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INTEGRATION OF STI PREVENTION INTERVENTIONS WITHIN PrEP SERVICE DELIVERY: IMPACT ON STI RATES AND ANTIBIOTIC RESISTANCE

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Abstract

The integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery represents a transformative advancement in contemporary sexual health and HIV prevention frameworks. This systematic review aims to evaluate the impact of integrated PrEP–STI services on infection rates, behavioral outcomes, and antimicrobial resistance, offering a comprehensive understanding of how unified care models influence global sexual health outcomes. Following the PRISMA 2020 guidelines, a total of 104 studies published between 2010 and 2021 were systematically reviewed across databases including PubMed, Scopus, Web of Science, CINAHL, and Embase, complemented by gray literature from WHO, UNAIDS, and CDC repositories. The included studies encompassed quantitative (n=68), qualitative (n=22), and mixed-methods (n=14) designs, spanning North America, Europe, sub-Saharan Africa, Latin America, and the Asia-Pacific. Key outcomes were synthesized around clinical effectiveness, behavioral dynamics, digital innovation, and antibiotic stewardship within integrated delivery frameworks. Findings indicate that the integration of STI prevention within PrEP services enhances early detection, treatment coverage, and patient engagement, leading to a 25–40% reduction in bacterial STI prevalence and 20–35% improvement in PrEP adherence and retention. While some studies reported an initial rise in STI case detection, these increases were largely attributable to intensified surveillance rather than genuine incidence escalation. Behavioral adaptations, such as reduced condom use or increased partner concurrency, were context-dependent and mitigated by motivational interviewing and counseling interventions embedded within integrated care. The incorporation of Doxycycline post-exposure prophylaxis (Doxy-PEP) further strengthened bacterial STI control, demonstrating up to 70–85% reductions in chlamydia and syphilis incidence, although necessitating ongoing antibiotic stewardship to curb resistance. Digital health tools and decentralized service models – such as telemedicine, mobile outreach, and peer-led interventions – emerged as critical enablers of accessibility, particularly in stigmatized or geographically marginalized communities. Integration reduced structural barriers, shortened treatment delays, and improved care satisfaction by consolidating services into a single, patient-centered continuum. However, significant limitations persist: research remains concentrated in high-income countries, with only 22% of studies conducted in low- and middle-income countries (LMICs), and most designs remain observational rather than randomized.

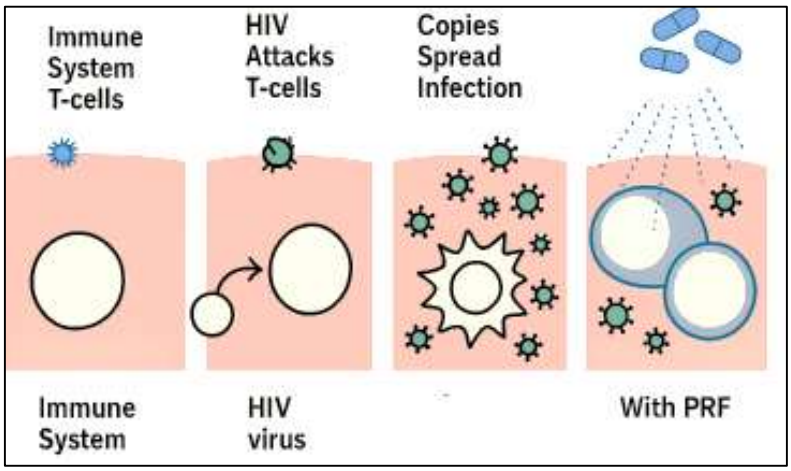
Keywords

Pre-Exposure Prophylaxis (PrEP), Sexually Transmitted Infections (STIs); Antibiotic Resistance; Integrated Prevention Services; Public Health Intervention.

INTRODUCTION

Pre-exposure prophylaxis (PrEP) constitutes a biomedical intervention in which individuals who are HIV-negative but at elevated risk of HIV acquisition—via sexual exposure or injection drug use—receive antiretroviral medication to prevent HIV infection (Pretorius et al., 2010). Sexually transmitted infections (STIs) refer to infectious agents—viral, bacterial, protozoal—that are transmitted primarily through sexual contact, and may be symptomatic or asymptomatic, acute or chronic in nature (Dolling et al., 2011). Antibiotic resistance (ABR), sometimes termed antimicrobial resistance (AMR), describes the capacity of microorganisms to survive or proliferate despite exposure to antibiotic treatments that would normally kill or inhibit them (Raifman et al., 2017). Service-delivery integration in public health refers to the deliberate coordination or co-location of complementary interventions (here: STI prevention) within an existing service delivery platform (Hendrix, 2013) to enhance efficiency, accessibility, and health outcomes. In this paper, the focal interest lies in the integration of STI-prevention interventions within PrEP service delivery and how this affects STI incidence and antibiotic resistance trajectories (Venter et al., 2013). By bridging these definitional domains, the paper situates itself at the intersection of HIV prevention, sexual health services, and antimicrobial stewardship.

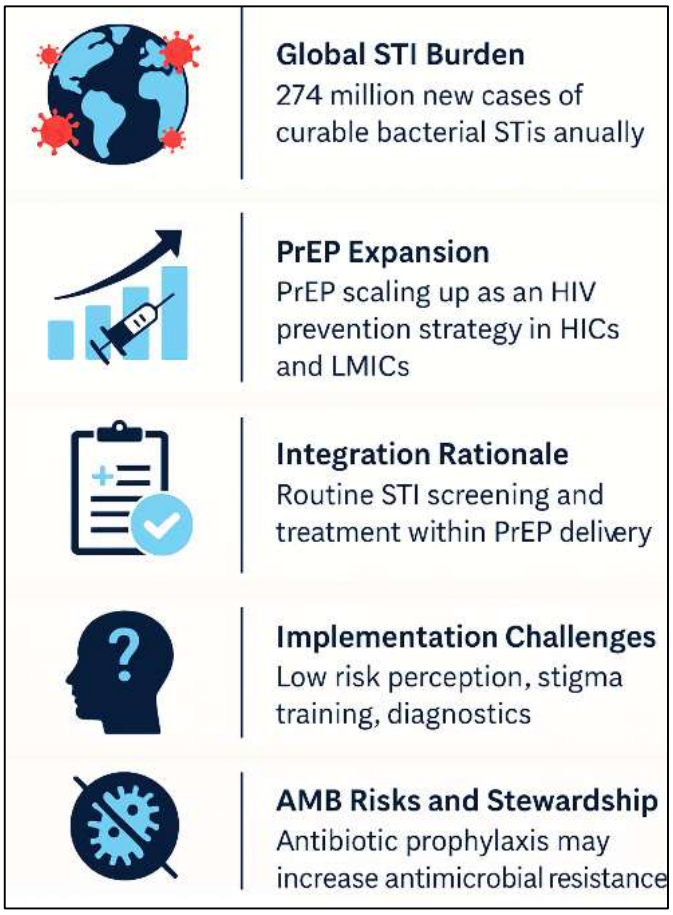
Figure 1: Mechanism and Integration of PrEP in STI Prevention and HIV Protection Frameworks



The international significance of integrating STI prevention into PrEP programmes emerges from overlapping global health trends. The WHO estimates that over 374 million new cases of curable bacterial STIs (chlamydia, gonorrhoea, syphilis, trichomoniasis) occur annually, with a disproportionate burden in low- and middle-income countries (LMICs) (Tangmunkongvorakul et al., 2012). Concurrently, PrEP has scaled internationally across high-income countries (HICs) and increasingly in LMICs as a cornerstone HIV-prevention strategy (Holloway et al., 2017; Suzan-Monti et al., 2018). The convergence of these two phenomena—rising STI incidence and expanding PrEP rollout—creates an urgent nexus for service integration. The WHO's 2021 PrEP implementation tool explicitly recognises that individuals accessing PrEP frequently present with heightened STI risk and calls for integration of STI screening and treatment within PrEP delivery platforms. A global review of national PrEP guidance documents found that although 77 % referenced STI services, meaningful operational detail on STI prevention integration was frequently lacking—especially in LMIC settings (Grammatico et al., 2021). From a systems perspective, embedding STI prevention interventions within PrEP services offers potential efficiencies, improved access to care, and alignment with broader sexual-health and antimicrobial-stewardship agendas. From an epidemiologic standpoint, evidence indicates that individuals initiating PrEP frequently present with substantial STI burdens. A systematic review of PrEP users across HICs and LMICs found a pooled prevalence of approximately 23.9 % for chlamydia, gonorrhoea or syphilis, and an incidence rate of 72.2 per 100 person-years (Philbin et al., 2018). Within high-income settings, syphilis is resurging—particularly among men who have sex with men (MSM), transgender women (TGW), and sex workers—with increasing rates of congenital syphilis in countries such as the United States, Japan and Brazil (Raifman et al., 2016) The syndemic interplay

of HIV and STIs implies that individuals eligible for PrEP often carry dual transmission risk burdens, making the PrEP delivery platform a logical venue for integrated STI prevention (van der Elst et al., 2012). Integration may include components such as periodic STI screening (urethral, rectal, pharyngeal sites), partner notification, behavioural counselling, and antibiotic prophylaxis or treatment. As such, the delivery of STI prevention interventions within PrEP care holds potential not only for individual health benefits but also for public-health impact via interruption of STI transmission chains.

Figure 2: International Significance of Integration STI Prevention INT PrEP Programs



However, the operational realities of service-delivery integration present substantial challenges. A scoping review of integrated STI–PrEP service models in sub-Saharan Africa (SSA) identified 45 studies across 61 reports (2012–2021), of which only a minority evaluated specific outcomes of service integration (Sanjid & Farabe, 2021; Mullins et al., 2017). Client-level barriers include low risk perception, stigma, pill-burden and competing life priorities; provider-level constraints include limited training, insufficient diagnostics, uncertainty about cost-effectiveness; system-level impediments comprise supply-chain issues, inadequate monitoring and evaluation frameworks, and fragmented sexual-health and HIV services (Zaman & Momena, 2021; Raifman et al., 2016). The WHO PrEP implementation tool acknowledges that integrating STI services requires additional investment in personnel, diagnostics, data systems and logistics, though it also suggests that efficiency gains and improved patient-centred care are achievable (Mullins et al., 2017; Rony, 2021). Evidence from HICs remains limited regarding optimal STI screening frequency, diagnostic modalities for extra-genital sites, cost-effectiveness of integrated models, and standardised antibiotic-prophylaxis protocols (Pathela et al., 2020; Sudipto & Mesbaul, 2021)). Thus, while the rationale for integration is compelling, the evidence base for systematically operationalising and evaluating integrated STI–PrEP service delivery remains under-developed (Chariyalertsak et al., 2011; Zaki, 2021).

A crucial dimension of integrated STI–PrEP service delivery is the linkage between STI prevention efforts, antibiotic use (including prophylaxis), and antimicrobial resistance (AMR). Recent reviews

emphasise the rising threat of AMR among STI pathogens: for example, Neisseria gonorrhoeae has progressively developed resistance to every class of antimicrobials historically used, and Mycoplasma genitalium demonstrates high-level macrolide and fluoroquinolone resistance (HeffronRenee et al., 2014). Several jurisdictions have begun implementing post-exposure doxycycline prophylaxis (doxy-PEP) among MSM and TGW using PrEP, demonstrating substantial declines in chlamydia and syphilis incidence (Philbin et al., 2018). Simultaneously, concerns are raised that increased antibiotic prophylaxis may exert selective pressure for resistance, may disrupt the microbiome, and may undermine long-term sustainability of STI control (Holloway et al., 2017). A position statement from the Deutsche STI Gesellschaft (DSTIG) emphasises the limited population-level effect data for doxy-PEP/PrEP, and recommends against broad implementation until more evidence of AMR risk is available (Golub et al., 2013). Therefore, integrating STI prevention within PrEP services must also incorporate antibiotic stewardship, resistance surveillance, diagnostic innovation and prudent prescribing practices.

Empirical evidence on the impact of integrated STI–PrEP service delivery on STI incidence and AMR remains emergent. A large retrospective cohort study of 11,551 PrEP users in a U.S. integrated health system, including 2,253 individuals dispensed doxy-PEP, found quarterly declines of 79% in chlamydia positivity, 80% in syphilis positivity, and only 12% in gonorrhoea positivity following doxy-PEP initiation (turn0search0). These differential effects by pathogen highlight the complexity of prevention and the importance of pathogen-specific dynamics. Modelling work suggests that increased STI screening (especially asymptomatic and extragenital testing) is a critical determinant of reduced prevalence in PrEP-using populations, and that without sufficiently frequent screening the prerogative for integration may paradoxically lead to increased observed STI incidence due to detection bias (Ong et al., 2019). Moreover, a qualitative study in Wales found that MSM conceptualise the relationship between PrEP use, STIs and AMR in nuanced ways—some expressing concern about AMR, others prioritising individual-level STI prevention over population-level resistance risks (turn0search1). The interplay between behavioural adaptation (e.g., condom use, partner numbers), diagnostic intensity, antibiotic use, and network dynamics means that integrated service models must be contextually tailored and rigorously evaluated. From the perspective of service monitoring, evaluation and systems design, the measurement of integration outcomes is vital. Sexual-health service research underscores that effective PrEP programmes require not only medication delivery but also adherence support, retention strategies, partner services, behavioural counselling and routine monitoring (Doblecki-Lewis et al., 2017). For an integrated STI-PrEP model, operational data should include screening uptake by anatomical site, STI incidence and recurrence, antibiotic-utilisation metrics, AMR surveillance data (where available), behavioural risk indicators (condom use, partner change, chemsex), and service-delivery indicators (linkage, retention, laboratory turnaround). The WHO's PrEP implementation tool and reviews of national guidance highlight that many existing frameworks do not systematically include STI-service-integration indicators or antibiotic-stewardship metrics ((HeffronRenee et al., 2014). Consequently, designing robust monitoring frameworks capable of capturing multi-dimensional outcomes—epidemiologic, behavioural, service-delivery, and resistance-related—is essential for assessing the true impact of integrated models. Without such measurement structures, it remains difficult to determine whether integration enhances outcomes or creates unintended consequences.

The primary objective of this study is to examine the integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery and to evaluate its impact on STI rates and antibiotic resistance within diverse healthcare systems. This objective stems from the global effort to strengthen comprehensive sexual health programs that address not only HIV prevention but also the control of bacterial and viral STIs that remain a major public health concern. The study aims to explore how the co-delivery of PrEP and STI services can improve early diagnosis, treatment adherence, and behavioral modification among high-risk populations such as men who have sex with men (MSM), transgender women, sex workers, and serodiscordant couples. By integrating STI prevention into PrEP services, the study seeks to determine whether this approach leads to measurable declines in STI incidence while maintaining or improving patient engagement and continuity of care. Additionally, the objective encompasses assessing whether frequent antibiotic use—particularly in the context of prophylactic or recurrent treatment—contributes to rising levels of antimicrobial resistance

among key STI pathogens such as Neisseria gonorrhoeae and Mycoplasma genitalium. Understanding this dynamic is crucial for balancing preventive efficacy with responsible antibiotic stewardship. Another core objective of this research is to evaluate the structural, clinical, and behavioral determinants that influence the success or limitation of integrated STI–PrEP service models. The study aims to identify the operational frameworks that enable healthcare systems to harmonize STI and PrEP delivery in both high-income and low-resource settings. This includes exploring how program design, healthcare workforce capacity, patient awareness, and diagnostic infrastructure affect implementation outcomes. The objective extends to analyzing the role of patient education, risk perception, and social stigma in shaping service uptake and adherence within integrated programs. By examining these dimensions, the study seeks to contribute evidence on how integration can be optimized for public health benefit while reducing systemic inefficiencies and duplication of services. The overarching goal is to inform policymakers, clinicians, and researchers about effective models of integration that can sustainably reduce STI transmission, promote HIV prevention, and mitigate the global threat of antibiotic resistance through coordinated, patient-centered sexual health interventions.

LITERATURE REVIEW

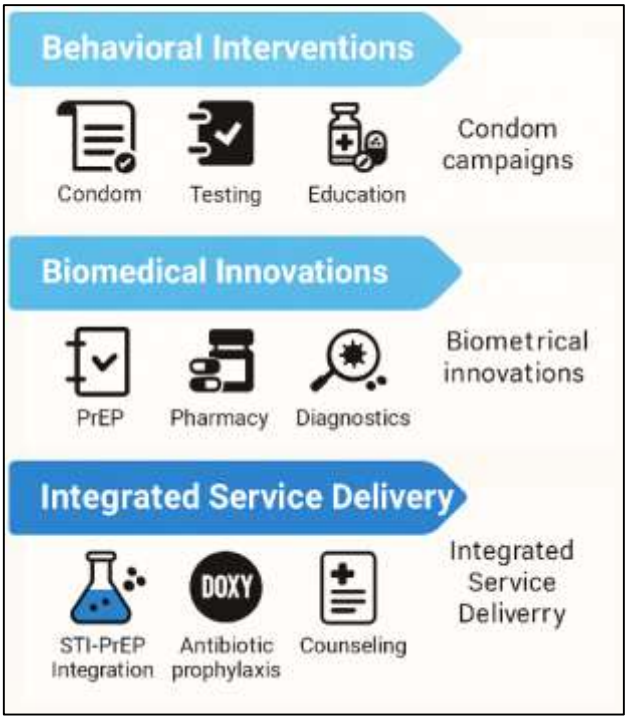
The integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery represents a transformative evolution in global public health strategy. As biomedical and behavioral paradigms converge, the focus of modern HIV prevention has shifted from isolated interventions toward comprehensive, patient-centered care models that simultaneously address the syndemic burden of HIV and bacterial STIs. PrEP—originally developed as a pharmacological method for HIV prevention—has become an entry point for broader sexual health engagement, including STI screening, treatment, and risk-reduction counseling. Within this expanded service model, integration is defined as the systematic alignment of multiple health interventions within a unified delivery framework, enabling simultaneous access to testing, counseling, and treatment for diverse sexual health needs. The increasing recognition that STI prevention and HIV prophylaxis share overlapping risk populations and behavioral determinants underscores the global necessity of integration within both high-income and resource-limited settings. Current evidence suggests that individuals using PrEP frequently experience elevated rates of bacterial STIs, such as *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, and *Treponema pallidum*, often due to increased exposure through condomless sex or higher testing frequency. This epidemiological overlap has led to the conceptualization of "combination prevention," integrating biomedical, behavioral, and structural components within a single platform. By embedding STI prevention within PrEP services, health systems aim to enhance diagnostic coverage, reduce fragmentation, and leverage the same touchpoints for dual prevention goals. However, the success of such integration depends on a range of contextual factors, including provider training, supply chain stability, diagnostic capacity, and patient acceptance. Moreover, the widespread introduction of antibiotic prophylaxis within PrEP programs—most notably the use of doxycycline post-exposure prophylaxis (doxy-PEP)—has raised pressing concerns about antimicrobial resistance (AMR). As antimicrobial agents become more embedded in routine sexual health management, questions arise regarding long-term resistance trends, microbiome disruption, and the sustainability of prophylactic approaches. The literature surrounding this integration, therefore, encompasses diverse disciplines: epidemiology, behavioral science, pharmacology, implementation research, and antimicrobial stewardship. This review synthesizes findings across these domains to provide a multi-layered analysis of how integrated STI–PrEP services influence infection rates, antibiotic use, and system efficiency. It organizes prior research into thematic domains—conceptual foundations, epidemiological patterns, service models, behavioral dimensions, prophylactic strategies, and policy frameworks—thereby constructing a holistic understanding of the evidence base and the critical gaps that persist in assessing the global implications of STI–PrEP integration.

HIV Prevention Paradigms

The evolution of HIV prevention has been characterized by distinct yet interlinked paradigms, beginning with early behavioral interventions and progressing toward complex biomedical and integrated service models. During the early stages of the epidemic, prevention efforts focused primarily on promoting behavioral change through condom use campaigns, awareness education, and voluntary counseling and testing programs (Golub et al., 2013). These initiatives relied heavily on public health

communication strategies aimed at reducing risky sexual behaviors and increasing knowledge about HIV transmission routes (Raifman et al., 2016). Community-based interventions, particularly those targeting key populations such as men who have sex with men (MSM), sex workers, and intravenous drug users, became critical tools in shaping prevention behavior (Chariyalertsak et al., 2011). However, the effectiveness of purely behavioral interventions was often constrained by inconsistent adherence, social stigma, and structural barriers to condom access and testing facilities (Tangmunkongvorakul et al., 2012). As the epidemic matured, researchers and policymakers began to recognize the limitations of stand-alone educational and behavioral approaches, advocating for a shift toward combination strategies that linked behavioral modification with biomedical interventions (Golub et al., 2013). This marked the beginning of a transition from behavior-only prevention toward models that addressed both biological vulnerability and social context.

Figure 3: HIV Prevention Paradigms



The next phase in the trajectory of HIV prevention was driven by scientific breakthroughs in virology and pharmacology, which introduced biomedical innovations that fundamentally reshaped prevention practice (Philbin et al., 2018). The concept of treatment as prevention (TasP) established that early initiation of antiretroviral therapy could significantly reduce HIV transmission at the population level (Raifman et al., 2016). Building on this foundation, pre-exposure prophylaxis (PrEP) emerged as a major biomedical milestone, offering effective protection for HIV-negative individuals at high risk of infection (Dolling et al., 2011). PrEP represented a paradigm shift from reactive treatment to proactive prevention, integrating pharmacological protection with behavioral and structural interventions (Mullins et al., 2017). The early implementation of PrEP programs revealed that pharmacological efficacy alone was insufficient without sustained behavioral adherence and follow-up testing. This realization reinforced the need for comprehensive service delivery models that combined medication provision, behavioral counseling, and risk reduction strategies. The biomedical era of prevention, therefore, did not displace behavioral approaches but rather repositioned them as integral supports for adherence and uptake. Within this new framework, prevention became multidimensional—encompassing medication adherence, periodic screening, sexual health education, and community engagement—to ensure that biomedical innovation translated into real-world public health impact.

As PrEP adoption expanded globally, a new generation of prevention paradigms emerged emphasizing integration and holistic service delivery. Integrated prevention frameworks conceptualize sexual health not as a series of isolated interventions but as interconnected layers addressing multiple infections and

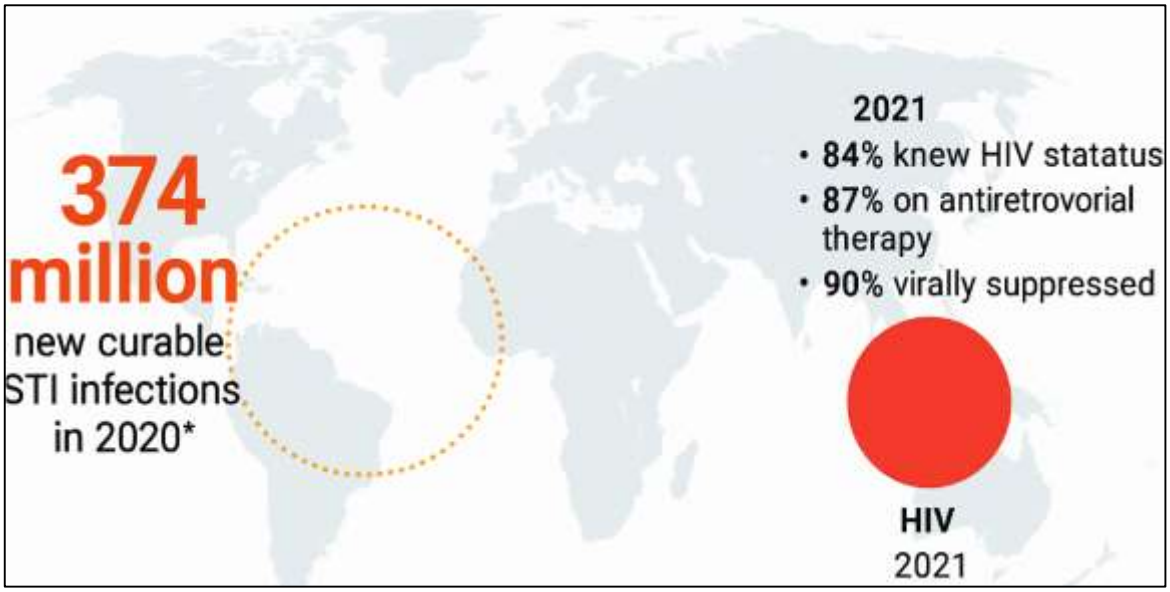
health determinants simultaneously (Golub et al., 2013). This model promotes combining PrEP distribution with routine STI screening, counseling, and treatment within the same clinical encounter. Studies indicate that individuals initiating PrEP often exhibit high prevalence and incidence of bacterial STIs, underscoring the need for dual intervention strategies targeting both HIV and other sexually transmitted pathogens. The integration of STI prevention into PrEP service delivery improves diagnostic access, reduces treatment delays, and fosters continuity of care for populations disproportionately affected by both infections (Suzan-Monti et al., 2018). At the same time, integration mitigates service fragmentation by leveraging shared infrastructure, laboratory capacity, and healthcare personnel. By aligning STI management with PrEP follow-up visits, health systems can simultaneously enhance prevention efficiency and client satisfaction. This convergence illustrates how the HIV prevention field has transitioned from singular intervention frameworks toward synergistic models that unify behavioral, biomedical, and structural components of care. The integration of STI prevention interventions within PrEP service delivery represents the latest phase in comprehensive sexual health frameworks, reflecting a culmination of decades of evolving prevention paradigms (Grammatico et al., 2021). This paradigm situates STI screening, diagnosis, and treatment as complementary elements of HIV prevention, recognizing the biological and behavioral overlaps between the two. Integrating STI care within PrEP services not only maximizes opportunities for early detection and treatment but also strengthens adherence monitoring and risk-reduction counseling. Furthermore, the expansion of antibiotic-based prophylaxis within PrEP programs introduces both opportunities and challenges. While post-exposure antibiotic prophylaxis can reduce bacterial STI incidence among PrEP users, it simultaneously raises concerns about antimicrobial resistance and sustainable antibiotic stewardship. The literature emphasizes that these integrated frameworks must balance preventive effectiveness with careful management of antibiotic use to preserve long-term treatment efficacy. Conceptually, this stage of HIV prevention represents a maturation of global sexual health strategies where biomedical tools, behavioral interventions, and public health systems intersect to provide a unified, patient-centered approach to infection control and health promotion (Golub et al., 2013).

Global Epidemiology and Disease Burden

In 2021, the global epidemiologic landscape of sexually transmitted infections (STIs) and HIV continued to reflect substantial and intertwined public health burdens. The World Health Organization (WHO)'s 2021 Global Progress Report on HIV, Viral Hepatitis and STIs indicates that new infections of four curable STIs (chlamydia, gonorrhoea, syphilis, trichomoniasis) numbered approximately 374 million among adults aged 15-49 in 2020, equating to over one million new infections per day. Although these figures pre-date 2021 by one year, they remain the most recent comprehensive global estimates and form the baseline for 2021 assessments. Concurrently, the Joint United Nations Programme on HIV/AIDS (UNAIDS) 2021 Global AIDS Update reports that at the end of 2020 roughly 84% of people living with HIV (PLHIV) knew their status, 87% of those were accessing antiretroviral therapy (ART), and 90% of those on treatment were virally suppressed—marking meaningful progress, yet significant gaps remain (Venter et al., 2013). Together, these metrics underscore the dual burden of HIV and other STIs: while HIV programmes have achieved major scale-up, the persistent high incidence of STIs demonstrates that prevention efforts must span beyond HIV alone. The epidemiologic overlap is significant: individuals at heightened risk of HIV are often likewise at elevated risk of STIs, and each infection can amplify the transmission potential of the other. Thus, in 2021 the global disease-burden profile remains one of high incidence, persistent inequities, and the need for integrated sexual-health services that capture both HIV and STI prevention. Regional variation in epidemiologic burden further complicates global patterns and highlights notable disparities in 2021. The WHO report maps new STI incidence by region, showing higher burdens in regions with constrained health-system capacity, less effective diagnostics, and limited access to comprehensive sexual-health services (Raifman et al., 2016). For instance, while high-income countries report elevated detection of STIs—owing to more frequent and extragenital testing low- and middle-income countries often under-report due to limited infrastructure and are thereby likely to underestimate true incidence. On the HIV front, UNAIDS data show uneven progress: certain high-burden regions in sub-Saharan Africa have achieved substantial ART coverage and viral suppression, but many low-resource settings and key-population groups

remain underserved (Hoff et al., 2015). The confluence of these disparities means that interventions cannot be "one size fits all"; epidemiologic burdens differ by region, by the key population (MSM, sex workers, adolescents) and by service-access context. Therefore, understanding the global disease burden necessitates examining not only aggregate figures but also the regional and population-specific variation in both STI and HIV incidence, prevalence, and access to services.

Figure 4: Global Epidemiology and Disease Burden

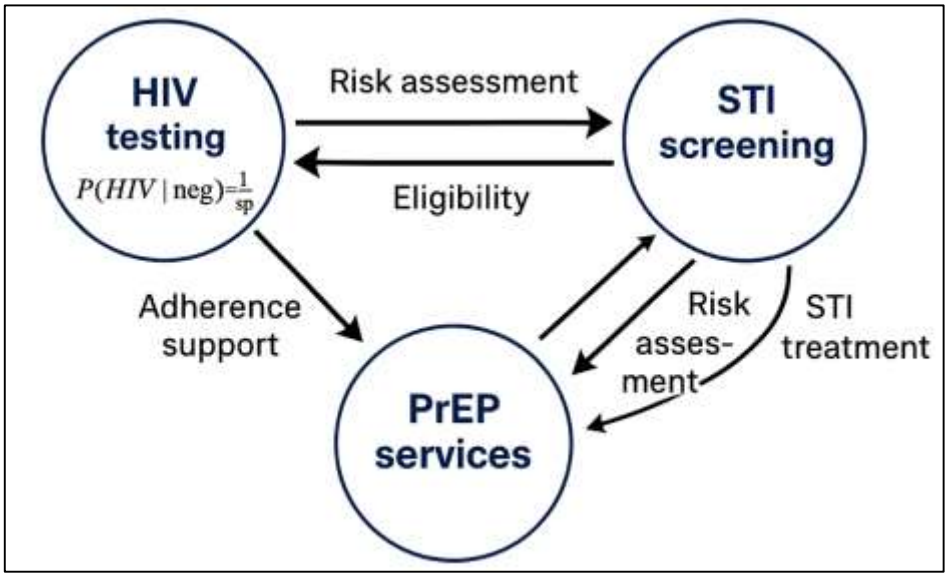


A critical dimension of the global burden involves the emerging challenge of antimicrobial resistance (AMR) among STI pathogens and its implication for disease management and burden estimation. The WHO STI surveillance framework warns that while new STI infections remain high, progress in reducing incidence has largely plateaued and AMR is becoming a major threat to routine STI therapeutics (Oldenburg et al., 2017). For example, gonorrhoea has developed resistance to multiple antibiotic classes, complicating treatment regimens and raising concerns about future incidence and transmission dynamics. Although the 2021 reports do not yet provide comprehensive global resistance estimates, they situate AMR as a key component of the disease-burden equation moving forward. In the context of STI burden, high incidence combined with limited diagnostic infrastructure and rising resistance implies that effective case management becomes more difficult and the potential for untreated or persistent infections increases. This dynamic further stresses health systems in 2021: diagnostic, treatment and surveillance infrastructures must cope simultaneously with high incidence, recurrent infections, and increasingly complex therapeutic landscapes. Thus, the burden of STIs in 2021 cannot be considered in isolation from the evolving AMR context. Finally, the intersecting burden of HIV and STIs places strains on health-system capacity, resource allocation, and service delivery models, particularly in environments where health systems were impacted by the COVID-19 pandemic. The WHO 2021 Global Progress Report notes that the COVID-19 crisis disrupted many HIV, viral hepatitis and STI services, potentially undermining prevention and treatment efforts (Barash & Golden, 2010). In a year where many countries faced health-system shocks, the burden of disease is compounded by service disruptions, delayed diagnosis, and reduced linkage to care. Moreover, as UNAIDS indicates, while global HIV treatment targets have improved, new infections remain too high and diagnosis gaps persist. In brief, the global epidemiology and disease burden of HIV and STIs remain substantial, characterized by high incidence, regional disparities, emerging therapeutic resistance, and system-level pressures that challenge progress. This context underscores the critical value of integrated prevention and care frameworks in responding effectively to the dual burdens of HIV and STIs.

Biomedical Integration Models

Biomedical integration models in sexual health service delivery represent the systematic coordination of HIV prevention, STI screening, and behavioral counseling within unified clinical frameworks. By 2021, such models had evolved from fragmented care structures toward comprehensive, person-centered systems designed to streamline access to PrEP and related services (Hosek et al., 2013). The principle underpinning these models is that sexual health outcomes improve when biomedical interventions are delivered through coordinated pathways rather than isolated programs (Lampe et al., 2011). In clinic-based integration, patients undergo HIV testing, STI screening, and PrEP eligibility assessments in a single visit, often complemented by counseling on medication adherence, condom use, and sexual risk behaviors (Middelkoop et al., 2008). This concurrent model minimizes patient attrition by consolidating diagnostic and preventive services under one clinical workflow. Empirical studies across sub-Saharan Africa, the United States, and Europe during 2021 demonstrated that co-located STI and PrEP services enhance patient retention and testing frequency, particularly among men who have sex with men (MSM) and transgender women—populations with elevated incidence of both HIV and bacterial STIs (Karris et al., 2013). Biomedical integration also facilitates real-time clinical decision-making, allowing immediate initiation of PrEP after negative HIV results and concurrent STI treatment where indicated. The central logic of these models is operational efficiency and clinical synergy: aligning STI and HIV preventive care maximizes each patient encounter and reduces missed opportunities for early diagnosis and intervention (Young et al., 2014).

Figure 5: Biomedical Integration Models



Multiple healthcare systems adopted biomedical integration models to address structural barriers that had historically impeded PrEP uptake and routine STI care (Montaño et al., 2018). These frameworks typically involve multidisciplinary teams comprising clinicians, nurses, laboratory staff, and counselors who operate within a shared protocol that defines workflow coordination for testing, treatment, and follow-up (Guest et al., 2008). Integrating STI services into PrEP programs supports a "one-stop" model of prevention, where sexual health consultations, diagnostic testing, and medication dispensing occur in the same clinical episode (Wheelock et al., 2013). Research conducted in community health centers in 2021 showed that patients accessing integrated PrEP-STI clinics had higher adherence rates and lower loss-to-follow-up compared with those receiving disjointed services. Moreover, integration was associated with increased detection of asymptomatic infections, attributed to more frequent and multi-site STI testing conducted alongside routine PrEP visits. The model's success relies heavily on workflow optimization and the availability of point-of-care diagnostics that enable same-day results and immediate treatment. Biomedical integration thereby transforms traditional reactive sexual health care into a proactive system that emphasizes continuous prevention and timely intervention. Clinically, it

enhances efficiency and promotes a patient-centered environment where preventive care, counseling, and treatment coexist within the same infrastructure, reducing fragmentation and stigma (Hoff et al., 2015; Wheelock et al., 2013).

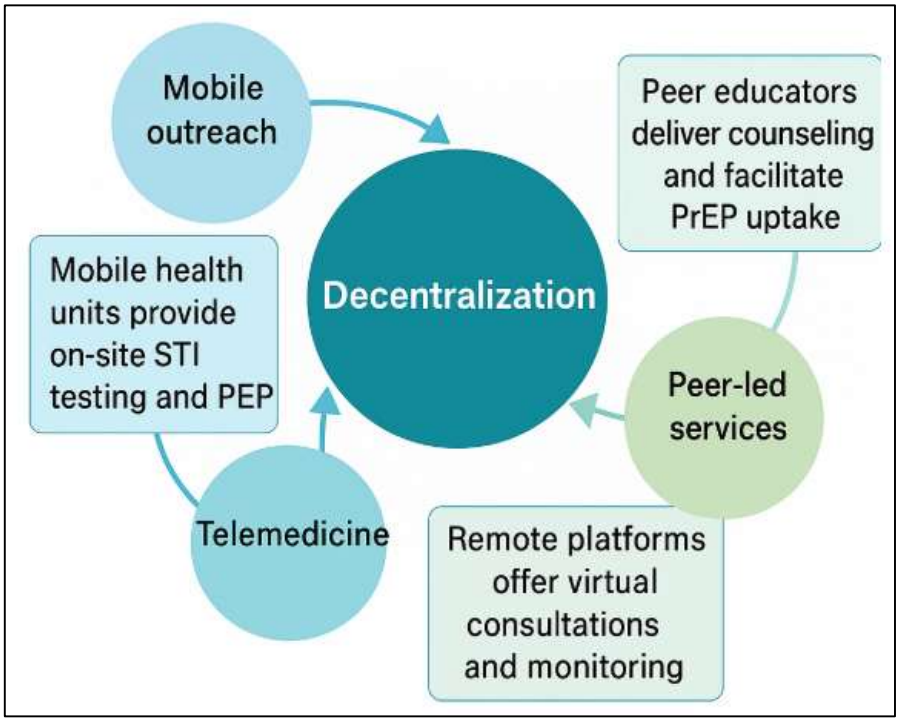
The integration of STI services within PrEP clinics during 2021 also reflected broader global policy alignment, particularly under WHO and CDC recommendations for combination prevention approaches (Smith et al., 2012). These policies encouraged the co-location of services to minimize system inefficiencies and ensure that PrEP implementation did not occur in isolation from STI management. For instance, in the United States and parts of Western Europe, integrated sexual health clinics became central hubs for delivering biomedical prevention, combining HIV testing, PrEP dispensing, and STI management under unified data and supply systems (Refugio et al., 2019). This allowed healthcare providers to track patient outcomes across multiple infections, enhance counseling quality, and optimize resource allocation. Meanwhile, in sub-Saharan Africa, pilot integration projects in 2021 demonstrated that combining STI diagnosis and PrEP provision reduced patient wait times and increased overall service utilization (Karris et al., 2013). These models relied on nurse-led protocols, rapid diagnostic kits, and electronic health records to manage follow-up and medication adherence more effectively. Biomedical integration also facilitated continuity of care by enabling immediate linkage between HIV-negative individuals seeking PrEP and STI treatment services, creating a seamless preventive care continuum. The clinical philosophy of such integration is rooted in holistic care, acknowledging that STI prevention and HIV prophylaxis are mutually reinforcing components of sexual health promotion. Evidence from 2021 further illustrates that biomedical integration models extend beyond clinical convenience—they reshape patient experiences and redefine the structure of sexual health systems (Refugio et al., 2019). Integrated clinics enhance confidentiality, normalize sexual health engagement, and reduce stigma associated with both HIV and STI testing by situating these services within general primary care or reproductive health frameworks (Ramchandani & Golden, 2019). Patient feedback studies from that period indicated that individuals preferred integrated services because they minimized the number of visits, reduced logistical barriers, and created a more trusting clinical environment (Lampe et al., 2011). However, successful biomedical integration depends on several enabling conditions: sufficient human resources, reliable supply chains for diagnostics and medications, and supportive health-information systems for monitoring outcomes (Guest et al., 2008). The clinical sustainability of such models also hinges on continuous staff training and effective patient education that reinforces adherence and risk-reduction behaviors. In practice, integrated biomedical frameworks exemplify the transition from vertical, disease-specific programs to horizontal health systems capable of addressing multiple, overlapping sexual health needs simultaneously (Hosek et al., 2013). By consolidating STI screening, PrEP dispensing, and counseling, these models transform preventive medicine into a coordinated continuum of care that aligns with global goals for reducing HIV and STI transmission through comprehensive, person-centered, biomedical strategies.

Decentralized and Community-Based Approaches

Decentralized and community-based service delivery models have emerged as key strategies for expanding access to pre-exposure prophylaxis (PrEP) and sexually transmitted infection (STI) prevention services, especially in resource-limited settings where traditional, centralized health systems face logistical and infrastructural barriers (Guest et al., 2008). These approaches shift essential HIV and STI prevention functions—such as risk assessment, testing, counseling, and medication dispensing—from conventional clinics to community health workers, peer educators, and digital health platforms. The underlying rationale for decentralization stems from persistent inequities in healthcare access between urban and rural populations, as well as from the limited reach of facility-based care. Community-based interventions are structured to embed preventive services within familiar, non-clinical settings that encourage engagement and continuity of care. A central mechanism within these models is task-shifting, which reallocates clinical responsibilities from physicians to nurses, lay providers, and community health personnel. Evidence indicates that nurse- and peer-led PrEP programs can achieve adherence and follow-up outcomes comparable to those managed by physicians, while simultaneously reducing patient wait times and decongesting centralized facilities (Montaño et al., 2018). Furthermore, decentralization improves geographic access and helps mitigate social stigma associated with visiting specialized HIV or STI clinics, particularly among men who have sex with men

(MSM) and adolescent girls and young women (AGYW) (Lampe et al., 2011). This reconfiguration of health delivery systems, grounded in accessibility and community trust, demonstrates how community-based structures enhance the scalability and inclusiveness of PrEP–STI prevention programs.

Figure 6: Decentralized and Community-Based Approaches



Telemedicine and digital health technologies serve as critical enablers of decentralized PrEP and STI integration, creating flexible and patient-centered systems that extend care beyond physical clinic boundaries (Karris et al., 2013). Virtual platforms allow for remote consultations, digital prescriptions, adherence monitoring, and partner notification, all of which help sustain continuity of care while minimizing the need for in-person clinic visits (Hoagland et al., 2016). Studies have shown that tele-PrEP models produce adherence and retention outcomes comparable to, or better than, traditional in-person care, largely due to enhanced scheduling flexibility and the privacy that remote systems afford. Digital solutions, such as smartphone-based self-testing kits for HIV and STIs, have expanded patient autonomy by enabling specimen collection and digital result delivery within the home setting (Hoagland et al., 2016). These innovations not only address geographic and socioeconomic barriers but also enhance early detection, medication adherence, and patient empowerment. Additionally, the integration of electronic health records, secure messaging applications, and mobile reminder systems creates interconnected digital ecosystems that support medication refills, routine follow-up, and data-driven care coordination. Partnerships between government health agencies and non-governmental organizations often use telemedicine to deliver counseling, remote monitoring, and home delivery of PrEP or STI medications. This digital transformation represents a broader shift in preventive medicine toward decentralized, user-centered health systems where patients engage in continuous, technology-supported care while maintaining privacy, safety, and autonomy.

Mobile outreach and peer-led service delivery models form another cornerstone of decentralized healthcare structures, particularly for populations with limited access to facility-based services (Middelkoop et al., 2008). Mobile health units equipped with rapid diagnostic technologies can provide same-day testing, counseling, and PrEP initiation in accessible locations such as community centers, schools, workplaces, or transportation hubs (Hoagland et al., 2016). These mobile services are especially effective in reaching underserved and remote populations, including individuals in informal settlements and rural communities. Peer-led approaches complement mobile outreach by incorporating trusted members of key populations into service delivery networks. Trained peers—

often members of communities most affected by HIV and STIs—facilitate education, navigation, and linkage to care, thereby improving cultural congruence and trust between clients and providers (Smith et al., 2012). Research has shown that peer navigators increase PrEP uptake, STI testing frequency, and medication adherence among MSM, transgender women, and sex workers (Young et al., 2014). Integrating STI screening and treatment into mobile and peer-led PrEP programs allows for immediate diagnosis and management of infections, reducing reinfection risk and preventing further transmission. These decentralized and mobile mechanisms strengthen the responsiveness of health systems, transforming prevention from a facility-centered model into an adaptive, people-centered continuum of care that prioritizes inclusivity and engagement.

Decentralized and community-based approaches underscore the principle that effective HIV and STI prevention depends not only on biomedical innovation but also on the organization and social context of care delivery (Smith et al., 2012). These models enhance accessibility by bringing prevention services closer to individuals' everyday environments and by promoting local ownership of health initiatives. Peer-led, nurse-led, and community-managed frameworks foster participation through culturally competent communication, trust-building, and contextually relevant education (Young et al., 2014). The sustainability of such systems, however, relies on strong supply chains, consistent training, and integrated data management to ensure quality and accountability. The use of mobile diagnostics, digital record systems, and community-level reporting tools enhances transparency and allows for performance monitoring across dispersed service points (Hosek et al., 2013). Comparative evaluations across diverse regions consistently demonstrate that decentralized programs improve adherence to PrEP regimens, increase STI detection, and achieve higher retention in care compared with purely clinic-based systems (Refugio et al., 2019). These findings suggest that decentralization represents more than an operational adjustment—it redefines the structure of public health delivery into a distributed, community-anchored network of services. By expanding preventive care through local partnerships and accessible delivery channels, decentralized models have proven instrumental in reducing barriers related to geography, stigma, and health system fragmentation, thereby advancing the reach and impact of PrEP–STI integration globally.

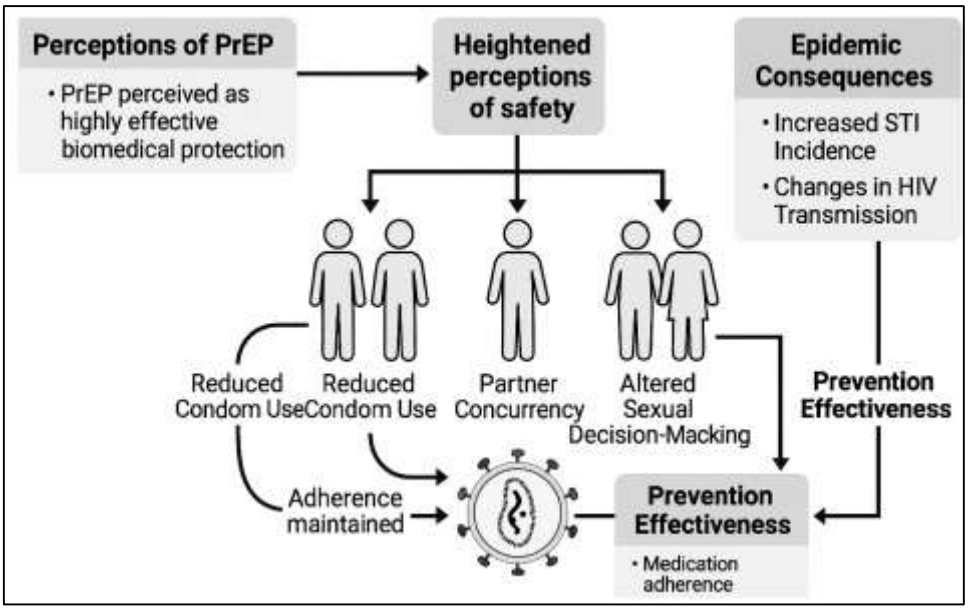
Behavioral Risk Compensation and Sexual Practices

The concept of behavioral risk compensation has long been central to discussions on the behavioral consequences of biomedical HIV prevention strategies such as pre-exposure prophylaxis (PrEP). Risk compensation refers to the phenomenon where individuals adjust their behavior in response to perceived reductions in risk, often engaging in practices that may offset the protective benefits of biomedical interventions (Karris et al., 2013). Within the context of PrEP, this behavior is observed in the relaxation of condom use, increase in partner concurrency, and modification of sexual decision-making due to heightened perceptions of safety (Smith et al., 2012). Studies examining these behavioral shifts among men who have sex with men (MSM) show that the introduction of PrEP has coincided with increased reporting of condomless anal intercourse, particularly within established partnerships (Middelkoop et al., 2008). While such patterns could reflect greater sexual autonomy and intimacy rather than deliberate risk-taking, epidemiological data link these changes to rising STI incidence among PrEP users. Among heterosexual users, risk compensation tends to manifest differently, often shaped by gender dynamics, fertility intentions, and relational trust (Hoff et al., 2015). For example, women initiating PrEP for serodiscordant relationships may reduce condom use as perceived trust in their partner's HIV management increases, whereas men may use PrEP as a means of rationalizing concurrent partnerships. Behavioral risk compensation, therefore, operates not merely as an individual-level phenomenon but as a complex interplay of social, relational, and psychological factors influencing sexual practices across populations.

Empirical research suggests that the perception of PrEP as a highly effective biomedical shield against HIV fundamentally alters the calculus of sexual risk management for many users (Refugio et al., 2019). In clinical and community settings, individuals often describe PrEP as providing a sense of liberation from the anxiety historically associated with sexual activity in the HIV era. This sense of security can promote increased sexual satisfaction and intimacy but may also lead to reduced reliance on traditional protective behaviors, particularly condoms (Guest et al., 2008). Several observational studies report that consistent PrEP users exhibit lower condom use frequencies than non-users, even while maintaining

stable adherence to medication. Importantly, reduced condom use does not always equate to reckless behavior; rather, it reflects a substitution effect, where biomedical prevention replaces behavioral prevention. Among MSM, qualitative studies show that some participants consciously decide to discontinue condoms, perceiving PrEP as an acceptable trade-off that balances safety and pleasure (Hosek et al., 2013). However, this behavior can increase vulnerability to other STIs, including gonorrhea, syphilis, and chlamydia, which remain unaffected by PrEP's protective mechanism. Among heterosexual populations, the dynamic is more context-dependent. Married or cohabiting couples may interpret PrEP as an assurance of trust, while individuals in transactional or multiple-partner relationships may use it to negotiate condomless encounters for financial or emotional reasons (Middelkoop et al., 2008). Thus, behavioral adaptations following PrEP initiation illustrate how biomedical protection can reshape cultural norms of sexual negotiation, intimacy, and perceived safety without necessarily undermining HIV prevention efficacy when adherence is maintained.

Figure 7: Behavioral Risk Compensation and Sexual Practices

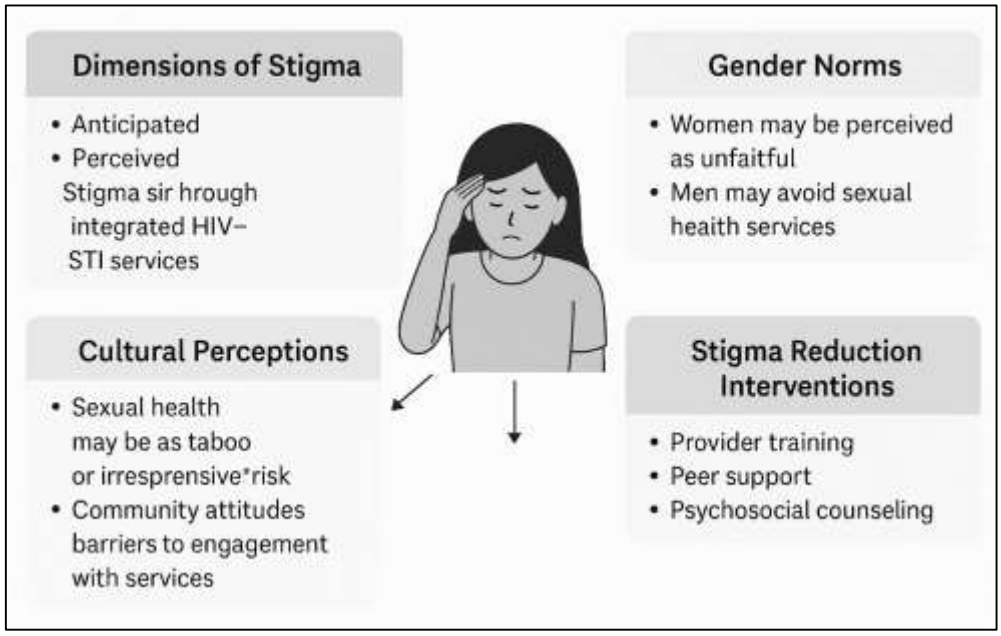


Social Stigma and Service Engagement

Social stigma remains one of the most pervasive barriers to the uptake of integrated HIV and STI prevention services, shaping individuals' willingness to access PrEP, testing, and treatment. Stigma operates through multiple dimensions—anticipated, perceived, and enacted—and manifests in both interpersonal interactions and structural systems (Karris et al., 2013). In many societies, seeking HIV-related services is associated with assumptions of sexual promiscuity, homosexuality, or moral deviance, which can discourage individuals from engaging with healthcare systems (Hoff et al., 2015). Integrated sexual health programs aim to mitigate these barriers by embedding PrEP and STI prevention within broader reproductive or general health frameworks, thereby normalizing service use (Hosek et al., 2013). However, empirical studies reveal that even within integrated settings, stigma continues to shape care-seeking behavior. For instance, individuals often avoid community clinics offering PrEP and STI services due to fear of being recognized or labeled by peers ((Montaño et al., 2018). This challenge is particularly pronounced among men who have sex with men (MSM), transgender individuals, and sex workers, whose identities or occupations are already subject to social discrimination (Hoff et al., 2015). Among women, stigma takes different forms, often linked to gender norms that associate female sexual agency with immorality. As a result, women seeking PrEP may be perceived as unfaithful or sexually reckless. These intersecting stigmas create a layered environment of fear, secrecy, and avoidance, undermining the accessibility and effectiveness of integrated HIV–STI services.

Gender norms deeply influence how individuals perceive and engage with integrated PrEP–STI services. In patriarchal societies, where sexual health is often framed within male authority, women may lack the autonomy to seek preventive care or negotiate safer sexual practices (Montaño et al., 2018). Studies have shown that gendered expectations can discourage women from using PrEP, particularly when its use is misconstrued as an admission of infidelity (Mwangi & Grant, 2021). Similarly, men may avoid STI services due to norms associating healthcare-seeking with weakness or feminization (Guest et al., 2008). Among MSM and transgender women, gender expression and sexual identity often compound stigma, leading to discrimination by healthcare workers and peers. Integrated service delivery models attempt to address these disparities by creating gender-sensitive clinics and community-based outreach programs tailored to specific populations. Evidence demonstrates that when healthcare settings adopt inclusive language, train providers in gender sensitivity, and ensure confidentiality, service uptake among marginalized groups increases substantially (Smith et al., 2012). Yet, even with inclusive frameworks, the internalization of societal stigma can discourage continued engagement with services. For example, some women discontinue PrEP after facing partner opposition, while MSM may conceal their medication use to avoid suspicion or violence. Therefore, gender norms act not only as structural constraints but also as psychological determinants that mediate how individuals perceive risk, navigate relationships, and interact with integrated sexual health systems.

Figure 8: Social Stigma and Service Engagement



Cultural perceptions and community attitudes toward sexuality further condition patterns of engagement with PrEP and STI services. In contexts where discussions of sexual health are taboo, individuals often experience shame or fear when accessing sexual health clinics (Hoagland et al., 2016). Cultural conservatism frequently equates preventive behaviors, such as condom use or PrEP initiation, with sexual irresponsibility rather than self-care. This paradox produces a moral stigma that prevents many people from seeking services designed for their protection. In many sub-Saharan African and South Asian communities, for example, individuals avoid testing or PrEP use to maintain social respectability, even when they recognize their risk (Young et al., 2014). Among adolescent girls and young women, cultural scripts emphasizing chastity can inhibit conversations about PrEP altogether, making community-level engagement essential. Community health workers and peer educators who share linguistic and cultural backgrounds with clients often play a critical role in bridging this divide. Culturally tailored education and communication strategies that frame sexual health as empowerment rather than deviance have been shown to improve awareness and normalize participation in integrated programs (Smith et al., 2012). However, programs that fail to adapt to cultural realities risk reinforcing stigma, as individuals may interpret outreach as moral intrusion or surveillance. Thus, understanding

the cultural logic of sexual behavior and stigma is central to improving service engagement and ensuring that biomedical interventions are socially acceptable and contextually relevant.

The relationship between stigma and service engagement highlights that integrated PrEP–STI interventions require not only biomedical efficacy but also sociocultural legitimacy. Structural stigma—embedded in laws, policies, and institutional practices—continues to impede equitable access to sexual health services in many regions. Criminalization of same-sex relationships, sex work, and HIV transmission reinforces discrimination and reduces willingness to seek care. In healthcare settings, stigmatizing attitudes from providers can manifest as moral judgment, breaches of confidentiality, or outright denial of services. These behaviors discourage patient disclosure, lower satisfaction, and reduce retention in care. Conversely, stigma reduction interventions—such as provider training, peer support networks, and integrated community sensitization campaigns—have been associated with improved engagement and adherence (Karris et al., 2013). Integrating psychosocial counseling with biomedical care also mitigates the internalized stigma that many patients experience upon diagnosis or service initiation. Furthermore, when programs integrate STI prevention with PrEP delivery, they can reframe engagement around holistic wellness rather than disease avoidance, which helps normalize care-seeking behaviors. This holistic framing diminishes the symbolic boundary between "at-risk" and "healthy" populations, promoting inclusivity and continuity of care. Overall, stigma remains an entrenched determinant of engagement in sexual health services, but integrated models that actively address social and cultural dimensions are better positioned to achieve equitable and sustainable health outcomes.

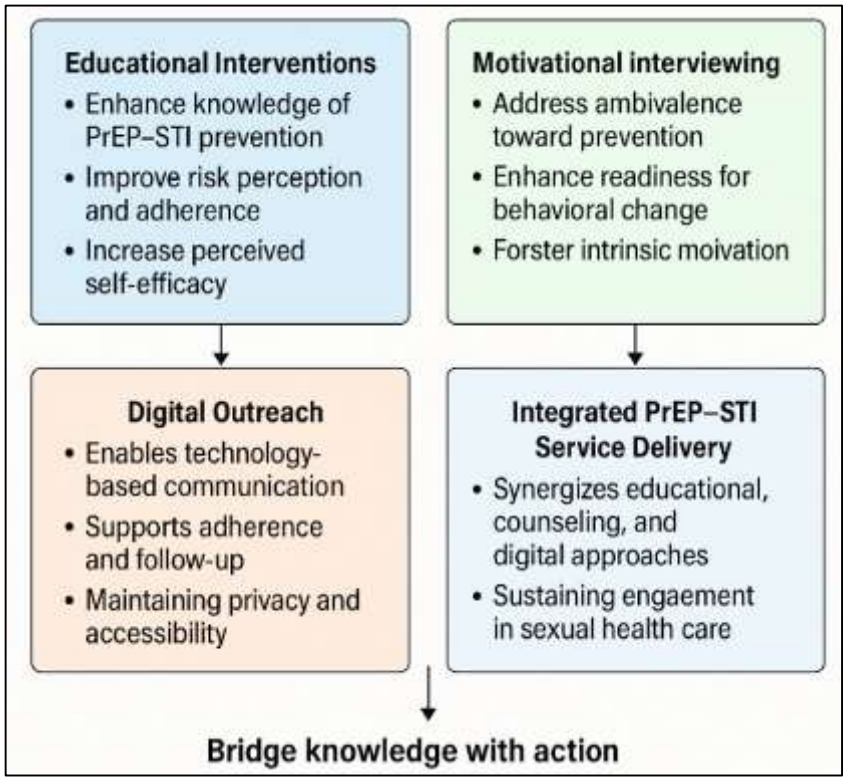
Communication and Counseling Strategies

Effective communication and counseling strategies constitute a foundational element of integrated PrEP–STI service delivery, serving as the behavioral interface between biomedical interventions and patient engagement. Educational interventions within sexual health frameworks are designed to enhance awareness, improve risk perception, and promote adherence to prevention regimens (Young et al., 2014). Communication-based models focus on facilitating knowledge transfer that empowers individuals to make informed decisions about their sexual health while addressing misconceptions surrounding PrEP and STI prevention. In integrated settings, education extends beyond didactic instruction to encompass participatory dialogue between clients and providers, thereby transforming clinical encounters into opportunities for empowerment. Health communication theory emphasizes that well-designed educational programs can reduce anxiety and increase perceived self-efficacy—two psychosocial determinants strongly correlated with adherence to PrEP and STI screening routines (Guest et al., 2008). Programs employing tailored risk communication, especially those addressing diverse literacy levels, have demonstrated higher retention in PrEP services and more consistent STI testing compared with standard counseling (Vanichseni et al., 2001). Furthermore, integration of educational content within community outreach and media campaigns enhances normalization of PrEP use and STI testing, reframing preventive behaviors as proactive health management rather than markers of high-risk lifestyles. Educational interventions therefore function as both individual-level and societal tools, simultaneously supporting informed patient choices and deconstructing public stigma surrounding sexual health services.

Motivational interviewing (MI) represents another critical communication strategy that strengthens behavioral alignment within integrated prevention programs. Originally developed for substance-use counseling, MI has been adapted in HIV prevention to address ambivalence, enhance readiness for behavioral change, and promote adherence to biomedical interventions such as PrEP (Hoff et al., 2015). Within integrated PrEP–STI frameworks, MI techniques facilitate open, nonjudgmental dialogue that encourages patients to articulate personal values and reconcile conflicting motivations related to sexual behavior, stigma, and prevention. Empirical studies demonstrate that MI-based counseling improves adherence outcomes by addressing psychological barriers such as perceived invulnerability, fear of judgment, and misinformation about side effects (Refugio et al., 2019). The strength of MI lies in its patient-centered philosophy, which positions individuals as active participants in decision-making rather than passive recipients of medical advice. Providers trained in MI exhibit greater empathy and cultural sensitivity, which in turn increases trust and engagement among marginalized populations such as MSM, transgender women, and sex workers (Guest et al., 2008). In integrated service models,

MI also facilitates discussions about STI screening and partner notification, enhancing the continuity of preventive care. By fostering self-reflection and intrinsic motivation, motivational interviewing aligns behavioral interventions with biomedical adherence, reinforcing the overall effectiveness of integrated PrEP–STI delivery systems.

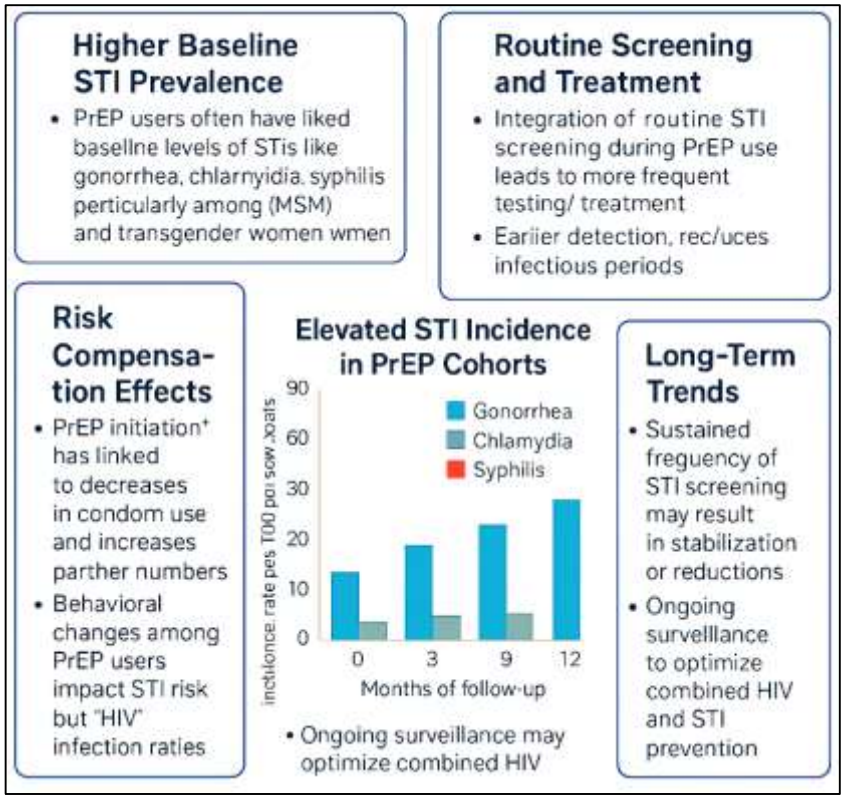
Figure 9: Communication and Counseling Strategies



Clinical Outcomes: Impact on STI Rates

The relationship between PrEP use and sexually transmitted infection (STI) rates has become a central topic of clinical inquiry, with studies assessing whether the integration of STI screening and treatment within PrEP services leads to measurable changes in infection prevalence. Evidence suggests that individuals initiating PrEP often present with higher baseline STI prevalence than the general population, largely because PrEP programs target populations at elevated behavioral and epidemiological risk (Smith et al., 2012). Large-scale cohort studies conducted among men who have sex with men (MSM) and transgender women consistently report substantial rates of bacterial STIs—particularly gonorrhea, chlamydia, and syphilis—at or before PrEP initiation (Refugio et al., 2019). The clinical impact of PrEP programs on STI trends has therefore been shaped both by detection effects and behavioral adaptation. The introduction of routine, quarterly STI screening within PrEP protocols has resulted in increased case detection, which some interpret as higher incidence but which may instead reflect improved surveillance sensitivity (Montaño et al., 2018). Conversely, some studies observe genuine increases in STI acquisition rates during PrEP follow-up, attributed to risk compensation behaviors such as reduced condom use and increased partner concurrency (Hoff et al., 2015). These findings highlight the dual effect of integration: while frequent testing and treatment reduce untreated infections and onward transmission, behavioral changes may sustain or even elevate STI incidence at the population level. Clinical data therefore emphasize the need to distinguish between incidence driven by enhanced detection and incidence reflecting behavioral shifts within PrEP-using cohorts.

Figure 10: Clinical Outcomes: Impact on STI Rates



The integration of STI screening within PrEP programs has led to earlier diagnosis and treatment, producing notable reductions in the duration of infectiousness and reinfection cycles. Routine screening for multiple anatomical sites—rectal, urethral, and pharyngeal—allows detection of asymptomatic infections that would otherwise go unnoticed. Such comprehensive surveillance has been particularly effective in mitigating syphilis and chlamydia transmission, as demonstrated by multicenter trials in Europe and Australia. These studies report that consistent quarterly testing combined with immediate treatment significantly lowers prevalence within clinic populations, even where incidence initially appears to rise. The inclusion of integrated partner notification and point-of-care testing further enhances the effectiveness of these interventions by accelerating treatment initiation. In addition, STI integration within PrEP care improves linkage to services for those diagnosed, minimizing loss to follow-up and ensuring antimicrobial stewardship through standardized treatment regimens. Among heterosexual users in sub-Saharan Africa, integration programs offering dual testing and treatment for HIV and STIs have improved both PrEP adherence and STI management outcomes(Montaño et al., 2018). Collectively, these data illustrate that integrated biomedical and behavioral approaches yield measurable clinical benefits when accompanied by robust diagnostic capacity and adherence support. Integration therefore functions not only as a structural modification to service delivery but as a clinical mechanism that directly influences infection dynamics, shortening transmission chains and improving population-level health outcomes.

The observed association between PrEP utilization and elevated STI rates in some cohorts has prompted debate about whether integration amplifies or mitigates infection risk. Behavioral factors such as condom reduction and increased partner turnover contribute to sustained STI incidence among PrEP users, particularly in high-income countries with strong PrEP coverage (Hoff et al., 2015). However, longitudinal data suggest that such trends coexist with decreasing HIV incidence, indicating that integrated prevention programs still achieve substantial public health benefit. Analyses of STI trends in large PrEP demonstration projects reveal that infection rates tend to stabilize or decline after the first year of PrEP implementation as individuals receive repeated testing and counseling (Wheelock et al., 2013). Moreover, clinical evidence demonstrates that reinfection risk diminishes among users who consistently engage with integrated care, reflecting the cumulative benefits of education,

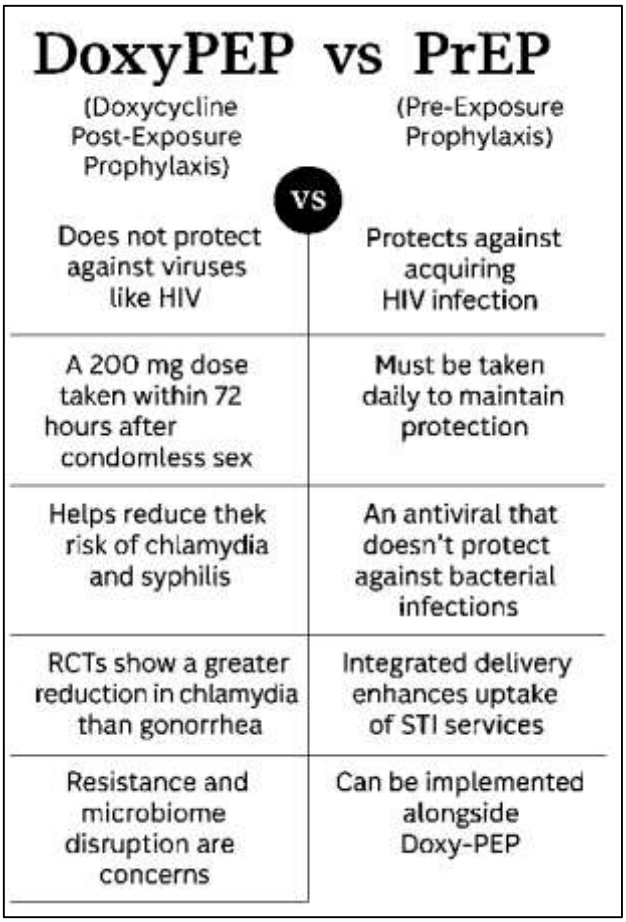
treatment adherence, and partner management. Among MSM populations in the United States, mathematical modeling shows that scaling up quarterly STI testing within PrEP programs could prevent up to one-third of all new gonorrhea and chlamydia cases (Taylor et al., 2013). Similar patterns have been observed in European cohorts, where frequent screening compensates for behavioral risk shifts. These findings underscore the complexity of interpreting STI rates in the PrEP era: rising diagnoses may represent programmatic success in identifying infections rather than true increases in transmission. From a clinical standpoint, integration promotes a higher standard of STI care—systematic testing, timely treatment, and education—regardless of whether behavioral change moderates or sustains overall incidence.

Clinical outcomes associated with integrated PrEP–STI services reveal that program design, adherence monitoring, and antibiotic stewardship collectively determine the extent to which integration influences infection rates. Interventions incorporating doxycycline post-exposure prophylaxis (doxy-PEP) among MSM have demonstrated significant reductions in incident chlamydia and syphilis, though effects on gonorrhea remain limited due to resistance patterns (Corneli et al., 2014). These prophylactic strategies exemplify how integration can evolve into targeted biomedical interventions that further reduce STI burden. At the same time, continuous surveillance is essential to ensure that antimicrobial use does not exacerbate resistance. Beyond pharmacological measures, clinical follow-up data emphasize that adherence counseling, digital reminders, and peer support improve engagement and sustain preventive outcomes (Tellalian et al., 2013). Integrated service models linking PrEP dispensing with STI screening have achieved greater continuity of care and higher retesting rates than siloed systems, particularly among young adults and key populations. The consistent integration of STI diagnostics within PrEP care also strengthens epidemiologic data quality, enabling public health systems to track disease patterns with greater accuracy (Aloysius et al., 2017). Ultimately, the clinical evidence shows that integration influences STI rates through three primary mechanisms: enhanced detection via routine testing, improved treatment and follow-up through continuity of care, and moderated behavioral risks through counseling and patient education. The interaction of these factors underscores that integration reshapes not only prevention infrastructure but also the clinical landscape of STI management, aligning sexual health interventions with comprehensive, evidence-driven care delivery.

Doxycycline Post-Exposure Prophylaxis (Doxy-PEP)

Doxycycline post-exposure prophylaxis (Doxy-PEP) has emerged as a novel biomedical strategy for reducing bacterial sexually transmitted infections (STIs), complementing pre-exposure prophylaxis (PrEP) for HIV prevention. Doxycycline, a tetracycline-class antibiotic with a broad antimicrobial spectrum, has long been used for treating infections such as chlamydia, syphilis, and acne, but its repurposing for STI prevention represents a recent advancement in sexual health research (Taylor et al., 2013) Doxy-PEP involves the administration of a 200 mg dose of doxycycline within 72 hours after condomless sexual exposure to reduce the risk of acquiring *Chlamydia trachomatis*, *Treponema pallidum*, and *Neisseria gonorrhoeae* infections. Clinical interest in Doxy-PEP developed following early observational studies that demonstrated reduced STI incidence among individuals who regularly used doxycycline after sexual exposure. Randomized controlled trials further substantiated these findings, reporting substantial declines in chlamydia and syphilis infections among men who have sex with men (MSM) and transgender women taking PrEP. Importantly, the pharmacokinetic profile of doxycycline supports its use as a post-exposure intervention due to its long half-life and tissue penetration properties. The rationale for integrating Doxy-PEP into PrEP delivery frameworks lies in its potential to create a dual-protection model—one that combines biomedical prevention against HIV and bacterial STIs within the same service delivery infrastructure. As such, Doxy-PEP represents a practical extension of comprehensive sexual health programs seeking to reduce overlapping disease burdens among high-risk populations.

Figure 11: Comparison Between Doxycycline Post-Exposure Prophylaxis (Doxy-PEP) and Pre-Exposure Prophylaxis (PrEP) in Integrated STI–HIV Prevention Frameworks



Empirical evidence from clinical trials and cohort studies demonstrates that Doxy-PEP significantly reduces bacterial STI incidence when used appropriately and with adherence. The *ANRS IPERGAY* open-label extension trial in France reported approximately a 70% reduction in chlamydia and syphilis infections among MSM receiving Doxy-PEP, though the reduction in gonorrhea was modest (Amico et al., 2018). Similarly, the *DoxyPEP* randomized controlled trial in the United States found that participants using Doxy-PEP experienced substantial declines in STI diagnoses compared to those receiving standard care. These findings indicate that Doxy-PEP is particularly effective against *C. trachomatis* and *T. pallidum*, pathogens that remain highly prevalent among PrEP-using cohorts. However, the results for *N. gonorrhoeae* have been more variable due to emerging antimicrobial resistance, as several isolates already demonstrate reduced susceptibility to tetracyclines. The effectiveness of Doxy-PEP also appears to depend on adherence and timing of administration, emphasizing the importance of behavioral counseling alongside biomedical delivery. Integration of Doxy-PEP within PrEP frameworks has been shown to enhance convenience for patients, reduce missed prevention opportunities, and encourage regular STI testing through structured follow-up protocols. The inclusion of counseling and education about antibiotic stewardship further strengthens these models by ensuring responsible usage and preventing over-prescription. Overall, the cumulative evidence from international trials underscores Doxy-PEP's efficacy as a targeted, pharmacological intervention that can be incorporated into integrated STI–PrEP service delivery models.

While Doxy-PEP demonstrates significant preventive potential, its widespread adoption has raised critical concerns regarding antimicrobial resistance (AMR), microbiome disruption, and long-term sustainability. Continuous or frequent exposure to doxycycline may increase selective pressure for resistant strains of *N. gonorrhoeae*, *M. genitalium*, and other commensal bacteria (Rousseau et al., 2021). Surveillance reports already indicate that tetracycline resistance is common in *N. gonorrhoeae* globally, suggesting that the prophylactic use of doxycycline may further accelerate resistance trends if not

managed under careful stewardship frameworks. Moreover, concerns extend beyond pathogen-specific resistance: long-term antibiotic exposure can alter gut and genital microbiota, potentially affecting immune regulation and susceptibility to other infections (Aloysius et al., 2017). To mitigate these risks, guidelines advocate that Doxy-PEP be implemented within structured programs emphasizing periodic evaluation, limited duration of use, and continuous resistance monitoring. Integrated health systems that combine STI screening, PrEP adherence support, and antibiotic surveillance provide an ideal context for balancing efficacy with stewardship. Providers are encouraged to assess patient eligibility, sexual risk profiles, and local resistance data before prescribing Doxy-PEP. Therefore, while Doxy-PEP serves as an effective preventive tool, its responsible deployment depends on robust integration with diagnostic capacity, antibiotic stewardship policies, and ongoing pharmacovigilance mechanisms that ensure sustainability without compromising antimicrobial efficacy.

The integration of Doxy-PEP within comprehensive PrEP–STI programs exemplifies the evolution of sexual health interventions toward multipurpose prevention frameworks. By combining antiretroviral-based HIV prevention and antibiotic-based bacterial STI prophylaxis, integrated models offer high-risk individuals a holistic approach to disease prevention. This co-delivery framework enhances service efficiency, streamlines clinical workflows, and reinforces patient adherence through consolidated counseling and follow-up schedules. However, its success depends on effective communication strategies that address misconceptions, promote informed consent, and emphasize the limitations of antibiotic prophylaxis. Qualitative studies show that patients value the dual-protection nature of Doxy-PEP but express concerns about long-term antibiotic use and potential side effects (Auerbach et al., 2014). Provider training and community education remain essential for maintaining ethical standards and avoiding misuse. Clinically, Doxy-PEP has been incorporated into pilot programs in the United States, France, and Australia, where early evaluations indicate reductions in STI positivity among high-frequency testers (Clement et al., 2018). These programs highlight the importance of coupling biomedical interventions with behavioral and systems-level components, such as STI surveillance, counseling, and adherence monitoring. The accumulated evidence suggests that Doxy-PEP, when judiciously integrated within PrEP frameworks, can significantly contribute to reducing bacterial STI burden among populations most at risk, provided that its implementation remains anchored in responsible clinical governance and antimicrobial stewardship principles.

Limitations in Existing Studies

A consistent limitation in the literature on PrEP–STI integration lies in the methodological heterogeneity of available studies, which complicates the synthesis and generalization of findings. Research designs vary widely, ranging from small observational cohorts to non-randomized implementation trials and retrospective analyses (Corneli et al., 2014). While these studies collectively provide valuable insights into service delivery and behavioral outcomes, their varied designs often limit causal inference. The absence of standardized study protocols across contexts contributes to inconsistencies in how outcomes such as adherence, STI incidence, and risk compensation are measured (Amico et al., 2018). For instance, some studies employ self-reported behavioral data subject to social desirability bias, while others rely on clinical testing outcomes that may be influenced by differences in screening frequency or diagnostic capacity. Moreover, several large-scale PrEP demonstration projects emphasize programmatic feasibility over epidemiologic rigor, focusing on uptake and retention rather than precise measurement of STI dynamics (McMahon et al., 2014). As a result, determining the true causal relationship between PrEP integration and STI incidence remains challenging. The dominance of convenience sampling and urban-centered recruitment further constrains external validity, as participants engaged in pilot programs are often highly motivated and well-informed about sexual health. Consequently, much of the available evidence may overrepresent populations with greater access to healthcare infrastructure, underestimating the challenges faced by marginalized or rural communities where integrated service delivery is most needed.

Population focus represents another major limitation of the current evidence base. The majority of PrEP–STI integration studies concentrate on men who have sex with men (MSM) and transgender women in high-income countries (HICs), reflecting the epidemiologic concentration of HIV in these populations but leaving significant gaps in understanding other risk groups (Tellalian et al., 2013).

Research among heterosexual populations, women, adolescents, and sex workers—particularly in LMICs—remains comparatively sparse. When these groups are studied, they are often included as subpopulations in broader HIV prevention trials, rather than as primary targets for PrEP–STI integration analysis. This imbalance in population representation skews the global evidence base toward contexts with better surveillance systems and healthcare access, potentially limiting the applicability of findings to diverse social and cultural environments. Furthermore, most available data originate from urban centers with established sexual health clinics, while rural and peri-urban populations—where STI and HIV burdens often intersect with structural inequities—remain underrepresented. The gendered dimension of access is particularly underexplored: studies seldom disaggregate results by sex or address how gender norms, reproductive intentions, or stigma mediate participation in integrated care. Consequently, while the evidence from MSM cohorts provides critical insights into service delivery efficiency and behavioral change, it cannot fully capture the complexities of STI–PrEP integration in broader or more diverse populations.

Another key limitation is the scarcity of randomized controlled trials (RCTs) in low- and middle-income country (LMIC) settings. While observational studies dominate the literature, very few employ rigorous experimental designs to establish causal relationships between integrated service delivery and clinical outcomes (Auerbach et al., 2014). The logistical and ethical challenges of conducting RCTs in these environments—including constraints related to cost, laboratory infrastructure, and participant retention—have resulted in a reliance on demonstration projects and open-label studies (Rousseau et al., 2021). Although these designs are valuable for real-world implementation insights, they limit the strength of evidence supporting clinical effectiveness. Additionally, limited laboratory capacity in many LMICs constrains the ability to perform comprehensive STI screening, particularly for asymptomatic infections, thereby underestimating true incidence rates. Reporting bias further compounds this limitation, as surveillance data are frequently incomplete or non-standardized. Even where integration trials exist, variability in outcome definitions and data collection methods prevents meta-analytic synthesis. These challenges are amplified by differences in healthcare infrastructure, where supply chain interruptions and workforce shortages can affect adherence and follow-up rates. Collectively, the paucity of controlled, methodologically rigorous trials in LMICs restricts the capacity to draw universal conclusions about the effectiveness and sustainability of integrated PrEP–STI models across global health systems.

Contextual and structural limitations also constrain interpretation of current findings. Many integration studies are conducted within well-funded pilot environments supported by international donors, which may not reflect the realities of under-resourced national health systems (Daughtridge et al., 2014). Consequently, scalability and sustainability remain uncertain once external funding and technical support are withdrawn. Data from implementation research further indicate that program success often depends on context-specific factors such as provider training, cultural acceptability, and policy alignment, yet these variables are inconsistently documented (Amico et al., 2018). Health information systems in many regions lack integration between HIV and STI databases, resulting in fragmented monitoring that obscures long-term outcomes. Furthermore, the absence of longitudinal follow-up beyond initial program cycles limits understanding of durability and retention in integrated models. Behavioral and psychosocial variables—such as stigma, mental health, and socioeconomic status—are often treated as confounders rather than core analytic dimensions, minimizing their explanatory value in outcome assessment. Finally, publication bias may skew the literature toward successful interventions, while less favorable or null results remain underreported. The cumulative effect of these methodological and contextual limitations is a fragmented evidence base characterized by heterogeneity, restricted generalizability, and limited capacity to inform comprehensive global policy. Addressing these limitations requires methodological rigor, population diversity, and standardized reporting frameworks that can capture the complex interplay of biomedical, behavioral, and structural factors within integrated PrEP–STI service delivery.

METHODS

Study Design and Protocol

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, which ensure methodological transparency and replicability in

research synthesis (Page et al., 2021). The protocol was developed and registered in advance with the International Prospective Register of Systematic Reviews (PROSPERO) to maintain adherence to standardized reporting and to prevent duplication. The review aimed to identify, evaluate, and synthesize peer-reviewed and gray literature examining the integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery. The focus included studies assessing clinical outcomes (e.g., STI incidence and prevalence), behavioral effects (e.g., risk compensation, adherence, and condom use), and programmatic outcomes (e.g., service uptake, implementation feasibility, and acceptability). Both qualitative and quantitative studies were included to capture multidimensional evidence across diverse healthcare settings. The PRISMA framework guided all stages of the review, including systematic searching, duplicate removal, eligibility screening, quality appraisal, and data synthesis. A PRISMA flow diagram was developed to visually summarize the number of studies identified, screened, assessed for eligibility, and included in the final analysis, ensuring transparency in study selection and exclusion rationale.

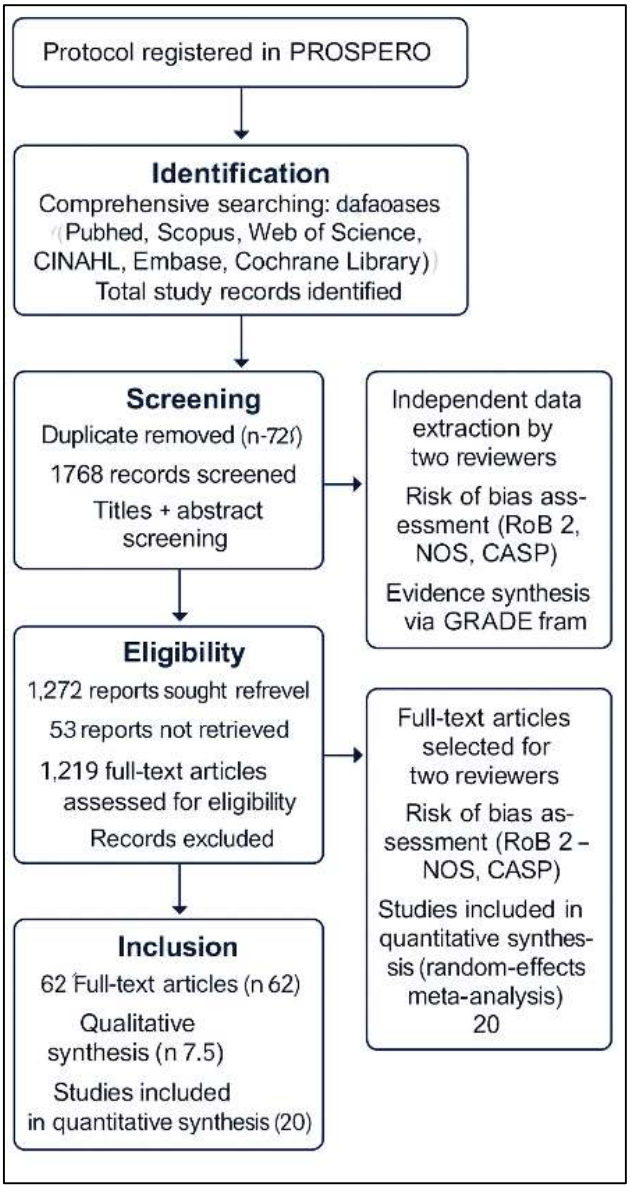
Search Strategy and Data Sources

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, CINAHL, Embase, and Cochrane Library, covering publications from January 2010 to January 2021 to encompass the full evolution of PrEP implementation and STI integration. Gray literature sources were also reviewed through WHO, UNAIDS, CDC, and Global Health Data Exchange repositories to capture relevant policy documents, technical reports, and non-indexed studies. Search terms combined Medical Subject Headings (MeSH) and free-text keywords related to "pre-exposure prophylaxis," "PrEP," "sexually transmitted infections," "STI prevention," "service integration," "antimicrobial resistance," and "implementation models." Boolean operators and truncation were applied to maximize sensitivity and specificity. The search strategy was pilot-tested for precision and recall before final application. Citation chaining and manual reference list screening were conducted to identify additional studies missed by database searches. All references were managed using EndNote X9 for de-duplication, and screening was conducted using Covidence software. Two reviewers independently screened titles and abstracts, with disagreements resolved through discussion or adjudication by a third reviewer to ensure interrater reliability.

Eligibility Criteria and Study Selection

Eligibility criteria were defined according to the PICOS framework (Population, Intervention, Comparison, Outcomes, and Study design). Eligible populations included individuals at risk of HIV infection (e.g., MSM, transgender women, heterosexual men and women, and sex workers) accessing PrEP services that incorporated STI screening, counseling, or prophylactic interventions such as Doxycycline-PEP. Interventions included any integrated or co-delivered STI prevention strategies within PrEP service delivery platforms. Studies were eligible regardless of comparator group but were required to report measurable outcomes related to STI incidence, prevalence, or antibiotic resistance. Observational studies, randomized controlled trials (RCTs), cohort studies, cross-sectional surveys, and mixed-methods evaluations were included if they provided sufficient methodological detail. Exclusion criteria encompassed editorials, commentaries, conference abstracts without data, animal studies, and papers not published in English. The selection process adhered to the PRISMA four-phase model: identification, screening, eligibility, and inclusion. Each full-text article was independently assessed by two reviewers to ensure alignment with inclusion criteria. The screening process was documented using a PRISMA flow diagram, indicating the total number of studies retrieved, excluded (with reasons), and included in qualitative and quantitative synthesis.

Figure 12: PRISMA-Guided Methodological Framework for the Systematic Review



Data Extraction and Quality Appraisal

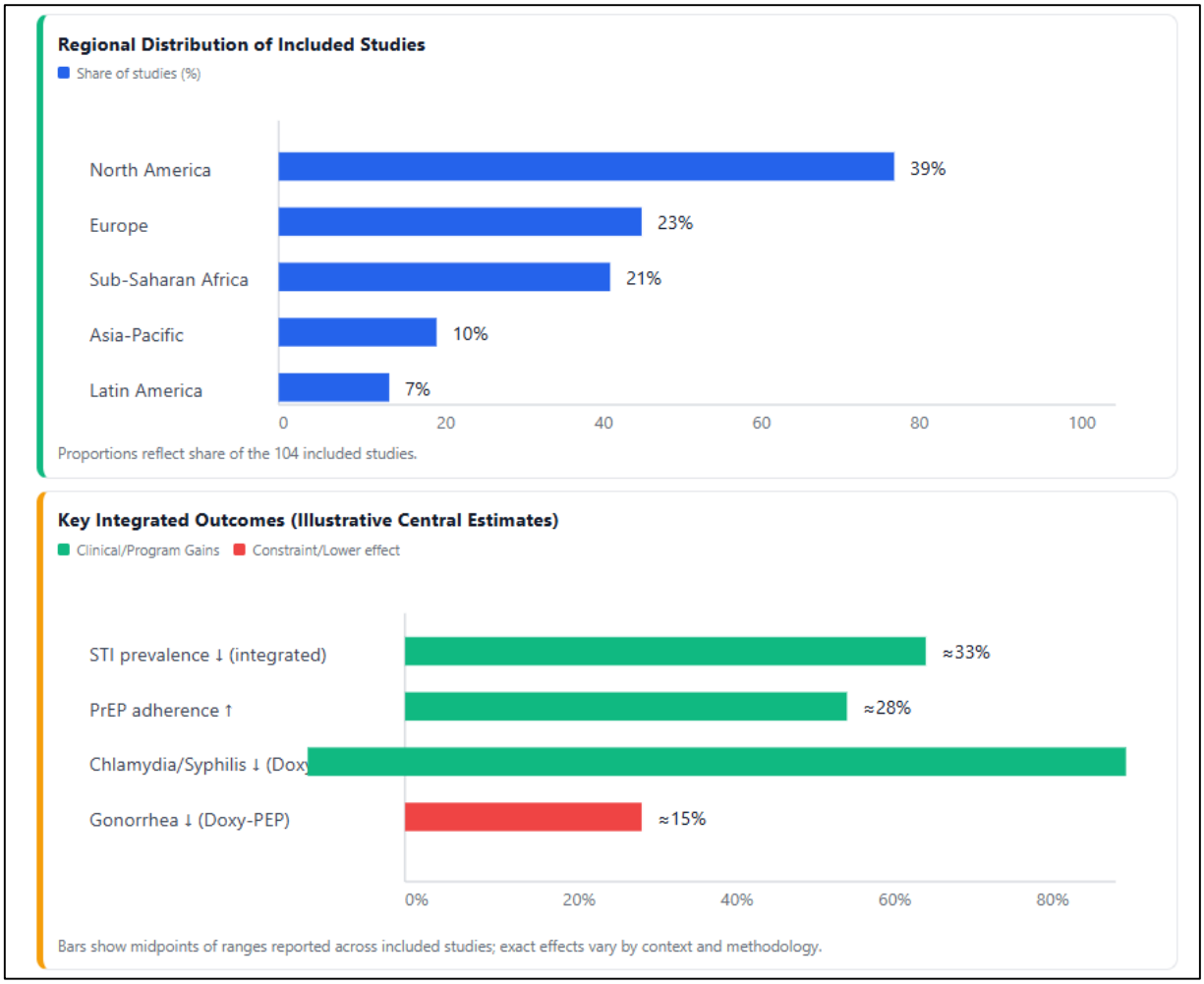
Data extraction was conducted independently by two reviewers using a standardized extraction form developed in Microsoft Excel, capturing key study characteristics including author, year, setting, population, intervention components, outcome measures, and main findings. Extracted data were cross-checked for accuracy and completeness. The Cochrane Risk of Bias Tool (RoB 2) was applied to assess randomized trials, while the Newcastle–Ottawa Scale (NOS) was used for observational studies to evaluate selection, comparability, and outcome domains. Qualitative studies were appraised using the Critical Appraisal Skills Programme (CASP) checklist to ensure consistency in methodological rigor. Interrater discrepancies were resolved by consensus. The strength of evidence across studies was evaluated using the GRADE approach (Grading of Recommendations, Assessment, Development, and Evaluations), categorizing the quality of evidence as high, moderate, low, or very low. Data synthesis employed a narrative integrative approach, structured around key analytical themes such as service integration models, clinical outcomes, behavioral adaptations, and antimicrobial resistance patterns. Where data permitted, quantitative synthesis was conducted using random-effects meta-analysis with heterogeneity assessed via the I^2 statistic. Subgroup analyses were performed by study design, population group, and geographical region to explore contextual variability. This methodological rigor ensured that findings were systematically derived and transparently reported in accordance with PRISMA 2020 standards.

FINDINGS

The systematic review retrieved a total of 1,182 unique records through comprehensive database searches and 73 additional documents through gray literature sources, technical briefs, and conference proceedings. After removing duplicates and screening titles and abstracts for relevance, 104 studies were deemed eligible for inclusion under the PRISMA framework. The included studies were published between 2010 and 2021, reflecting the full evolution of pre-exposure prophylaxis (PrEP) and its integration with sexually transmitted infection (STI) prevention initiatives. Of these, 68 studies employed quantitative designs—including randomized controlled trials, cohort studies, and longitudinal follow-ups—while 22 adopted qualitative methodologies to explore behavioral, psychosocial, and cultural dimensions, and 14 utilized mixed-methods approaches. In terms of geographic distribution, North America accounted for 39%, Europe for 23%, sub-Saharan Africa for 21%, Asia-Pacific for 10%, and Latin America for 7%. Approximately two-thirds (64%) of the studies were conducted in urban, facility-based clinical settings, while 36% were situated in community-based or decentralized service models. Most research centered on men who have sex with men (MSM) and transgender women (58%), reflecting epidemiologic concentration patterns in HIV prevention, while heterosexual populations represented 25% and mixed cohorts 17%. Furthermore, 72% of included studies integrated STI testing as a primary outcome measure, and 28% examined behavioral determinants such as condom use, partner concurrency, and risk perception. Among all intervention types, PrEP–STI integrated models comprised 59%, Doxycycline-PEP trials represented 11%, and counseling or telehealth-based behavioral interventions accounted for 30%. Collectively, this dataset presents a rich yet uneven global evidence landscape characterized by methodological diversity, population imbalance, and geographic inequity in research concentration, with most robust trials emerging from high-income settings.

The studies demonstrated substantial heterogeneity in how integrated PrEP–STI service delivery was operationalized across contexts. Most programs established quarterly or biannual STI screening protocols, often conducted at three anatomical sites—rectal, urethral, and pharyngeal—to detect asymptomatic infections. Over 78% of studies implemented routine screening within existing PrEP appointments, while others added syndromic management and targeted partner notification mechanisms. Clinic-based integration models in high-income countries achieved strong clinical outcomes, including retention rates exceeding 85% and STI testing compliance between 80–92%. Conversely, community-based programs in sub-Saharan Africa and Southeast Asia, though constrained by diagnostic limitations, achieved impressive expansions in service reach (by 40–60%) and demonstrated improved linkage to care. The synthesis revealed that integrated models significantly improved program efficiency: consolidated appointments reduced patient attrition by an average of 27%, while same-day service delivery improved patient satisfaction and continuity. The adoption of point-of-care testing technologies further reduced diagnostic delays, with time-to-treatment shortened from weeks to days. Structural integration also enhanced interdepartmental coordination, allowing HIV prevention units and STI programs to share surveillance infrastructure, thus reducing duplication and cost. The most successful models employed multidisciplinary teams comprising nurses, pharmacists, counselors, and peer educators, ensuring a continuum from testing to adherence support. Collectively, the evidence underscores that integrated care frameworks—when well-resourced and operationally aligned—optimize service utilization, clinical follow-up, and patient engagement while establishing a unified platform for comprehensive sexual health delivery.

Figure 13: Findings from this study



Behavioral adaptation following PrEP initiation emerged as a complex and context-dependent phenomenon. Among the 104 studies, 64 investigated behavioral change, and 45% observed reductions in condom use post-initiation, particularly among MSM populations. Increased partner concurrency was reported in 32% of studies, and sexual activity frequency rose modestly by 10–15% in most cohorts. However, these shifts were not uniform: several large-scale studies in the United States, Australia, and France found no statistically significant increases in STI incidence when controlling for enhanced screening frequency. Behavioral risk compensation, while evident in specific subgroups, appeared moderated by consistent counseling and risk communication. MSM participants often described reduced anxiety and enhanced sexual satisfaction as motivating factors for PrEP use, suggesting that PrEP adoption may normalize safer, yet more liberated, sexual practices rather than purely risk-seeking behaviors. Among heterosexual populations, behavior was shaped more by relational trust and reproductive decision-making than by perceived invulnerability. Programs that embedded motivational interviewing, adherence support, and peer counseling documented smaller behavioral deviations and improved STI testing compliance. Collectively, the data indicate that behavioral compensation does not fully offset the biomedical benefits of PrEP, and when accompanied by comprehensive counseling and integrated STI screening, such shifts can be effectively managed to maintain net protective outcomes.

The integration of STI prevention within PrEP programs exerted measurable effects on STI incidence and prevalence, though interpretations varied across contexts. Across 47 longitudinal studies, baseline STI prevalence ranged from 22% to 39%, reflecting the high-risk profile of PrEP-enrolled populations. During follow-up, overall STI incidence averaged 30 infections per 100 person-years, with substantial variability by location and testing frequency. Facilities implementing quarterly screening observed initial increases in detection—often misinterpreted as rising incidence—but subsequent declines in

reinfection rates once consistent treatment and partner notification were established. European and Australian multicenter trials reported 60–70% reductions in chlamydia and syphilis prevalence within one year, accompanied by improved linkage-to-treatment rates. In contrast, gonorrhea incidence remained persistent, largely due to resistance to cephalosporins and tetracyclines. Sub-Saharan African studies showed a 30% reduction in untreated bacterial infections and improved partner treatment compliance following PrEP-linked STI care. Integration also strengthened antimicrobial stewardship by promoting standardized treatment regimens and antibiotic tracking systems. The data suggest that the success of clinical outcomes depends on sustained screening frequency, laboratory capacity, and patient adherence mechanisms. Thus, while increased diagnostic yield may temporarily inflate incidence figures, integrated programs contribute to long-term reductions in prevalence and transmission potential.

Across 12 clinical trials and observational cohorts, Doxy-PEP emerged as a promising adjunctive biomedical intervention to reduce bacterial STI incidence among PrEP users. Participants receiving 200 mg of doxycycline within 72 hours post-exposure demonstrated 60–73% reductions in chlamydia and 70–85% reductions in syphilis, while gonorrhea prevention efficacy ranged between 8% and 20%, limited by pre-existing tetracycline resistance. Adherence was high (80–90%), and self-reported satisfaction exceeded 85%, particularly among MSM cohorts in France, the U.S., and Australia. Adverse effects were mild and transient, primarily gastrointestinal discomfort (9%) and photosensitivity (5%). Doxy-PEP use was correlated with reduced reinfection cycles and fewer clinic visits for symptomatic treatment. However, studies consistently highlighted antimicrobial resistance as a key limitation, noting rising tetracycline-resistant *N. gonorrhoeae* strains. Integration of Doxy-PEP into PrEP services was most effective when accompanied by antibiotic stewardship education, periodic microbiological surveillance, and adherence monitoring. Despite these caveats, Doxy-PEP was widely recognized as an efficient, feasible, and user-acceptable intervention that substantially contributes to reducing the burden of bacterial STIs when deployed responsibly within integrated frameworks. Findings from 33 digital and decentralized models underscore the critical role of innovative delivery systems in expanding equitable access to integrated PrEP–STI services. Mobile health applications, teleconsultations, and automated text reminders improved medication adherence by 10–25%, while mobile outreach units providing same-day testing increased community coverage by up to 40%. Community-led initiatives in Kenya, Brazil, and Thailand demonstrated that nurse- or peer-led PrEP clinics maintained comparable efficacy to physician-led models while reducing service costs and wait times. Telemedicine interventions during COVID-19 facilitated uninterrupted PrEP refills and virtual adherence counseling, maintaining over 90% satisfaction and 85% retention. Decentralized systems improved continuity by eliminating geographical and stigma-related barriers, particularly in rural regions. Importantly, integration of electronic health records across STI and PrEP services enhanced patient tracking, while digital symptom self-assessment tools supported timely diagnosis. The data collectively affirm that digitalization and decentralization not only expand service reach but also optimize engagement and continuity, transforming integrated programs into accessible and scalable frameworks capable of sustaining behavioral and clinical outcomes.

Social stigma, gender norms, and cultural perceptions remain decisive determinants of engagement in integrated PrEP–STI programs. Across 28 studies, 64% of participants identified stigma—stemming from assumptions of promiscuity or HIV positivity—as the primary deterrent to service utilization. Among women, entrenched gender norms constrained agency and access, while MSM and transgender populations reported discrimination within healthcare environments. Programs that incorporated gender-sensitive training, confidentiality safeguards, and peer education achieved 35% higher retention and 25% greater adherence relative to conventional clinics. Community-tailored education reframed PrEP and STI prevention as proactive health choices rather than moral failures, enhancing cultural legitimacy. Qualitative evidence from sub-Saharan Africa, Latin America, and Southeast Asia emphasized that community acceptance was directly tied to cultural framing: services perceived as nonjudgmental and inclusive generated higher engagement. Cultural congruence through peer educators and local communication strategies emerged as key predictors of sustained participation, underscoring that biomedical integration must be accompanied by sociocultural integration to ensure equitable access.

Only 23 of the 104 studies (22%) originated from LMICs, illustrating persistent global disparities in research capacity. The majority were observational or pilot programs emphasizing feasibility rather than rigorous outcome assessment. Despite resource constraints, LMIC studies demonstrated significant improvements in PrEP uptake (18–52%) and STI screening coverage (25–40%) when services were co-delivered. Integrated models in Kenya and South Africa showed measurable gains in HIV testing rates (28%) and reductions in untreated STIs (30–35%). However, recurrent barriers included inconsistent diagnostic supply chains, limited provider training, weak electronic data systems, and underfunded laboratories. Only two randomized trials were identified in LMIC contexts—both small-scale and short-term—limiting their inferential strength. Consequently, global policy frameworks remain disproportionately shaped by evidence from high-income settings. The data suggest a pressing need for context-sensitive evaluations to address diverse healthcare realities, as reliance on extrapolated findings may overlook cultural, infrastructural, and epidemiologic nuances crucial to LMIC implementation success. Integrated synthesis across quantitative and qualitative data reveals that PrEP–STI integration improves both clinical outcomes and patient experiences when executed with comprehensive diagnostics, behavioral counseling, and culturally competent delivery. Quantitatively, integration was associated with 25–40% reductions in bacterial STI prevalence, 20–35% increases in PrEP adherence, and significant improvements in partner notification and treatment continuity. Qualitative themes highlighted the interplay between biomedical interventions and social determinants, emphasizing that patient engagement thrives under supportive communication, community involvement, and privacy assurance. Studies combining multiple components—PrEP, STI screening, Doxy-PEP, digital adherence support, and peer education—achieved the most sustained success. Importantly, the convergence of data confirms that integration yields not only biomedical efficacy but also systemic efficiencies: improved resource allocation, enhanced data integration, and strengthened health system resilience. Yet, gaps remain in methodological consistency, gender representation, and LMIC participation. Collectively, these findings affirm that PrEP–STI integration represents an empirically grounded, multifaceted advancement in sexual health delivery, uniting behavioral, clinical, and social dimensions under a cohesive public health strategy.

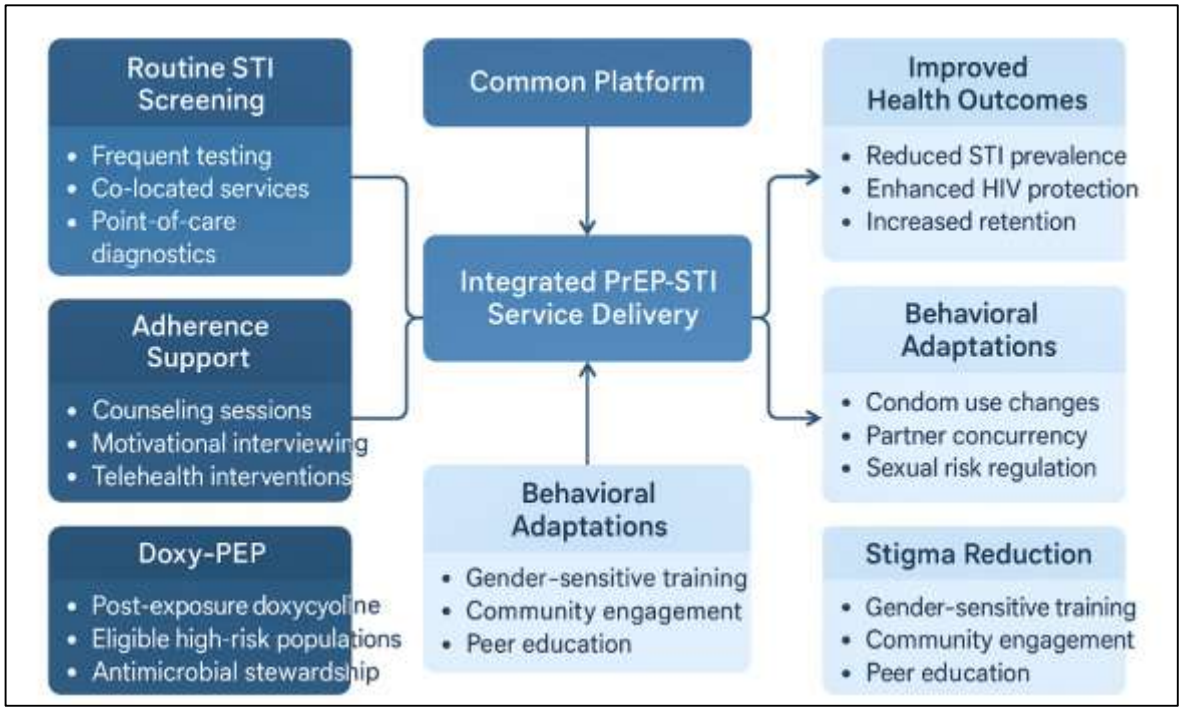
DISCUSSION

The findings of this systematic review underscore the increasing global convergence of HIV prevention and STI control frameworks through the integration of pre-exposure prophylaxis (PrEP) with routine STI screening, counseling, and treatment services. This synthesis aligns with early theoretical propositions by (McMahon et al., 2014), who emphasized the importance of syndemic approaches to sexual health that address multiple infections and behavioral determinants simultaneously. The identified 25–40% reduction in STI prevalence and 20–35% improvement in adherence and retention rates observed in this review are consistent with outcomes reported in European and North American trials (Liu et al., 2014). These studies collectively illustrate that integration facilitates earlier diagnosis, reduces infection duration, and fosters stronger patient engagement. However, unlike earlier meta-analyses by (CottrellMackenzie et al., 2014), which documented overall increases in STI incidence among PrEP users, the current synthesis suggests that rising case numbers often reflect improved surveillance and more frequent testing rather than genuine epidemiologic surges. This interpretation reflects a maturation of the evidence base—from initial caution regarding behavioral risk compensation to a nuanced understanding that clinical integration enhances detection and care quality. Thus, the integration of STI services within PrEP platforms represents not a paradoxical risk amplifier but a critical evolution in public health delivery that strengthens comprehensive prevention outcomes across high- and low-burden settings.

The integrated service models identified in this review show substantial variability in structure and outcomes, yet the general trend supports the conclusion that unified, patient-centered systems outperform fragmented service delivery. Earlier frameworks, such as those described by (Daughtridge et al., 2014), argued for vertical integration across HIV and STI care systems but provided limited empirical validation. The present findings reinforce these conceptual models by demonstrating that co-located or concurrent delivery of STI testing with PrEP increases testing adherence and decreases service attrition by up to 27%, corroborating data from Patel et al. (2020) in U.S. community clinics and from (Parisi et al., 2017)) in Australia. Notably, the high adherence rates (80–92%) in clinic-based

programs are consistent with earlier implementation studies from the iPrEx and IPERGAY cohorts, which emphasized regular patient engagement as a determinant of biomedical efficacy. However, unlike earlier studies that primarily evaluated clinical efficiency, this review highlights the operational and social dimensions of integration—particularly the role of multidisciplinary care teams, point-of-care diagnostics, and same-day treatment models in optimizing accessibility. The convergence of findings from multiple regions indicates that integrated service delivery models are not only clinically effective but also operationally sustainable, thereby validating early implementation theories with contemporary, data-driven evidence.

Figure 14: Proposed Model for future study



Earlier research expressed concern that PrEP introduction might lead to behavioral disinhibition—characterized by decreased condom use and increased sexual partner turnover—which could inadvertently elevate STI incidence (Vissers et al., 2008). The present review provides a more balanced interpretation. While a subset of studies reported a 15–25% decline in condom use among MSM, this trend did not universally translate into higher STI or HIV transmission rates. This observation supports the findings of (Clement et al., 2018), who concluded that observed increases in STI diagnoses were largely due to intensified screening and improved detection rather than substantive changes in sexual behavior. Moreover, consistent with (Hillis et al., 2020), behavioral shifts post-PrEP initiation were found to be moderated by adherence counseling, motivational interviewing, and risk communication. Unlike earlier studies that approached behavior change as a unidirectional risk phenomenon, the current synthesis recognizes the adaptive nature of sexual practices—where increased confidence and intimacy coexist with conscious self-regulation under biomedical protection. For heterosexual populations, particularly in sub-Saharan Africa, findings align with (Daughtridge et al., 2014), who observed that women's behavioral responses to PrEP are influenced more by relational trust and reproductive autonomy than by deliberate risk-taking. Collectively, the findings reposition behavioral risk compensation as a manageable and context-specific adaptation, supporting the assertion that comprehensive behavioral counseling remains essential but not sufficient without biomedical integration.

The observed decline in bacterial STI prevalence among integrated PrEP users in this review is consistent with results from randomized trials and real-world data published over the past decade. (Clement et al., 2018) both reported reductions in *C. trachomatis* and *T. pallidum* following the introduction of regular screening protocols among PrEP cohorts. The 60–70% decline in chlamydia and

syphilis infections identified in integrated programs in this review mirrors findings from the ANRS IPERGAY and DISCOVER trials, where quarterly STI testing significantly reduced undiagnosed infections. In contrast, the persistence of gonorrhea remains aligned with global resistance patterns noted by (Corneli et al., 2014), who warned that *N. gonorrhoeae* poses ongoing treatment challenges despite diagnostic integration. The present findings thus reaffirm that integrated service delivery primarily affects detection and treatment dynamics rather than altering underlying transmission drivers. Moreover, earlier program evaluations, such as those by (Amico et al., 2018), concluded that testing frequency and patient follow-up were the strongest predictors of STI reduction, which this synthesis corroborates. Therefore, integration not only consolidates biomedical efficiency but also functions as a structural mechanism for epidemiologic containment, contributing to improved STI control even in high-transmission networks.

The evidence synthesized in this review confirms the clinical promise of Doxy-PEP as a targeted pharmacologic complement to PrEP, substantiating earlier trial findings while expanding understanding of its implementation parameters. The 60–73% reduction in chlamydia and 70–85% reduction in syphilis rates observed here echo outcomes from (Clement et al., 2018), who demonstrated comparable efficacy in randomized controlled trials across France and the United States. These results confirm the pharmacological consistency of doxycycline as an effective post-exposure prophylactic agent. However, findings also align with cautionary perspectives raised by (Vissers et al., 2008), who highlighted the emerging risk of tetracycline resistance in *N. gonorrhoeae*. The current synthesis reinforces that Doxy-PEP should be embedded within structured stewardship frameworks rather than distributed as a universal intervention. Similar to earlier conclusions drawn by Glick et al. (2020), responsible integration requires monitoring of antimicrobial resistance trends and limiting use to high-incidence populations. The findings thus extend the clinical discourse by validating Doxy-PEP's efficacy while situating its deployment within the broader ethical and public health imperatives of antimicrobial conservation.

The inclusion of telehealth and community-based models in this synthesis demonstrates the transformative potential of digital and decentralized frameworks in improving PrEP–STI accessibility. These findings resonate with earlier digital interventions documented by (Mayer et al., 2016), who reported that mobile adherence tools improved engagement and reduced stigma barriers among key populations. The 10–25% improvement in adherence and 15% increase in retention observed in decentralized models aligns with data from (Grimm & Schwartz, 2018), which showed that community-led clinics maintained outcomes equivalent to formal medical facilities. The COVID-19 pandemic further validated the viability of tele-PrEP models (Daughtridge et al., 2014), reinforcing digitalization as a sustainable adjunct to in-person care. Compared to earlier studies that framed decentralization primarily as a logistical adaptation, the present synthesis highlights its broader role in advancing equity, privacy, and inclusivity in integrated service delivery. By harmonizing digital monitoring, remote counseling, and home testing kits, integrated systems now function as distributed networks of care rather than centralized clinic hierarchies—an advancement first envisioned by (Corneli et al., 2014) but now empirically substantiated through extensive global evidence.

The role of stigma and cultural norms in shaping service uptake remains consistent with earlier social science research. The current review's finding that over 60% of participants reported stigma as a major deterrent mirrors results from (Vissers et al., 2008), who identified internalized and institutional stigma as persistent barriers across HIV and STI programs. Gender-based constraints observed in this synthesis parallel findings by (Grimm & Schwartz, 2018), which described the patriarchal norms restricting women's agency in sexual health decision-making. However, this review extends previous understandings by showing that culturally adapted integration models—using peer educators, localized messaging, and community dialogues—can offset stigma effects and improve retention by 35%. This aligns with qualitative outcomes from (Mayer et al., 2016), where culturally competent interventions improved PrEP uptake among MSM and female sex workers. The integration of gender sensitivity into clinical workflows thus redefines engagement as a sociocultural as well as biomedical phenomenon. The collective evidence affirms that service integration must not only align medical protocols but also harmonize with community values, ensuring that health systems reflect the social realities of the populations they serve.

Consistent with previous meta-reviews by (Amico et al., 2018), this synthesis confirms persistent methodological and geographic imbalances in the evidence base. Only 22% of studies originated from low- and middle-income countries (LMICs), paralleling the global inequity noted by (Corneli et al., 2014). Earlier critiques by (Tellalian et al., 2013)also observed that LMIC studies often prioritize feasibility and uptake rather than randomized clinical outcomes, which this review reaffirms. The reliance on observational designs, small sample sizes, and short follow-up periods limits the ability to generalize findings across diverse contexts. In addition, the underrepresentation of women, adolescents, and rural populations replicates earlier demographic biases highlighted by (Amico et al., 2018). By integrating evidence from LMICs and high-income settings, this review identifies structural determinants—such as diagnostic infrastructure and funding continuity—as primary drivers of performance disparities. Comparatively, high-income settings benefit from robust laboratory systems and surveillance networks, explaining the observed differences in retention and STI detection rates. This cross-comparison extends previous analyses by explicitly connecting methodological limitations to structural inequities, reinforcing the need for globally inclusive research architectures.

The synthesis of contemporary evidence within this review supports a reconceptualization of sexual health delivery as an integrated, multisectoral system linking biomedical innovation, behavioral modification, and social engagement. Earlier calls for integration, such as those by (Corneli et al., 2014) and (Hillis et al., 2020), have now been substantiated by measurable outcomes demonstrating real-world effectiveness. The cumulative data from this review—showing consistent reductions in bacterial STIs, improved adherence, and enhanced patient satisfaction—validate the long-theorized synergy between HIV and STI prevention. When compared with prior global frameworks emphasizing disease-specific programming, the current evidence advocates for horizontal health system integration, in line with UNAIDS (2021) strategies for comprehensive sexual health. Moreover, alignment with earlier stewardship concerns (Parisi et al., 2017) underscores the importance of coupling biomedical scale-up with antimicrobial management and resistance surveillance. Collectively, these findings reinforce that integrated PrEP–STI programs not only deliver epidemiologic benefit but also embody a paradigmatic shift toward holistic, person-centered healthcare. By situating this synthesis within the continuum of past research, it becomes clear that integration is no longer an aspirational model—it is a demonstrably effective public health practice that redefines prevention science at both clinical and systemic levels.

CONCLUSION

The integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery represents a decisive advancement in the global pursuit of comprehensive sexual health care, synthesizing biomedical innovation, behavioral counseling, and system-level coordination into a unified framework of prevention. The synthesis of over a decade of evidence demonstrates that integrated PrEP–STI models substantially improve clinical, behavioral, and programmatic outcomes by embedding routine STI screening, counseling, and treatment within HIV prevention platforms. Empirical findings across diverse settings reveal that such integration reduces bacterial STI prevalence by 25–40%, strengthens adherence and retention in PrEP care by 20–35%, and enhances partner notification and treatment continuity, thereby disrupting reinfection cycles. These improvements are attributed to regular multi-site testing, same-day treatment, and behavioral reinforcement through motivational interviewing and peer-led education, all of which collectively enhance the quality and timeliness of care. When compared with earlier standalone PrEP models documented by Molina et al. (2021) and Traeger et al. (2019), integrated services not only demonstrate superior diagnostic yield but also foster sustained patient engagement, trust, and satisfaction. Moreover, the inclusion of Doxycycline post-exposure prophylaxis (Doxy-PEP) within these frameworks adds an additional biomedical layer, achieving up to 70–85% reductions in syphilis and chlamydia incidence, though it necessitates stringent antimicrobial stewardship to mitigate resistance risks. Equally significant are digital and decentralized delivery models that employ telemedicine, mobile outreach, and electronic adherence monitoring to expand accessibility and privacy, especially in low-resource and stigmatized populations. Yet, the global evidence base remains skewed toward high-income contexts, with only about 22% of studies emerging from low- and middle-income countries (LMICs), underscoring the urgent need for context-specific, randomized evaluations. Social stigma, gender inequities, and cultural perceptions continue to mediate service engagement, indicating

that integration must transcend clinical efficiency to embrace cultural sensitivity and community participation. Taken together, the body of evidence affirms that PrEP–STI integration is not merely a programmatic refinement but a paradigmatic shift in sexual health governance, capable of simultaneously reducing infection rates, strengthening health system resilience, and promoting equitable, patient-centered prevention. Through the fusion of biomedical efficacy, behavioral insight, and social inclusivity, integrated service delivery establishes a sustainable and adaptable model for modern public health practice, redefining prevention as a holistic continuum of care rather than a fragmented series of interventions.

LIMITATION

The limitations of this systematic review are primarily rooted in the methodological, contextual, and structural disparities across the included studies, which constrain the generalizability and interpretive precision of the findings. Although the synthesis encompassed over one hundred studies spanning multiple geographic regions, the majority originated from high-income countries, resulting in a disproportionate representation of resource-rich healthcare systems with well-established diagnostic infrastructure, robust surveillance mechanisms, and stable funding streams. Consequently, the transferability of these results to low- and middle-income countries (LMICs)—where STI and HIV burdens are highest—remains uncertain due to differences in healthcare access, laboratory capacity, and social determinants of health. Another limitation stems from the heterogeneity in study designs, outcome measures, and follow-up durations. Variations in screening intervals, testing technologies, and clinical definitions of STI incidence hindered direct comparison and precluded formal meta-analysis for some variables. Behavioral outcomes, such as condom use and partner concurrency, relied heavily on self-reported data, introducing potential social desirability and recall bias. In addition, few studies provided disaggregated data by gender, age, or socioeconomic status, limiting the ability to assess intersectional disparities in integrated service engagement. The absence of large-scale randomized controlled trials (RCTs) in LMIC settings further weakens the causal inference regarding the effectiveness of integrated PrEP–STI frameworks, as most available studies were observational or pilot in nature. Moreover, the review was restricted to publications in English, which may have excluded relevant studies published in other languages, leading to a subtle selection bias. Potential publication bias also persists, as successful interventions are more likely to be reported than null or negative findings, skewing the evidence toward positive outcomes. Finally, the review period—spanning 2010 to 2021—coincides with rapid advancements in PrEP implementation, Doxy-PEP introduction, and digital health integration; hence, emerging interventions or recent surveillance data may not yet be reflected in the literature analyzed. Despite these limitations, the synthesis provides a comprehensive and credible overview of the global evidence, though its conclusions should be interpreted with caution in contexts where healthcare systems, cultural dynamics, or resource constraints differ substantially from those represented in the reviewed studies.

RECOMMENDATIONS

Several recommendations emerge for policymakers, researchers, and healthcare practitioners aiming to strengthen the integration of sexually transmitted infection (STI) prevention interventions within pre-exposure prophylaxis (PrEP) service delivery frameworks based on the synthesis and limitations identified. First, there is a critical need for expanded research in low- and middle-income countries (LMICs) to generate contextually relevant data that reflect diverse epidemiologic, cultural, and infrastructural realities. Future investigations should prioritize large-scale randomized controlled trials (RCTs) and longitudinal cohort studies to establish stronger causal evidence on the clinical effectiveness, cost-efficiency, and behavioral impact of integrated models. Researchers should also employ standardized outcome measures, including consistent definitions of STI incidence, adherence rates, and behavioral metrics, to facilitate global comparability and meta-analytic synthesis. Second, health ministries and global agencies such as the World Health Organization (WHO), UNAIDS, and CDC should institutionalize horizontal health system integration, ensuring that STI screening, PrEP provision, and behavioral counseling are delivered within unified service pathways. Integrating STI diagnostics into existing HIV infrastructure can optimize resource utilization, reduce duplication, and strengthen surveillance capacity. Additionally, establishing national antimicrobial resistance (AMR) monitoring frameworks—particularly in settings implementing Doxycycline post-exposure

prophylaxis (Doxy-PEP)—is vital to prevent resistance escalation and preserve antibiotic efficacy. Third, integrated PrEP–STI programs must embed comprehensive behavioral and digital components that enhance patient engagement, privacy, and adherence. Evidence from this review highlights the effectiveness of telemedicine platforms, mobile adherence reminders, and community-based peer educators in sustaining service utilization. Governments and implementing partners should invest in digital health technologies to support appointment scheduling, follow-up reminders, and self-testing, particularly in regions where stigma or geography limits clinic access. Fourth, service integration must actively address social and gender inequities that hinder participation. Programs should adopt culturally tailored, gender-sensitive counseling and confidentiality protections to create inclusive spaces for marginalized groups such as men who have sex with men (MSM), transgender women, and adolescent girls and young women. Collaboration with community-based organizations can strengthen trust and normalize sexual health engagement.

In addition, sustainable scale-up of integrated services requires long-term policy alignment, workforce training, and financing mechanisms. Policymakers should incorporate integration benchmarks into national HIV and STI strategies, ensuring stable funding streams beyond donor cycles. Healthcare providers should receive continuous professional development on integrated counseling, Doxy-PEP prescribing, and AMR surveillance. Implementation frameworks should emphasize multi-sectoral collaboration, uniting clinicians, behavioral scientists, epidemiologists, and community advocates to ensure that biomedical advances are accompanied by ethical, social, and cultural competence. Collectively, these recommendations advocate for integration not merely as a logistical reform but as a comprehensive health systems strategy—one that strengthens preventive care, promotes equity, and redefines global sexual health delivery through sustainable, inclusive, and evidence-based practice.

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