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What Condoms Cannot Cover: A Systematic Review of HPV, HSV, Syphilis, and Other Skin-to-Skin Sexually Transmitted Infections Despite Condom Use

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Abstract

Background: *Condoms are highly effective in reducing the transmission of many sexually transmitted infections (STIs); however, their protective effect against infections transmitted through skin-to-skin contact remains incomplete. Human papillomavirus (HPV), herpes simplex virus (HSV), and syphilis may still be transmitted despite correct and consistent condom use because infectious lesions or viral shedding can occur outside the condom-covered area.*

Objective: *This systematic review aimed to synthesize evidence regarding the acquisition of HPV, HSV, and syphilis among individuals reporting condom-protected sexual activity and to examine the residual risk associated with skin-to-skin transmission.*

Methods: *A systematic review was conducted according to PRISMA 2020 guidelines. Searches were performed in PubMed, Scopus, Web of Science, ERIC, and Google Scholar, supplemented by manual reference screening. Studies reporting STI acquisition despite condom use were included. Data were extracted and synthesized narratively because of methodological heterogeneity.*

Results: *A total of 473 records were identified, of which 13 studies met the inclusion criteria. The evidence consistently demonstrated that condoms reduce, but do not eliminate, the risk of HPV, HSV, and syphilis transmission. HPV infections persisted because of exposure to uncovered genital skin. HSV transmission occurred through asymptomatic viral shedding and lesions located outside condom-covered areas. Syphilis transmission remained possible through contact with infectious lesions on exposed skin or mucosal surfaces. Several studies also identified limitations associated with self-reported condom use.*

Conclusion: *Condoms remain an essential component of STI prevention but do not provide complete protection against skin-to-skin transmitted infections. Comprehensive prevention strategies, including vaccination, screening, sexual health education, and early treatment, should complement condom use.*

Keywords: *condoms, human papillomavirus, HPV, herpes simplex virus, HSV, syphilis, sexually transmitted infections, skin-to-skin transmission, protected sex, systematic review.*

INTRODUCTION

Sexually transmitted infections (STIs) are infections caused by bacterial, viral, parasitic, or fungal pathogens that are transmitted primarily through sexual contact, including vaginal, anal, oral, and intimate skin-to-skin contact [1]. STIs may be classified according to their causative organisms (viral, bacterial, parasitic, and fungal) or according to their predominant mode of transmission, including fluid-borne and skin-to-skin transmitted infections [2].

Viral STIs include human papillomavirus (HPV) and herpes simplex virus (HSV), whereas bacterial STIs include syphilis caused by *Treponema pallidum* [3]. Unlike fluid-borne infections such as HIV, gonorrhea, and chlamydia, several STIs can be transmitted through direct contact with infected skin, mucous membranes, or lesions located outside the anatomical area protected by a condom [4]. Consequently, transmission may occur despite consistent and correct condom use [5].

Human papillomavirus is the most common viral STI globally and encompasses more than 200 genotypes, which are broadly classified into low-risk and high-risk oncogenic types World Health Organization, [6, 7]. High-risk HPV types, particularly HPV-16 and HPV-18, are strongly associated with cervical cancer, anal cancer, penile cancer, vulvar cancer, and oropharyngeal malignancies [8, 9]. HSV is categorized into HSV-1 and HSV-2, both of which are capable of causing genital herpes through direct skin-to-skin transmission [10, 11]. Syphilis is a systemic bacterial infection characterized by primary, secondary, latent, and tertiary stages, with infectious lesions capable of facilitating transmission through direct contact during sexual activity [12]. Other skin-to-skin transmissible STIs include molluscum contagiosum, pubic lice (*Pthirus pubis*), scabies, chancroid, and lymphogranuloma venereum, all of which may spread through close genital or sexual contact even when barrier protection is used appropriately [13, 14].

The diagnosis and assessment of these infections involve a variety of clinical and laboratory approaches [15]. HPV infection is commonly assessed using HPV DNA testing, cytology-based screening, visual inspection methods, and histopathological examination of lesions [6, 16, 17]. HSV diagnosis relies on viral culture, polymerase chain reaction (PCR), nucleic acid amplification testing, and serological assays [18, 19]. Syphilis is typically diagnosed through a combination of non-treponemal tests such as the Rapid Plasma Reagin (RPR) and Venereal Disease Research Laboratory (VDRL) tests, followed by confirmatory treponemal assays including fluorescent treponemal antibody absorption (FTA-ABS) and *Treponema pallidum* particle agglutination (TPPA) [12, 20]. Clinical examination remains important for detecting lesions or manifestations occurring outside condom-covered anatomical regions, which may represent reservoirs for ongoing transmission [3, 21]. Sexually transmitted infections remain a major global public health concern [22]. The World Health Organization estimates that more than one million curable STIs are acquired every day worldwide, with hundreds of millions of new infections occurring annually [23]. Persistent HPV infection contributes substantially to the global burden of cervical and anogenital cancers, while HSV infection affects billions of individuals worldwide and remains one of the most prevalent chronic viral infections [24-26]. Syphilis continues to cause substantial morbidity and mortality, including adverse pregnancy outcomes and congenital infections [20]. Beyond their direct clinical consequences, STIs impose considerable economic burdens on healthcare systems and contribute to stigma, psychological distress, reduced quality of life, and increased susceptibility to HIV acquisition [27-29].

Condoms are widely recognized as one of the most effective and accessible methods for reducing STI transmission [4]. Numerous epidemiological studies have demonstrated that consistent and correct condom use substantially reduces the risk of HIV, gonorrhea, chlamydia, and several other fluid-borne infections [30-33].

Nevertheless, leading public health authorities emphasize that condoms do not provide complete protection against infections transmitted primarily through skin-to-skin contact [34, 35]. Lesions, viral shedding sites, and infected skin areas may occur on the scrotum, vulva, perineum, pubic region, buttocks, thighs, or surrounding genital tissues that remain uncovered during sexual intercourse [3, 35]. Consequently, HPV, HSV, syphilis, and other contact-transmitted infections may still be acquired despite adherence to recommended condom-use practices [20, 36].

Although the limitations of condoms against skin-to-skin transmitted infections are widely acknowledged, the available literature remains fragmented [37, 38]. Existing reviews frequently focus on individual pathogens, particularly HPV or HSV, or evaluate the overall effectiveness of condoms in preventing STIs without specifically examining documented infections acquired despite correct condom use [39-41]. Furthermore, evidence regarding the frequency, mechanisms, anatomical routes, and epidemiological circumstances of transmission remains dispersed across observational studies, cohort investigations, surveillance reports, and clinical case series [42, 43]. To our knowledge, no published systematic review has comprehensively synthesized evidence regarding HPV, HSV, syphilis, and other skin-to-skin transmissible STIs acquired despite correct and consistent condom use [44-46].

Therefore, this systematic review aims to synthesize the available evidence on HPV, HSV, syphilis, and other skin-to-skin transmitted STIs acquired despite correct condom use. Specifically, the review seeks to (1) identify the types of STIs reported following condom-protected sexual activity, (2) describe the proposed mechanisms and anatomical routes of transmission, (3) summarize the epidemiological and clinical characteristics of reported cases and studies, and (4) evaluate current evidence regarding the residual risk of skin-to-skin STI transmission despite appropriate condom use. By consolidating existing evidence, this review aims to inform clinicians, sexual health educators, policymakers, and the general public about both the protective benefits and recognized limitations of condoms in preventing sexually transmitted infections.

METHODOLOGY

Study Design

This study was conducted as a systematic review to synthesize available evidence regarding the acquisition of human papillomavirus (HPV), herpes simplex virus (HSV), syphilis, and other skin-to-skin transmissible sexually transmitted infections (STIs) despite condom-protected sexual activity. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological rigor, transparency, and reproducibility throughout the review process [47]. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number: CRD420261430307.

Eligibility Criteria

Studies were selected according to predefined inclusion and exclusion criteria. Eligible studies included original research articles that reported the occurrence, transmission, prevalence, incidence, or acquisition of HPV, HSV, syphilis, or other skin-to-skin transmissible STIs among individuals reporting condom-protected sexual activity. Studies involving participants of any age, sex, gender, sexual orientation, or geographical location were considered. Quantitative, qualitative, and mixed-methods studies, including cohort studies, case-control studies, cross-sectional studies, surveillance studies, case series, and case reports, were eligible for inclusion. Only full-text articles published in peer-reviewed journals and written in English were included.

Studies were excluded if they focused exclusively on fluid-borne sexually transmitted infections without addressing skin-to-skin transmissible infections, failed to discuss condom use, involved condom failure due to breakage, slippage, incorrect use, or inconsistent use, or did not provide relevant outcomes related to STI transmission. Review articles, systematic reviews, meta-analyses, editorials, conference abstracts, letters to the editor, dissertations, protocols, and laboratory-based studies were also excluded.

For the purposes of this review, correct condom use refers to the application of a condom before any genital contact, continuous use throughout sexual intercourse, and the absence of condom breakage, slippage, or other forms of mechanical failure. Because definitions varied among the included studies, the operational definition of correct condom use was based on the criteria reported by the original investigators.

Information Sources and Search Strategy

A comprehensive literature search was conducted using five electronic databases: PubMed, Scopus, Web of Science, ERIC, and Google Scholar. The search strategy combined controlled vocabulary terms and free-text keywords related to sexually transmitted infections, condom use, and skin-to-skin transmission. Search terms included combinations of "human papillomavirus," "HPV," "herpes simplex virus," "HSV," "syphilis," "sexually transmitted infection," "condom use," "protected sex," "barrier protection," "skin-to-skin transmission," "transmission," "acquisition," and "infection." Boolean operators (AND, OR) were used to refine the search and maximize retrieval of relevant studies. Additional records were identified through grey literature searches and manual screening of reference lists from relevant publications.

Study Selection

All records identified through database searching were exported to a reference management system for organization and duplicate removal. Study selection was conducted in three stages: duplicate removal, title and abstract screening, and full-text eligibility assessment.

Two reviewers independently evaluated studies according to the predefined eligibility criteria. Disagreements were resolved through discussion and consensus.

A total of 456 records were identified through database searching, while an additional 17 records were identified through other sources, resulting in 473 records. After the removal of 83 duplicates, 390 records remained for title and abstract screening. Of these, 330 records were excluded for failing to meet the eligibility criteria. Sixty full-text articles were assessed for eligibility, and 47 articles were excluded with documented reasons. Ultimately, 13 studies met the inclusion criteria and were included in the qualitative synthesis. The study selection process is presented in the PRISMA 2020 flow diagram.

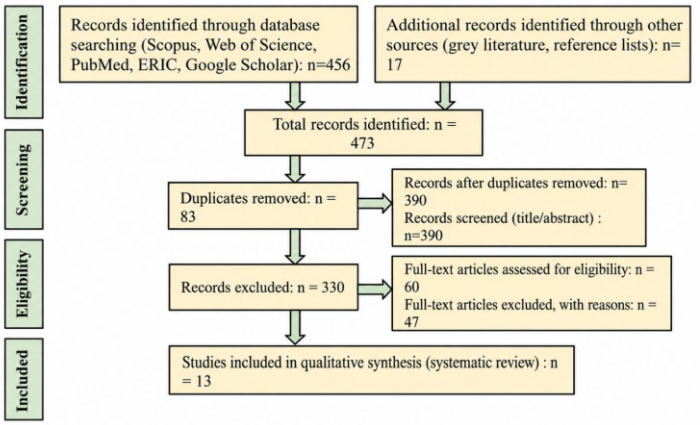

Figure 1: PRISMA 2020 flow diagram of the study selection process for the systematic review.

Data Extraction

A standardized data extraction form was developed to ensure consistency across studies. Extracted information included author and year of publication, country of study, study design, participant characteristics, type of STI investigated, condom-use characteristics, reported evidence of STI acquisition despite condom use, proposed transmission mechanisms, key findings, and study limitations. Data extraction was conducted independently by two reviewers, and discrepancies were resolved through discussion.

Quality Assessment

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tools appropriate to each study design [48]. The appraisal process evaluated participant selection, measurement of exposure and outcomes, management of confounding factors, completeness of follow-up, and potential sources of bias. Quality assessment was conducted independently by two reviewers. Studies were not excluded based solely on quality assessment results; however, appraisal findings were considered during the interpretation of the evidence.

Risk of Bias

Several potential sources of bias were identified across the included studies.

The most common was reliance on self-reported condom use, which may be affected by recall bias and social desirability bias. Selection bias was also present in studies recruiting participants from STI clinics, high-risk populations, or specific demographic groups, potentially limiting generalizability. In addition, differences in sexual behavior, number of sexual partners, healthcare-seeking behavior, and STI screening practices may have acted as confounding factors. These limitations were considered during the interpretation of findings.

Data Synthesis

Given the heterogeneity of study designs, populations, outcome measures, and sexually transmitted infections investigated, quantitative meta-analysis was not appropriate. Therefore, a narrative synthesis approach was employed. The included studies were grouped according to the type of infection investigated, including HPV, HSV, syphilis, and other skin-to-skin transmissible STIs. The synthesis focused on identifying patterns of infection acquisition despite condom use, anatomical sites of transmission, proposed biological mechanisms of residual transmission, epidemiological characteristics of affected populations, and the reported limitations of condom protection. Findings were summarized descriptively to facilitate comparison across studies.

Ethical Considerations

Ethical approval was not required because this study involved the analysis of data derived exclusively from previously published literature and did not involve direct interaction with human participants or access to identifiable personal information.

RESULTS

Study Characteristics

A total of 13 primary studies were included in this review. The studies were published between 1995 and 2022 and originated from North America, South America, Europe, Asia, and multinational cohorts. Study designs included prospective cohort studies (n = 6), cross-sectional studies (n = 3), one pooled analysis of prospective cohorts (n = 1), one case-crossover study (n = 1), one case report (n = 1), and one additional prospective analysis study (n = 1). The studies investigated three major skin-to-skin sexually transmitted infections (STIs): human papillomavirus (HPV) (n = 4), herpes simplex virus (HSV) (n = 6), and syphilis (n = 3).

Across all included studies, condoms were consistently associated with reduced STI risk; however, infections continued to occur among individuals reporting correct and consistent condom use.

Human Papillomavirus (HPV)

Four studies evaluated the relationship between condom use and HPV acquisition.

[36] reported that consistent condom use significantly reduced the incidence of genital HPV infection among newly sexually active women. Despite this reduction, HPV infections still occurred among participants reporting 100% condom use. Similarly, Campbell et al. [49] found that men who always used condoms had approximately half the risk of HPV acquisition compared with those who never used condoms; however, incident HPV infections continued to be observed among consistent users.

Repp et al. [50] examined HPV prevalence among men from Brazil, Mexico, and the United States and found that HPV prevalence remained high even among participants who reported always using condoms, although prevalence was lower than among inconsistent users. Likewise, Stewart et al. [51] demonstrated continued acquisition of high-risk HPV strains following condom-protected sexual encounters among male clients of female sex workers.

The findings suggest that condoms reduce HPV transmission but do not completely eliminate infection risk. Persistent transmission despite condom use is likely attributable to exposure of infected genital skin surfaces not covered by the condom.

Herpes Simplex Virus (HSV)

Six studies investigated HSV transmission in the context of condom use.

The strongest evidence came from Martin et al. [52], who pooled data from six prospective studies involving 5,384 HSV-seronegative individuals. Consistent condom users experienced a 30% lower risk of HSV-2 acquisition compared with non-users; however, laboratory-confirmed infections still occurred among consistent users.

Wald et al. [53] similarly demonstrated a significant reduction in HSV-2 acquisition associated with increased condom use, although transmission was not completely prevented. Magaret et al. [54], reported that condoms reduced per-act HSV-2 transmission by up to 96% from infected men to susceptible women and by 65% from infected women to susceptible men. Nevertheless, transmission events persisted despite condom use.

Additional evidence from Chohan et al. [55], and Stanaway et al. [56] showed continued HSV-2 acquisition among individuals reporting condom use. A clinical case reported by Goyal and Prabhu [57] documented HSV-2 infection occurring on the base of the penis, an area not protected by the condom, providing direct evidence of transmission through uncovered genital skin.

Collectively, these findings indicate that condoms provide moderate to substantial protection against HSV but cannot completely prevent infection because viral shedding and lesions may occur beyond the area covered by the condom.

Syphilis

Three studies examined syphilis acquisition and its relationship to condom use.

Dong et al. [58] reported incident syphilis infections among young men who have sex with men despite condom use, although inconsistent use significantly increased risk. Zenilman et al. [59] found that new syphilis and other STI diagnoses occurred among individuals reporting consistent condom use, with infection rates comparable to those reported by non-users. Liu et al. [60], further highlighted the limitations of self-reported condom-use measures. Using biological markers of semen exposure among female sex workers, the investigators found that individuals with active or prevalent syphilis were significantly more likely to over-report condom use. Between 26% and 46% of participants who reported no recent unprotected sex had objective evidence suggesting otherwise. The available evidence suggests that condoms reduce syphilis transmission risk but may not provide complete protection because infectious lesions can occur on genital and perianal areas not covered by condoms. Furthermore, reporting bias may contribute to underestimation of true exposure.

Cross-Infection Patterns

Several recurring patterns emerged across the included studies:

1. Condoms consistently reduced, but did not eliminate, STI transmission risk.

All included studies reported protective effects of condom use, although none demonstrated complete protection against HPV, HSV, or syphilis.

2. Residual transmission occurred despite correct and consistent use.

Infections continued to occur among individuals reporting proper condom use, particularly for HPV and HSV.

3. Skin-to-skin transmission was the predominant explanation for residual risk.

HPV, HSV, and syphilis may be transmitted through contact with infected genital, perianal, or surrounding skin not covered by the condom.

4. Behavioral and reporting factors influenced observed outcomes.

Several studies identified discrepancies between self-reported condom use and biological indicators of exposure, suggesting that condom effectiveness may be underestimated or misclassified in observational research.

Summary of Findings

The evidence demonstrates that condoms remain an effective strategy for reducing the transmission of HPV, HSV, and syphilis. However, transmission of these infections may still occur despite correct and consistent condom use. Residual risk appears to arise primarily from exposure to infected skin surfaces outside the area covered by the condom, together with limitations inherent in self-reported sexual behavior data.

These findings highlight the importance of combining condom use with complementary preventive strategies, including vaccination, regular screening, prompt treatment, and sexual health education.

DISCUSSION

This systematic review examined evidence regarding the acquisition of skin-to-skin sexually transmitted infections (STIs) despite correct and consistent condom use. Across all included studies, condoms were associated with significant reductions in the transmission of human papillomavirus (HPV), herpes simplex virus (HSV), and syphilis. However, none of the studies demonstrated complete protection. Infections continued to occur among individuals reporting consistent condom use, indicating that condoms provide substantial but incomplete protection against STIs transmitted through direct skin-to-skin contact [36, 49, 52, 58].

The most consistent finding across the included studies was that residual transmission risk persists because condoms do not cover all potentially infectious genital surfaces. Unlike infections such as HIV, gonorrhea, and chlamydia, which are primarily transmitted through infected bodily fluids, HPV, HSV, and syphilis can be transmitted through contact with infected skin or mucosal surfaces outside the area covered by a condom [20, 35, 61]. Several studies included in this review identified this biological mechanism as the most plausible explanation for continued transmission despite proper condom use. Evidence from HPV and HSV studies demonstrated that infectious viral shedding can occur from adjacent genital skin, while syphilitic chancres may develop on external genital or perianal areas that remain exposed during sexual activity [20, 36, 52, 57].

The evidence was particularly strong for HPV. Multiple prospective cohort studies demonstrated that consistent condom use significantly reduced HPV acquisition but did not eliminate infection [36, 49, 50]. This finding supports the understanding that HPV is primarily transmitted through direct epithelial contact [62]. The continued detection of HPV among consistent condom users suggests that exposure to infected skin surfaces surrounding the genital area remains sufficient for transmission. These findings are consistent with broader epidemiological evidence showing that although condoms reduce HPV transmission and facilitate viral clearance, vaccination remains the most effective strategy for primary prevention of HPV-related disease [49, 63].

Similarly, the studies evaluating HSV consistently demonstrated moderate but incomplete protection. Large prospective analyses showed that consistent condom use substantially reduced HSV-2 acquisition, yet laboratory-confirmed infections continued to occur among condom users [52, 53]. The ability of HSV to undergo asymptomatic viral shedding from genital skin not covered by condoms likely contributes to this residual risk [52].

The included case report describing herpes lesions at the base of the penis further illustrates how transmission can occur through exposed skin surfaces despite correct condom use [57]. These findings reinforce the importance of combining condom use with other preventive measures such as antiviral therapy, partner notification, and patient education regarding asymptomatic transmission [64].

Evidence regarding syphilis also suggested incomplete protection despite condom use. Although consistent condom use was associated with lower infection risk, incident syphilis cases continued to be reported among condom users [58, 59]. Because syphilitic chancres can occur on external genital, perianal, oral, or surrounding skin surfaces, condoms may fail to cover the site of infection completely [20, 27]. Furthermore, studies examining condom use and syphilis highlighted an additional challenge: the reliability of self-reported sexual behavior data. Biological marker studies demonstrated substantial over-reporting of condom use among individuals with active syphilis, suggesting that observational studies relying solely on self-report may underestimate the true effectiveness of condoms or misclassify exposure status [59, 60, 65].

An important implication of these findings is that public health messaging should accurately communicate both the strengths and limitations of condoms. Condoms remain one of the most effective and accessible methods for reducing STI transmission and should continue to be strongly promoted [35, 61]. However, educational messages should also emphasize that condoms do not provide absolute protection against infections transmitted through uncovered skin [20, 43]. Overstating condom effectiveness may create unrealistic perceptions of risk, whereas acknowledging residual risk can encourage complementary preventive behaviors such as HPV vaccination, routine STI screening, reduction in the number of sexual partners, prompt treatment of infections, and open communication between sexual partners [63, 64].

The findings of this review also support the growing emphasis on combination prevention strategies. No single intervention is capable of eliminating STI transmission risk. Rather, the greatest protection is achieved through the combined use of condoms, vaccination, regular screening, behavioral risk reduction, and timely clinical management [63, 64]. Such an approach is particularly important for HPV and HSV, where asymptomatic infection and transmission are common [62, 66].

Several limitations should be considered when interpreting the findings of this review. First, many studies relied on self-reported condom use, which is subject to recall bias and social desirability bias [59, 60, 65]. Second, definitions of "consistent" condom use varied across studies, potentially affecting comparability. Third, most included studies focused on HPV, HSV, and syphilis, while relatively limited evidence was available for other skin-to-skin STIs such as molluscum contagiosum, scabies, and pubic lice. Finally, differences in study populations, geographic settings, and sexual behaviors may have contributed to variability in reported outcomes.

Despite these limitations, the overall evidence consistently demonstrates that condoms substantially reduce but do not completely eliminate the risk of acquiring HPV, HSV, and syphilis. The residual risk observed across studies is largely attributable to the skin-to-skin mode of transmission characteristic of these infections [35, 36, 52, 58]. Future research should investigate condom effectiveness against less-studied skin-to-skin STIs and explore strategies that complement condom use in reducing residual transmission risk.

Condoms remain an essential component of STI prevention and significantly reduce the risk of acquiring HPV, HSV, and syphilis. However, the evidence indicates that these infections may still be transmitted despite correct and consistent condom use because infectious lesions and viral shedding can occur on genital skin not covered by the condom [20, 36, 52]. Consequently, condoms should be viewed as a highly effective but incomplete protective measure against skin-to-skin STIs. Comprehensive prevention strategies that integrate condom use with vaccination, routine screening, sexual health education, and early treatment are necessary to further reduce the burden of these infections [63, 64].

Table 1: Characteristics of Studies Included in the Systematic Review

Author (Year)	Country	Study Design	Population/Sample	STI Investigated	Main Findings
Zenilman et al. (1995)	USA	Prospective cohort	598 STI clinic attendees	Syphilis and other STIs	Self-reported condom use was not consistently associated with lower STI incidence.
Wald et al. (2005)	USA	Prospective cohort	HSV-discordant couples	HSV-2	Increased condom use significantly reduced HSV-2 acquisition but did not eliminate transmission.
Winer et al. (2006)	USA	Prospective cohort	Young sexually active women	HPV	Consistent condom use reduced HPV incidence but infections still occurred.
Martin et al. (2009)	USA	Pooled analysis of prospective studies	5,384 participants	HSV-2	Consistent condom use reduced HSV-2 acquisition by approximately 30%.
Chohan et al. (2009)	Kenya	Prospective cohort	High-risk HIV-seronegative women	HSV-2	HSV acquisition occurred despite reported condom use.
Repp et al. (2012)	Brazil, Mexico, USA	Cross-sectional	2,621 men	HPV	HPV prevalence remained high among consistent condom users.
Stanaway et al. (2012)	USA	Case-crossover study	HSV-seronegative individuals	HSV-2	Condom use reduced HSV-2 risk but did not provide complete protection.
Campbell et al. (2013)	Multinational	Prospective cohort	High-risk men	HPV	Consistent condom use reduced HPV burden but incident infections persisted.
Dong et al. (2014)	China	Prospective cohort	Young men who have sex with men	Syphilis	Incident syphilis infections occurred despite condom use.

Magaret et al. (2015)	Multinational	Prospective cohort	HSV-discordant couples	HSV-2	Condom use substantially reduced per-act HSV-2 transmission risk.
Liu et al. (2016)	China	Cross-sectional	1,245 female sex workers	Syphilis	Biological markers suggested over-reporting of condom use among infected individuals.
Stewart et al. (2018)	Peru	Cross-sectional	Male clients of female sex workers	HPV	High-risk HPV infection occurred despite reported condom use.
Goyal & Prabhu (2022)	India	Case report	Adult male patient	HSV-2	HSV lesions developed on genital skin not covered by the condom.

Table 2: Summary of Evidence Regarding STI Acquisition Despite Condom-Protected Sexual Activity

STI Category	Number of Studies	Evidence of Residual Risk Despite Condom Use	Key Findings
Human Papillomavirus (HPV)	4	Yes	Condoms reduce HPV transmission but cannot fully prevent infection because exposed genital skin may remain infectious.
Herpes Simplex Virus (HSV)	5	Yes	Consistent condom use provides substantial but incomplete protection because viral shedding may occur outside condom-covered areas.
Syphilis	3	Yes	Syphilis transmission may occur through contact with infectious lesions located outside areas covered by condoms.
Cross-cutting Behavioral Factors	1	Yes	Self-reported condom use may not always reflect actual exposure, contributing to misclassification of residual risk.
Overall Findings	13	Yes	All studies demonstrated risk reduction associated with condoms, but none demonstrated complete protection against skin-to-skin STIs.

Table 3: Methodological Quality Assessment of Included Studies

Author (Year)	Study Design	Quality Rating	Main Methodological Considerations
Zenilman et al. (1995)	Prospective cohort	High	Prospective follow-up with laboratory-confirmed STI outcomes.
Wald et al. (2005)	Prospective cohort	High	Large cohort and objective HSV diagnosis.
Winer et al. (2006)	Prospective cohort	High	Longitudinal design and laboratory-confirmed HPV infection.
Martin et al. (2009)	Pooled prospective analysis	High	Large sample size and robust statistical analysis.
Chohan et al. (2009)	Prospective cohort	High	Prospective follow-up among high-risk women.
Repp et al. (2012)	Cross-sectional	Moderate	Large multinational sample but cross-sectional design limits causality.
Stanaway et al. (2012)	Case-crossover study	High	Within-subject design minimized confounding.
Campbell et al. (2013)	Prospective cohort	High	Multinational cohort with repeated HPV measurements.
Dong et al. (2014)	Prospective cohort	High	Longitudinal assessment of syphilis incidence.
Magaret et al. (2015)	Prospective cohort	High	Per-act transmission analysis strengthened causal inference.
Liu et al. (2016)	Cross-sectional	High	Biological validation reduces reporting bias.
Stewart et al. (2018)	Cross-sectional	Moderate	Cross-sectional design limits temporal relationships.
Goyal & Prabhu (2022)	Case report	Moderate	Provides direct clinical evidence but limited generalizability.

Overall Quality Assessment: Of the 13 included studies, 9 (69.2%) were rated as high quality and 4 (30.8%) as moderate quality. No studies were classified as low quality. The most common limitations included reliance on self-reported condom use, potential recall and social desirability bias, and the inability of cross-sectional studies to establish causal relationships.

CONCLUSION

This systematic review demonstrates that while condoms significantly reduce the risk of acquiring human papillomavirus (HPV), herpes simplex virus (HSV), and syphilis, they do not provide complete protection against these infections. Evidence from the included studies consistently showed that transmission may still occur despite correct and consistent condom use, primarily because these pathogens can be spread through contact with infected skin and mucosal surfaces not covered by the condom. These findings highlight the importance of recognizing condoms as a highly effective but incomplete preventive measure for skin-to-skin sexually transmitted infections. Consequently, optimal prevention requires a comprehensive approach that combines condom use with vaccination, routine screening, early diagnosis and treatment, sexual health education, and other evidence-based risk-reduction strategies to further decrease the burden of these infections. From a public health perspective, healthcare providers and policymakers should continue promoting condoms as an essential component of safer sexual practices while educating individuals about their limitations against infections transmitted through exposed skin and mucosal surfaces. Finally, continued research will strengthen evidence-based recommendations and contribute to more effective STI prevention programs worldwide.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this review. First, many of the included studies relied on self-reported condom use, which is susceptible to recall bias and social desirability bias and may not accurately reflect actual condom use behavior. Second, variations in study design, participant populations, definitions of consistent condom use, and outcome measurements limited direct comparison across studies. Third, most available evidence focused on HPV, HSV, and syphilis, with relatively few studies examining other skin-to-skin sexually transmitted infections, limiting the generalizability of the findings to all STIs transmitted through direct skin contact.

Fourth, several studies were conducted among specific high-risk populations, such as men who have sex with men, female sex workers, or STI clinic attendees, which may reduce the applicability of the findings to the general population. Finally, because many of the included studies were observational in nature, causal relationships between condom use and STI acquisition cannot be established with complete certainty. Despite these limitations, the consistency of findings across diverse settings and populations strengthens the conclusion that condoms substantially reduce, but do not completely eliminate, the risk of acquiring skin-to-skin sexually transmitted infections. Publication bias could not be formally assessed because a quantitative meta-analysis was not conducted and the included studies were heterogeneous in design, populations, and outcome measures. It is possible that studies reporting no association between condom use and STI acquisition were less likely to be published, which may have influenced the available evidence.

RECOMMENDATIONS

Based on the findings of this review, health authorities, healthcare providers, educators, and policymakers should strengthen sexual health education programs by emphasizing that condoms significantly reduce, but do not completely eliminate, the risk of acquiring skin-to-skin sexually transmitted infections such as HPV, HSV, and syphilis. Public health agencies should promote comprehensive STI prevention strategies through public education, emphasizing consistent and correct condom use with HPV vaccination, routine STI screening, early diagnosis and treatment, partner notification, and risk-reduction counseling. Healthcare providers should ensure that patients receive accurate information regarding both the benefits and limitations of condoms to support informed decision-making and realistic risk perception. Educational institutions should incorporate evidence-based sexual health education that addresses skin-to-skin STI transmission and preventive measures. Researchers are encouraged to conduct further high-quality prospective studies on less-studied skin-to-skin STIs and to explore interventions that may further reduce residual transmission risk among sexually active populations. Future studies should employ standardized definitions of consistent condom use, laboratory-confirmed STI outcomes and longer follow-up periods to improve the quality and comparability of evidence.

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