

Review Article

The Potential Role of Vaping in the Increasing Burden of Endometriosis Among Women of Reproductive Age in Sub-Saharan Africa: A Public Health Concern

Kalala Elisee Kabuya^{1,*} , Mukasa Charline Sangany² 

¹Department of Public Health, Africa University, Manicaland-Mutare, Zimbabwe

²Department of Health Science, School of Laboratory of Medicine and Medical Science, University of Kwazulu-Natal, Durban, South Africa

Abstract

The use of electronic nicotine delivery systems (ENDS) is increasing rapidly across Sub-Saharan Africa (SSA), particularly among young women, while endometriosis remains substantially underdiagnosed in the region. Emerging evidence suggests that vaping may influence hormonal, inflammatory, and oxidative pathways relevant to endometriosis. This scoping review followed PRISMA guidelines and searched PubMed, Web of Science, Scopus, African regional databases, and grey literature to identify studies examining vaping exposure in relation to reproductive or hormonal outcomes and gynecologic pathology. Eligible studies were appraised using the Newcastle–Ottawa Scale and STROBE criteria, and findings were narratively synthesized due to methodological heterogeneity. Across epidemiologic and mechanistic domains, the evidence indicates that nicotine-product use is associated with higher odds of dysmenorrhea and suspected endometriosis; disrupts the hypothalamic–pituitary–gonadal axis and estrogen–progesterone signaling; induces oxidative stress, mitochondrial dysfunction, and NF-κB activation; and may drive epigenetic and immune alterations that promote endometrial adhesion, angiogenesis, and impaired fertility. Contextual vulnerabilities in SSA including environmental co-exposures, infectious disease burden, limited diagnostic capacity, and dual use of vaping with alcohol may further amplify these risks. Although direct causal data from SSA remain limited, the convergence of biological plausibility and emerging epidemiologic signals highlights vaping as a potential reproductive health concern, underscoring the need to integrate vaping into sexual and reproductive health guidelines and to prioritize region-specific research.

Keywords

Vaping, Endometriosis, Sub-Saharan Africa, Women of Reproductive Age, Public Health

1. Introduction

Sub-Saharan Africa (SSA), home to the world's youngest population, is undergoing rapid social and behavioral transitions amid persistent public health and socio-economic

challenges. One emerging concern is the growing popularity of vaping and electronic nicotine delivery systems (ENDS), particularly among urban youth and women of reproductive

*Corresponding author: kabuyakalala8@gmail.com (Kalala Elisee Kabuya)

Received: 27 November 2025; **Accepted:** 18 December 2025; **Published:** 20 January 2026



Copyright: © The Author(s), 2026. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

age. As traditional cigarette sales decline in high-income countries, multinational tobacco companies are increasingly targeting SSA as a growth market [1]. In this context, vaping has evolved into a prominent lifestyle trend, often perceived as a safer alternative to smoking, despite insufficient evidence regarding its long-term health effects especially among women [2].

Currently, an estimated 13 million women in SSA use various tobacco products, including snuff, chewing tobacco, and water pipes such as shisha and hookah. Alarming, the gender gap in tobacco and nicotine use is narrowing, with prevalence among girls now ranging from 4.6% to 36.6%, comparable to rates among boys [3, 4]. Despite being preventable, tobacco-related conditions contribute to approximately 22,000 female deaths annually in the region [5], with projections showing a doubling of such deaths in low- and middle-income countries by 2030 [6]. Moreover, about 64% of adult deaths from second-hand smoke occur among women, most of whom are exposed through household contact with male smokers [7]. Yet, emerging patterns of direct exposure to vaping and nicotine among young women warrant renewed scrutiny from a reproductive health perspective.

In parallel, endometriosis, a chronic and often debilitating gynecological disorder characterized by ectopic growth of endometrial tissue remains underdiagnosed and undertreated in SSA [8]. Limited access to diagnostic tools, shortages of trained healthcare personnel, financial barriers, and cultural stigma surrounding menstrual health significantly impede early detection and effective management [9]. The condition contributes to severe pelvic pain, infertility, and a decline in overall quality of life. Qualitative research in countries like Kenya has documented the profound psychosocial and medical challenges faced by women with endometriosis, emphasizing delayed diagnoses and fragmented care pathways [10].

Despite its burden, endometriosis is still erroneously perceived as rare among African women, leading to an alarming lack of research, awareness, and targeted interventions [11]. The double burden of rising nicotine exposure through vaping and the already inadequate response to endometriosis represents a neglected but urgent public health issue. Nicotine and other chemicals present in e-cigarettes are known to disrupt hormonal function, induce oxidative stress, and provoke inflammatory responses, mechanisms also implicated in the pathogenesis of endometriosis [12]. Yet, no existing studies have directly explored the potential relationship between vaping and endometriosis in the African context.

Given the increasing uptake of vaping among reproductive-aged women in SSA and the persistent underrecognition of endometriosis, this study addresses a critical gap [13]. It aims to systematically review the existing evidence on the health effects of vaping, with a particular emphasis on its potential role in the development or progression of endometriosis. The study also seeks to assess the prevalence and awareness of

vaping among women in the region, explore biological mechanisms linking nicotine exposure to reproductive dysfunction, and identify research and policy gaps. Ultimately, the goal is to inform comprehensive public health responses and policies aimed at safeguarding women's reproductive health amid evolving tobacco and nicotine consumption patterns in SSA.

2. Literature Review

Tobacco and nicotine use among women and girls in SSA has historically been low compared to men [14]; however, recent trends indicate a growing prevalence of smoking and, increasingly, vaping among young women [15]. Studies from Nigeria and other African countries highlight that although current smoking rates among women of reproductive age remain relatively low, shifting social norms and targeted marketing necessitate more women-focused prevention strategies [16, 17]. In parallel, the rapid expansion of the e-cigarette market has facilitated increased adoption of vaping across SSA, particularly among adolescents and young adults [18]. This rise is largely driven by widespread perceptions of reduced harm relative to traditional cigarettes, aggressive global marketing campaigns, and the growth of online and informal markets that bypass regulatory oversight [19, 20].

E-cigarettes deliver nicotine alongside heavy metals and volatile organic compounds that exert multiple physiological effects relevant to women's reproductive health [21]. Nicotine exposure is known to trigger catecholamine release, increase systemic oxidative stress, and stimulate inflammatory pathways, creating biological conditions that may negatively affect reproductive tissues [22, 23]. Despite persistent claims of reduced harm, misconceptions about the safety of vaping remain common among young women, particularly in urban settings where targeted digital advertising and social media portray vaping as trendy, modern, and socially acceptable [24]. Regulatory frameworks in SSA are inconsistent, ranging from comprehensive restrictions in some countries to complete policy absence in others, thereby facilitating widespread accessibility and unregulated marketing [25, 26]. Emerging evidence suggests increasing uptake among girls and young women aged 15 years and older, driven by motivations such as stress relief, social acceptance in nightlife contexts, and targeted online promotion [27].

The potential implications of these trends for women's reproductive health are particularly important in relation to endometriosis, a chronic gynecological disorder characterized by the presence of endometrial-like tissue outside the uterus [28]. Endometriosis is driven by interrelated processes such as hormonal dysregulation, immune dysfunction, oxidative stress, and angiogenesis, all of which contribute to lesion proliferation, chronic inflammation, pelvic pain, and infertility [29]. [30] asserted that in SSA, endometriosis remains substantially underdiagnosed due to limited diagnostic expertise, insufficient specialist services, cultural

stigma surrounding menstrual pain and infertility, and low public awareness of the condition. These factors delay care-seeking and contribute to severe disease presentation among many women [31, 33]. Research from countries such as Uganda further highlights widespread misconceptions about reproductive disorders, with some women viewing infertility as more socially devastating than other health conditions, underscoring the sociocultural dimensions that complicate diagnosis and management [34].

Existing evidence suggests several plausible biological pathways through which nicotine exposure from vaping could interact with the mechanisms underlying endometriosis [35]. Nicotine has been shown to increase oxidative stress, alter estrogen receptor expression, [36] modulate immune responses, and promote pro-inflammatory cytokine activity mechanisms that overlap significantly with endometriosis pathophysiology and may facilitate the survival or progression of ectopic lesions [37]. Although animal studies suggest that e-cigarettes may produce fewer reproductive impacts in males than combustible tobacco, the evidence base for women's reproductive health remains extremely limited and inconclusive [38], with virtually no studies directly examining vaping and endometriosis [39]. This scientific gap is particularly concerning given the rapid increase in vaping among young women in urban African contexts.

Contextual factors in SSA may further compound the potential reproductive health risks associated with vaping. High levels of urban air pollution, [40] environmental exposure to heavy metals, and poor regulation of consumer products may intensify oxidative stress pathways already implicated in both vaping aerosol exposure and endometriosis development [41]. Cultural stigma surrounding gynecologic pain and limited health literacy reduce early diagnosis and compound women's vulnerability to reproductive morbidity [42]. Simultaneously, expanding urban nightlife, increased social media exposure, and the normalization of vaping among peer groups contribute to rising uptake among young women, even as policy enforcement remains weak, and health education interventions are limited [43].

Taken together, these trends highlight an urgent and understudied intersection between rising vaping prevalence and the existing burden of endometriosis in SSA [44]. The biological plausibility linking nicotine and vaping constituents to endometriosis mechanisms, combined with contextual vulnerabilities such as poor regulation, stigma, and environmental stressors, indicates that vaping may represent a modifiable risk factor for exacerbating reproductive health challenges [45]. This review therefore aims to synthesize available evidence on vaping and its potential contribution to endometriosis among women of reproductive age in SSA, examining prevalence patterns, awareness levels, biological pathways, and regulatory gaps to inform comprehensive public health policies and targeted interventions that safeguard women's reproductive health in the region.

3. Methodology

3.1. Review Design

This study employed a systematic scoping review framework aligned with PRISMA guidelines to promote transparency, reproducibility, and methodological rigor. Its primary aim was to explore whether vaping (e-cigarette use) is associated with the rising burden of endometriosis among women of reproductive age in SSA. The literature search encompassed studies published up to 2024 that investigated vaping, hormonal or reproductive health outcomes, and gynecological conditions pertinent to endometriosis.

3.2. Search Strategy

A systematic search was conducted in PubMed, Scopus, and Web of Science to identify studies examining vaping, nicotine exposure, and endometriosis among women of reproductive age, with relevance to Sub-Saharan Africa (SSA). Searches combined controlled vocabulary and keywords related to:

- 1) Exposure: "vaping," "e-cigarette," "electronic nicotine delivery systems," "nicotine exposure"
- 2) Outcome: "endometriosis," "reproductive health," "female fertility"
- 3) Mechanisms: "oxidative stress," "estrogen imbalance," "inflammation"
- 4) Context: "Sub-Saharan Africa," "developing countries"

Boolean operators such as (vaping OR e-cigarette) AND (endometriosis OR reproductive health) were applied. Limits included English-language, human females aged 15–49, and publications up to December 2024.

To enhance completeness, manual reference-checking and grey literature searches were conducted using OpenGrey, WHO Global Health Library, and African Journals Online (AJOL).

3.3. Inclusion and Exclusion Criteria

Predefined inclusion and exclusion criteria ensured the relevance and quality of the selected studies.

Inclusion Criteria:

- 1) Were peer-reviewed and published in English
- 2) Included human data or translational animal/mechanistic data relevant to endometriosis
- 3) Assessed vaping, nicotine exposure, or biological mechanisms linked to endometriosis
- 4) Reported outcomes related to endometriosis or reproductive health
- 5) Were conducted in SSA or produced findings applicable to SSA contexts

Exclusion Criteria

- 1) Were non-English
- 2) Showed no relevance to nicotine/vaping or endometriosis

- 3) Did not report original data (e.g., narrative reviews, commentaries)
- 4) Focused exclusively on non-reproductive populations or unrelated outcomes

3.4. Screening Process

All retrieved records were imported into EndNote, and duplicates removed. Screening followed PRISMA guidelines:

Title and Abstract Screening: Two independent reviewers screened records against the eligibility criteria.

Full-Text Review: Full texts of potentially relevant studies were reviewed independently by two reviewers. Disagreements were resolved through discussion or third-reviewer adjudication.

All screening decisions were documented to ensure transparency and reproducibility.

3.5. Data Extraction Process

A standardized data extraction form was developed to ensure uniformity and minimize errors. Two reviewers independently extracted the following data:

Study characteristics: Authors, year of publication, study design, and country.

Population details: Sample size, participant age range, and reproductive health status.

Exposure variables: Type and frequency of vaping or e-cigarette use, duration, and nicotine concentration.

Outcome variables: Endometriosis diagnosis, symptom severity, hormonal levels (e.g., estrogen, progesterone), menstrual cycle regularity, and fertility indicators.

Confounding factors: Lifestyle behaviors, co-use of tobacco or alcohol, and occupational exposures.

Policy or regulatory context: Existing national or institutional frameworks addressing vaping or women's health.

Disagreements were resolved by consensus or by consultation with a senior reviewer.

3.6. Risk of Bias Assessment

The Newcastle-Ottawa Scale (NOS) was used to assess the risk of bias in observational studies. Each study was evaluated on three domains:

- Selection of participants,
- Comparability of groups, and
- Ascertainment of exposure and outcomes.

Two reviewers conducted the assessments independently. Studies with high risk of bias were not excluded but were interpreted cautiously in the narrative synthesis.

3.7. Quality Assessment of Studies

The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist was used to

evaluate the methodological quality of included studies. Each study's adherence to STROBE criteria such as clarity in objectives, participant selection, data collection, and statistical analysis was documented in a summary table and considered in the synthesis.

3.8. Data Synthesis and Analysis

Due to the heterogeneity in study designs, populations, and outcome measures, a meta-analysis was not feasible. Instead, a narrative synthesis was conducted to summarize evidence on:

1. The association between vaping exposure and endometriosis prevalence or severity.
2. Biological mechanisms linking nicotine, oxidative stress, and hormonal dysregulation to endometriosis.
3. Regional variations and contextual factors influencing vaping behaviors among women in SSA.
4. Policy implications and gaps in existing reproductive health interventions.

Where feasible, subgroup analyses were conducted based on age group, duration of vaping, nicotine concentration, and concurrent tobacco or alcohol use.

3.9. PRISMA Flow Diagram

A PRISMA flow diagram was constructed to detail the literature selection process, including the number of studies identified, screened, excluded (with reasons), and included in the final review.

3.10. Summary of Evidence

A summary table was created to present the characteristics of included studies:

- Study location (country or city in SSA).
- Study design (cross-sectional, case-control, cohort).
- Sample size and participant demographics.
- Type of vaping exposure (nicotine-based or nicotine-free).
- Primary outcomes (endometriosis incidence, menstrual pain, infertility).

3.11. Limitations and Future Research

This review recognizes limitations such as limited regional data, potential underreporting of vaping among women, and heterogeneous diagnostic criteria for endometriosis across studies. Future research should focus on longitudinal and interventional studies to better establish causality, biochemical studies to elucidate hormonal mechanisms, and policy-oriented research to assess regulatory frameworks and prevention strategies in SSA.

4. Pathophysiological Basis

In female mammals, reproduction is regulated through complex mechanisms that integrate environmental, hormonal, and resource-related cues, particularly suppressing reproductive activity during periods of resource scarcity [46]. Disruptions to these regulatory systems such as hormonal imbalances or adverse environmental exposures can lead to reproductive disorders, including endometriosis [47]. Endometriosis is characterized by the ectopic growth of endometrial tissue and is associated with chronic pelvic pain, infertility, and inflammation [48].

The endometrium is a dynamic tissue composed of luminal and glandular epithelial cells supported by stromal cells, forming the innermost lining of the uterus [49]. Estrogen dominance plays a central role in the pathophysiology of endometriosis, driving the proliferation of ectopic tissue, sustaining chronic inflammation, and contributing to pain [50]. Elevated estrogen levels facilitate the implantation and growth of lesions outside the uterus, enhance inflammatory responses, and impair immune clearance of ectopic cells [51]. This is often accompanied by reduced progesterone activity, which further contributes to disease progression [52]. Therapeutic strategies aimed at correcting estrogen dominance through lifestyle modifications, hormonal treatments (e.g., oral contraceptives, GnRH agonists), and natural hormone-regulating interventions have demonstrated efficacy in symptom management and slowing disease progression [53]. Immune dysfunction, oxidative stress, and inflammation are interrelated contributors to endometriosis severity [54]. Impaired immune surveillance permits the persistence of ectopic tissue, while oxidative stress resulting from an imbalance between reactive oxygen species (ROS) and antioxidants induces cellular damage and promotes inflammatory cascades. This sustained inflammatory environment drives symptom severity, adhesion formation, and disease persistence [55]. Hence, effective interventions must target these overlapping pathways by modulating immune function, minimizing oxidative stress, and reducing inflammation.

Over the past decade, the global use of ENDS, including e-cigarettes, has increased significantly [56]. ENDS are non-combustible tobacco products that operate by heating and aerosolizing liquids containing humectants, flavoring agents, and frequently nicotine [57]. Emerging research suggests that exposure to the chemical constituents of vaping products may exacerbate the underlying mechanisms of immune dysregulation, oxidative stress, and inflammation in endometriosis [58].

Vaping aerosols commonly contain compounds such as nicotine, formaldehyde, acrolein, and various flavoring agents, all of which can generate ROS and overwhelm cellular antioxidant defenses [59]. These substances can impair immune function by disrupting immune cell activity, altering cytokine profiles, and promoting pro-inflammatory conditions

[60]. Moreover, direct tissue toxicity caused by these chemicals may contribute to further inflammation and oxidative injury in reproductive tissues [61]. The cumulative effect of these exposures may amplify immune and inflammatory dysregulation, thereby aggravating the symptoms and progression of endometriosis.

Nicotine, a principal toxic component of tobacco products, is known to negatively affect reproductive health in both men and women [62]. It can interfere with hormonal regulation by stimulating the adrenal glands to release stress hormones such as cortisol, potentially disrupting the balance of key reproductive hormones like estrogen and progesterone [63]. Additionally, nicotine may disrupt the hypothalamic-pituitary-ovarian (HPO) axis, leading to decreased progesterone and relatively elevated estrogen levels, contributing to an estrogen-dominant state [64]. This hormonal imbalance may foster ectopic endometrial growth, intensify endometriosis symptoms, and hinder normal reproductive functions.

Mechanism: Nicotine, Hormones, and Endometriosis Progression

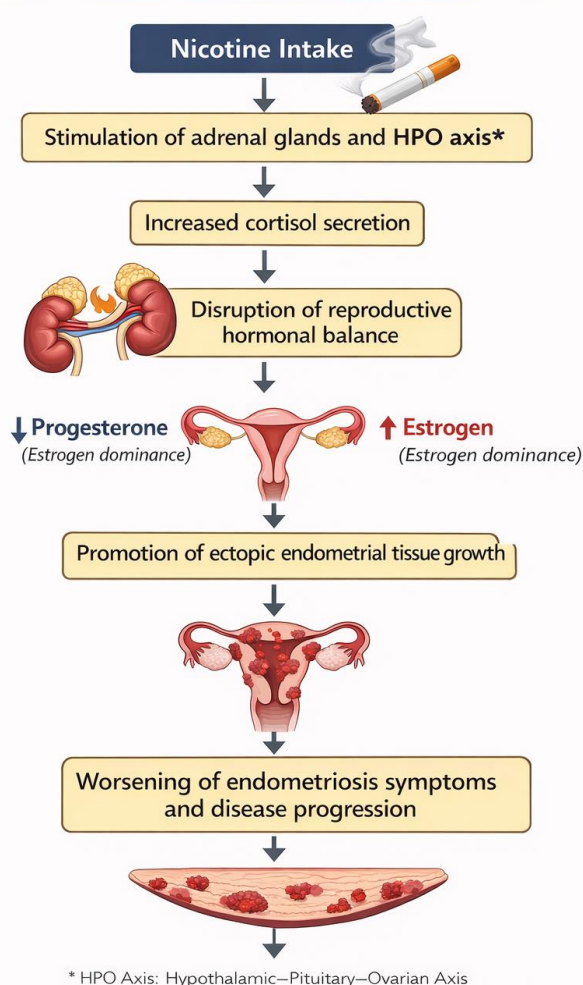


Figure 1. Mechanism: Nicotine and Hormonal Dysregulation in Endometriosis.

Furthermore, volatile organic compounds (VOCs) and heavy metals present in vaping aerosols can further disrupt immune function. These substances promote oxidative stress by generating ROS, damaging immune cells, and impairing their functionality [65]. Ebrahimi and colleagues (2020) highlight the pervasive nature of heavy metal exposure in daily life, particularly from sources like cadmium, lead, and

nickel found in vaping aerosols [66]. These metals accumulate in tissues, disturb immune signaling, and enhance inflammatory responses, thereby diminishing the body's ability to manage infections or eliminate aberrant tissues [67]. VOCs are also known to activate inflammatory pathways, sustaining a chronic inflammatory state that may contribute to the exacerbation of endometriosis [68].

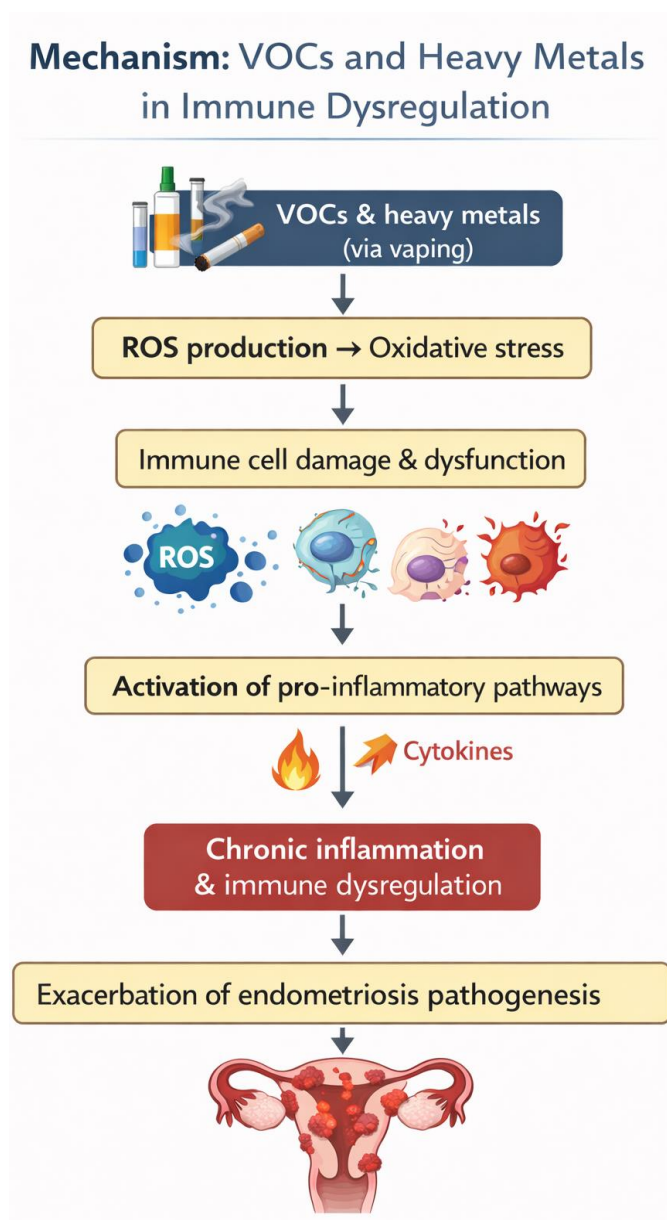


Figure 2. Mechanism: VOCs and Heavy Metals in Immune Dysregulation.

Flavoring agents used in vaping liquids present additional health risks. These compounds can exert cytotoxic effects through mechanisms such as membrane disruption, oxidative damage, and induction of apoptosis or necrosis [69]. Furthermore, certain flavorants may induce epigenetic modifications including changes in DNA methylation, histone

structure, and microRNA expression that alter gene regulation and cellular function [70]. These cellular and molecular disruptions may contribute to tissue damage and immune dysfunction, ultimately exacerbating the development and severity of endometriosis.

Table 1. West Africa.

Domain / Focus Area	Mechanism or Observation	Key Findings (Study Type / Evidence Source)	Subgroup / Regional Relevance (SSA Context)
Epidemiologic associations	Vaping exposure ↔ endometriosis prevalence/severity	Case-control & cross-sectional studies from mixed settings suggest higher odds of dysmenorrhea and diagnosis among nicotine product users; heterogeneity prevents meta-analysis.	Underdiagnosis due to limited laparoscopy, stigma; rising youth e-cigarette uptake in urban Nigeria, Ghana; peri-urban mining zones (heavy metals) may interact with vaping exposures.
Nicotine & hormonal dysregulation	Nicotine → HPG axis disruption, altered ER/PR signaling	Experimental and human biomarker studies show increased inflammatory markers and disrupted progesterone signaling after nicotine exposure.	In West Africa, contraceptive access gaps and high adolescent pregnancies may amplify hormonal vulnerability.
Oxidative stress & inflammation	E-cig aerosols → ROS, mitochondrial damage	In vitro & animal studies show ROS, NF-κB activation; human studies link biomarkers to vaping/alcohol co-use.	Malnutrition and infectious comorbidities (e.g., malaria) could worsen oxidative damage in West African populations.
Epigenetic / miRNA	Altered DNA methylation, miR expression (HOXA10, miR-200)	Smoking literature robust; early vaping epigenetic signals emerging.	Environmental pollutants (artisanal mining) + vaping may create cumulative epigenetic risk in coastal and inland mining communities.
Immune & angiogenic pathways	Flavors → macrophage polarization, ↑VEGF	Preclinical pro-angiogenic findings; early human inflammatory marker elevation in young initiators.	High rates of pelvic infection could mask or modify immune signals from vaping.
Fertility & implantation	Nicotine delays implantation, reduces receptivity	Animal and limited human fertility studies show implantation delays and poorer outcomes.	Fertility services are limited; such effects could have large social impact in contexts where family size is highly valued.
Duration & intensity	Long-term / high-nicotine use → worse symptoms	Observational correlation between use duration and menstrual pain severity.	Young urban professionals and students increasingly use high-nicotine pods; occupational exposure (mining) matters.
Concurrent exposures	Vaping + alcohol/tobacco → synergistic harm	Mixed-exposure studies show amplified oxidative/hormonal disruption.	Social nightlife culture in cities like Lagos/Accra increases dual exposures among women.
Policy & interventions	Weak regulation, low reproductive education	WHO/AU recommend action; few region-specific guidelines exist.	Need to integrate vaping education in adolescent reproductive health programs and mining occupational health policies.

The table presents a coherent, multidisciplinary synthesis of how vaping exposure might influence endometriosis-relevant outcomes in SSA, with a clear focus on West Africa. It organizes mechanisms—from nicotine-induced hormonal disruption to oxidative stress, epigenetic changes, and immune/angiogenic pathways alongside epidemiologic evidence and region-specific contextual factors such as diagnosis gaps, adolescent vaping trends, and mining-related exposures. While the narrative links are plausible and well-structured, several rows would benefit from explicit study designs, standardized exposure metrics, and cautious

interpretation where evidence is primarily observational or preclinical.

Policy implications are appropriately foregrounded, highlighting weak regulation and the need to embed vaping education within adolescent reproductive health and mining occupational health programs. To strengthen the table for synthesis, consider adding uniform definitions of exposure, concrete biomarkers or outcomes, and explicit gaps or future directions per domain. This would enhance clarity for readers aiming to identify methodological needs and prioritize regionally relevant research and interventions.

Table 2. East Africa.

Domain / Focus Area	Mechanism or Observation	Key Findings (Study Type / Evidence Source)	Subgroup / Regional Relevance (SSA Context)
Epidemiologic associations	Rising urban vaping ↔ endometriosis symptoms	Cross-sectional surveys in tertiary clinics indicate associations between nicotine exposure and pelvic pain but limited diagnostics.	Kenya/Uganda show increasing e-cig uptake among youth; rural healthcare access gaps lead to late presentation.
Nicotine & hormones	Nicotine alters estrogen/progesterone signaling	Lab and clinical biomarker studies show upregulated inflammatory pathways, aromatase activity.	Limited hormone monitoring capacity and contraceptive counseling in peripheral facilities.
Oxidative stress	Aerosol constituents cause ROS and lipid peroxidation	In vitro and animal evidence; human biomarker studies show higher oxidative markers in dual-users.	High burden of infectious diseases (HIV/TB) could amplify oxidative pathways.
Epigenetics	miRNA shifts regulating endometrial adhesion	Early evidence from smokers; vaping epigenetic evidence emerging.	Urban pollution (traffic) + vaping may have combined epigenetic impacts in cities like Nairobi and Dar es Salaam.
Immune & angiogenesis	Flavored condensates → VEGF, macrophage shift	Animal models show pro-angiogenic changes relevant to lesion growth.	High STI prevalence and pelvic inflammation could confound diagnosis of endometriosis.
Fertility	Reduced uterine receptivity after nicotine	Mouse models + small human cohorts show implantation issues.	Assisted reproduction limited; fertility impacts have outsized social consequences.
Duration/intensity	Chronic use → severe dysmenorrhea	Observational link between years of vaping and pain scores.	University students and young professionals in capital cities are an at-risk group.
Concurrent use	Alcohol/Tobacco/vaping interactions	Synergistic oxidative & endocrine disruption reported.	Cultural alcohol consumption patterns at social events may increase joint exposures.
Policy	Few reproductive guidelines referencing vaping	Regional health policy lags behind use trends.	Opportunities for school-based prevention and adolescent SRH programming.

The table offers a context-specific synthesis of how vaping could relate to endometriosis-related outcomes in East Africa, anchored by Kenya and Uganda. It notes tentative epidemiologic links between urban vaping and endometriosis-like symptoms, while stressing diagnostic limits in SSA. It outlines plausible biological pathways, nicotine-hormone interactions, oxidative stress, epigenetic changes, immune/angiogenic processes, and

fertility considerations framed by regional factors such as STI prevalence and healthcare access. A policy note highlights few reproductive health guidelines on vaping and advocates preventive actions in schools and adolescent SRH programs. Overall, it signals a plausible public health concern while carefully noting the observational and preclinical nature of the evidence.

Table 3. Central Africa.

Domain / Focus Area	Mechanism or Observation	Key Findings	Subgroup / Regional Relevance
Epidemiology	Sparse data; probable underestimation of vaping-related gynecologic disease	Clinic case series suggest links but diagnostic capacity limited.	DRC, CAR: few laparoscopies; artisanal mining exposures (lead, mercury) common — potential synergists.

Domain / Focus Area	Mechanism or Observation	Key Findings	Subgroup / Regional Relevance
Nicotine & hormones	Nicotine → endocrine disruption demonstrated experimentally	Limited human biomarker work; animal studies generalizable.	Nutritional deficiencies and anemia prevalent — could worsen hormonal effects.
Oxidative stress	Aerosol-induced ROS exacerbated by infections	Preclinical evidence strong; human data limited.	High infectious disease burden may amplify oxidative/inflammatory pathways.
Epigenetics	Environmental pollutants + vaping may change epigenome	Smoking literature strong; vaping not well-studied.	Mining towns (Lubumbashi) are priority areas to study combined exposures.
Immune pathways	Proinflammatory shifts with flavored aerosols	Animal studies: macrophage polarization and angiogenesis.	Coexisting pelvic infections increase diagnostic complexity.
Fertility	Nicotine harms implantation in animal models	Relevant but poorly documented in human Central African cohorts.	Social importance of fertility and very limited ART services increase impact of subfertility.
Duration & intensity	Chronic users show worse menstrual outcomes elsewhere; local data lacking	Need longitudinal tracking.	Young urban migrants to mining towns may be high-risk group.
Concurrent exposures	High prevalence of multi-toxin exposures (smoke, mining pollutants)	Likely synergistic but under-researched.	Occupational exposures create unique exposure profiles.
Policy & interventions	Minimal e-cig regulation, limited SRH integration	Public health priorities often focus on infectious disease.	Integrate vaping topics into maternal/occupational health guidance for mining regions.

The Central Africa tab offers a concise, mechanism-focused overview of how vaping might affect gynecologic and reproductive health within a setting marked by high infectious disease burden and environmental exposures (notably artisanal mining with lead and mercury). It groups evidence into domains epidemiology, nicotine and hormones, oxidative stress, epigenetics, immune pathways, fertility, duration/intensity, concurrent exposures, and policy to show both plausible biological links and the contextual limitations. A key message is the reliance on animal and preclinical data for many mechanisms, coupled with significant gaps in human biomarkers and region-specific longitudinal data, which hinders translation into public health action.

The text highlights several priorities: (1) the need for longitudinal, human-focused research on nicotine-hormone interactions and fertility, particularly in contexts with nutritional deficiencies and anemia that could amplify effects; (2) attention to synergistic exposures from mining pollutants and smoking, especially in mining towns and among young urban migrants; and (3) practical policy steps to incorporate vaping considerations into maternal and occupational health guidance despite limited regulation and SRH integration. Overall, the tab offers a compact, provisional map of Central Africa-specific factors and clearly identifies critical data gaps to support evidence-based policy and practice.

Table 4. Southern Africa.

Domain / Focus Area	Mechanism or Observation	Key Findings	Subgroup / Regional Relevance
Epidemiology	Rising urban vaping (SA) with some clinic data on pelvic pain associations	Case-control and hospital series from South Africa more numerous than other SSA regions.	South Africa leads in vaping prevalence and diagnostic capacity; neighboring countries show emerging uptake.
Nicotine & hormones	Robust experimental evidence for endocrine disruption	Human biomarker studies available; vaping data building.	Better lab capacity (Cape Town, Johannesburg) enables mechanistic studies.
Oxidative stress	Aerosols cause ROS & mitochondrial damage	Both in vitro and small clinical studies support this.	Intersection with high HIV prevalence and TB could magnify impacts.
Epigenetics	Smoking and vaping associated with methylation changes	South African cohorts feasible for epigenetic studies.	Urban industrial pollution + vaping → cumulative exposures.
Immune & angiogenesis	Flavors → angiogenic pathways in animal models	Mechanistic signals present.	Pelvic infection patterns may complicate diagnosis.
Fertility	Nicotine reduces implantation in models; limited human data	Feasible to study at fertility clinics in major cities.	Fertility clinics concentrated in SA enable cohort studies.
Duration & intensity	Chronic, high-nicotine users experience worse symptoms	Observational data align with global findings.	University student cohorts and nightlife cultures are clear target groups.
Concurrent exposures	Alcohol + vaping common in nightlife settings	Synergistic damage observed in mixed-use studies.	Strong nightlife economy in SA increases dual exposures among young women.
Policy & interventions	Some regulatory movement but gaps remain	South Africa has some policy activity; regional harmonization lacking.	Opportunity to pilot reproductive-health integration into tobacco control programs.

In Southern Africa, especially South Africa, vaping epidemiology is rapidly evolving with potential links to gynecologic and reproductive health issues like pelvic pain and possibly endometriosis. South Africa's advanced diagnostic infrastructure positions it as a regional data hub for mechanistic and clinical findings, showing nicotine's endocrine disruption, oxidative stress from aerosols, mitochondrial dysfunction, and epigenetic changes. These pathways matter amid coexisting HIV, TB, and urban pollution, and are reinforced by hospital-based case series and student cohorts that emphasize the role of duration and intensity of use. Socioculturally, high alcohol-vaping co-use in nightlife and concentrated fertility clinics offer both risk context and research opportunities, while policy progress on electronic nicotine delivery systems is tempered by implementation gaps and weak regional harmonisation.

Overall, there is a clear need for region-specific research and integrated public health strategies to address the unique exposure landscape affecting women's health in Southern Africa.

Narrative Interpretation

Due to heterogeneity in study designs, populations, and outcome measures, quantitative synthesis was not possible. Instead, evidence was narratively organized across epidemiologic, mechanistic, and contextual domains.

- 1) Epidemiologic patterns suggest a plausible but underexplored association between vaping and endometriosis, particularly in reproductive-age women with concurrent substance use.
- 2) Biological evidence supports nicotine-induced oxidative stress, hormonal imbalance, and epigenetic dysregulation as mechanistic pathways linking vaping

exposure to lesion development and symptom severity.

- 3) Regional contextual factors including regulatory weakness, cultural barriers, and high environmental toxin exposure likely amplify risks among women in Sub-Saharan Africa.
- 4) Policy implications highlight an urgent need for reproductive health surveillance and targeted awareness campaigns.
- 5) Subgroup analyses emphasize greater vulnerability among younger women, chronic vapers, and dual users (vaping + smoking/alcohol).

5. Implications for Public Health in SSA

Women's health encompasses far more than pregnancy and childbirth [71]. In SSA, menstrual health remains underprioritized due to persistent stigma, inadequate access to menstrual products and sanitation facilities, and limited educational outreach, with marginalized populations disproportionately affected [72]. Access to essential sexual, reproductive, and maternal health services is further constrained by gender inequality and discrimination [73]. Period poverty defined as the inability to afford or access menstrual products, sanitation and hygiene facilities, and related education places preventable burdens on women and girls [74]. Addressing this requires health services and products that are affordable, accessible, acceptable, and delivered with quality, equity, and dignity.

According to the WHO, adolescent health behaviors are also shifting, with rising cigarette consumption and increasing e-cigarette use (vaping) introducing new risks for women of reproductive age in SSA [75]. While long-term population-level data remain limited, the WHO warns that e-cigarettes are harmful, addictive, and may increase uptake of combustible tobacco among youth, a trend that could broaden nicotine exposure among reproductive-age women if not addressed [76]. Nicotine and many aerosol constituents in e-cigarettes have biologically plausible effects on reproductive tissues and systemic inflammation, which could influence gynecological health [77]. Endometriosis, a highly prevalent and morbid condition primarily affecting women in their 20s–40s, already contributes substantially to disability-adjusted life years (DALYs) and infertility in low- and middle-income settings [78]. Global and regional analyses indicate that incidence and disability remain concentrated in young women, with variation by region [79]. Thus, any new exposure impacting reproductive health, such as vaping, could amplify both individual suffering and the broader burden in SSA [80]. Even in the absence of definitive causal evidence, early findings that e-cigarettes influence ovarian reserve, menstrual function, and inflammatory pathways warrant precautionary action from a public-health perspective [81].

The health-system implications are immediate and practical. If vaping exacerbates pelvic pain, delays conception, or increases healthcare utilization, SSA health

systems already strained by infectious disease burdens and limited gynecologic capacity will face rising diagnostic and treatment demands, including laparoscopy, imaging, [82] chronic pain management, and fertility services. Such pressures risk worsening inequities, as women in rural or low-income urban areas often have the least access to timely diagnosis and evidence-based management for endometriosis [83].

Surveillance and research gaps further hinder timely response. Current data on e-cigarette prevalence in SSA are sparse and heterogeneous, limiting the ability to project reproductive-health impacts [84]. Few longitudinal or mechanistic studies from African populations directly link vaping to endometriosis or related outcomes, [85], with most evidence extrapolated from animal models, in vitro experiments, or high-income settings. Strengthening surveillance and prioritizing prospective cohort and mechanistic research in SSA are essential to progress from plausible concern to evidence-informed policy [86].

Policy and prevention implications are therefore critical. In line with the precautionary principle and WHO guidance [87], SSA countries should integrate e-cigarettes into existing tobacco-control frameworks through measures such as age restrictions, marketing and flavor bans, taxation, and restrictions on public use [88]. Tailored messaging for women of reproductive age and adolescents is essential [89]. Public-health campaigns should concurrently address established drivers of endometriosis morbidity while incorporating information on nicotine and vaping-related reproductive risks into counseling and family-planning services [90]. Partnerships with schools and youth programs will be crucial, given that adolescent uptake strongly predicts adult prevalence [91].

Equity considerations must remain central. Any increase in vaping-related reproductive harms will disproportionately affect marginalized populations with limited healthcare access, lower health literacy, and greater exposure to targeted marketing [92]. Policy responses should therefore include safeguards such as subsidized diagnostic and fertility services, culturally tailored risk communication, and community engagement to avoid further stigmatization of women seeking care for chronic pelvic pain or infertility [93, 94].

Although vaping is not yet a proven cause of endometriosis, the combination of biological plausibility, emerging reproductive-health signals, and rising use among urban youth in SSA justifies a public-health response [95, 96]. Immediate steps including enhanced surveillance, targeted research, integration of e-cigarette regulation into tobacco-control policies, [97] and strengthened reproductive-health education are needed both to protect women's reproductive health and to generate the evidence base required for robust causal inferences and policy decisions [98].

6. Research Gaps and Recommendations

Despite growing global attention to vaping and women's reproductive health, significant gaps persist in SSA [99]. Current evidence on the association between e-cigarette use and endometriosis is largely extrapolated from animal studies, in vitro experiments, and high-income country populations, with little region-specific data [100, 101]. Existing epidemiological studies in SSA are sparse, fragmented, and often cross-sectional, making it difficult to establish causal pathways or quantify the potential burden of vaping-related reproductive health outcomes [102]. Additionally, surveillance systems rarely disaggregate tobacco use by product type, gender, or reproductive age group, thereby obscuring the true prevalence and patterns of vaping among women [103, 104].

The biological plausibility linking nicotine and e-cigarette aerosols to systemic inflammation, ovarian reserve depletion, and menstrual dysfunction underscores the need for region-specific mechanistic studies [105, 106]. However, limited laboratory capacity, underfunded reproductive-health research, and competing health priorities in SSA constrain progress in this area [107, 108]. Moreover, few longitudinal cohort studies are underway to explore the temporal relationship between vaping, gynaecological morbidity, and fertility outcomes [109-110]. Without such evidence, policymakers lack the data required to develop targeted interventions or integrate vaping into reproductive-health frameworks.

7. Recommendations

Strengthen Surveillance: Incorporate e-cigarette use into national health surveys and reproductive health surveillance systems, with disaggregation by sex, age, and socioeconomic status.

Invest in Epidemiological Research: Support longitudinal cohort studies and case-control investigations in SSA to assess the association between vaping and endometriosis incidence, severity, and fertility outcomes.

Advance Mechanistic Studies: Develop laboratory and clinical research capacity to examine the biological pathways through which vaping may influence ovarian function, pelvic pain, and inflammatory responses in African populations.

Integrate with Tobacco Control: Align vaping regulation with existing tobacco-control measures (age restrictions, taxation, advertising bans) while including reproductive health considerations in policy frameworks.

Enhance Health Education: Incorporate evidence-based information on vaping's reproductive risks into family-planning services, school-based health programs, and community campaigns.

Promote Equity in Research and Care: Ensure that marginalised groups particularly women in rural and low-income settings are represented in research and have access to diagnostic, preventive, and therapeutic services.

Foster Multisectoral Collaboration: Encourage partnerships between governments, academia, civil society, and international health bodies to mobilize resources, share data, and drive regionally tailored interventions.

Addressing these research gaps and implementing the above recommendations will generate the evidence base needed to move from biological plausibility to policy action, ultimately safeguarding the reproductive health of women of reproductive age in SSA.

8. Conclusion

This review highlights a critical need for robust, region-specific epidemiologic and mechanistic studies to clarify the relationship between vaping and endometriosis in Sub-Saharan Africa. The convergence of biologically plausible pathways, rapidly increasing ENDS use among reproductive-aged women, and persistent gaps in diagnostic, menstrual, and reproductive health services indicates that vaping may represent an overlooked contributor to gynaecologic morbidity in the region. Strengthening surveillance systems, integrating ENDS into tobacco control and reproductive-health policies, and expanding targeted education for adolescents and young women are urgently required. Coordinated multisectoral action spanning public health, clinical services, environmental regulation, and youth-focused interventions is essentially both to mitigate potential harms and to generate the evidence base required for informed policy and programmatic decisions across SSA.

Abbreviations

AJOL	African Journals Online
AU	African Union
CAR	Central African Republic
DRC	Democratic Republic of the Congo
ENDS	Electronic Nicotine Delivery Systems
ER	Estrogen Receptor
GnRH	Gonadotropin-Releasing Hormone
HPO Axis	Hypothalamic–Pituitary–Ovarian Axis
HPG Axis	Hypothalamic–Pituitary–Gonadal Axis
HIV	Human Immunodeficiency Virus
LMICs	Low- and Middle-Income Countries
NF-κB	Nuclear Factor Kappa-Light-Chain-Enhancer of Activated B Cells
NOS	Newcastle–Ottawa Scale
PR	Progesterone Receptor
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ROS	Reactive Oxygen Species
Scopus	Scientific Citation Index Database (Elsevier)
SSA	Sub-Saharan Africa
SRH	Sexual and Reproductive Health

VEGF	Vascular Endothelial Growth Factor
STROBE	Sexually Transmitted Infection Strengthening the Reporting of Observational Studies in Epidemiology
TB	Tuberculosis
VOCs	Volatile Organic Compounds
WHO	World Health Organization

Acknowledgments

We give thanks to God for His provision, guidance, and grace throughout the course of this research. We acknowledge these blessings as gifts that sustained and enabled the successful completion of this work, and we offer our sincere gratitude.

A special acknowledgement goes to our co-author Mukasa Charline Sangany, whose invaluable support as a scientific mentor and her dedication in reserving library hours significantly facilitated the progress of this work. Her contributions have been instrumental in shaping the quality of this research.

Author Contributions

Kalala Elisee Kabuya: Conceptualization, Methodology, Resources, Validation, Visualization, Writing – original draft, Project administration, Supervision

Mukasa Charline Sangany: Project administration, Resources, Data curation, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

References

- [1] Agaku, I. T., Sulentic, R., Dragicevic, A., Njie, G., Jones, C. K., Odani, S.,... & Ayo-Yusuf, O. (2024). Gender differences in use of cigarette and non-cigarette tobacco products among adolescents aged 13–15 years in 20 African countries. *Tobacco Induced Diseases*, 22, 10-18332.
- [2] Agaku, I. T., Egbe, C. O., & Ayo-Yusuf, O. A. (2021). Geospatial spread of e-cigarette vape shops in South Africa and the relationship with tobacco product use among adults. *Health & Place*, 68, 102507.
- [3] Tobacco Control: <https://www.afro.who.int/health-topics/tobacco-control> accessed on the 05th of June 2025.
- [4] Egbe, C. O., Gwambe, S., Londani, M., Erinoso, O., & Ayo-Yusuf, O. A. (2023). Trends in the use and dual use of factory-made combustible cigarettes, other tobacco products and electronic cigarettes: Results from South African Social Attitudes Surveys during 2007 to 2018. *Tobacco Induced Diseases*, 21, 94.
- [5] Londani, M., & Oladimeji, O. (2024). Tobacco use and behaviour among South African adolescents and young adults: systematic review and meta-analysis. *BMJ open*, 14(2), e079657.
- [6] De Silva, R., Silva, D., Piumika, L., Abeysekera, I., Jayathilaka, R., Rajamanthri, L., & Wickramaarachchi, C. (2024). Impact of global smoking prevalence on mortality: a study across income groups. *BMC Public Health*, 24(1), 1786.
- [7] Carreras, G., Lugo, A., Gallus, S., Cortini, B., Fernández, E., López, M. J.,... & Perez, P. (2019). Burden of disease attributable to second-hand smoke exposure: a systematic review. *Preventive medicine*, 129, 105833.
- [8] Adokiye, E. A. (2024). EFFECTS OF ENDOMETRIOSIS ON QUALITY OF LIFE (Benefit of combined hystero-laparoscopic surgery on quality of life and fertility performance in endometriosis) (Doctoral dissertation, University of Pécs (Hungary)).
- [9] Giudice, L. C., Oskotsky, T. T., Falako, S., Opoku - Anane, J., & Sirota, M. (2023). Endometriosis in the era of precision medicine and impact on sexual and reproductive health across the lifespan and in diverse populations. *The FASEB Journal*, 37(9), e23130.
- [10] Price, L. R., & Martinez, J. (2020). Cardiovascular, carcinogenic and reproductive effects of nicotine exposure: A narrative review of the scientific literature. *F1000Research*, 8, 1586.
- [11] Mecha, E. O., Njagi, J. N., Makunja, R. N., Omwandho, C. O., Saunders, P. T., & Horne, A. W. (2022). Endometriosis among African women. *Reproduction and Fertility*, 3(3), C40-C43.
- [12] Awad, A. A., Itumalla, R., Gaidhane, A. M., Khatib, M. N., Ballal, S., Bansal, P., ... & Shabil, M. (2024). Association of electronic cigarette use and suicidal behaviors: a systematic review and meta-analysis. *BMC psychiatry*, 24(1), 608.
- [13] Green, M. M. (2023). Maturation of the Endocannabinoid System in the Medial Prefrontal Cortex and the Effect of Perinatal Cananbinoid Exposure. *Indiana University*.
- [14] Sreeramareddy, C. T., & Acharya, K. (2021). Trends in prevalence of tobacco use by sex and socioeconomic status in 22 sub-Saharan African countries, 2003-2019. *JAMA Network Open*, 4(12), e2137820-e2137820.
- [15] Pierce, J. P., Luo, M., McMenamin, S. B., Stone, M. D., Leas, E. C., Strong, D.,... & Messer, K. (2025). Declines in cigarette smoking among US adolescents and young adults: indications of independence from e-cigarette vaping surge. *Tobacco Control*, 34(3), 286-293.
- [16] Nyatsanza, S., Isip, U., Bongos-Ikwue, O., Adamu, F., Olajide, O. C., Emoruwa, A.,... & Shettima, I. (2025). The Evolution of Tobacco Marketing to Women and Girls in sub-Saharan Africa. *medRxiv*, 2025-02.

- [17] Ogbuabor, D. C., Ogbuabor, A. O., & Igwe, M. C. (2023). Determinants of cigarette smoking and smoking frequency among women of reproductive age in Nigeria: evidence from a nationwide cross-sectional survey. *Substance Abuse Treatment, Prevention, and Policy*, 18(1), 20.
- [18] Yan, Duo, Zicheng Wang, Linnea Laestadius, Kavita Mosalpuria, Fernando A. Wilson, Alice Yan, Xiaoyang Lv, Xiaotian Zhang, Soumitra S. Bhuyan, and Yang Wang. "A systematic review for the impacts of global approaches to regulating electronic nicotine products." *Journal of Global Health* 13 (2023): 04076.
- [19] Murphy, John D., Benmei Liu, and Mark Parascandola. "Smoking and HIV in Sub-Saharan Africa: a 25-country analysis of the demographic health surveys." *Nicotine and Tobacco Research* 21, no. 8 (2019): 1093-1102.
- [20] Hampsher-Monk, S. C., Priege, J. E., & Patwardhan, S. (2024). E-cigarette Regulations and Why They Fail. In *Tobacco Regulation, Economics, and Public Health, Volume III: Clearing the Air on E-Cigarettes and Harm Reduction* (pp. 1-130). Cham: Springer Nature Switzerland.
- [21] Montjean, D., Godin Pagé, M. H., Bélanger, M. C., Benkhalifa, M., & Miron, P. (2023). An overview of e-cigarette impact on reproductive health. *Life*, 13(3), 827.
- [22] Larcombe, A. (2023). Dispelling misconceptions about who uses e - cigarettes and why. *Medical Journal of Australia*, 218(3).
- [23] Kabuya, K. E., & Mwelwa, M. K. (2024). The Impact of Sharing a Shisha (Hookah) Mouthpiece during Smoking: Case of Tuberculosis and Hepatitis in South Saharan Africa. *Journal of Tuberculosis Research*, 12(1), 34-55.
- [24] Theis, R. P., Pilla, J., Okker-Edging, K., Pluta, K., LeLaurin, J. H., Hanby, E.,... & Tan, A. S. (2025). Perspectives of sexual and gender minority youth on anti-vaping messages in social media. *Nicotine and Tobacco Research*, 27(2), 291-299.
- [25] Smith, M. J. (2022). Understanding the role of evidence in e-cigarette regulation and policy development (Doctoral dissertation, University of Glasgow).
- [26] O'Connell, M., & Kephart, L. (2022). Local and state policy action taken in the United States to address the emergence of e-cigarettes and vaping: a scoping review of literature. *Health Promotion Practice*, 23(1), 51-63.
- [27] Kundu, S., Shaw, S., Khan, J., Chattopadhyay, A., Baptista, E. A., & Paswan, B. (2023). Age, gender and socioeconomic patterns of awareness and usage of e-cigarettes across selected WHO region countries: evidence from the Global Adult Tobacco Survey. *BMJ open*, 13(1), e070419.
- [28] Namazi, M., Behboodi Moghadam, Z., Zareiyan, A., & Jafarabadi, M. (2021). Impact of endometriosis on reproductive health: an integrative review. *Journal of Obstetrics and Gynaecology*, 41(8), 1183-1191.
- [29] Nri-Ezedi, C., Mbwele, B., Ikwuka, D., Phiri, P., Elneil, S., Delanerolle, G.,... & Ikechebelu, J. I. (2025). Menstrual Health and Endometriosis: An Urgent Issue in Africa.
- [30] Taylor, L. (2025). Black Women's Experiences of Reaching a Diagnosis of Endometriosis.
- [31] Tohit, N. F. M., & Haque, M. (2024). Forbidden conversations: A comprehensive exploration of taboos in sexual and reproductive health. *Cureus*, 16(8).
- [32] Kocas, H. D., Rubin, L. R., & Lobel, M. (2023). Stigma and mental health in endometriosis. *European journal of obstetrics & gynecology and reproductive biology*: X, 19, 100228.
- [33] Hudson, N. (2022). The missed disease? Endometriosis as an example of 'undone science'. *Reproductive biomedicine & society online*, 14, 20-27.
- [34] Bergen, S., Murimi, D., Gruer, C., Munene, G., Nyachio, A., Owiti, M., & Sommer, M. (2023). Living with endometriosis: a narrative analysis of the experiences of Kenyan women. *International journal of environmental research and public health*, 20(5), 4125.
- [35] Vallée, A., Feki, A., Josseran, L., & Ayoubi, J. M. (2025). Smoking and endometriosis: A narrative review. *Tobacco Induced Diseases*, 23, 10-18332.
- [36] Trapphoff, T., Ontrup, C., Krug, S., & Dieterle, S. (2024). Consumption of hookahs, e-cigarettes, and classic cigarettes and the impact on medically assisted reproduction treatment. *Scientific Reports*, 14(1), 9597.
- [37] Szumilas, K., Szumilas, P., Grzywacz, A., & Wilk, A. (2020). The effects of e-cigarette vapor components on the morphology and function of the male and female reproductive systems: a systematic review. *International journal of environmental research and public health*, 17(17), 6152.
- [38] Marczylo, T. (2020). How bad are e-cigarettes? What can we learn from animal exposure models?. *The Journal of physiology*, 598(22), 5073-5089.
- [39] Corona, G., Sansone, A., Pallotti, F., Ferlin, A., Pivonello, R., Isidori, A. M.,... & Jannini, E. A. (2020). People smoke for nicotine, but lose sexual and reproductive health for tar: a narrative review on the effect of cigarette smoking on male sexuality and reproduction. *Journal of endocrinological investigation*, 43, 1391-1408.
- [40] Wiafe, S., Mihan, A., & Davison, C. M. (2021). Neighborhood-level influences and adolescent health risk behaviors in rural and urban Sub-Saharan Africa: A systematic review. *International journal of environmental research and public health*, 18(14), 7637.
- [41] Kabuya, K. E., Mwelwa, M. K., & Sangany, C. M. (2025). Air Pollution and Non-communicable Diseases (NCDs) in Sub-Saharan African Cities: A Review.
- [42] Waghmare, B. V., & Jajoo, S. (2024). Navigating the challenges: A comprehensive review of adolescent gynecological problems. *Cureus*, 16(3).
- [43] Brillinger, J. (2020). A Mixed Methods Investigation of Bar Atmospherics and Smoking in New Zealand (Doctoral dissertation, University of Otago).

- [44] Omiyale, W. (2020). Adiposity and smoking in relation to risk of endometrial cancer (Doctoral dissertation, University of Oxford).
- [45] Patel, P. S. Nicotine addiction and vaping in post-pandemic adolescents: Investigating the prevalence, neurodevelopmental impact, and pulmonary pathogenesis in relation to Covid-19-driven behavioral shifts.
- [46] Das, P. K., Mukherjee, J., & Banerjee, D. (2023). Female reproductive physiology. In *Textbook of veterinary physiology* (pp. 513-568). Singapore: Springer Nature Singapore.
- [47] Interdonato, L., Siracusa, R., Fusco, R., Cuzzocrea, S., & Di Paola, R. (2023). Endocrine disruptor compounds in environment: Focus on women's reproductive health and endometriosis. *International Journal of Molecular Sciences*, 24(6), 5682.
- [48] Babaniyi, G. G., Ajao, B. H., Akor, U. J., & Babaniyi, E. (2024). Reproductive endocrinology drug development: Hormones, metabolism, and fertility in female reproductive health. In *Perspectives of Quorum Quenching in New Drug Development* (pp. 187-206). CRC Press.
- [49] Marquardt, R. M., Kim, T. H., Shin, J. H., & Jeong, J. W. (2019). Progesterone and estrogen signaling in the endometrium: what goes wrong in endometriosis?. *International journal of molecular sciences*, 20(15), 3822.
- [50] Chantalat, E., Valera, M. C., Vaysse, C., Noirrit, E., Rusidze, M., Weyl, A.,... & Lenfant, F. (2020). Estrogen receptors and endometriosis. *International journal of molecular sciences*, 21(8), 2815.
- [51] Harding, A. T., & Heaton, N. S. (2022). The impact of estrogens and their receptors on immunity and inflammation during infection. *Cancers*, 14(4), 909.
- [52] Buzzaccarini, G., Vitagliano, A., Andrisani, A., Santarsiero, C. M., Cicinelli, R., Nardelli, C.,... & Cicinelli, E. (2020). Chronic endometritis and altered embryo implantation: a unified pathophysiological theory from a literature systematic review. *Journal of Assisted Reproduction and Genetics*, 37, 2897-2911.
- [53] Schrager, S., Larson, M., Carlson, J., Ledford, K., & Ehrental, D. B. (2020). Beyond birth control: noncontraceptive benefits of hormonal methods and their key role in the general medical care of women. *Journal of Women's Health*, 29(7), 937-943.
- [54] Adilbayeva, A., & Kunz, J. (2024). Pathogenesis of endometriosis and endometriosis-associated cancers. *International journal of molecular sciences*, 25(14), 7624.
- [55] Ansariniya, H., Yavari, A., Javaheri, A., & Zare, F. (2022). Oxidative stress -related effects on various aspects of endometriosis. *American Journal of Reproductive Immunology*, 88(3), e13593.
- [56] Lavacchi, D., Roviello, G., & Rodriquenz, M. G. (2020). Electronic nicotine delivery systems (ENDS): not still ready to put on END. *Journal of thoracic disease*, 12(7), 3857.
- [57] Özcan, S., Ögüt, E. G., Levent, S., & Can, N. Ö. (2024). Review of an up-to-date, emphatic, and concise perspective on e-cigarettes. *European Journal of Life Sciences*, 3(1), 31-43.
- [58] Quinones Tavarez, Z., Li, D., Croft, D. P., Gill, S. R., Ossip, D. J., & Rahman, I. (2020). The interplay between respiratory microbiota and innate immunity in flavor e-cigarette vaping induced lung dysfunction. *Frontiers in Microbiology*, 11, 589501.
- [59] Emma, R., Caruso, M., Campagna, D., Pulvirenti, R., & Li Volti, G. (2022). The impact of tobacco cigarettes, vaping products and tobacco heating products on oxidative stress. *Antioxidants*, 11(9), 1829.
- [60] Ebersole, J., Samburova, V., Son, Y., Cappelli, D., Demopoulos, C., Capurro, A.,... & Khlystov, A. (2020). Harmful chemicals emitted from electronic cigarettes and potential deleterious effects in the oral cavity. *Tobacco induced diseases*, 18, 41.
- [61] Nicholson, T., Scott, A., Newton Ede, M., & Jones, S. W. (2021). The impact of E-cigarette vaping and vapour constituents on bone health. *Journal of Inflammation*, 18(1), 16.
- [62] Bhardwaj, J. K., Siwach, A., & Sachdeva, S. N. (2025). Nicotine as a female reproductive toxicant A review. *Journal of Applied Toxicology*, 45(4), 534-550.
- [63] Schwartz, A., & Bellissimo, N. (2021). Nicotine and energy balance: A review examining the effect of nicotine on hormonal appetite regulation and energy expenditure. *Appetite*, 164, 105260.
- [64] Cui, J., & Wang, Y. (2024). Premature ovarian insufficiency: a review on the role of tobacco smoke, its clinical harm, and treatment. *Journal of Ovarian Research*, 17(1), 8.
- [65] Ogbodo, J. O., Arazu, A. V., Iguh, T. C., Onwodi, N. J., & Ezike, T. C. (2022). Volatile organic compounds: a proinflammatory activator in autoimmune diseases. *Frontiers in immunology*, 13, 928379.
- [66] Ebrahimi, M., Khalili, N., Razi, S., Keshavarz-Fathi, M., Khalili, N., & Rezaei, N. (2020). Effects of lead and cadmium on the immune system and cancer progression. *Journal of Environmental Health Science and Engineering*, 18, 335-343.
- [67] Ohiagu, F. O., Chikezie, P. C., Ahaneku, C. C., & Chikezie, C. M. (2022). Human exposure to heavy metals: toxicity mechanisms and health implications. *Material Science & Engineering International Journal*, 6(2), 78-87.
- [68] Hossein-Khannazer, N., Azizi, G., Eslami, S., Alhassan Mohammed, H., Fayyaz, F., Hosseinzadeh, R.,... & Noorisepehr, M. (2020). The effects of cadmium exposure in the induction of inflammation. *Immunopharmacology and immunotoxicology*, 42(1), 1-8.
- [69] Morris, A. M., Leonard, S. S., Fowles, J. R., Boots, T. E., Mnatsakanova, A., & Attfield, K. R. (2021). Effects of e-cigarette flavoring chemicals on human macrophages and bronchial epithelial cells. *International Journal of Environmental Research and Public Health*, 18(21), 11107.
- [70] Tommasi, S., Blumenfeld, H., & Besaratinia, A. (2023). Vaping dose, device type, and e-liquid flavor are determinants of DNA damage in electronic cigarette users. *Nicotine and Tobacco Research*, 25(6), 1145-1154.

- [71] McNestry, C., Killeen, S. L., Crowley, R. K., & McAuliffe, F. M. (2023). Pregnancy complications and later life women's health. *Acta Obstetrica et Gynecologica Scandinavica*, 102(5), 523-531.
- [72] Sibó, M., Esimo, M., Lobota, M., Monka, I., Kayembe, K. K., Grace, T.,... & Darai, E. (2023). Diagnosis Delay and Assessment of the Quality of Life of Patients with Endometriosis Using the Endometriosis Health Profile 5 Questionnaire in a Sub-Saharan Population. *Open Journal of Obstetrics and Gynecology*, 13(5), 907-917.
- [73] Wang, Y., & Torbica, A. (2024). Investigating the relationship between health and gender equality: What role do maternal, reproductive, and sexual health services play?. *Health policy*, 149, 105171.
- [74] Crawford, B. J., & Waldman, E. G. (2020). Period poverty in a pandemic: harnessing law to achieve menstrual equity. *Wash. UL Rev.*, 98, 1569.
- [75] Africa.unwomen:
<https://africa.unwomen.org/en/stories/news/2024/05/period-poverty-why-millions-of-girls-and-women-cannot-afford-their-periods> Accessed on the Sept 24.
- [76] Tobacco: E-cigarettes:
https://www.who.int/news-room/questions-and-answers/item/tobacco-e-cigarettes?utm_source=chatgpt.com Accessed on the Sept 24.
- [77] Konstantinidou, F., Stuppia, L., & Gatta, V. (2020). Looking inside the world of granulosa cells: the noxious effects of cigarette smoke. *Biomedicines*, 8(9), 309.
- [78] Sun, X., He, L., & Wang, S. (2025). Knowledge and awareness of endometriosis among women in Southwest China: a cross-sectional study. *BMC Women's Health*, 25(1), 113.
- [79] Xu, S., Zhang, Y., Ye, P., Huang, Q., Wang, Y., Zhang, Y.,... & Ding, J. (2025). Global, regional, and national burden of endometriosis among women of childbearing age from 1990 to 2021: a cross-sectional analysis from the 2021 global burden of disease study. *International Journal of Surgery*, 111(9), 5927-5940.
- [80] Beguy, D., Mberu, B., & Nyamai, K. (2025). Sexual and Reproductive Health of Young People in Urban Africa. *Urban Health in Africa*, 213.
- [81] Anadón, A., Ares, I., Martínez-Larrañaga, M. R., & Martínez, M. A. (2022). Cigarette and E-cigarettes smoking and reproductive and developmental toxicity. In *Reproductive and Developmental Toxicology* (pp. 395-420). Academic Press.
- [82] Allen, M. S., & Tostes, R. C. (2023). Cigarette smoking and erectile dysfunction: an updated review with a focus on pathophysiology, e-cigarettes, and smoking cessation. *Sexual Medicine Reviews*, 11(1), 61-73.
- [83] Li, R., Zhang, L., & Liu, Y. (2025). Global and regional trends in the burden of surgically confirmed endometriosis from 1990 to 2021. *Reproductive Biology and Endocrinology*, 23(1), 88.
- [84] Mhazo, P., Swartz, A., Asfar, T., & Wallace, M. (2024). Knowledge, perceptions, and experiences of e-cigarettes among young adults in Cape Town, South Africa: Insights from focus groups to inform regulations and prevention strategies. *Tobacco prevention & cessation*, 10, 10-18332.
- [85] Doyle, T. (2025). Delayed and Misdiagnosed Endometriosis.
- [86] Petch, S., Nolan, C., Glover, L., Crosby, D., Petch, S., & Nolan, C. The impact of e-cigarette use (vaping) on ovarian reserve and outcomes of fertility treatment. A systematic review.
- [87] Electronic cigarettes: call to action:
https://www.who.int/publications/m/item/electronic-cigarettes---call-to-action?utm_source=chatgpt.com Accessed on the Sept 24.
- [88] Egbe, C. O., Khan, A., Scheibe, A., & Ayo-Yusuf, O. A. (2024). E-cigarettes and harm reduction: a view from sub-Saharan Africa. *Tobacco Control*, 33(4), 419-421.
- [89] Guerrero, F., Lucar, N., Garvich Claux, M., Chiappe, M., Perez-Lu, J., Hindin, M. J.,... & Bayer, A. M. (2020). Developing an SMS text message intervention on sexual and reproductive health with adolescents and youth in Peru. *Reproductive health*, 17(1), 116.
- [90] Diaz, L. A. (2023). Improving Informed Decision Making to Reduce the Health Risks of Vaping Among Adolescents: A Quality Improvement Project.
- [91] Roy, D. (2024). Closing the Gaps: Optimizing Emergency Department Protocols for Vaping-Related Respiratory Illnesses (Doctoral dissertation, Walden University).
- [92] Jouanny, C., Abhyankar, P., & Maxwell, M. (2024). A mixed methods systematic literature review of barriers and facilitators to help-seeking among women with stigmatised pelvic health symptoms. *BMC Women's Health*, 24(1), 217.
- [93] Poku, N. K. (2021). Sexual and reproductive health and rights in Sub-Saharan Africa. Springer Nature.
- [94] Bahceci, M., Bozdag, G., Boynukalin, F. K., Gultomruk, M., & Ozkavukcu, S. (2024). P-706 The pregnancy rates in a large cohort of patients with thin endometrium when stratified according to estradiol levels on the day of triggering. *Human Reproduction*, 39(Supplement_1), deae108-1036.
- [95] Roupert, M., Babjuk, M., Burger, M., Capoun, O., Cohen, D., Comperat, E. M.,... & Shariat, S. F. (2021). European Association of Urology guidelines on upper urinary tract urothelial carcinoma: 2020 update. *European urology*, 79(1), 62-79.
- [96] Antin, T. M. (2023). *Routledge handbook of intoxicants and intoxication*. G. Hunt, T. M. Antin, & V. A. Frank (Eds.). London: Routledge.
- [97] Golden, S. D., Baggett, C. D., Kuo, T. M., Kong, A. Y., Delamater, P. L., Tao, V. Q., & Ribisl, K. M. (2022). Trends in the number and type of tobacco product retailers, United States, 2000–2017. *Nicotine and Tobacco Research*, 24(1), 77-84.
- [98] Weissig, V., & Edeas, M. (2023). Targeting Mitochondria 2023 Abstract Book. *Journal of Mitochondria, Plastids and Endosymbiosis*, 1(sup1), 2270281.

- [99] Prasad, K. N., & Bondy, S. C. (2022). Electronic cigarette aerosol increases the risk of organ dysfunction by enhancing oxidative stress and inflammation. *Drug and Chemical Toxicology*, 45(6), 2561-2567.
- [100] Ni Dhonnabháin, B., Relton, R., Rodrigues Vaz, S., Vasavan, T., Getreu, N., & O'Neill, H. (2024). P-697. The effect of smoking and vaping on hormonal ovarian reserve markers in women of reproductive age in the United Kingdom. *Human Reproduction*, 39(Supplement_1), deae108-1027.
- [101] Bravi, F., Parazzini, F., Cipriani, S., Chiaffarino, F., Ricci, E., Chiantera, V.,... & La Vecchia, C. (2014). Tobacco smoking and risk of endometriosis: a systematic review and meta-analysis. *BMJ open*, 4(12), e006325.
- [102] Ussher, M., Fleming, J., & Brose, L. (2024). Vaping during pregnancy: a systematic review of health outcomes. *BMC Pregnancy and Childbirth*, 24(1), 435.
- [103] Alkattan, R., Tashkandi, N., Mirdad, A., Ali, H. T., Alshibani, N., & Allam, E. (2025). Effects of Electronic Cigarettes on Periodontal Health: A Systematic Review and Meta-Analysis. *International Dental Journal*.
- [104] Maulenkul, T., Kuandyk, A., Makhadiyeva, D., Dautova, A., Terzic, M., Oshibayeva, A.,... & Sarria-Santamera, A. (2024). Understanding the impact of endometriosis on women's life: an integrative review of systematic reviews. *BMC women's health*, 24(1), 524.
- [105] Parsa, S., Noroozpoor, R., Dehghanbanadaki, H., Khateri, S., & Moradi, Y. (2025). Endometriosis and risk of cardiovascular disease: a systematic review and meta-analysis. *BMC public health*, 25(1), 245.
- [106] Petraglia, F., Vannuccini, S., Dolmans, M. M., Speciale, A. R., Bourdon, M., Marcellin, L., ... & Chapron, C. (2025). The endocrine aspects of endometriosis. *European journal of endocrinology*, 193(4), R17-R30.
- [107] Bushi, G., Khatib, M. N., Balaraman, A. K., Ballal, S., Bansal, P., Tomar, B. S.,... & Shabil, M. (2024). Prevalence of dual use of combustible tobacco and E-cigarettes among pregnant smokers: a systematic review and meta-analysis. *BMC Public Health*, 24(1), 3200.
- [108] Khodaei, A., Reed, A., & Khodaei, M. (2025). Electronic cigarette use (vaping) among adolescents: a narrative review of an emerging public health epidemic. *Cureus*, 17(8).
- [109] Kabani, Z., Ramos-Nino, M. E., & Ramdass, P. V. (2022). Endometriosis and COVID-19: a systematic review and meta-analysis. *International Journal of Molecular Sciences*, 23(21), 12951.
- [110] Peitsidis, P., Tsikouras, P., Laganà, A. S., Laios, A., Gkegkes, I. D., & Iavazzo, C. (2023). A systematic review of systematic reviews on the use of aromatase inhibitors for the treatment of endometriosis: the evidence to date. *Drug Design, Development and Therapy*, 1329-1346.