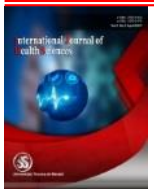


International Journal of Health Sciences

Available online at www.sciencescholar.us
Vol. 10 No. 2, August 2026, pages: 184-195
E-ISSN: 2550-696X
https://doi.org/10.53730/ijhs.v10n2.15984

Cervical Cytomorphological Patterns in Postmenopausal Women Aged 45–60 Years: A Comparative Pap Smear Study

Suhas K. Thazha [a], Sukesh [b], Shalini Kuruvilla [c], Shashidhar Kotian [d], Bibin Scaria [e]

Manuscript submitted: 27 April 2026, Manuscript revised: 09 June 2026, Accepted for publication: 16 July 2026

Corresponding Author [a]

Keywords

bethesda system;
cervical cancer screening;
cervical cytology;
cytomorphology;
epithelial atrophy;
pap smear;
postmenopausal women;

Abstract

Background: Menopause is associated with a progressive decline in estrogen production that influences the structure, maturation, and exfoliation of cervical epithelial cells. These changes may appear in cervical smears as epithelial atrophy, inflammation, reduced cellularity, and degenerative alterations. Atrophic cellular patterns may occasionally resemble epithelial atypia, creating diagnostic challenges. Evidence comparing cervical cytomorphological findings among symptomatic and asymptomatic postmenopausal women remains limited, particularly in community-based populations. **Methods:** A prospective comparative observational study was conducted from 2023 to 2025 among 300 naturally postmenopausal women aged 45–60 years who participated in a community-based cervical cancer screening programme in Kerala, India. Participants were categorized into women with postmenopausal syndromes (n = 149) and women without postmenopausal syndromes (n = 151). Conventional cervical smears were collected, immediately fixed in 85% isopropyl alcohol, stained using the Papanicolaou technique, and evaluated according to the 2014 Bethesda System for Reporting Cervical Cytology. Cytomorphological findings were analysed by age and postmenopausal symptom status, using frequencies and percentages. **Results:** Atrophic smears were the most frequent cytomorphological finding and were observed in 123 women (41.0%). Normal cytology was identified in 100 women (33.3%), inflammatory smears in 50 (16.7%), and atrophic smears with inflammation in 23 (7.7%). One woman (0.3%) had a low-grade squamous intraepithelial lesion, two women (0.7%) showed cytological features of malignancy, and one smear (0.3%) was unsatisfactory. Overall, 296 smears (98.7%) were negative for intraepithelial lesion or malignancy. Normal cytology decreased from 73.8% among women aged 45–50 years to 5.4% among those aged 55–

[a] Department of Allied Health Sciences, Srinivas Institute of Medical Sciences and Research Centre, Srinivas University, Mangalore, India
[b] Department of Pathology, Srinivas Institute of Medical Sciences and Research Centre, Srinivas University, Mangalore, India
[c] Department of Pathology, MIMS College of Allied Health Sciences, Malappuram, Kerala, India
[d] Research Centre, Srinivas University, Mangalore, India
[e] Department of Medical Laboratory Technology, AKG Co-operative Institute of Health Sciences, Kannur, India

60 years. Atrophic and inflammatory changes became more frequent with advancing age. The LSIL case and both malignant findings occurred exclusively among women aged 55–60 years. Cytomorphological distributions were comparable between symptomatic and asymptomatic women. **Conclusion:** Benign atrophic and inflammatory changes constituted the majority of cervical cytological findings among postmenopausal women. Age-related changes were more apparent than differences associated with postmenopausal symptom status. Although epithelial abnormalities were uncommon, their occurrence among women aged 55–60 years highlights the importance of appropriate cervical screening and careful cytological assessment in later postmenopause.

Contents

1 Introduction

Cervical cancer remains an important global health concern despite being largely preventable through vaccination, screening, early diagnosis, and appropriate treatment. The burden is disproportionately high in low- and middle-income countries, where organized screening programmes and timely follow-up services may be less accessible. Persistent infection with oncogenic human papillomavirus is the principal cause of cervical precancer and invasive cervical carcinoma. However, the effectiveness of screening also depends on age, previous screening history, specimen quality, accessibility of the transformation zone, and the ability to distinguish physiological cellular changes from genuine epithelial abnormalities (Arbyn et al., 2020; Sung et al., 2021).

The Papanicolaou smear has contributed substantially to reducing cervical cancer incidence and mortality by enabling the detection of premalignant epithelial changes before progression to invasive disease. Although HPV-based screening is increasingly recommended, conventional cervical cytology remains widely used in many healthcare settings because it is affordable, accessible, and supported by established laboratory expertise. In addition to detecting epithelial abnormalities, cervical cytology provides information regarding inflammation, epithelial maturation, hormonal status, and other benign cellular changes (Fontham et al., 2020; World Health Organization [WHO], 2021).

Interpretation of cervical cytology becomes more challenging after menopause. The decline in ovarian estrogen production affects epithelial proliferation and maturation within the cervix and vagina. During reproductive life, estrogen promotes the maturation of squamous epithelial cells into intermediate and superficial cell layers. Following menopause, reduced estrogen stimulation leads to epithelial thinning,

diminished superficial-cell maturation, and an increased representation of parabasal cells. These alterations commonly produce an atrophic cytological pattern (Nayar & Wilbur, 2015, 2023).

Atrophic epithelial cells may demonstrate relatively large nuclei, scant cytoplasm, mild hyperchromasia, cellular crowding, and degenerative changes. In smears with marked inflammation or poor preservation, these benign alterations may resemble atypical squamous cells or high-grade squamous intraepithelial lesions. Conversely, inflammation, degeneration, and low cellularity may obscure abnormal epithelial cells. Accurate interpretation therefore requires familiarity with the expected cytomorphological effects of menopause and careful evaluation of nuclear features, cellular arrangement, and the smear background (Cibas & Ducatman, 2020; Nayar & Wilbur, 2015).

Menopause also alters the anatomy of the cervix. The squamocolumnar junction gradually retracts into the endocervical canal, making the transformation zone more difficult to visualize and sample. Reduced epithelial exfoliation, cervical narrowing, and mucosal fragility may further influence specimen adequacy. Appropriate sampling and immediate fixation are therefore particularly important when cervical smears are collected from postmenopausal women (Nayar & Wilbur, 2023).

The clinical experience of menopause varies considerably. Some women report vasomotor, psychological, urogenital, or musculoskeletal symptoms, whereas others remain relatively asymptomatic. Although estrogen deficiency contributes to both menopausal symptoms and cervical epithelial atrophy, the relationship between symptom status and cervical cytomorphology remains uncertain. Symptom expression is influenced by biological sensitivity, lifestyle, psychological factors, cultural perceptions, and health-seeking behaviour and may not directly reflect the degree of cervical epithelial change (Monteleone et al., 2018; Santoro et al., 2021; Kyrgiou et al., 2007).

Limited evidence is available regarding comparative cervical cytological patterns among symptomatic and asymptomatic postmenopausal women within the same age range. The present study evaluated cervical cytomorphological findings among naturally postmenopausal women aged 45–60 years and compared Pap-smear patterns according to age and the presence or absence of postmenopausal syndromes (Compston et al., 2009).

2 Materials and Methods

Study design and setting

A prospective comparative observational study was conducted from 2023 to 2025. Participants were recruited through a community-based women's health and cervical cancer screening programme conducted in Kozhikode District, Kerala, India. Cervical specimens were processed and evaluated in the Department of Pathology of a tertiary-care hospital.

Study population

The study included 300 naturally postmenopausal women aged 45–60 years. Natural menopause was defined as the absence of menstruation for at least 12 consecutive months without another physiological or pathological explanation.

Participants were categorized according to postmenopausal symptom status. Group I included 149 women with postmenopausal syndromes, while Group II included 151 women without postmenopausal syndromes.

Women aged 45–60 years who had undergone natural menopause, were clinically suitable for cervical examination, provided written informed consent, and had complete clinical information were eligible for participation.

Women with surgically or medically induced menopause, previous hysterectomy, known cervical carcinoma, current hormone replacement therapy, previous chemotherapy or pelvic radiotherapy, active genital bleeding, acute genital infection interfering with cervical sampling, incomplete study information, or unwillingness to participate were excluded.

Clinical assessment

Demographic and clinical information was collected using a structured data collection form. Age, menopausal status, relevant medical history, and the presence of postmenopausal symptoms were documented. Women

reporting vasomotor, psychological, urogenital, musculoskeletal, or related menopausal manifestations were categorized as symptomatic.

Cervical smear collection and processing

Participants underwent cervical examination using a sterile speculum. Excess mucus or discharge was gently removed without causing epithelial injury. Minimal water-based lubricant was used when required and was kept away from the cervical sampling area.

Cervical cells were collected using an Ayre's spatula. The spatula was positioned at the external cervical os and rotated through 360 degrees to obtain epithelial material from the ectocervix and transformation-zone region. Particular attention was given to obtaining representative material because the squamocolumnar junction commonly retracts into the endocervical canal after menopause.

The collected material was transferred immediately to a clean glass slide and spread evenly. Smears were fixed without delay in 85% isopropyl alcohol for approximately 15 minutes to prevent air-drying artefacts.

Slides were stained using the conventional Papanicolaou technique. The staining procedure included Harris haematoxylin for nuclear staining, Orange G and EA-50 for cytoplasmic differentiation, graded alcohol dehydration, xylene clearing, and DPX mounting.

Cytological evaluation

Stained smears were examined using a binocular light microscope. Initial screening was performed under low magnification to evaluate cellularity, smear background, inflammation, cellular distribution, and possible abnormal areas. Nuclear and cytoplasmic features were assessed under higher magnification when required. Specimen adequacy and cytological findings were reported according to the 2014 Bethesda System for Reporting Cervical Cytology (Nayar & Wilbur, 2015). Findings were categorized as normal cytology, atrophic smear, atrophic smear with inflammation, inflammatory smear, low-grade squamous intraepithelial lesion, cytological features of malignancy, or unsatisfactory for evaluation. Normal, atrophic, atrophic-inflammatory, and inflammatory smears were included within the broader Bethesda category of negative for intraepithelial lesion or malignancy.

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences, version 21. Categorical variables were summarized as frequencies and percentages. Cervical cytomorphological patterns were examined according to age group and postmenopausal symptom status. Because LSIL, malignant, and unsatisfactory findings occurred in very small numbers, the results were interpreted primarily using descriptive comparisons. Statistical conclusions were not inferred from rare categories with sparse observations.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee of Srinivas University. Participants received information regarding the study purpose and procedures before enrolment. Written informed consent was obtained from all participants. Confidentiality was maintained through unique study identification codes. The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable national ethical guidelines.

3 Results and Discussions

3.1 Results

A total of 300 naturally postmenopausal women aged 45–60 years were included. The largest proportion of participants belonged to the 50–55-year age group, comprising 165 women (55.0%). Seventy-four women (24.7%) were aged 55–60 years, while 61 (20.3%) were aged 45–50 years.

Table 1
Age distribution of study participants (n = 300)

Age group	n	%
45–50 years	61	20.3
50–55 years	165	55.0
55–60 years	74	24.7
Total	300	100.0

Atrophic cytology was the most frequent finding and was identified in 123 women (41.0%). Normal cytology was observed in 100 women (33.3%). Inflammatory smears were reported in 50 women (16.7%), while 23 women (7.7%) demonstrated epithelial atrophy accompanied by inflammation. One participant (0.3%) had LSIL, two women (0.7%) showed cytological features of malignancy, and one smear (0.3%) was unsatisfactory because of inadequate cellularity.

Table 2
Overall distribution of cervical cytomorphological findings (n = 300)

Cytomorphological finding	n	%
Normal cytology	100	33.3
Atrophic smear	123	41.0
Atrophic smear with inflammation	23	7.7
Inflammatory smear	50	16.7
LSIL	1	0.3
Unsatisfactory smear	1	0.3
Malignancy	2	0.7
Total	300	100.0

Overall, 296 smears (98.7%) were classified as negative for intraepithelial lesion or malignancy. One smear was categorized as LSIL, two demonstrated malignant cytological features, and one was unsatisfactory.

Table 3
Bethesda classification of cervical smears (n = 300)

Bethesda category	n	%
Negative for intraepithelial lesion or malignancy	296	98.7
Low-grade squamous intraepithelial lesion	1	0.3
Malignancy	2	0.7
Unsatisfactory	1	0.3
Total	300	100.0

Cytomorphological findings differed across age groups. Among women aged 45–50 years, normal cytology was the predominant pattern and was observed in 45 of 61 participants (73.8%). Atrophic smears were identified in 10 women (16.4%), atrophic-inflammatory smears in four (6.6%), and inflammatory smears in two (3.3%). No epithelial abnormalities or malignant findings occurred in this age group.

Among women aged 50–55 years, atrophic cytology was the most frequent finding and was identified in 84 of 165 participants (50.9%). Normal smears occurred in 51 women (30.9%), inflammatory smears in 19 (11.5%), and atrophic-inflammatory smears in 10 (6.1%). One specimen (0.6%) was unsatisfactory. Among women aged 55–60 years, normal cytology was observed in only four of 74 participants (5.4%). Atrophic and inflammatory smears were each identified in 29 women (39.2%), while nine women (12.2%) showed atrophy with inflammation. The single LSIL case and both malignant findings occurred in this age group.

Table 4
Age-wise distribution of cervical cytomorphological findings (n = 300)

Cytomorphological finding	45–50 years, n (%)	50–55 years, n (%)	55–60 years, n (%)	Total
Normal cytology	45 (73.8)	51 (30.9)	4 (5.4)	100
Atrophic smear	10 (16.4)	84 (50.9)	29 (39.2)	123
Atrophic smear with inflammation	4 (6.6)	10 (6.1)	9 (12.2)	23
Inflammatory smear	2 (3.3)	19 (11.5)	29 (39.2)	50
LSIL	0	0	1 (1.4)	1
Unsatisfactory smear	0	1 (0.6)	0	1
Malignancy	0	0	2 (2.7)	2
Total	61 (100.0)	165 (100.0)	74 (100.0)	300

The proportion of normal smears declined markedly with advancing age. In contrast, atrophic and inflammatory changes became increasingly prominent. All epithelial abnormalities were identified among women aged 55–60 years. Among the 149 symptomatic women, atrophic smears were the most frequent finding and occurred in 59 participants (39.6%). Normal cytology was identified in 51 women (34.2%), inflammatory smears in 25 (16.8%), and atrophic-inflammatory smears in 11 (7.4%). One LSIL and one malignant finding were recorded. Among the 151 asymptomatic women, atrophic smears were identified in 64 participants (42.4%), normal cytology in 49 (32.5%), inflammatory smears in 25 (16.6%), and atrophic-inflammatory smears in 12 (7.9%). One malignant finding and one unsatisfactory smear were identified.

Table 5
Cervical cytomorphological findings according to postmenopausal symptom status (n = 300)

Cytomorphological finding	Symptomatic women, n (%)	Asymptomatic women, n (%)	Total, n (%)
Normal cytology	51 (34.2)	49 (32.5)	100 (33.3)
Atrophic smear	59 (39.6)	64 (42.4)	123 (41.0)
Atrophic smear with inflammation	11 (7.4)	12 (7.9)	23 (7.7)
Inflammatory smear	25 (16.8)	25 (16.6)	50 (16.7)
LSIL	1 (0.7)	0	1 (0.3)
Unsatisfactory smear	0	1 (0.7)	1 (0.3)
Malignancy	1 (0.7)	1 (0.7)	2 (0.7)
Total	149 (100.0)	151 (100.0)	300 (100.0)

The overall distributions were closely comparable between symptomatic and asymptomatic women. Atrophic cytology predominated in both groups, while normal, inflammatory, and atrophic-inflammatory findings occurred in similar proportions.

3.2 Discussions

The present study evaluated cervical cytomorphological patterns among 300 naturally postmenopausal women aged 45–60 years and compared findings according to age and postmenopausal symptom status. Atrophic cytology was the predominant pattern, followed by normal cytology, inflammatory changes, and atrophy with inflammation. Most smears were negative for intraepithelial lesion or malignancy. Nevertheless, one LSIL and two malignant cytological findings were detected, demonstrating that clinically significant epithelial abnormalities may occur even when their overall prevalence is low (William et al., 2018).

Atrophic cytology accounted for 41.0% of all smears. When smears showing atrophy with inflammation were included, almost half of the study population demonstrated an atrophic epithelial pattern. This finding is consistent with the expected effects of estrogen deprivation on squamous epithelial maturation. Estrogen supports epithelial proliferation, glycogen accumulation, and maturation toward the intermediate and superficial cell layers. Following menopause, reduced estrogen stimulation leads to thinning of the squamous epithelium and increased representation of basal and parabasal cells (Nayar & Wilbur, 2015).

The cytological interpretation of atrophy requires particular care. Parabasal cells have relatively large nuclei and limited cytoplasm and may occur in cohesive sheets or crowded groups. Degenerative changes, nuclear enlargement, and hyperchromasia may become more apparent when atrophy is accompanied by inflammation. These features can resemble epithelial atypia, particularly when the smear is poorly preserved or contains abundant inflammatory material (Cibas & Ducatman, 2020).

Accurate distinction between atrophy and squamous epithelial abnormalities depends on assessment of chromatin quality, nuclear contour, cellular arrangement, background features, and the overall pattern of epithelial maturation. Awareness of menopausal status provides important clinical context and may reduce unnecessary interpretation of benign atrophic changes as atypical squamous lesions (Nayar & Wilbur, 2023).

Inflammatory changes were also common. Inflammatory smears accounted for 16.7% of the study population, while an additional 7.7% demonstrated atrophy with inflammation. Therefore, almost one-quarter of participants had an inflammatory component in their cervical smears.

The postmenopausal decline in estrogen alters the vaginal and cervical microenvironment. Reduced epithelial glycogen may decrease lactobacillary colonization and increase vaginal pH. At the same time, epithelial thinning and reduced tissue elasticity may increase susceptibility to irritation and minor injury. These changes may contribute to inflammatory backgrounds characterized by neutrophils, cellular debris, degenerating epithelial cells, and reactive cellular alterations (Portman & Gass, 2014).

Inflammation may create difficulties during cytological interpretation. Dense inflammatory material can obscure epithelial cells, while reactive nuclear changes may resemble mild atypia. However, the presence of inflammation should not automatically be interpreted as evidence of infection because hypoestrogenic epithelial injury may itself produce inflammatory changes.

Age was associated with a clear shift in cytomorphological patterns. Normal cytology was identified in 73.8% of women aged 45–50 years but declined to 30.9% among women aged 50–55 years and 5.4% among those aged 55–60 years. In contrast, atrophic and inflammatory findings became more prominent with advancing age.

The higher proportion of normal smears among women aged 45–50 years may reflect a shorter duration since the final menstrual period and partial preservation of estrogen-dependent epithelial maturation. With increasing age and longer exposure to hypoestrogenism, progressive epithelial thinning, reduced maturation, altered local microbiota, and increased tissue fragility may contribute to the predominance of atrophic and inflammatory patterns (Santoro et al., 2021).

Atrophic cytology was most frequent among women aged 50–55 years, affecting approximately half of that age group. Among women aged 55–60 years, atrophic and inflammatory smears were equally frequent. The increasing inflammatory component in the oldest group may reflect the combined effects of prolonged estrogen deficiency, epithelial fragility, altered vaginal ecology, local irritation, and age-related changes in immune function. Hormonal and microbiological investigations were not performed; therefore, these possible mechanisms could not be evaluated directly.

The single LSIL and both malignant cytological findings occurred exclusively among women aged 55–60 years. Although the number of epithelial abnormalities was small, their occurrence in the oldest age group has clinical importance. Cervical cancer risk does not end with menopause. Persistent oncogenic HPV infection

may remain clinically relevant, and women who have not participated regularly in screening may carry undetected cervical lesions into later life (Castle et al., 2005; Gravitt, 2012).

Ageing may also influence HPV persistence and immune control. Previously acquired infections may persist at low levels or become detectable again later in life. Therefore, menopausal status should not be considered protective against cervical precancer or malignancy. Screening decisions should follow applicable age- and risk-based recommendations and should consider previous screening history rather than the presence or absence of menstrual activity.

Cervical screening may become technically more difficult after menopause because the squamocolumnar junction frequently retracts into the endocervical canal. The transformation zone may be incompletely visualized, and abnormal cells may be less likely to appear in an ectocervical sample. Careful sampling of the endocervical region is therefore important, particularly among older women and those with incomplete screening histories (WHO, 2021).

The comparison between symptomatic and asymptomatic women showed closely similar cytomorphological distributions. Atrophic smears were present in 39.6% of symptomatic women and 42.4% of asymptomatic women. Normal cytology, inflammatory changes, and atrophic-inflammatory patterns also occurred in comparable proportions.

These findings suggest that cervical epithelial changes are related primarily to the underlying hypoestrogenic state rather than to the subjective presence of postmenopausal symptoms. Menopausal symptom expression varies widely and is influenced by neuroendocrine responses, tissue sensitivity, psychological factors, lifestyle, cultural perceptions, social circumstances, and health-seeking behaviour (Monteleone et al., 2018; Santoro et al., 2021).

The presence of symptoms may therefore not reflect the degree of cervical epithelial atrophy. Some women may have marked atrophic cytology without experiencing significant menopausal complaints, whereas others may report substantial vasomotor or psychological symptoms despite having relatively preserved cervical epithelial maturation.

Urogenital symptoms may have a closer biological relationship with local epithelial atrophy because both are influenced by estrogen-sensitive tissues. However, the present analysis compared women according to overall symptom status and did not evaluate the relationship between individual symptoms and specific cytomorphological findings. Further studies examining symptom-specific associations may provide additional insight.

The identification of one malignant finding in each group also indicates that the absence of postmenopausal symptoms cannot be used to exclude cervical disease. Cervical precancer and early malignancy may remain asymptomatic. Screening should therefore be offered according to eligibility criteria, risk profile, previous screening history, and current guidelines rather than symptom status alone.

Only one smear was reported as unsatisfactory, producing an inadequacy rate of 0.3%. Obtaining adequate cervical specimens after menopause may be challenging because of reduced epithelial exfoliation, cervical stenosis, mucosal fragility, and retraction of the transformation zone. The low unsatisfactory rate observed in this study may reflect careful cervical visualization, targeted sampling, immediate fixation, standardized staining, and systematic evaluation of specimen adequacy.

However, adequate cellularity does not necessarily confirm representative transformation-zone sampling. The use of appropriate collection devices, including endocervical brushes or broom-type devices where indicated, may improve specimen representation in postmenopausal women (Nayar & Wilbur, 2023).

The findings have practical implications for cytology laboratories and cervical screening programmes. Menopausal status and age should be clearly documented on cytology request forms because these details assist in the interpretation of atrophic cellular patterns. Cytotechnologists and cytopathologists should recognize the range of benign postmenopausal changes while remaining alert to genuine epithelial abnormalities that may be present in a background of atrophy or inflammation.

Women with abnormal or suspicious cytological findings require timely follow-up according to established management guidelines. Depending on the cytological category and individual risk profile, further evaluation may include HPV testing, colposcopy, biopsy, or other appropriate clinical investigations (Perkins et al., 2020). Cytological findings suggestive of malignancy require urgent clinical assessment and histopathological confirmation.

Community-based cervical screening may improve access among women who do not routinely seek preventive healthcare. Educational programmes should address the misconception that cervical screening is unnecessary after menopause. Screening services should also include effective referral and follow-up pathways to ensure that women with abnormal findings receive appropriate evaluation and management.

Strengths and limitations

The study included a relatively large sample of 300 naturally postmenopausal women and achieved nearly equal representation of symptomatic and asymptomatic participants. Community-based recruitment provided an opportunity to evaluate women outside a specialist referral setting. Cervical smears were collected and processed using standardized procedures and interpreted according to the 2014 Bethesda System. Age-wise and symptom-wise analyses provided clinically relevant information regarding the distribution of postmenopausal cervical cytological patterns.

The study also had limitations. It was conducted within a defined geographical population, which may limit the generalizability of the findings. Conventional cytology was used, and high-risk HPV testing was not performed. Histopathological follow-up of LSIL and malignant cytological findings was not included in the present analysis. Hormone levels, vaginal pH, microbiological findings, duration since menopause, and previous cervical screening history were not evaluated. The small number of epithelial abnormalities limited statistical comparison of rare cytological outcomes. In addition, the analysis compared overall symptom status rather than individual postmenopausal symptoms.

4 Conclusion

Cervical cytology among postmenopausal women aged 45–60 years was predominantly characterized by benign atrophic and inflammatory changes. Atrophic smears were the most frequent finding and occurred in similar proportions among women with and without postmenopausal syndromes. Cervical cytomorphological patterns changed substantially with advancing age. Normal cytology became progressively less frequent, while atrophic and inflammatory findings became increasingly prominent. The occurrence of LSIL and malignant cytology exclusively among women aged 55–60 years demonstrates that clinically significant epithelial abnormalities remain relevant during later postmenopause.

The presence of postmenopausal symptoms was not a reliable indicator of cervical cytological status. Eligible women should therefore receive cervical screening according to age, risk factors, previous screening history, and applicable guidelines, irrespective of symptom status. Careful specimen collection, recognition of benign atrophic changes, accurate differentiation from epithelial atypia, and timely follow-up of abnormal results are essential for effective cervical cancer prevention among postmenopausal women.

Declarations

Ethics approval and consent to participate
The study was approved by the Institutional Ethics Committee of Srinivas University. Written informed consent was obtained from all participants before enrolment and cervical-smear collection.

Consent for publication
Not applicable. The manuscript contains no personally identifiable participant information.

Availability of data and materials
The data supporting the findings are available from the corresponding author upon reasonable request and subject to institutional and ethical requirements.

Competing interests
The authors declare that they have no competing interests.

Funding
The study received no external funding.

Authors' contributions
The principal investigator contributed to study conception, participant recruitment, data collection, cervical-smear coordination, data analysis, interpretation, and manuscript preparation. The research supervisors contributed to study design, scientific guidance, interpretation of findings, and critical revision of the manuscript.

Acknowledgements
The authors acknowledge the study participants, community programme organizers, clinical personnel, laboratory staff, and institutional authorities who supported the study.

References

Arbyn, M., Weiderpass, E., Bruni, L., de Sanjosé, S., Saraiya, M., Ferlay, J., & Bray, F. (2020). Estimates of incidence and mortality of cervical cancer in 2018: a worldwide analysis. *The Lancet Global Health*, *8*(2), e191-e203.

Castle, P. E., Schiffman, M., Herrero, R., Hildesheim, A., Rodriguez, A. C., Bratti, M. C., ... & Burk, R. D. (2005). A prospective study of age trends in cervical human papillomavirus acquisition and persistence in Guanacaste, Costa Rica. *The Journal of infectious diseases*, *191*(11), 1808-1816.

Cibas, E. S., & Ducatman, B. S. (2020). *Cytology: Diagnostic principles and clinical correlates* (5th ed.). Elsevier.

Compston, J., Cooper, A., Cooper, C., Francis, R., Kanis, J. A., Marsh, D., ... & Wilkins, M. (2009). Guidelines for the diagnosis and management of osteoporosis in postmenopausal women and men from the age of 50 years in the UK. *Maturitas*, *62*(2), 105-108. https://doi.org/10.1016/j.maturitas.2008.11.022

Fontham, E. T., Wolf, A. M., Church, T. R., Etzioni, R., Flowers, C. R., Herzig, A., ... & Smith, R. A. (2020). Cervical cancer screening for individuals at average risk: 2020 guideline update from the American Cancer Society. *CA: a cancer journal for clinicians*, *70*(5), 321-346.

Gravitt, P. E. (2012). The known unknowns of HPV natural history. *The Journal of Clinical Investigation, 121*(12), 4593–4599.

Kyrgiou, M., Koliopoulos, G., Martin-Hirsch, P., Kehoe, S., Flannelly, G., Mitrou, S., ... & Paraskevaidis, E. (2007). Management of minor cervical cytological abnormalities: a systematic review and a meta-analysis of the literature. *Cancer treatment reviews*, *33*(6), 514-520. https://doi.org/10.1016/j.ctrv.2007.05.002

Monteleone, P., Mascagni, G., Giannini, A., Genazzani, A. R., & Simoncini, T. (2018). Symptoms of menopause—Global prevalence, physiology and implications. *Nature Reviews Endocrinology, 14*(4), 199–215.

Nayar, R., & Wilbur, D. C. (Eds.). (2015). *The Bethesda System for Reporting Cervical Cytology: Definitions, criteria, and explanatory notes* (3rd ed.). Springer.

Nayar, R., & Wilbur, D. C. (Eds.). (2023). *The Bethesda System for Reporting Cervical Cytology: Definitions, criteria, and explanatory notes* (4th ed.). Springer.

Perkins, R. B., Guido, R. S., Castle, P. E., Chelmow, D., Einstein, M. H., García, F., ... & Wentzensen, N. (2020). Directrices de consenso de gestión basada en riesgos de la ASCCP de 2019 para pruebas de detección de cáncer de cuello uterino anormales y precursores del cáncer. *Journal of Lower Genital Tract Disease24*, *2*, 102-131.

Portman, D. J., & Gass, M. L. (2014). Genitourinary syndrome of menopause: new terminology for vulvovaginal atrophy from the International Society for the Study of Women's Sexual Health and the North American Menopause Society. *The journal of sexual medicine*, *11*(12), 2865-2872.

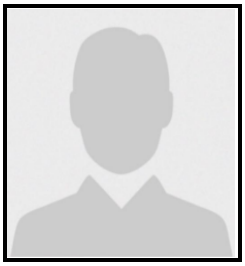
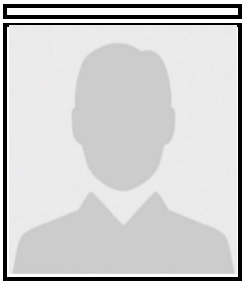
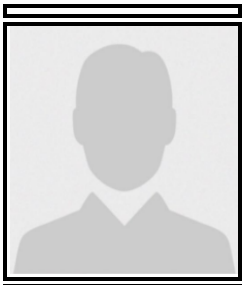
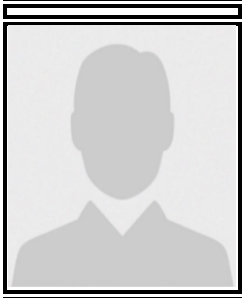
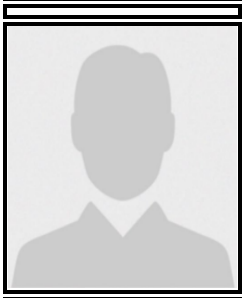
Santoro, N., Roeca, C., Peters, B. A., & Neal-Perry, G. (2021). The menopause transition: Signs, symptoms, and management options. *The Journal of Clinical Endocrinology & Metabolism, 106*(1), 1–15.

Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: a cancer journal for clinicians*, *71*(3), 209-249.

William, W., Ware, A., Basaza-Ejiri, A. H., & Obungoloch, J. (2018). A review of image analysis and machine learning techniques for automated cervical cancer screening from pap-smear images. *Computer methods and programs in biomedicine*, *164*, 15-22. https://doi.org/10.1016/j.cmpb.2018.05.034

World Health Organization. (2021). *WHO guideline for screening and treatment of cervical pre-cancer lesions for cervical cancer prevention* (2nd ed.). World Health Organization.

Biography of Authors

	**Suhas K. Thazha (Corresponding Author)** Research Scholar, Department of Allied Health Sciences, Srinivas Institute of Medical Sciences and Research Centre, Srinivas University, Mangalore, India *Email: suhaskaniyarakkal@gmail.com*
	**Sukesh** Professor, Department of Pathology, Srinivas Institute of Medical Sciences and Research Centre, Srinivas University, Mangalore, India
	**Shalini Kuruvilla** Professor, Department of Pathology, MIMS College of Allied Health Sciences, Malappuram, Kerala, India
	**Shashidhar Kotian** Professor, Research Centre, Srinivas University, Mangalore, India
	**Bibin Scaria** Professor and Head, Department of Medical Laboratory Technology, AKG Co-operative Institute of Health Sciences, Kannur, India