770.ijrcog20214645>
7. Karimi-Zarchi, M., et al. (2015). Comparison of Pap Smear and Colposcopy in Screening for Cervical Cancer. *Journal of Family & Reproductive Health*, 9(4), 207-211. <https://pmc.ncbi.nlm.nih.gov/articles/PMC4700903/>
8. Jain, N., & Sharma, R. (2020). A Comparison of 3 ways of conventional pap smear, liquid based cytology and colposcopy guided biopsy as a screening method for early detection of precursor lesion of ca cervix. *International Journal of Gynaecology*, 4(3), 68-71. <https://www.gynaecologyjournal.com/archives/2020/vol4issue3/B/4-2-73>
9. Nema, P., et al. (2020). Correlation of Pap Smear and Colposcopic Findings in Relation to Histopathological Diagnosis. *International Journal of Contemporary Pathology*, 6(1), 89-94. <https://medicopublication.com/index.php/ijcpath/article/view/11925>
10. Kohale, M., et al. (2024). Diagnostic comparison of Pap smear, colposcopy, and biopsy in cervical intraepithelial neoplasia detection.
11. Consul, S., et al. (2012). The comparative diagnostic accuracy of Pap smear and colposcopy for CIN.
12. Barut, M. U., et al. (2015). Diagnostic value of combined screening tests in cervical cancer.
13. Dasgupta, A. (2023). Early detection strategies for cervical neoplasia: Pap smear, colposcopy, and histology.
14. Ansari, S., et al. (2017). Evaluating diagnostic accuracy of Pap smear and colposcopy for cervical lesions.
15. WHO Classification of Tumors. (2003). *Pathology and Genetics of Tumors of the Breast and Female Genital Organs*.