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Errors and challenges in the collection of the colpocytological exam: a scoping review

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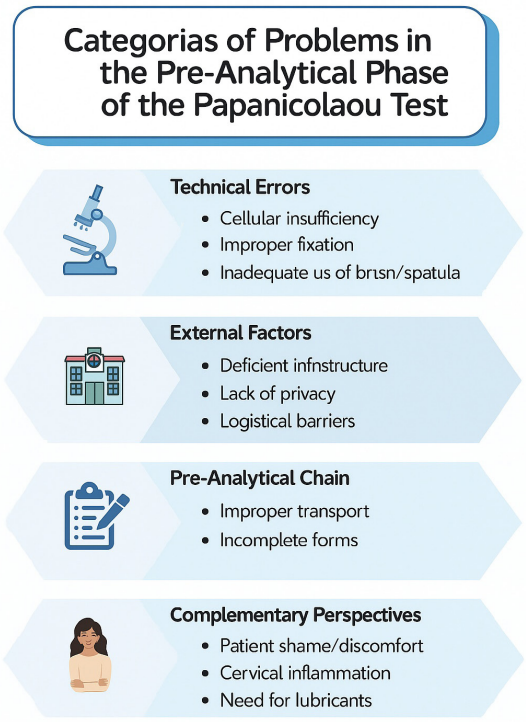
Graphical Abstract



Highlights

- *It was found that 57% of errors occur during the pre-analytical phase of the Papanicolaou test.*
- *Incomplete test requisitions accounted for 38% of the failures.*
- *Sample adequacy increased from 70% to 80% following targeted training.*
- *Adequacy improved to 84% after anti-inflammatory treatment.*

Abstract

Cervical cancer, the third most common malignancy in Brazil, can be screened through the colpocytological exam, whose success depends on proper sample collection and directly impacts the reduction of cases of this disease. Up to 75% of false-negative results stem from failures in the pre-analytical phase, underscoring the need for continuous training of healthcare professionals responsible for sample collection. This study aimed to map the errors and difficulties encountered by professionals during the pre-analytical phase of the colpocytological exam. A scoping review was conducted following the methodology of the Joanna Briggs Institute and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Extension for Scoping Reviews (PRISMA-ScR) guidelines. Searches were carried out in databases and grey literature covering the period from 2013 to 2023. Nine studies were included, revealing technical, structural, and educational problems such as inadequate fixation, improper slide transport, misuse of collection devices, and incomplete requisition forms. External factors, including deficient infrastructure and logistical barriers, were also highlighted. The quality of the colpocytological exam depends on precise sample collection. Training initiatives increase the proportion of satisfactory samples, as observed in Goiânia and Santa Catarina, reducing false negatives. Continuing education and strict quality control, combined with molecular diagnostic technologies, strengthen cervical cancer screening. Strategies such as ongoing training, infrastructure improvements in remote services, and techniques like speculum lubrication have proven promising in reducing errors and improving collection quality. Investments in professional development and the standardization of procedures are crucial to enhancing cervical cancer screening effectiveness.

Keywords: Cytopathology. Quality Control. Training. HPV.

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INTRODUCTION

Cervical cancer (CC) develops slowly; therefore, it can be screened, detected early, and, in most cases, successfully treated with a favorable prognosis. Screening is performed using the colpocytological exam, a non-invasive and cost-effective procedure for the Brazilian Unified Health System (SUS)[1,2,3,4,5]. Excluding non-melanoma skin cancer, CC is the third most common malignancy in Brazil. The Instituto Nacional de Câncer José de Alencar (INCA) estimates for 2023–2025 an annual incidence of 17,010 new cases, with a crude rate of 15.38 per 100,000 women, and the highest incidence observed in the Northern Region (20.48/100,000), particularly in the state of Pará[2].

Two main preventive strategies are adopted: (a) screening for precursor lesions through annual colpocytological exams in the target population (women aged 25–64 years); and (b) diagnosing cancer at an early stage[3]. Adequate sample collection depends on correctly locating the transformation zone, the junction between the ectocervix and endocervix[4].

Pre-analytical errors are among the leading causes of false-negative results, often associated with inadequate collection, delayed fixation, or excessive material. Recent literature indicates that pre- and analytical-phase errors account for a significant portion of the limitations of cytological tests, compromising their diagnostic sensitivity. These findings reinforce the need for internal quality monitoring and systematic communication between laboratories and primary healthcare units regarding rejected samples and unsatisfactory slides[5-6].

Over the past decades, the Brazilian healthcare system has shifted its focus toward health promotion and surveillance actions. In this context, Higher Education Institutions (HEIs) have adopted active learning methodologies that bring students closer to real service settings, such as Problem-Based Learning (PBL), teamwork, and teaching–service integration, contributing to the training of critical professionals committed to SUS[7].

Like any laboratory test, the colpocytological exam involves three phases: pre-analytical, analytical, and post-analytical. The first encompasses the medical request, patient identification and anamnesis, sample collection, fixation, and slide transport, being decisive for diagnostic reliability[8,9]. Errors in this phase — such as incorrect identification, incomplete anamnesis, absence of fixation, or excessive material — reduce test sensitivity, with false-negative rates ranging from 6% to 56%[10]. Reducing these errors requires continuous training and lifelong education[11].

Sample quality depends on the collector's skill, and systematic reviews demonstrate that practical training increases the proportion of satisfactory slides, enhancing early diagnosis. Despite advances, gaps persist in the training of professionals in primary care, including lack of structured internships, insufficient workload, and shortage of qualified instructors[12]. Therefore, improving education through active methodologies and digital resources is essential to enhance technical and scientific quality in cytological collection[13,14,15,16,17,18].

The recent Brazilian Guidelines for Cervical Cancer Screening (Part I), approved by the Ministry of Health, officially incorporate molecular HPV-DNA testing into the organized screening program of SUS, establishing it as the primary triage method for women aged 25 to 64 years[19]. Implementing this guideline requires specialized professional training to properly collect HPV-DNA samples, interpret molecular results, and refer patients according to standardized clinical pathways. To support this transition, INCA launched the "Manual DNA-HPV," an operational guide for health managers and technicians outlining the steps for sample collection, interpretation, triage, and regulation of molecular testing within SUS[20].

Cervical cancer remains one of the main preventable causes of female mortality in Brazil. The World Health Organization[21] aims to eliminate CC as a public health problem by 2030, through the 90–70–90 targets. However, the Northern and Northeastern regions of Brazil still show incidence rates well above these goals[2]. The persistence of such indicators is directly related to low cytological sample quality and weaknesses in the pre-analytical phase. Therefore, improving training and technical competence in cytological collection is a strategic action to reduce regional disparities and increase screening effectiveness.

This study is justified by its focus on the pre-analytical phase of the colpocytological exam, recognized as a critical point for diagnostic reliability. Recent research has shown that failures in sample collection, fixation, and slide identification are the main causes of false negatives[6,22]. In this regard, active learning and structured training have been identified as effective interventions to correct technical deficiencies and enhance practical skills[17 18].

Thus, developing and evaluating educational strategies based on active methodologies for cytological collection training is relevant, timely, and aligned with Brazil's goals for cervical cancer elimination.

METHODS

A scoping review of the literature was conducted following the methodology recommended by the Joanna Briggs Institute (JBI)[23]. To ensure transparency in reporting, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[24] was applied, which is specifically designed for scoping reviews.

The study was registered in the Open Science Framework (OSF) under DOI: https://doi.org/10.17605/OSF.IO/2AXUK.

Inclusion criteria comprised publications in Portuguese, English, and Spanish with experimental and quasi-experimental designs, including randomized controlled trials, non-randomized controlled trials, before-and-after studies, and interrupted time series. Analytical observational studies were also considered, such as prospective and retrospective cohort studies, case-control studies, and analytical cross-sectional studies, as well as descriptive observational designs, including case series, single case reports, and descriptive cross-sectional studies. The time frame was restricted to the period from 2013 to 2023 in order to map the most recent publications. Duplicated studies, those not available in full text, reviews, editorials, letters to the editor, and opinion articles were excluded.

The search for publications was carried out in October 2024 across the Scopus, PubMed, Embase, Biblioteca Virtual em Saúde do Brasil (BVS), and Web of Science databases. Grey literature was identified through Google Scholar and the Brazilian Digital Library of Theses and Dissertations.

The PCC strategy (Population, Concept, and Context)[23] was employed to formulate the research question:

- P (Population): healthcare professionals involved in the collection and processing of colpocytological samples, and patients undergoing colpocytological exams;
- C (Concept): errors and challenges in the pre-analytical phase of the colpocytological exam and issues related to the request, collection, identification, and preparation of samples;
- C (Context): laboratory environment, pre-analytical phase protocols and guidelines, technologies, and equipment used in sample collection and processing.

Accordingly, this review sought to answer the following question: What are the difficulties and errors encountered by healthcare professionals during the pre-analytical phase of the colpocytological exam?

For the development of the search strategy in the databases, the terms corresponding to each component of the acronym were used, based on the MeSH/DeCS (Medical Subject Headings/Descritores em Ciências da Saúde) descriptors, as shown in Table 1.

Table 1 – Descriptors used for the search strategy. Parauapebas, Pará, Brazil, october 2024.

Descriptors	Population	Concept	Context
DeCS	Physicians, health professionals, healthcare providers, nurses, laboratory technicians, cytotechnologists, patients, women, female population	Pre-analytical errors, pre-analytical difficulties, specimen collection errors, incorrect identification, inadequate preparation, sample collection, biological specimens, Papanicolaou smear	Clinical laboratory, pathology service, healthcare facilities, collection protocols, pre-analytical guidelines, standardization
MeSH	Physicians, health personnel, healthcare providers, nurses, laboratory technicians, cytotechnologists, patients, women, female population	Pre-analytic errors, pre-analytical issues, specimen collection errors, incorrect identification, improper preparation, specimen collection, biological specimens, Pap test, Papanicolaou test	Clinical laboratory services, pathology departments, health facilities, collection protocols, pre-analytic guidelines, standardization
EMTREE	Doctors, health personnel, healthcare workers, nursing staff, laboratory technicians, cytotechnologists, patients, women, female	Preanalytical error, specimen collection errors, incorrect identification, inadequate sample preparation, sample collection, biological specimen, Pap smear	Clinical laboratory service, pathology services, healthcare facility, sample collection protocols, preanalytical guidelines, standardization

Source: Authors, 2024.

To ensure the replicability of the research, search strategies were defined and developed by one of the researchers, combining the descriptors with the Boolean operators AND and OR.

The selection of studies included in the review occurred in four stages:

(1) removal of duplicates;

(2) preliminary screening through title and abstract analysis;

(3) full-text reading of the preselected studies; and

(4) summarization and categorization of findings.

During the duplicate removal stage, the reference manager Mendeley[25] was used. Subsequently, the records were exported to Rayyan[26] software, where a second duplicate check was performed, followed by the application of eligibility criteria and screening of titles and abstracts by two independent reviewers in a blinded manner. Discrepancies were resolved through discussion between the reviewers, and in cases without consensus, a third evaluator participated in the decision-making process.

Data extraction was conducted by two independent reviewers, also in a blinded manner, and recorded in a Microsoft Excel® spreadsheet. The extracted information included authorship, country of origin, year of publication, study objective, method, setting, population, and sample size, as well as errors and difficulties in colpocytological sample collection, and other data relevant to answering the research question.

The final stage of the study consisted of data summarization, creation of a word cloud, and thematic analysis. This analysis was supported by the ChatGPT artificial intelligence tool developed by OpenAI[27].

It is important to note that complementary assessments of evidence quality, such as sensitivity analyses, subgroup analyses, or meta-regression, are not required in this type of study, according to JBI methodology[23]. The PRISMA-ScR[24] framework establishes that scoping reviews aim to provide an overview of the available evidence, without evaluating the methodological quality of the included studies or assessing risk of bias.

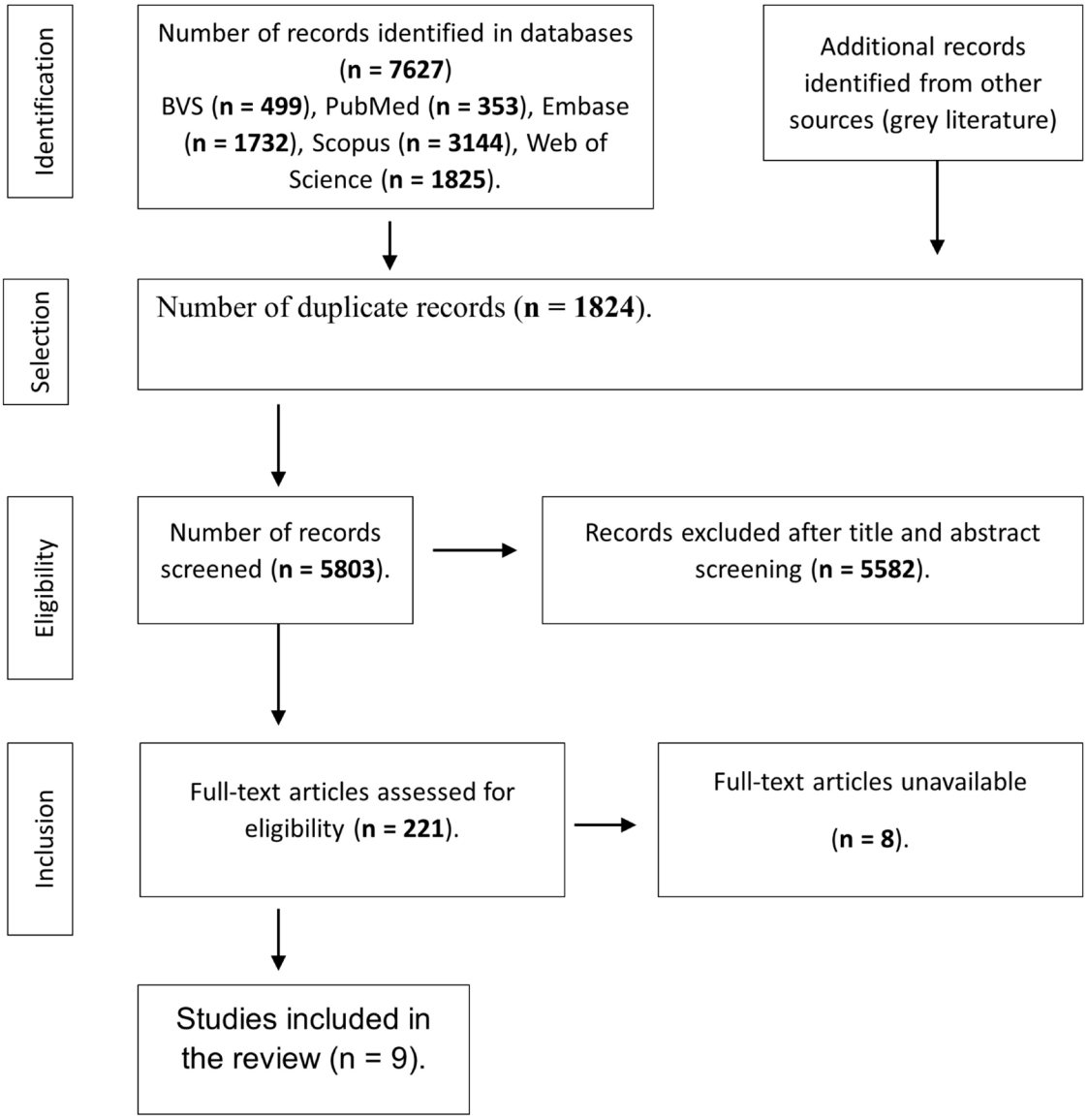
Since this study is a literature review without direct involvement of human participants or use of individualized data, it was exempted from ethical review by a Research Ethics Committee, in accordance with Resolution No. 510/2016 of the Brazilian National Health Council.

RESULTS

The initial identification process yielded a total of 7,627 records, including 74 from grey literature. After duplicate removal, 5,803 studies remained. Title and abstract screening resulted in 221 articles selected for full-text reading. Of these, eight were unavailable in full text and were therefore excluded. Consequently, nine studies were ultimately included in this review.

The complete details of the search and selection process are illustrated in the PRISMA-ScR[2] flow diagram presented in Figure 1.

In the fourth selection stage, the main pieces of evidence were categorized and synthesized, as presented in Table 2, which summarizes the outcome of the article selection process. This table concisely highlights the key findings of the studies included in the review.



Source: Authors, 2024.

Figure 1 – Flowchart of publication selection. Parauapebas, Pará, Brazil, October 2024.

Source: Authors, 2024.

Figure 2 – Word cloud of the selected articles. Parauapebas, Pará, Brazil, october 2024.

Table 2 - Summary of Study Selection Results. Parauapebas, Pará, Brazil, october 2024.

Article	Country	Objective	Sample	Results
A1[28]	India	To provide a practical, evidence-based overview of the main aspects related to the collection and preparation of Papanicolaou smears.	Not provided	The study highlights best practices for Pap smear collection and preparation, preventing errors and ensuring greater diagnostic accuracy.
A2[29]	Taiwan	To propose a modified technique using saline lubrication and two slides to reduce the rate of inadequate exams.	1,207 (patients)	The technique proved effective in reducing the rate of inadequate samples using simple and low-cost methods.
A3[30]	India	To study the pre-analytical phase of quality management in an ISO 15189:2012-certified cytopathology laboratory, identify its causes, and propose improvements to ensure quality, patient satisfaction, and adequate professional training.	20,130 (tests)	Total errors were observed in 7.1% of samples, 57% of which occurred in the pre-analytical phase. The most common error was incomplete or incorrect completion of requisition forms (38% of pre-analytical errors). A gradual decrease in errors was observed over time.
A4[31]	Brazil	To evaluate the effect of lubricant use during sample collection, analyzing sample quality, artifact presence, results, and patient discomfort.	83 (patients)	The use of liquid petroleum jelly during collection did not compromise sample quality and significantly reduced patient discomfort.
A5[32]	Poland	To assess improvement in adequacy and accuracy of conventional cytological exams in women who received anti-inflammatory treatment after initial inadequate results due to severe inflammation.	581 (patients)	Anti-inflammatory treatment followed by recollection improved adequacy in 84% of cases, identifying 3.48% positive lesions, including one case of squamous carcinoma.
A6[33]	Taiwan	To investigate the quality and factors affecting the adequacy of cervical smears collected in mobile screening services in remote areas, compared with smears from medical offices.	5,670 (tests)	Cervical smears collected in mobile services showed lower adequacy rates and were more often compromised by the absence of endocervical components, highlighting the need to improve collection techniques to increase diagnostic sensitivity.
A7[34]	United Kingdom	To evaluate the transformation zone sampling rate (TZSR) as a performance indicator for liquid-based cervical cytology collection and to implement training interventions to improve the performance of professionals with low TZSR.	175 (professionals)	The mean TZSR was 70%, with 18 professionals below the 10th percentile (44%). The main causes were insufficient pressure on the brush (14 cases) and difficulty visualizing the cervix. After personalized training, 72% of these professionals improved, demonstrating the effectiveness of targeted intervention.
A8[35]	Brazil	To identify spatial patterns in Pap smear adequacy in northeastern Brazil and propose improvements to reduce regional inequalities.	2,745,379 (tests)	The study identified an overall adequacy rate of 80.6%, with the best results in Alagoas (85.9%) and Sergipe (84.2%), and the lowest in Maranhão (70.3%) and Piauí (74.8%). It highlighted limited professional training, infrastructure deficiencies, and absence of the endocervical component as major challenges to improving exam quality.
A9[36]	Brazil	To analyze the perceptions of nursing students regarding the collection procedure for colpocytological material during professional training in primary healthcare.	14 (students)	The students recognized the importance of practical experience during training but faced difficulties due to women's resistance, particularly toward male interns. They proposed strategies such as awareness campaigns and professional conduct to overcome these barriers.

Source: Authors, 2024.

Of the nine studies included, 66.67% (n = 6) were published in English, and Brazil was the country with the highest number of publications, representing 33.33% (n = 3). The studies presented diverse methodological approaches, including descriptive reviews on collection practices[28], ret-

rospective studies focused on improving sample adequacy and reducing errors[29,32], qualitative and quantitative analyses of pre-analytical phases[30], cross-sectional investigations on comfort and collection quality[31], individual performance audits[34], and ecological and qualitative studies addressing factors and perceptions related to the colpocytological exam[33,35,36].

A word frequency analysis was performed on the text corpus of the included studies using a text mining technique[37]. The most recurrent terms were identified and visualized through a word cloud, providing a graphical representation proportional to term frequency, as illustrated in Figure 2.

The scope review identified several errors and difficulties associated with the collection of the colpocytological exam, grouped into four main categories, as shown in Table 3.

Table 3 - Main Categories of Errors and Difficulties in Colpocytological Sample Collection. Parauapebas, Pará, Brazil, october 2024.

Category of Analysis	Errors and Difficulties in Colpocytological Collection	Related Articles
1. Technical errors directly related to collection	Cellular insufficiency	A1, A6, A7
	Improper fixation	A1, A2
	Interfering substances in the sample	A2, A5
	Inadequate use of collection devices	A7
2. External factors	Inadequate infrastructure	A6, A8
	Lack of privacy	
	Transportation difficulties	
3. Problems in the pre-analytical chain	Improper transport	A3.
	Incorrect completion of requisition forms	
4. Complementary perspectives	Shame and discomfort	A4, A5, A9
	Use of lubricants	
	Impact of inflammatory conditions	

DISCUSSION

The quality of the colpocytological exam is essential for effective cervical cancer screening, particularly in regions with high incidence rates and limited resources. The accuracy of this test depends on the professional's ability to perform proper sample collection, minimizing errors in the pre-analytical and analytical phases[1,4,8,9,10,13]. Errors at any stage may lead to false-negative results, with serious implications for public health[38].

Evidence indicates that training programs have a significant impact on improving sample quality and reducing technical errors. For example, a training program conducted in Goiânia increased the proportion of satisfactory samples from 70.4% to 80.2%, while reducing obscuring factors such as blood and drying artifacts[39]. Similar results were observed in Santa Catarina, where the representation of endocervical cells rose from 55.39% to 85.03% after training[40].

The integrative review demonstrates that insufficient professional training is one of the main factors associated with false-negative results, reinforcing the need for continuous and specialized training[41]. The pre-analytical phase is decisive for the success of the colpocytological exam since failures such as improper fixation, desiccation, or excessive material directly affect the analysis and interpretation of samples[42]. To mitigate these errors, the implementation of quality control programs and continuing education initiatives is recommended, in accordance with international quality standards[43].

Continuing health education is fundamental for transforming professional practices and ensuring better outcomes[44]. In international contexts, training programs for visual inspection of the cervix with acetic acid have demonstrated effectiveness in low- and middle-income countries, highlighting the importance of practical and context-sensitive approaches[45].

Advances in technologies such as molecular methodologies and artificial intelligence complement professional training and enhance diagnostic accuracy. HPV-based methods and specific staining techniques, such as p16/Ki-67, show potential to reduce false-negative results; however, adequate technical training remains indispensable for their correct application[38].

CONCLUSION

This study revealed that errors and difficulties in colpocytological sample collection are largely influenced by technical, structural, and educational factors. The main causes identified include insufficient professional training, inadequate infrastructure, and pre-analytical phase errors such as improper fixation, inadequate slide transport, and incorrect completion of requisition forms. These factors are directly associated with reduced diagnostic sensitivity and increased occurrence of false-negative results.

Strategies such as continuous professional training, infrastructure improvements in remote and mobile services, and enhancement of collection techniques such as speculum lubrication are promising. Additionally, the implementation of quality control programs and the use of complementary technologies, including molecular methodologies, can enhance diagnostic accuracy and the overall effectiveness of cervical cancer screening.

There is, therefore, an urgent need for investment in professional training, standardization of procedures, and improvement of healthcare service infrastructure to optimize the quality of colpocytological exams. Undergraduate curricula should also be improved to include early exposure of students to the exam context during the basic training cycle, rather than only in supervised internships.

Beyond technical training for sample collection, it is essential that future professionals develop the ability to communicate effectively with the population, providing education on prevention, vaccination, and the consequences of HPV.

As a limitation of this study, despite efforts to include grey literature, some relevant works may not have been identified due to database restrictions. The focus of this review was the pre-analytical phase; therefore, the analytical and post-analytical stages were not comprehensively addressed, even though they also influence test outcomes. It is also noteworthy that the predominance of studies conducted in Brazil and middle-income countries may limit the generalizability of the findings to high-income settings or those with different healthcare systems.

CRediT author statement

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All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the workreported in this paper.

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