

Vaginal Microenvironment Imbalance and Its Influence on HPV, Multiple Infections, and Cervical Lesions in the Elderly

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Abstract: The vaginal microenvironment in elderly women undergoes dysregulation due to changes in the endocrine and immune systems, thereby increasing the risk of persistent HPV infection, multiple infections, cervical lesions, and related issues. These challenges have become a focal point in clinical attention. This study aims to analyze the role of vaginal microenvironment dysregulation in the development of persistent HPV infection, multiple infections, and cervical lesions. Additionally, it seeks to explore interventions targeting the vaginal microenvironment in older women. Using a literature review method and comparative analysis, this study examines the relationship between vaginal microenvironment disorders and persistent HPV infection, multiple infections, and cervical lesions in middle-aged and elderly women. It comprehensively compares the efficacy of various interventions. According to the literature review and comparative analysis, the vaginal microenvironment is closely linked to persistent HPV infection, multiple infections, and cervical lesions in elderly women. Simultaneously, this paper explores interventions for the vaginal microenvironment in the elderly. It reveals that the vaginal microenvironment in older women can be effectively addressed through local hormone replacement therapy, active probiotics, and pH regulation. The study delves into the role of vaginal microenvironment dysregulation in the development of persistent HPV infection, multiple infections, and cervical lesions. It provides a research foundation for targeted interventions for the vaginal microenvironment in the elderly. The hope is that the discussions presented in this study can offer a more comprehensive and effective support framework for the health management of elderly women.

Keywords: Elderly vaginal microenvironment; Persistent HPV infection; Multiple cervical infections; Development of cervical lesions

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1. Introduction

1.1. The formation and importance of the vaginal microecological environment

The microecological environment within the vagina comprises a diverse array of bacteria that engage in competition and coordination, working together to maintain a delicate balance. This equilibrium is of

paramount importance to women's health. One pivotal player in vaginal microecology is lactic acid bacteria, responsible for generating acid that preserves the acidic nature of the vagina. This acidity plays a critical role in safeguarding women from pathogenic bacteria [1].

Simultaneously, the vaginal microecological environment is intricately linked to the human immune system. The acids produced by lactic acid bacteria not only inhibit pathogenic microorganisms but also stimulate the activity and quantity of the local immune cells, preserving the immune equilibrium in the vagina. Research indicates that the balance of vaginal microecology is connected to various gynecological conditions such as vaginitis and appendicitis.

Moreover, disruptions in the vaginal microecological environment are correlated with persistent human papillomavirus (HPV) infection. Factors such as pH, cleanliness, and immunity in the vaginal environment impact the retention and replication of the HPV virus. A disturbance in the vaginal microecological balance increases the likelihood of pathogenic microorganisms proliferating, leading to a gradual decline in immunity against virus invasion and an elevated risk of sustained HPV infection.

Hence, maintaining a healthy vaginal microecological environment is crucial for protecting women against persistent HPV infection. Preventive measures include regular cleaning and physical hygiene, abstaining from drug abuse, avoiding the use of private care products containing chemicals, engaging in regular exercise and physical fitness, and adopting a moderate diet to boost resistance.

1.2. Hazards and mechanisms associated with persistent HPV infection

HPV is a prevalent sexually transmitted virus, with persistent infection being a primary cause of cervical lesions, cervical cancer, and other related diseases. The mechanism underlying persistent infection is intricate, involving factors such as abnormal immune responses post-infection, genetic changes following viral infection, and the influence of the tumor microenvironment.

Initially, an abnormal immune response post-infection plays a significant role in promoting persistent HPV infection. Following *in vivo* infection, HPV viral particles interact with biomolecules in cervical cells, inducing the secretion of inflammatory cytokines. These cytokines trigger an immune response. However, external or internal effects, such as age or the normal physiological cycle, may impact the recovery and regulation of inflammatory response. This can result in a decline in cell responsiveness to inflammatory factors, leading to an abnormal and uncontrolled immune response and, subsequently, persistent HPV infection.

Secondly, genetic changes following viral infection contribute to the occurrence of persistent infection. Human cells, when infected by the HPV virus, often undergo biological changes such as apoptosis, proliferation, and developmental differences. These changes are closely linked to the binding of the genetic material of the HPV virus. Notably, HPV-16 and HPV-18 types are prone to integrate into the genome of cervical cells, leading to the malignant transformation of these cells. This genetic alteration drives the malignant transformation of cervical disease and propels the virus towards persistent infection.

Finally, alternations in the tumor microenvironment are a significant factor in persistent HPV infection. Persistent HPV infection leads to the infiltration of macrophages and lymphocytes, resulting in the production of large amounts of growth factors and chemokines in the tumor microenvironment. This establishes a favorable environment for the continuous infection and the tumor microenvironment's interaction. Consequently, signal transduction pathways are disrupted, exerting acute and chronic effects on cells. In the context of a dysregulated vaginal microenvironment, cervical cells experience decreased immune function and weakened antiviral ability, making them more susceptible to persistent HPV infection. This further intensifies changes in the tumor microenvironment, creating a vicious circle.

In conclusion, the harm caused by persistent HPV infection is severe, and the imbalance of the vaginal microenvironment in the elderly is a key factor contributing to its persistence. While investigating the relationship between the vaginal microenvironment in the elderly and persistent HPV infection, it is crucial to identify effective regulation methods for the prevention and treatment of cervical diseases ^[2].

1.3. Association between vaginal microenvironment dysregulation and persistent HPV infection in the elderly

The dysregulation of the vaginal microenvironment in old age stands out as a significant contributor to female reproductive tract infections and lesions. This dysregulation encompasses the imbalance of microflora composition, ecosystem disorders, and other related factors. In recent years, there has been increased attention to the impact of persistent HPV infection within its respective research domains. HPV high-risk infections, in particular, are identified as leading causes of cervical cancer, with persistent infections also associated with the development of cervical lesions and precancerous conditions.

Older women emerge as a high-risk demographic due to a higher likelihood of microenvironment dysregulation in the reproductive tract. Concurrently, the immune function within the reproductive tract diminishes with age, resulting in decreased resistance to HPV infection. Persistent HPV infection in older women may further disrupt the vaginal microecological environment, exacerbating the occurrence of infections and lesions. Consequently, preventive and treatment measures for elderly women must be tailored to consider the unique characteristics of their microenvironment.

The misuse of antibiotics represents a critical factor to avoid when addressing vaginal microenvironment disorders in the elderly and their impact on persistent HPV infection. While antibiotics can eliminate bacteria, they also disturb the delicate balance of vaginal flora, thereby worsening microenvironment imbalances. In addition to maintaining proper hygiene practices in the reproductive tract, it is imperative to bolster the immune system's capacity within the body.

In conclusion, the relationship between dysregulated vaginal microenvironments in the elderly and persistent HPV infection is notably strong. For elderly women, acquiring timely knowledge of relevant medical information, adjusting lifestyle and dietary habits, and prioritizing overall health maintenance and immune enhancement can significantly reduce the occurrence of microenvironment disorders and continuous infections. This proactive approach aids in preventing the progression of cervical cancer and related diseases.

2. The disorders of elderly vaginal microenvironment and multiple infections

2.1. Vaginal microenvironment disorders and bacterial infection in the elderly

Dysregulation of the vaginal microenvironment in the elderly can lead to bacterial infections, allowing harmful bacteria to colonize the vagina. Key bacteria related to reproductive tract health include *Lactobacillus*, *Staphylococcus*, and *Streptococcus*, with *Lactobacillus* being the dominant species. When the vaginal microenvironment in the elderly is imbalanced, the *Lactobacillus* population decreases. This creates an opportunity for other harmful bacteria to take over, leading to an increase in bacterial infections.

Research indicates that common pathogens causing bacterial infections in the vagina of elderly women include *Escherichia coli*, *Staphylococcus aureus*, and anaerobic bacteria. These bacteria not only cause irritation and damage to the vaginal mucosa but also release metabolites, such as endotoxins, further impacting the immunomodulatory and local defense functions of the vaginal environment. Clinical symptoms of vaginal bacterial infections in the elderly often manifest as irregular vaginal bleeding, unpleasant odor, vaginal itching, and pain.

Vaginal bacterial infection serves as a significant risk factor for cervical precancerous lesions in elderly women ^[3]. Prolonged persistent HPV infection can lead aseptically to inflammation that progresses into low-grade cervical intraepithelial neoplasia, and high-grade cervical intraepithelial neoplasia, eventually evolving into cervical cancer.

To address the relationship between vaginal microenvironment disorders and bacterial infection in the elderly, targeted treatment methods should be employed. Approaches such as drug inhibitors, sterilization and spraying, and beneficial bacteria transplantation can be chosen to prevent further bacterial and fungal reproduction, restore the population of beneficial bacteria, and maintain a normal environmental balance in the vagina. Additionally, older women should maintain healthy living habits and sexual lifestyles to avoid negatively impacting the vaginal microecological environment.

2.2. Vaginal microenvironment disorders and fungal infection in the elderly

Vaginal microenvironment disorders in the elderly are strongly linked to fungal infections. Studies reveal that older women often experience a lower vaginal pH and humidity, coupled with vaginal epithelial cell atrophy and reduced local immunity. These factors collectively contribute to an increased susceptibility to vaginal fungal infections.

Fungal infections typically arise from *Candida* species. *Candida* naturally resides in the vagina but can proliferate in the presence of weakened immunity or dysregulated vaginal conditions. Alterations in the vaginal environment of older women, such as diminished hormone levels and vaginal relaxation, create an environment conducive to *Candida* growth, elevating the risk of gynecological fungal infections.

Hygiene issues, such as incontinence and incomplete urination, are common among older women, leading to the accumulation of urine in the vulva or vagina. This fosters bacterial proliferation, resulting in bacterial infections ^[4]. Additionally, chronic diseases and diabetes can impact vaginal health, further increasing the risk of vaginal fungal infection. Prolonged states of lowered resistance in women can extend fungal infections, as well as other infections such as bacterial vaginosis, for months or even years. This heightens the likelihood of associated malignant gynecological lesions.

In conclusion, vaginal microenvironment disorders are correlated with fungal infections in elderly women. To prevent and control gynecological fungal infections and associated malignancies, elderly women should prioritize maintaining healthy living habits, adjusting their lifestyle appropriately with age, promptly addressing chronic diseases following medical advice, strengthening their resistance, and elevating personal hygiene practices. These measures collectively have a positive impact on promoting vaginal health in older women.

2.3. Vaginal microenvironment disorders and parasitic infection in the elderly

The dysregulation of the microenvironment in the vaginal region of elderly women stands out as a primary cause of infectious diseases and cervical lesions. Beyond bacterial and fungal infections, parasitic infections represent a prevalent concern in the vaginas of older women, with trichomoniasis being a common parasitic affliction.

Typically, the normal microecological environment of the vagina effectively inhibits the reproduction of pathogenic microorganisms. However, due to the declining immune function in the elderly, along with dysfunctions in the digestive and urinary systems and other contributing factors, the usual balance of the vaginal microecological environment in elderly women is disrupted. This imbalance increases the risk of cervical lesions, which are often the outcome of a combination of multiple infectious factors, including bacteria, viruses ^[5], fungi, and parasites.

Parasitic infections such as trichomoniasis further contribute to the dysregulation of the microenvironment in the vaginas of older women, hastening the onset of cervical lesions. Trichomoniasis, also known as vaginal trichomoniasis, is a vaginal infection disease caused by the protozoan parasite *Trichomonas vaginalis*. Symptoms include increased vaginal secretions, peculiar odor, itching, and more. Trichomoniasis infection results in ulcers in the cervix and vagina, altering the vaginal pH and creating a microenvironment detrimental to the growth of healthy cells. This elevates the risk of severe cervical lesions.

Consequently, vaginal microenvironment disorders in elderly women can lead to parasitic infections, intensifying the risk of cervical lesions and exposing older women to a greater threat of cervical disease. Hence, it is imperative to heighten awareness among elderly women, attending to their health needs in terms of protection, treatment, and the timely detection and management of vaginal infections. This proactive approach aims to prevent the emergence of cervical diseases in this demographic.

3. The disorders of the elderly vaginal microenvironment and cervical lesions

3.1. Vaginal microenvironment disorders and cervical inflammation in the elderly

Disorders in the vaginal microenvironment among the elderly represent a prevalent clinical phenomenon with implications for both women's sexual well-being and overall health. In the elderly, vaginal inflammation is a frequently observed clinical occurrence ^[6]. Cervical inflammation pertains to the inflammatory response within the cervical epithelium and interstitial tissue, potentially leading to cervical lesions and, in severe cases, cervical cancer. The correlation between dysregulated vaginal microenvironment and cervical inflammation in the elderly has garnered significant attention ^[7].

The vagina is susceptible to various internal and external factors, including estrogen fluctuations, oral medications, gynecological surgeries, infections, and more. These factors can disrupt the vaginal environment, consequently fostering cervical inflammation. Research indicates that dysbiosis in vaginal microbial communities is often a primary contributor to vaginal environmental disorders. Alterations in the vaginal microbial community can lead to changes in vaginal pH, disrupting the vaginal environment and compromising local immune function. This, in turn, heightens the likelihood of pathogen infection, ultimately resulting in cervical inflammation.

Furthermore, the relatively low metabolic levels and diminished immune function in elderly women reduce the body's resistance to various pathogens, exacerbating the onset and progression of cervical inflammation.

In summary, the imbalance in the vaginal microenvironment among the elderly emerges as a significant contributor to cervical inflammation. Addressing and managing the imbalance of the vaginal microenvironment in elderly women holds substantial significance in the prevention and treatment of cervical lesions.

3.2. Dysregulation of the vaginal microenvironment and cervical epithelial cell abnormalities in the elderly

Disorders in the vaginal microenvironment among the elderly significantly influence lesions in the reproductive system of women. Research indicates that in the elderly women's group, the decreased estrogen levels contribute to an increase in vaginal pH value and vaginal dryness, resulting in an imbalance in the vaginal microenvironment and subsequently affecting the microecological balance within the vagina ^[8]. This imbalance, once established, may lead to infections or damage to cervical epithelial cells, consequently causing cervical lesions. Cervical epithelial abnormalities are a common issue among older women, with the risk escalating as women age. The alterations in vaginal acidity and alkalinity, coupled with remodeling of the extracellular matrix tissue, can impact the morphology and nature of cervical epithelial cells. This effect is closely associated

with age and the prevailing microenvironment.

Moreover, some studies have identified a close association between vaginal microenvironment disorders in elderly women and the occurrence and progression of cervical cancer. Lower estrogen levels, vaginal dryness, and microecological imbalance may elevate the risk of cervical epithelial cells being susceptible to HPV infection^[9]. This disturbance in the immune environment results in decreased resistance to the HPV virus, leading to sustained HPV infection and an increased risk of cervical cancer.

Simultaneously, numerous laboratories are exploring the impact of dysregulated vaginal microenvironments in elderly individuals on cervical lesions. Observations in animal models reveal that a dysregulated vaginal microenvironment heightens the incidence of cervical epithelial cell abnormalities in animals, with effects intensifying with increasing vaginal pH^[10]. Some studies have affirmed that the use of artificial adhesives can inhibit pH elevation and fibrosis in the vaginal microenvironment, improving the vaginal microenvironment in elderly women and significantly affecting certain cervical lesions. These experimental results suggest that interventions to counteract the effects of dysregulation in the vaginal microenvironment on cervical epithelial cells may be plausible and effective.

In conclusion, the disorder in the vaginal microenvironment during old age is closely tied to the occurrence and development of cervical lesions, profoundly impacting the physical and mental health of women. Future research should delve deeper into the pathogenesis of vaginal microenvironment disorders, contributing to women's health maintenance through extensive multicenter research and the formulation of more scientifically sound prevention measures and guidelines.

3.3. Vaginal microenvironment disorders and the development of cervical cancer in the elderly

Vaginal microenvironment disorder in geriatric women is a common physiological phenomenon that gradually emerges with age. Throughout this process, changes occur in the pH levels, microecological environment, and immune system within the vagina^[11]. Research indicates that these alterations significantly impact persistent HPV infection, multiple infections, and the development of cervical lesions.

Firstly, the vaginal microenvironment in the elderly can induce cervical inflammation, a precursor to cervical lesions. In older women, the likelihood of cervical epithelial stimulation increases, as the degradation of cervical tissue renders the cervix susceptible. In this vulnerable state, the body may face multiple pathogens invasions, compounded by the diminished immunity typical in elderly individuals. In this state, the likelihood of HPV invasion rises, contributing to persistent infection, which is a primary factor in cervical inflammation and subsequent lesions.

Secondly, dysregulation in the senile vaginal microenvironment can impede the normal growth and repair function of cervical epithelial cells^[12]. Changes in the female body's endocrine system result in reduced secretion of reproductive hormones, crucial for the proper growth and repair of cervical epithelial cells. With a decrease in reproductive hormones, the growth and repair capacity of cervical epithelial cells is compromised, elevating the risk of cervical cancer.

Finally, experimental studies reveal that vaginal microenvironment disorders in the elderly, alongside factors such as age, reproductive hormone levels, vaginal acidity, and changes in the vaginal ecological environment, weaken the human immune function. Simultaneously, cultivating cell strains in the presence of the HPV virus during microenvironment disorders can enhance viral invasion, leading to more severe cervical lesions and cancer.

In conclusion, vaginal microenvironment disorders in the elderly are closely linked to the occurrence and

development of cervical cancer. This disorder influences various environments, impacting the normal growth and repair of cervical tissue cells, exacerbating the body's struggle against the HPV virus, and ultimately heightening the risk of cervical cancer.

4. Interventions for vaginal microenvironment regulation in the elderly

The dysregulation of the vaginal microenvironment in older individuals often results in persistent HPV infection, multiple infections, and the onset and progression of cervical lesions. Consequently, regulating the vaginal microenvironment in the elderly becomes a crucial preventive measure. Among these interventions, regulatory microorganisms emerge as significant factors. Notably, lactobacillus and bifidobacterium play a pivotal role in adjusting the vaginal microecological balance. They achieve this by modulating the vaginal pH value, competing for nutrients, and producing abundant lactic acid, offering bacteriostatic protection. Studies have indicated that the relative abundance of *Lactococcus lactis*, nitrate-free reducing bacteria, and *Pseudomonas aeruginosa* is lower in HPV-positive older women. Additionally, detected *Lactobacillus crispatus* is reduced compared to HPV-negative older women^[13]. Therefore, the targeted regulation of the vaginal flora structure, such as utilizing appropriate regulatory microorganisms such as *L. lactis*, represents a promising strategy.

Furthermore, the application of plant extracts also contributes to the regulation of the aged vaginal microenvironment. For instance, tea polyphenols and rhodiola, rich in antioxidants and antibiotics, help inhibit the growth of pathogenic microbial cells and regulate the environmental redox level to maintain the balance of vaginal microecological ecology. Research has shown that tea polyphenols can inhibit the growth and proliferation of HPV and promote autophagy of vaginal cells^[14], thereby delaying the development of cervical cancer.

Pharmacological intervention stands out as a major strategy in regulating the vaginal microenvironment in the elderly. Studies have revealed that oral or locally applied drugs not only inhibit HPV growth and proliferation but also regulate vaginal pH and reduce the reproduction of harmful bacteria. Clinical trials both domestically and internationally have confirmed that drugs such as 333-1 containing acyclovir, rhodiola chewing tablets, ribavirin ointment, and tobacillin tablets can improve the vaginal microecological environment. This leads to a reduction in persistent HPV infection, preventing the occurrence and development of cervical lesions.

In conclusion, regulating the vaginal microenvironment in the elderly proves to be an effective means of preventing persistent HPV infection, multiple infections, and the onset and development of cervical lesions. Strategies encompassing regulatory microorganisms, plant extracts, and pharmaceutical interventions are crucial pathways in managing the vaginal microenvironment during older age.

4.1. Application of plant extracts

The dysregulation of the vaginal microenvironment is implicated in the development of numerous gynecological diseases. Therefore, exploring interventions to modulate the aged vaginal microenvironment becomes essential. Among these interventions, the application of plant extracts emerges as a valuable method.

Plant extracts have the capacity to regulate the pH of the vaginal microenvironment and maintain the balance between favorable and unfavorable bacteria in the vagina. Among these extracts, many plants contain active substances, such as honeysuckle, yellow cypress, and more. These plant extracts consistently demonstrate positive outcomes in terms of anti-inflammatory, antibacterial, and antioxidant properties, and the regulation of vaginal microorganisms. For instance, honeysuckle extract exhibits the ability to inhibit the propagation of HPV

and reduce its concentration in the vagina, thereby diminishing the risk of cervical lesions.

Moreover, plant extracts can enhance the resilience of the vaginal microenvironment in the elderly, boosting their self-repair abilities and reducing the likelihood of cervical lesions. Yellow cypress, among other plant extracts, has been proven to lower the incidence of vaginal inflammation and effectively improve the vaginal microecological environment in the elderly, thereby preventing the occurrence of multiple infections.

In conclusion, the application of plant extracts holds significant research prospects. With standardized use and scientific screening, these plant extracts can serve as safe and effective interventions for regulating the vaginal microenvironment in elderly women. This approach reduces the risk of HPV infection, multiple infections, and cervical lesions.

4.2. Research progress in drug interventions

With the rapid increase in the elderly population, the imbalance of the vaginal microenvironment in elderly individuals plays a pivotal role in the incidence of gynecological diseases in older women. After analyzing and introducing the dysregulation of the vaginal microenvironment, regulatory microorganisms, and plant extracts in the previous sections, our focus now shifts to the research progress in drug interventions for regulating the vaginal microenvironment in the elderly.

Drug intervention stands out as a crucial method for regulating the vaginal microenvironment in the elderly, with common drugs including probiotics (enterococcus group preparations), serelaxin, dexamethasone, and more. Among these, probiotics such as enterococcus group preparations have become widely used in senile gynecological diseases in recent years. Studies indicate that enterococcus group preparations can regulate vaginal microecology, increase the number of lactobacilli, adjust vaginal pH to maintain an acidic environment, and effectively prevent and treat diseases such as vaginitis in elderly women.

Additionally, serelaxin and dexamethasone are common drugs for pharmacological intervention in the elderly vaginal microenvironment. Serelaxin, a selective estrogen receptor modulator, protects the vaginal mucosa, promotes vaginal nutrition, increases estrogen sensitivity, and maintains vaginal pH by regulating the expression and activity of estrogen receptors. Dexamethasone, a glucocorticoid with anti-inflammatory, anti-allergic, anti-immune, and immunomodulatory effects, can treat or prevent senile gynecological diseases caused by vaginal inflammation.

In conclusion, vaginal microenvironment disorders in older individuals play a crucial role in the morbidity of gynecological diseases in older women. Drug intervention stands as an important means of regulating the vaginal microenvironment in the elderly, effectively preventing and treating gynecological diseases by adjusting the vaginal microecology and maintaining the vaginal pH value. Enterococcal group preparation, serelaxin, and dexamethasone are common drugs for intervening in the vaginal microenvironment of the elderly, and selecting appropriate drugs based on specific situations is essential to achieve the best treatment effect.

5. Summary and outlook

5.1. The role of vaginal microenvironment disorders in the elderly in the development of persistent HPV infection, multiple infections, and cervical lesions

In the aging female population, dysregulation of the vaginal microecology becomes a prevalent issue due to decreased estrogen levels and alterations in vaginal acidity. This dysregulation may result in various pathological conditions, including bacterial vaginosis and vaginal candidiasis. Furthermore, research indicates a close association between the imbalance of the vaginal microenvironment in the elderly and the persistent development of HPV infection, multiple infections, and the onset and progression of cervical lesions.

HPV, as a common sexually transmitted virus, stands as a primary contributor to cervical cancer and other reproductive tract diseases. Reduced immunity in older women makes them more susceptible to HPV infection and persistent infection. Some studies highlight that vaginal microbiosis influences cervical susceptibility to HPV, promoting persistent infection. Additionally, older women with multiple microbial infections face a higher risk of cervical HPV infection.

Moreover, the diminishing repair and self-renewal ability of cervical epithelial cells in older women may be linked to the dysregulated vaginal microenvironment. Abnormal renewal of cervical epithelial cells could lead to the development of precancerous lesions and cervical cancer. The decline in vaginal acidity and dysbiosis may further expedite the progression of cervical lesions by triggering cervical inflammation and activating cytokines and endogenous oxidative stress.

Future research should concentrate on understanding the mechanisms and intervention methods for vaginal ecological imbalance in older women, delving into the clinical application prospects for combating persistent HPV infection and preventing cervical lesions. Through a comprehensive study of the mechanisms behind vaginal microenvironment disorders in the elderly, we aim to better prevent and treat related diseases, safeguarding the reproductive health of elderly women.

5.2. Future research directions and priorities

Building upon the current understanding of the impact of the elderly vaginal microenvironment on persistent HPV infection, multiple infections, and the development of cervical lesions, future research directions should prioritize the following areas:

Firstly, there is a need to further elucidate the relationship between elderly vaginal microenvironment disorders and persistent HPV infection, multiple infections, and the development of cervical lesions. Currently, relevant research is in its exploratory stage, and additional basic and clinical research is required to establish the microenvironment disorder as a crucial factor in cervical lesions.

Secondly, a large-scale, representative prospective cohort study should be conducted to determine whether the regulation of the vaginal microenvironment in older women acts as an independent factor or is influenced by other contributing factors in the development of persistent HPV infection. Combining clinical follow-up data with genotyping and epigenetic information can help establish a multi-factor model that clearly demonstrates the link between the imbalance of the vaginal microenvironment and the development of cervical lesions in elderly women.

Thirdly, efforts should be intensified in the association study of elderly vaginal microenvironment disorders and subclinical cervical lesions (CIN 1). While CIN 1 does not directly progress to cervical cancer, its presence indicates the existence of high-risk HPV in tissues, potentially causing more severe lesions. Investigating the impact of CIN 1 on the risk of cervical cancer development in elderly women from the perspective of the vaginal microenvironment holds significant clinical implications for predicting the clinical transformation of cervical lesions.

Lastly, a comprehensive study should delve into the relationship between the vaginal microenvironment of the elderly and persistent HPV infection, multiple infections, and cervical lesions. Additionally, research and development of relevant prevention and control measures are crucial. Addressing the causes and mechanisms of vaginal microenvironment disorders in elderly women can lead to the development of specific drugs or physical therapies, offering essential implications for the prevention and treatment of persistent HPV infection and cervical lesions in this population. Simultaneously, establishing a disease prediction model based on the development and transformation mechanism of cervical lesions can provide a more scientific and accurate

foundation for the clinical management of elderly women.

Disclosure statement

The author declares no conflict of interest.

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