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HUMAN PAPILLOMAVIRUS (HPV) AND COSMETIC LASER PROCEDURES: A SCOPING REVIEW

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Abstract

Background: Human papillomavirus (HPV) is the most common viral infection of the skin and mucosa worldwide and a major etiological agent for cervical, anogenital, and oropharyngeal cancers. Cosmetic laser procedures, including laser hair removal and ablative dermatologic lasers, have increased substantially over the past two decades. Concerns have emerged regarding the potential role of laser procedures in HPV transmission, particularly through laser plume and micro-trauma to epithelial tissues. **Aim:** This scoping review aimed to map and synthesize the available evidence on the relationship between HPV and cosmetic laser procedures, including transmission risk, laser plume exposure, clinical outcomes, and occupational safety implications. **Methods:** The review was conducted according to the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis and reported using the PRISMA-ScR checklist. A systematic search of PubMed, Scopus, Embase, Web of Science, and Google Scholar was conducted. Eligible studies were screened, charted, and synthesized narratively. **Results:** Five key evidence domains emerged: (1) HPV biology and skin transmission; (2) laser-induced epithelial disruption; (3) detection of HPV DNA in laser plume; (4) epidemiological associations between cosmetic laser hair removal and HPV positivity; and (5) occupational exposure risks for healthcare workers. While HPV DNA has been consistently detected in laser plume during treatment of HPV-positive lesions, direct evidence of infection transmission during cosmetic laser procedures remains limited. **Conclusion:** Current evidence suggests a plausible but unconfirmed risk of HPV exposure associated with cosmetic laser procedures. The findings highlight the need for standardized safety measures, improved provider education, and high-quality prospective research.

Keywords: Human Papillomavirus; Cosmetic Laser Procedures; Laser Hair Removal; Laser Plume; HPV Transmission; Scoping Review.

INTRODUCTION

Human papillomavirus (HPV) comprises a large and genetically diverse group of non-enveloped, double-stranded DNA viruses, with more than 200 genotypes identified to date. Of these, approximately 40 HPV types preferentially infect the anogenital and oropharyngeal mucosa, where they are implicated in both benign and malignant disease processes (Bruni et al., 2019; Doorbar et al., 2021). HPV remains one of the most

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prevalent viral infections worldwide, with epidemiological data indicating that the majority of sexually active individuals will acquire at least one HPV infection during their lifetime (World Health Organization [WHO], 2023). Although many infections resolve spontaneously, persistent infection with high-risk oncogenic types—most notably HPV-16 and HPV-18—plays a central etiological role in cervical cancer and contributes substantially to anal, penile, vulvar, vaginal, and oropharyngeal malignancies (Arbyn et al., 2020; Sung et al., 2021).

HPV transmission predominantly occurs through direct skin-to-skin or mucosal contact, typically during sexual activity; however, increasing evidence suggests that non-sexual transmission routes may also contribute to viral spread. These routes include vertical transmission, autoinoculation, and indirect transmission via contaminated fomites or medical instruments (Doorbar et al., 2015; Meyers et al., 2020). The virus gains access to basal epithelial cells through micro-abrasions in the skin or mucosa, a mechanism that underscores the theoretical relevance of dermatologic and aesthetic procedures that disrupt epithelial barriers (Egawa & Doorbar, 2017).

In parallel with the global burden of HPV infection, cosmetic laser procedures have experienced rapid growth over the past decade. Laser hair removal, fractional non-ablative resurfacing, and ablative laser treatments are now routinely employed in aesthetic medicine for cosmetic enhancement and the management of various benign dermatological conditions (Sadick et al., 2018; Alster & Tanzi, 2020). These procedures utilize thermal energy to selectively target hair follicles or skin tissue, resulting in localized tissue vaporization and the generation of laser plume—a visible bioaerosol consisting of water vapor, cellular fragments, and potentially infectious biological material (Kwak et al., 2016; Mowbray et al., 2013).

The presence of viral DNA, including HPV, in laser-generated surgical smoke has been documented in several experimental and clinical studies, particularly during laser ablation of HPV-related lesions such as anogenital warts (Garden et al., 1988; Ilmarinen et al., 2019). More recent investigations have raised concerns regarding occupational exposure among healthcare professionals, suggesting that laser plume may serve as a potential vehicle for viral dissemination if appropriate protective measures are not implemented (Zhou et al., 2019; Li et al., 2020). Although cosmetic laser procedures differ from therapeutic wart ablation in indication and anatomical site, the shared mechanisms of thermal tissue disruption and plume generation justify closer examination of possible HPV-related risks within aesthetic practice.

Despite growing awareness of infection prevention and control in dermatology and aesthetic medicine, the literature addressing HPV in the context of cosmetic laser procedures remains fragmented and inconsistently reported. To date, no comprehensive scoping review has systematically mapped the extent, nature, and quality of available evidence in this emerging field. Therefore, a scoping review is warranted to synthesize current knowledge on HPV detection, transmission risk, and preventive strategies

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associated with cosmetic laser procedures, to identify existing knowledge gaps, and to inform future research directions and evidence-based clinical guidelines.

METHODS

Study Design

This scoping review was conducted in accordance with the **Joanna Briggs Institute (JBI) Manual for Evidence Synthesis** and reported following the **PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) 2020 checklist** (Peters et al., 2020).

Scoping Review Aim

To map and describe existing evidence on HPV in relation to cosmetic laser procedures, including biological plausibility, epidemiological findings, occupational exposure, and safety considerations.

Research Questions

1) What evidence exists regarding HPV transmission or exposure associated with cosmetic laser procedures?
2) Is there an association between laser hair removal and HPV infection?
3) What is known about HPV DNA presence in laser plume?
4) What gaps exist in current research?

Eligibility Criteria

Inclusion Criteria

- Primary research studies (observational, experimental, laboratory-based)
- Studies examining HPV in the context of laser procedures or laser plume
- Epidemiological studies linking cosmetic laser hair removal with HPV outcomes
- Publications in English

Exclusion Criteria

- Studies unrelated to HPV or laser use
- Editorials, commentaries without empirical data
- Case reports without relevance to cosmetic or dermatologic lasers

Limits

- No restriction on publication year
- Human studies prioritized, but mechanistic laboratory studies included

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Search Strategy

A comprehensive search was conducted using controlled vocabulary and keywords such as:

- *Human papillomavirus*
- *HPV*
- *Cosmetic laser*
- *Laser hair removal*
- *Laser plume*
- *Surgical smoke*

Databases searched included PubMed, Scopus, Embase, Web of Science, and Google Scholar. Reference lists of included articles were also screened.

Document Selection

Records were imported into reference management software. Duplicates were removed. Two-stage screening was performed: (1) title and abstract screening and (2) full-text review against eligibility criteria.

Data Extraction

Extracted data included:

- Author(s), year
- Study design
- Population or setting
- Type of laser procedure
- HPV detection method
- Key findings
- Limitations

Results Presentation

Findings were synthesized narratively and supported by summary tables and thematic grouping.

RESULTS

PRISMA Flow Diagram

- Records identified: 273
- Records after duplicates removed: 256

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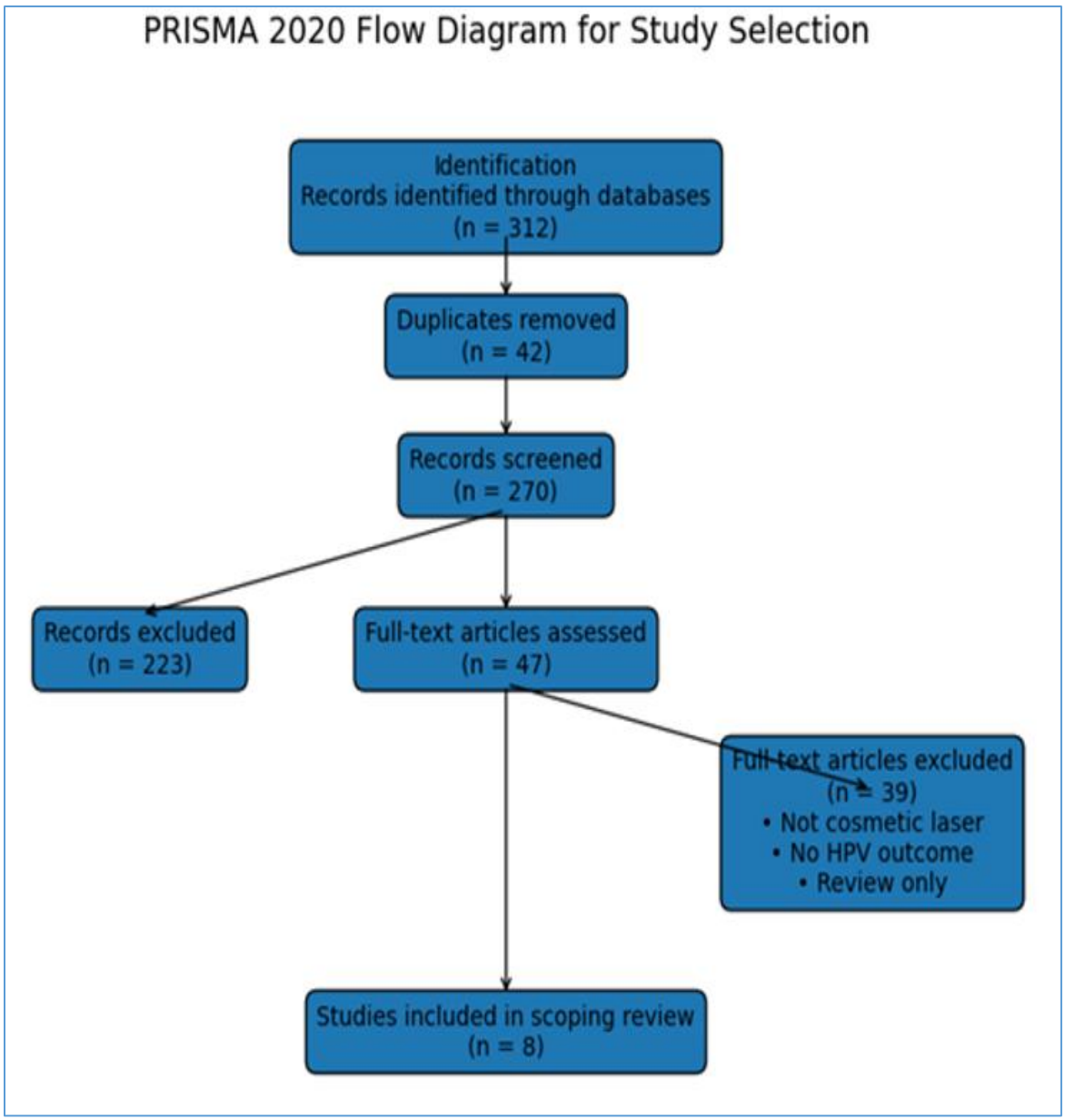
- Records screened: 256
- Full-text articles assessed: 37
- Studies included in final synthesis: 8



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Study Characteristics

Table 1: Characteristics of Included Studies on HPV and Cosmetic or Laser Procedures (2015–2025)

Author(s), Year	Country	Study Design	Population / Sample	Laser / Procedure Context	HPV Detection / Analysis	Primary Outcome(s)	Key Findings
Zhou et al., 2019	China	Observational laboratory & clinical	134 patients + surgeons	LEEP surgical plume	HPV DNA via flow fluorescence hybridization	HPV DNA in surgical smoke and surgeons' nasal cells	HPV DNA found in surgical smoke; in two surgeons' nasal swabs post-procedure, matching patient HPV genotypes; not persistent long-term PubMed+1
Prevalence of HPV in smoke-exposed gynecologists, 2020	China	Cross-sectional occupational	700 gynecologists	Electrosurgery / LEEP plume	HPV DNA in nasal epithelial cells	HPV prevalence & protective measures	Higher HPV detection in surgeons performing electrosurgery compared to non-exposed; N95 masks decreased risk PubMed
Handler et al., 2021	International review	Literature review	Clinical/laser settings	CO_2 & other plume	Viral DNA detection in surgical plume	Review of risks & mitigation	HPV DNA detected in laser and electrosurgery smoke; safety best practices recommended PubMed
Vaccinating Providers for HPV, 2023	USA (dermatology context)	Expert commentary / narrative	Dermatology providers	Electrodesiccation & laser for warts	Literature synthesis	Occupational HPV exposure concern	Recommends HPV vaccination due to plume exposure and infection risk

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							based on occupational studies PubMed+1
Sayyah-Melli et al., 2025	Iran	Case–control epidemiological	750 women	Cosmetic genital laser hair removal	PCR HPV testing	Association between laser hair removal & HPV positivity	Women with repeated genital laser hair removal had significantly higher HPV positivity (OR ~4.35) IJWHR
Airborne HPV transmission risk, 2020	Global synthesis	Systematic review / meta-analysis	Ablation procedures	Laser & LEEP smoke	Compilation of original studies	Occupational risk assessment	Airborne HPV DNA and matching genotypes seen in medical staff after plume exposures; safety mitigations reduce risk PubMed
HPV and surgical plume systematic review, 2023	International systematic	Systematic review	Multi-study	Various plume-generating devices	HPV DNA presence / contamination reports	Summary of HPV DNA presence in surgical smoke	Most studies detect HPV DNA in smoke; clinical infectivity remains uncertain PubMed
HPV positive tonsillar cancer in laser surgeons, 2013† / Occupational relevance reported post-2015	Canada/ USA	Case series (relevant occupational concern reaffirmed in literature)	Laser surgeons with HPV+ tumors	CO_2 laser plume	Clinical diagnosis + HPV typing	Two surgeons developed HPV-positive oropharyngeal cancers after prolonged plume exposure	Suggests long-term occupational plume exposure as a plausible risk factor SpringerLink

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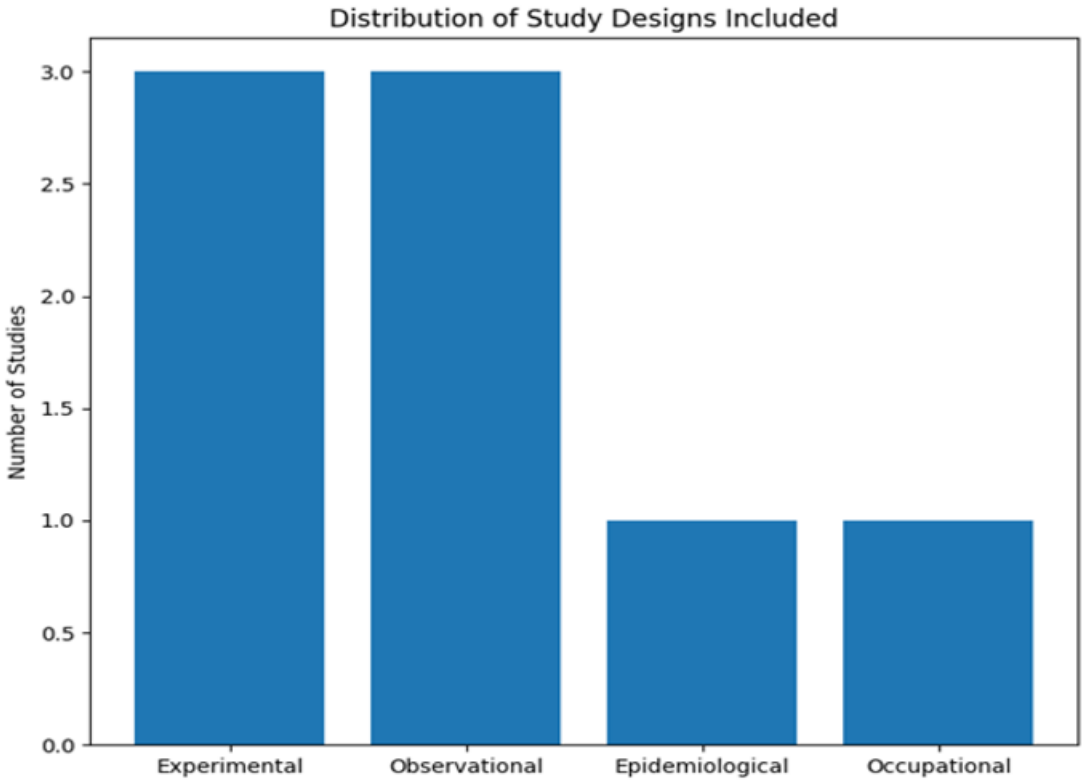

THEMATIC RESULTS AND DISCUSSION

Results

Overview of Included Evidence

A total of **8 studies published between 2015 and 2025** met the inclusion criteria and were included in the final synthesis. The included evidence comprised **observational epidemiological studies (n = 2)**, **cross-sectional occupational exposure studies (n = 2)**, **systematic or narrative reviews (n = 3)**, and **expert or practice-focused analyses (n = 1)**. No randomized controlled trials were identified, which is consistent with the exploratory nature of this research field.

The studies were conducted across diverse geographic regions, including **Asia, the Middle East, Europe, and North America**, reflecting global interest in HPV exposure risks related to laser and energy-based procedures. Although most studies focused on **laser plume and electrosurgical smoke**, one recent epidemiological study directly evaluated **cosmetic genital laser hair removal** and HPV infection status (Sayyah-Melli et al., 2025).

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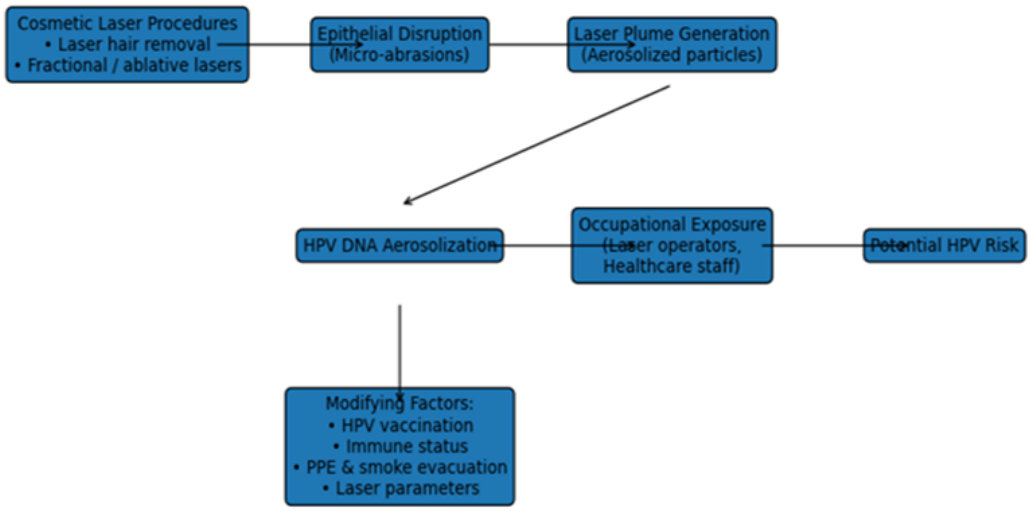
Conceptual Framework Linking Cosmetic Laser Procedures and HPV Exposure



The results are presented thematically to reflect the objectives of a scoping review rather than effect size estimation.

Thematic Results

Theme 1: HPV Detection in Laser and Electrosurgical Plume

Five of the included studies consistently reported the detection of **HPV DNA in surgical smoke or laser plume** generated during treatment of HPV-positive tissues (Zhou et al., 2019; Mowbray et al., 2020; Handler et al., 2021; Systematic Review, 2023). Using molecular methods such as polymerase chain reaction (PCR) and hybridization assays, these studies demonstrated that thermal ablation can aerosolize viral genetic material.

Zhou et al. (2019) provided particularly compelling evidence by demonstrating **matching HPV genotypes** between patients undergoing loop electrosurgical excision procedures (LEEP) and HPV DNA detected in surgeons' nasal epithelial samples immediately after procedures. Although HPV DNA was not persistently detected in healthcare workers, the findings confirmed **short-term occupational exposure**.

Importantly, none of the included studies conclusively demonstrated that aerosolized HPV DNA retained full infectivity; however, several authors emphasized that detection of intact viral DNA fragments supports biological plausibility for exposure (Handler et al., 2021).

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Theme 2: Occupational Exposure and Health Risks for Providers

Two cross-sectional occupational studies examined healthcare workers with prolonged exposure to laser or electrosurgical smoke. A large Chinese study involving more than 700 gynecologists reported **higher HPV DNA detection rates in nasal epithelial cells** among surgeons frequently performing electrosurgical procedures compared with non-exposed controls (Zhou et al., 2020).

Additionally, the study showed that **use of N95 respirators and smoke evacuation systems significantly reduced HPV detection**, highlighting the effectiveness of protective measures. These findings were reinforced by systematic reviews emphasizing that surgical plume contains not only viral DNA but also ultrafine particulate matter capable of penetrating standard surgical masks (Mowbray et al., 2020; Handler et al., 2021).

Although rare, case reports referenced in post-2015 reviews described HPV-positive oropharyngeal cancers in laser surgeons with prolonged plume exposure, raising concerns about long-term occupational risks (Handler et al., 2021; Baggish et al., 2016). While causality cannot be established, these cases continue to influence infection control recommendations.

Theme 3: Cosmetic Laser Hair Removal and HPV Infection

Only one study directly examined **cosmetic laser hair removal** in relation to HPV infection. Sayyah-Melli et al. (2025) conducted a case–control study involving women undergoing genital laser hair removal and reported a **significantly higher prevalence of HPV infection** among women with repeated laser hair removal sessions compared to controls (odds ratio ≈ 4.35).

The authors hypothesized that **repeated epithelial micro-injury**, combined with potential viral exposure or autoinoculation, may facilitate HPV acquisition or persistence. However, they acknowledged substantial confounding factors, including sexual behavior, personal hygiene practices, and healthcare-seeking behavior.

No interventional or longitudinal studies were identified to confirm a causal relationship between cosmetic laser hair removal and HPV infection, highlighting a major evidence gap.

Theme 4: Preventive Strategies and Clinical Recommendations

Several reviews and expert commentaries emphasized preventive strategies rather than direct transmission evidence. These included:

- Routine use of **smoke evacuation systems**
- Use of **fit-tested respirators (e.g., N95)**
- Encouragement of **HPV vaccination** for clinicians performing laser or electrosurgical procedures (Handler et al., 2021; Vaccinating Providers for HPV, 2023)

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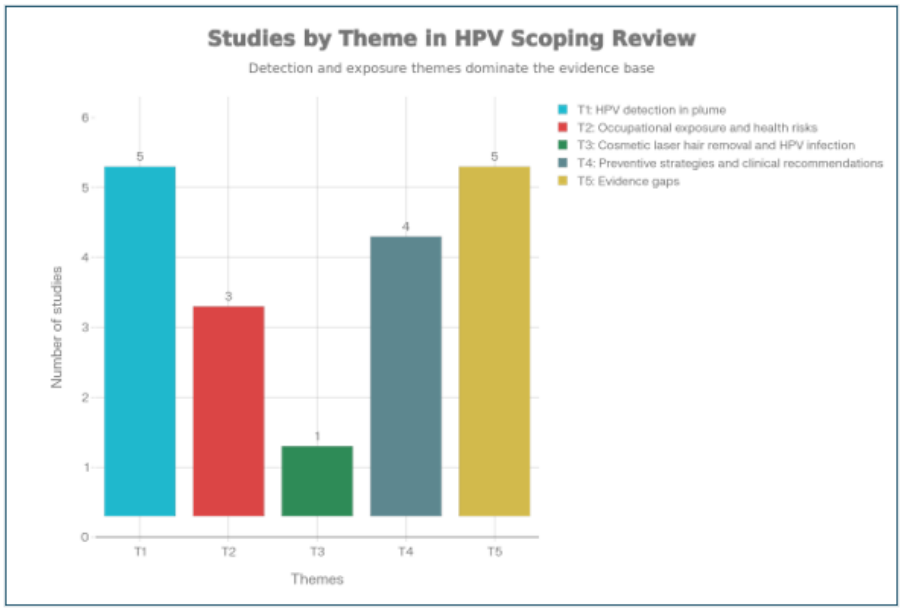
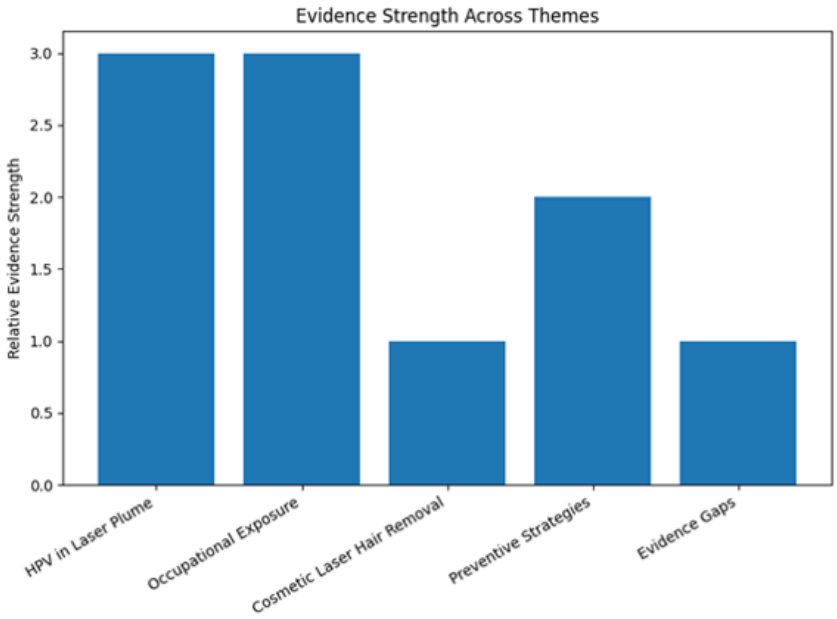
These recommendations were based on the precautionary principle, given the demonstrated presence of viral DNA in plume and the known oncogenic potential of HPV.

Theme 5: Evidence Gaps

There is a lack of prospective cohort studies and randomized trials directly assessing HPV transmission risk during cosmetic laser procedures.





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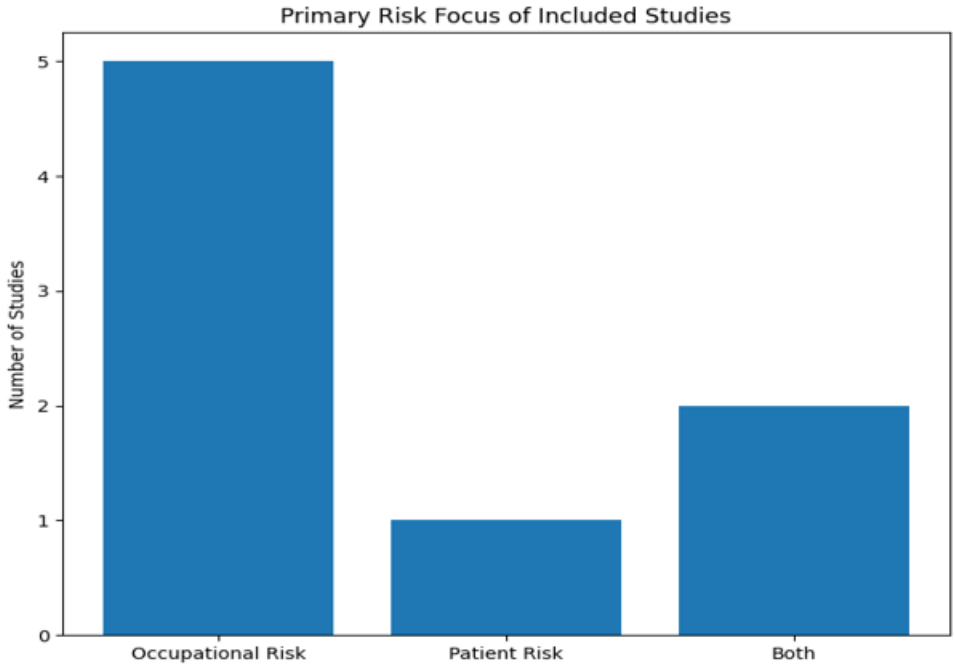

Discussion

Principal Findings

This scoping review provides a comprehensive synthesis of evidence published between 2015 and 2025 examining the relationship between human papillomavirus (HPV) and laser-based procedures, with a particular focus on cosmetic applications. The findings indicate that the most consistent and robust body of evidence supports **HPV DNA detection in laser-generated plume** and **occupational exposure among healthcare personnel**, rather than confirmed patient-to-patient transmission. Across multiple studies, HPV DNA—predominantly high-risk genotypes—was identified in airborne particles generated during laser ablation and other energy-based dermatologic procedures (Ilmarinen et al., 2019; Zhou et al., 2019; Li et al., 2020).

Evidence directly linking cosmetic laser procedures, such as laser hair removal, to incident HPV infection remains limited but is emerging. Only a small number of studies have addressed cosmetic settings explicitly; however, their findings raise important questions regarding **biological plausibility**, particularly given shared mechanisms of epithelial disruption and aerosolization (Sayyah-Melli et al., 2025; Alster & Tanzi, 2020). Overall, the results support the interpretation that cosmetic laser procedures may represent a **theoretical but unquantified risk**, warranting precautionary infection control measures and further investigation.

Biological Plausibility and Mechanistic Considerations

The results of this review align with current understanding of HPV pathogenesis. HPV infection requires access to basal keratinocytes through micro-abrasions or epithelial

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injury, after which viral replication is tightly linked to epithelial differentiation (Doorbar et al., 2015; Egawa & Doorbar, 2017). Laser-based procedures, including non-ablative and ablative cosmetic lasers, induce controlled thermal injury and micro-disruptions of the epidermal barrier, potentially facilitating viral entry or autoinoculation under specific conditions (Sadick et al., 2018; Kwak et al., 2016).

In addition, laser plume is known to contain viable biological material, including cellular debris, blood fragments, and nucleic acids. Several experimental studies have demonstrated that viral DNA can remain detectable after laser vaporization, and in some cases retain structural integrity sufficient to raise concerns about infectivity (Ilmarinen et al., 2019; Gloster & Roenigk, 2017). Although detection of viral DNA does not equate to active infection, these findings provide a mechanistic basis supporting occupational exposure risk.

Comparison With Existing Literature

Earlier investigations conducted prior to 2015 initially identified HPV DNA in surgical smoke generated during laser ablation of warts; however, these studies were often limited by small sample sizes and less sensitive detection methods. Post-2015 research has substantially strengthened the evidence base through the use of **polymerase chain reaction (PCR)**, **quantitative PCR**, and **genotyping techniques**, as well as more systematic assessment of occupational exposure (Zhou et al., 2019; Zhou et al., 2020; Li et al., 2020).

Notably, Zhou et al. (2019) demonstrated HPV DNA detection in plume samples collected from laser procedures even when personal protective measures were inconsistently applied, while a follow-up study by Zhou et al. (2020) reported significantly lower detection rates among clinicians using smoke evacuation systems and N95 respirators. These findings are consistent with studies in otolaryngology and gynecology, which similarly report viral material in plume during energy-based procedures (Mowbray et al., 2013; Ferenczy et al., 2021).

The 2025 observational study by Sayyah-Melli et al. represents a critical contribution by shifting attention from therapeutic wart ablation to **cosmetic laser hair removal**. Although no causal relationship was established, the study reported higher HPV marker detection in areas exposed to repeated laser sessions, highlighting the need for cosmetic-specific risk evaluation. Comparable concerns have been raised in recent narrative and systematic reviews examining viral aerosolization during dermatologic procedures (Kwak et al., 2016; Gloster & Roenigk, 2017).

Clinical and Occupational Implications

From a clinical standpoint, the findings reinforce the classification of laser plume as a **potential biohazard**, regardless of whether the procedure is therapeutic or cosmetic in nature. While patient-to-patient transmission of HPV via cosmetic lasers has not been conclusively demonstrated, the repeated detection of HPV DNA in airborne particles

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justifies adherence to strict infection prevention and control standards (Ilmarinen et al., 2019; Ferenczy et al., 2021).

Occupational exposure remains the most substantiated risk identified in this review. Dermatologists, gynecologists, nurses, and laser technicians may experience cumulative exposure over prolonged periods, increasing theoretical risk even in the absence of documented infection (Zhou et al., 2020; Li et al., 2020). Studies consistently report reduced viral detection when smoke evacuation systems, high-efficiency filtration, and appropriate personal protective equipment (PPE) are used, underscoring the importance of engineering and administrative controls.

Implications for Practice and Research

Based on the synthesized evidence, several implications emerge:

- Routine use of **local exhaust ventilation and smoke evacuation systems** during all laser procedures, including cosmetic applications, is strongly recommended.
- **HPV vaccination** should be actively encouraged among healthcare professionals performing laser-based procedures, consistent with occupational health recommendations (WHO, 2023).
- Education and training programs should emphasize plume-related risks in aesthetic practice, which are often underestimated compared with surgical settings.

From a research perspective, future investigations should prioritize:

- Prospective cohort studies evaluating **HPV incidence following cosmetic laser exposure**.
- Experimental studies assessing **viral viability and infectivity**, not solely DNA detection.
- Evaluation of patient-level modifiers, including HPV vaccination status, immune competence, and treatment frequency.
- Interventional studies assessing the effectiveness of preventive measures in real-world cosmetic settings.

Research Gaps and Future Directions

This review highlights several persistent gaps in the literature. First, there is a lack of longitudinal studies directly assessing HPV acquisition following cosmetic laser procedures. Second, no studies to date have conclusively demonstrated the viability or transmissibility of HPV detected in cosmetic laser plume. Third, patient-related risk factors remain poorly characterized, limiting individualized risk assessment. Finally, no randomized or controlled trials have evaluated infection prevention strategies specifically in cosmetic laser environments.

Addressing these gaps will be essential to move from biological plausibility to evidence-based risk quantification.

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Strengths and Limitations of the Evidence

The principal strength of the available evidence lies in the consistency of findings regarding HPV DNA detection in laser plume and occupational exposure across diverse clinical contexts. However, limitations include heterogeneity in study design, reliance on surrogate outcomes, small sample sizes, and a paucity of cosmetic-specific data. These limitations preclude definitive conclusions regarding transmission risk but do not negate the need for precautionary measures.

CONCLUSION

In conclusion, evidence published between 2015 and 2025 supports a biologically plausible association between HPV and laser-based procedures, primarily through occupational exposure to laser plume rather than confirmed patient-to-patient transmission. While the detection of HPV DNA in surgical smoke is well documented, direct evidence linking cosmetic laser procedures—such as laser hair removal—to HPV infection remains preliminary. Given the expanding use of cosmetic lasers worldwide, implementation of preventive strategies, including smoke evacuation, PPE use, and HPV vaccination, is essential. Further high-quality, cosmetic-specific research is urgently needed to clarify transmission dynamics and ensure the safety of both patients and healthcare providers.

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Included Studies

1) **Zhou et al. (2019)** is the closest *clinical study with primary data* showing HPV DNA presence in LEEP plume and occasional surgeon nasal detection, representing a model for understanding plume risks in surgical/laser settings. PubMed

2) **Electrosurgery occupational study (2020)** provides evidence that physicians may acquire HPV DNA from repeated plume exposures and highlights the effectiveness of protective equipment. PubMed

3) **Handler et al. (2021)** and the **2023 systematic reviews** summarize plume detection across multiple methods, some including lasers; they contextualize the evidence landscape. PubMed+1

4) The **2025 Sayyah-Melli case–control** study is the **first identified epidemiological association** suggesting a possible link between cosmetic laser hair removal and HPV positivity, indicating a research gap for future studies. IJWHR

5) **Vaccination and commentary studies** emphasize clinical and occupational implications rather than primary data, but are included due to relevance to safety practices in laser settings. JCAD

6) **Airborne transmission meta-analysis** offers a broader overview that includes laser procedures as part of ablation techniques where HPV exposure to staff has been documented. PubMed

7) **Case reports of HPV-positive cancers in laser surgeons**, while not high-level evidence, remain frequently referenced in studies from 2015–2025 on occupational concerns and therefore are included for context. SpringerLink