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Epidemiological impact of expedited partner therapy for men who have sex with men: A modeling study

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Abstract

Background—Expedited partner therapy (EPT) is an intervention for patients with gonorrhea (NG) or chlamydia (CT), providing index patients with prescriptions or medication to give to their partners. EPT is recommended for heterosexuals but not for men who have sex with men (MSM), partially due to concerns about overtreatment of uninfected partners and missed opportunities for HIV diagnosis.

Methods—We extended our stochastic network-based mathematical model of HIV, NG, and CT among MSM to include EPT. EPT implementation was simulated for 10 years. Counterfactual scenarios varied EPT coverage, provision, uptake, and partnership window duration. We estimated sexually transmitted infection (STI) incidence, proportion of infections averted (PIA), and process outcomes under each scenario.

Results—Delivery of EPT to 20% of eligible MSM index patients (coverage) reduced cumulative STI incidence by 27% (interquartile range (IQR): 13%-39%) over 10 years compared to current estimated STI screening levels. A 20% increase in providing medication to non-index partners (provision) averted 32% (IQR: 20%-41%) of STI infections compared to estimated STI screening levels. When targeted by partnership type, EPT solely to casual partners maximized the population infections averted. The proportion of partners given medication who had no current STI varied from 52% to 63%, depending on coverage level. The proportion of partners given medication with undiagnosed HIV infection was 4% across scenarios.

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DATA AVAILABILITY

All data and software code necessary to simulate these models and run these analyses are stored on GitHub at: http://github.com/statnet/EpiModelHIV (branch is EPT) and http://github.com/EpiModel/EPT.

Conclusions—EPT could reduce bacterial STI incidence for MSM. However, this intervention could result in missed opportunities for HIV/STI prevention and a substantial increase in use of antimicrobials by STI-uninfected MSM, raising concerns about cost and antimicrobial resistance.

Keywords

Sexually transmitted infections; Men who have sex with men; Mathematical model; Sexual network; Expedited partner therapy

INTRODUCTION

Rates of bacterial sexually transmitted infections (STIs) such as *Neisseria gonorrheae* (NG, gonorrhea) and *Chlamydia trachomatis* (CT, chlamydia) among US MSM are high and increasing.[1] To address and control this epidemic, MSM with STI infection and their exposed partners require timely antibiotic treatment to reduce STI and STI-associated HIV transmission. Reinfection from untreated sexual partners contributes to repeat STIs; reducing these repeat infections may help arrest community-level STI and HIV transmission.[2]

Traditional STI partner services efforts include work by disease intervention specialists (DIS) to refer partners to diagnosis and treatment either directly (by DIS) or indirectly (index patient referral). Partner services are recommended for NG and CT[3] but more commonly implemented for HIV and infectious syphilis.[4] Given the large burden of NG and CT, and limited public health resources, DIS-initiated partner services for these two infections are less common. Methods such as expedited partner therapy (EPT) may yield substantial, efficient prevention benefits with reduced public health costs.

EPT involves providing antibiotic treatment (medication EPT) or a prescription (prescription EPT), without direct evaluation and treatment by a health care provider, to recent sex partners (non-index partners) of a diagnosed index patient who are otherwise unlikely to receive timely evaluation and treatment. In a systematic review including four trials among heterosexual men and women for NG and CT,[5-8] medication EPT reduced repeat infections in index patients by 20–29% and increased the number of partners believed to be treated.[9] The Centers for Disease Control and Prevention (CDC) recommends that clinicians consider EPT as a “useful option” to supplement but not replace traditional partner services for heterosexual partners of persons diagnosed with NG or CT.[10]

Few EPT trials have included MSM,[11-13] and EPT is not currently recommended for MSM for at least two reasons. First, given high STI and HIV incidence among MSM, there are concerns about missed opportunities for HIV and STI screening and treatment to address undiagnosed HIV or STIs not treated by EPT.[14,15] Second, there are concerns that EPT could lead to ineffective treatment, thus promoting the development of antibiotic resistance through decreased treatment efficacy at extragenital sites and decreasing NG antimicrobial susceptibility.[16]

In lieu of observational research on the effectiveness and side effects of EPT among MSM, mathematical modeling provides an exploratory framework to assess EPT implementation at

the population level. In this study, we used modeling to investigate the potential impact of medication EPT implementation on STI incidence among US MSM. By simulating EPT scale-up under different behavioral and clinical scenarios, we evaluated this strategy for treating NG and CT infections among MSM, mirroring present EPT recommendations for heterosexuals. Our goal was to inform future research and policy on the use of EPT among MSM.

MATERIALS AND METHODS

Overview.

This study builds upon previous HIV/STI transmission mathematical modeling among US MSM using the *EpiModel* software platform.[17] Study model extensions included the parameterization, structure, and analysis methods for EPT. The full model simulates intra-host, inter-host, and sexual partnership network evolution to model the transmission dynamics of HIV, NG, and CT among MSM (Supplementary Appendix).

Sexual Networks and Partnerships.

Dynamic MSM sexual networks were simulated using network data on Atlanta MSM.[18] Sexual partnerships were classified as main (feel committed to above all others), casual (persistent but non-main), or one-time. Partnership formation and dissolution were determined by partnership type, partner ages, sexual role preferences, and the number of ongoing sexual partnerships. For main (mean: 407 days) and casual (mean: 166 days) partnerships, median relational durations governed the dissolution of existing partnerships. Receptive and insertive anal intercourse (AI) were simulated within partnerships, with rates affected by disclosure of HIV status, sexual role, and partnership type. The mean degree (number of ongoing partnerships) was 0.288 for main partners and 0.405 for casual partners, and the weekly rate of new one-time partnerships was 0.068.

STI Transmission and Recovery.

HIV and rectal and urethral STI transmission were simulated across this sexual network. We did not model pharyngeal transmission due to limited data on oral intercourse for MSM. NG and CT transmission were directional and site-specific (e.g. receptive AI with a partner infected with urethral NG was necessary to acquire rectal NG infection). STI acquisition likelihood was influenced by condom usage, sexual role, and sexual act frequency. Dual-site (e.g., rectal and urethral NG) and co-infections (e.g., rectal NG and CT) were possible. We used a Bayesian statistical approach[19] to account for uncertainty in measuring site- and disease-specific STI transmission parameters, increased risk of HIV acquisition given prevalent STIs, and care-seeking. Defined prior distributions and simulation fitting to empirical incidence produced posterior parameter distributions used for the intervention model scenarios.

STI Symptoms, Screening, and Diagnosis.

Symptomatic status of new infections varied by infection site, with lower probability at rectal sites. The probability of testing and treatment (care-seeking) increased with symptomatic infection. Men presenting with symptoms were tested for both NG and CT at

that anatomic site. For men infected at both anatomical sites with the same STI, treatment prompted by diagnosis at one site was assumed to result in effective recovery at the other site.

To represent current STI screening practices, the reference (no EPT) model implemented asymptomatic STI screening following CDC recommendations,[10] with screening rates calibrated to HIV serostatus-specific National HIV Behavioral Surveillance (NHBS) estimates for the period prevalence of any testing for STIs in the past year and no preexposure prophylaxis (PrEP) usage.[20] Any sexual activity in the prior year indicated MSM for annual NG and CT screening per nucleic acid amplification testing at anatomical sites of exposure. The reference model included annual screening and symptoms-based testing, but, lacking nationally representative data, did not explicitly represent partner-linked testing (disclosure, notification). Screening tests were assumed to have 100% sensitivity and specificity, and all diagnosed men progressed to effective treatment. We varied treatment efficacy in Supplementary Table 13.

EPT Structure.

EPT was implemented as a continuum (Figure 1):[21] provision of EPT medication to index patient to give to partners (coverage), provision of medication from index patients to partners (provision), uptake of medication by partners (uptake), and treatment success (success). Parameters were derived from empirical literature (Appendix). Provision and uptake likelihood varied by partnership type (main, casual, or one-time) and by whether the relationship was ongoing or had ended. All partners with whom an index patient had sexual contact within the 60 days prior to diagnosis (EPT partnership window) with NG and/or CT were eligible to receive medication for NG and/or CT, depending on the index diagnosis. Partners could receive EPT only at the time step following index diagnosis, and partners already being treated for that STI could not receive EPT.

Model Scenarios.

Model scenarios and results were compared to the reference, CDC-recommended STI screening model. In our primary analysis, we varied EPT coverage — ranging from 10% to 100% — of index patients diagnosed with NG/CT provided with partner medication. Other analyses varied the duration prior to index patient diagnosis during which sexual activity made a partner eligible for EPT (the EPT partnership window), the probability of the index providing medication to partners, and the probability of medication uptake by partners. We explored variations in EPT coverage and provision to specific partnership types, such as increasing provision solely to casual partners. Base EPT implementation values for each continuum step modeling parameter (Table 1), unless noted, were held fixed at these values when another modeling parameter is being varied in subsequent scenarios.

Simulation and Analysis.

The best available NG and CT incidence estimates, sourced from a recent meta-analysis, were used to calibrate a pre-intervention equilibrium model, accounting for recent increasing STI trends, in an open population of 10,000 MSM (Appendix). Primary epidemiological outcomes included: NG and CT incidence per 100 person-years at risk, calculated for the

final simulation year; proportion (PIA) of cumulative infections averted compared to the reference model; prevalence of undiagnosed HIV or any NG/CT infection among partners receiving EPT; total number of EPT doses provided to index partners; and the per-capita cumulative number of times infected with NG and/or CT (the average number of times one person acquired NG and/or CT). Process outcomes included per-time step proportions of non-index partners provided with medication by partnership type and STI status. Each model scenario was simulated 250 times over a 10-year time horizon. Outcomes were summarized by medians and interquartile ranges (IQR) to account for model stochasticity.

RESULTS

Table 2 examines the effects of varying each step of the EPT continuum with respect to epidemiological outcomes. As EPT coverage increased, the PIA increased, with effects leveling off at about 80% coverage. Provision of EPT to 20% of index patients was projected to reduce cumulative STI infections by 27%. Expanding the EPT partnership window from the recommended 60 days did little to increase the PIA or decrease incidence. When limiting eligibility to sexual partners from the prior month, the median PIA was 26%, equivalent to the median PIA for a 6-month window. Increasing provision from index patients to non-index partners under fixed coverage levels increased the PIA, although the effects were smaller than those observed with increased coverage of EPT medication. The per-capita number of times infected with an STI decreased with increased coverage (0.98 at 10% coverage, 0.63 at 60% coverage), provision (0.85 with 10% increase, 0.75 with 50% increase), and uptake (0.85 with 10% increase, 0.82 with 20% increase); no change was observed when varying partnership window duration. Most partners receiving EPT medication (52% to 63% across coverage levels) did not have an STI when given EPT, a proportion increasing slightly with coverage and longer partnership window duration. Across all scenarios, around 4% of partners receiving EPT had undiagnosed HIV infection and EPT had a greater impact on NG than CT, likely due to the shorter duration of infection and lower prevalence of NG (Appendix).

Table 3 and Figure 2 examine the effects of increasing EPT implementation among different partnership types, varying the first step of the EPT continuum (coverage) while holding other continuum step parameter values fixed. The greatest partnership type-specific effect, consuming the most EPT doses, on cumulative STI incidence was observed with EPT provision to casual partners, where 60% coverage averted one-third of infections compared to 17% and 6% with 60% coverage when provision was limited to main and one-time partners, respectively. The effect on per-capita number of times infected showed similar partnership-type dynamics, with increasing effect at higher coverage. The intervention impact was variable; even for the most effective strategy of increasing coverage among casual partners, relatively high coverage levels (>10%) were required to ensure that lower PIA bounds exceeded 0, although this may be addressed by running a greater quantity of simulations.

Table 4 examines the effects of increasing EPT implementation among different partnership types, varying the second step of the EPT continuum (provision) while holding other continuum step parameter values fixed. As observed for coverage, the greatest effect on

incidence resulted from increasing provision solely to casual partners, with an increase to 80% provision associated with a PIA of 34%. When limited to main or one-time partners, 80% provision was associated with PIA of 16% and 8%, respectively. Similar to Table 3, intervention effects were highly variable; provision to 100% of main or one-time partners did not result in the lower PIA bounds exceeding 0. The number of EPT doses taken by partners and the per-capita number of times infected both decreased with increasing medication provision to non-index partners.

DISCUSSION

An EPT intervention broadly following recommendations for heterosexuals in the CDC's STD Treatment Guidelines may reduce population-level STI incidence and reinfection rates among MSM. Overall, this model of partner-driven medication delivery intervention demonstrated that 27% of STI infections expected over 10 years among MSM could be averted if EPT were provided to just 20% of index patients diagnosed with NG or CT. Increasing coverage (to index patients) and provision (from index patients to their partners) of EPT averted the most infections and any increased implementation reduced the per-capita number of times infected over 10 years. EPT provision to casual partners showed greater population-level impact compared to focusing on other partnership types. The majority of partners receiving EPT did not have a prevalent STI, and a significant fraction of those partners had undiagnosed HIV infection. Despite potential concerns for MSM, including missed opportunities for comprehensive HIV/STI prevention services and decreased antimicrobial susceptibility, EPT may reduce reinfection and avert NG/CT infections among partners.

The population-level impact among MSM of implementation along the EPT continuum differed by continuum step. Comparatively, the epidemiological impact of increased coverage exceeded that of both increased provision to and uptake by partners. In our continuum framework, interventions focusing on an earlier, or more upstream, continuum step or a larger group of potential partners (casual vs. main) increased the group size of partners receiving and taking EPT medication more so than targeting downstream steps or smaller groups. With increased coverage, partners of newly reached index patients could receive medication, while increased provision and uptake improved the likelihood of partners taking medications without expanding EPT availability to new index patients. Similar effects have been observed with interventions focusing on the PrEP care continuum.[22]

The CDC STD Treatment Guidelines recommend that EPT be offered to patients for all heterosexual partners in the past 60 days for whom providers cannot ensure treatment.[10] The likelihood of being able to contact and provide medication to partners may differ by partnership type. EPT effectiveness differed when prioritized for different partner types, consistent with differential effects in empirical trials.[13] EPT is intended to reduce reinfection, presumably more likely within ongoing main partnerships. However, the population-level impact on morbidity was greatest with EPT implementation limited to casual partners, despite casual partnerships being modeled with lower act rates and greater condom usage. A potential driver of these differential effects is the size of the group

receiving EPT. As modeled, casual partnerships are shorter in duration than main partnerships, and an individual can have concurrent casual partnerships (versus only one main partner). Thus, the pool of casual partners eligible to receive EPT would be expected to be larger. A systematic review of partner notification strategies, highlighting variations in HIV and STI transmission potential concealed by process-level outcomes and likely higher levels of concurrency among casual and ended partnerships, proposed a partnership-oriented focus to prioritize which index cases would receive more thorough partner-level interventions.[23] These findings may have implications for messaging and policy for partner-linked interventions surrounding casual partnerships.

Given sparse data on EPT among MSM, there remain substantive concerns with potential implementation. These data are varied, with small trials demonstrating: increased treatment but reduced partner testing for HIV and syphilis;[11] no significant effect on reinfection;[12] and increased notification of partners and decreased STIs.[13] While this model showed reductions in STI incidence, the high percentage of partners receiving EPT without prevalent STIs and the prevalence of undiagnosed and overall HIV infection, while unchanging across different scale-up implementation scenarios, highlight concerns about the biological and financial costs of inefficient antimicrobial usage and missed opportunities to provide comprehensive HIV/STI services, including HIV testing and PrEP referral, to partners[11,14,15,24] The model did not enforce any correlation of STI and HIV testing among partners receiving EPT that could occur with appropriate follow-up by DIS or by partners with health care providers, as recommended by the materials provided with EPT medication. Importantly, the model allowed us to quantify the magnitude of potential EPT concerns among MSM, providing evidence to support the need for cautious, careful scale-up and identify potential gaps in implementation.

Varying the length of the partnership window had limited effect on the PIA, contrary to our hypothesis that a longer partnership window would increase the number of partners eligible to receive EPT. There are at least two potential explanations. First, as the length of the window increases, the number of former partners who might be eligible for EPT may increase. This effect may be limited by the lesser likelihood, as parameterized, that a former partner would receive medication from an index patient than a current partner. Second, EPT was only made available to non-index partners who had not been recently treated, and less recent partners (e.g. partner from 3 months ago compared to 1 month ago) would subsequently have been more likely to have gotten treated for any infection. Thus, even though a person could have had more partners in the past 6 months compared to the past 2 months, increasing the time period may not necessarily have increased the number of eligible partners. As modeled, treating relatively recent partners was more likely to play a role in reducing reinfection.

Compared to compartmental (ordinary differential equation) models, network models using separable temporal exponential random graph models (STERGMs) offer two major benefits specifically for modeling EPT. Network models rigorously represent complex sexual partnership configurations, including repeated sexual contacts over time, critical for evaluating interventions like EPT. Modeled MSM have a mixture of main, casual, and one-time partnerships based on data-driven estimates of how these relationships form and break.

Although some compartmental models (pair-formation models) can represent partnerships, they are too limited in practice to effectively evaluate interventions like EPT. Second, network models are a form of individual-based model. Tracking individuals in a population, rather than groups, allows for the simulation of complex, interacting interventions like EPT, which has dependencies on STI screening and treatment represented with many individual-level attributes and histories of treatment. An additional advantage of these individual-level models is their stochasticity: they allow for variation in final outcomes (e.g., a simulation interval), whereas compartmental models are deterministic, producing only a single outcome value. The range of outcomes allows us to probabilistically assess the impact of EPT as an intervention.

Although our modeling study projects EPT's impact, there are potential provider- or patient-level barriers to implementation along the continuum.[21,25] Although EPT is now permissible (43 states, Washington, D.C.) or potentially allowable (5 states, Puerto Rico) in different forms (medication or prescription EPT) for heterosexual partnerships in nearly all states,[26] explicit policies permitting and protecting an EPT approach by medical and pharmacy boards may further improve EPT uptake.[27] Payment issues and costs related to EPT may also pose challenges for implementation as different states have different laws and allowable payment mechanisms surrounding EPT. Although EPT among heterosexual men and women was more cost-effective than standard partner referral societally and possibly among individual payers,[28] upfront costs could be prohibitive. Funding for EPT that does not rely on patients or partners to cover medication costs may improve uptake.[8,29,30] Programs seeking to increase partner treatment using EPT should consider addressing these gaps on the provider/payer side[21] as well as providing legal protections for health care providers (prescribers and dispensers) to improve the coverage of EPT among providers and acceptance and uptake of the medication by patients and partners.

Limitations.

As one of the few studies of EPT in MSM, and the first modeling study, our model required simplifying assumptions due to empirical data sparsity. Our model did not include forms of partner-linked testing for NG or CT such as post-exposure partner notification and partner services that occurs in some health jurisdictions.[4,31] Instead, because there were sparse data on reasons for STI testing, screening processes were calibrated to overall aggregated estimates of testing for any reason.[20] This may overestimate the effects of EPT, as some non-EPT partner-driven testing and treatment could have eliminated some infections prevented with EPT in our model. Our future empirical research seeks to quantify the baseline levels of partner-driven STI screening to advance subsequent models, as well as to model and evaluate comprehensive HIV and STI prevention (PrEP, EPT, screening) strategies. Second, due to limited data on oral-genital exposure among MSM, this model did not represent pharyngeal infections, for which there is particular concern about antimicrobial resistance for NG.[32,33] Current CDC NG EPT recommendations among heterosexuals acknowledge concerns about oral cefixime treatment efficacy, which we demonstrate in Supplementary Table 13, at extragenital sites (especially pharyngeal), but discuss the benefits of EPT for persons unlikely to be reached for timely treatment via standard partner services.[34] A 2014 analysis concluded that eliminating oral therapy for NG would have only

minimal short-term impact on treatment failure while potentially increasing overall NG rates.[35] Additionally, network data and model parameters were drawn from studies of Atlanta MSM that, despite similarities to broader national data[36,37], could limit the transportability of these models to other settings of MSM in the US. Finally, this analysis did not investigate the effect of differing antimicrobial regimens or EPT modalities (such as prescription EPT) or possible spread of antimicrobial-resistant NG.

Conclusions.

EPT and related partner-linked interventions could reduce reinfection and decrease population-level incidence of STIs among MSM. Despite significant reductions in STI incidence and reinfection, our model suggests concerns about undiagnosed HIV, inefficient use of antimicrobials for STIs, and potential missed opportunities for HIV/STI screening and prevention are warranted. Partners receiving EPT should continue to be counseled to seek additional medical evaluation. Further modeling and empirical research on EPT and other partner interventions among MSM could address concerns about missed opportunities for comprehensive HIV/STI prevention and antimicrobial resistance, assess EPT's cost-effectiveness, and inform implementation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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DISCLAIMER: The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

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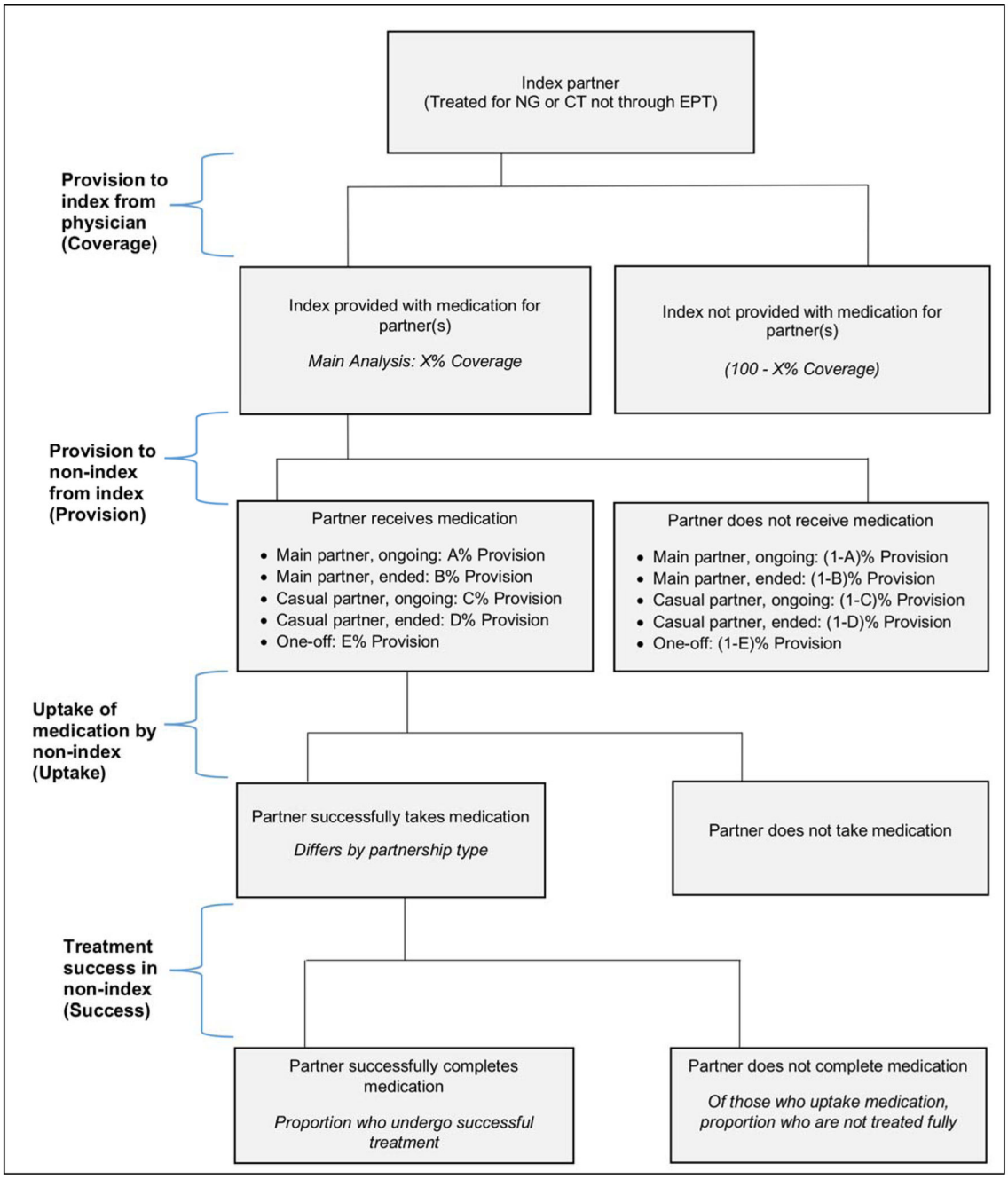

Figure 1.
Expedited Partner Therapy Schematic

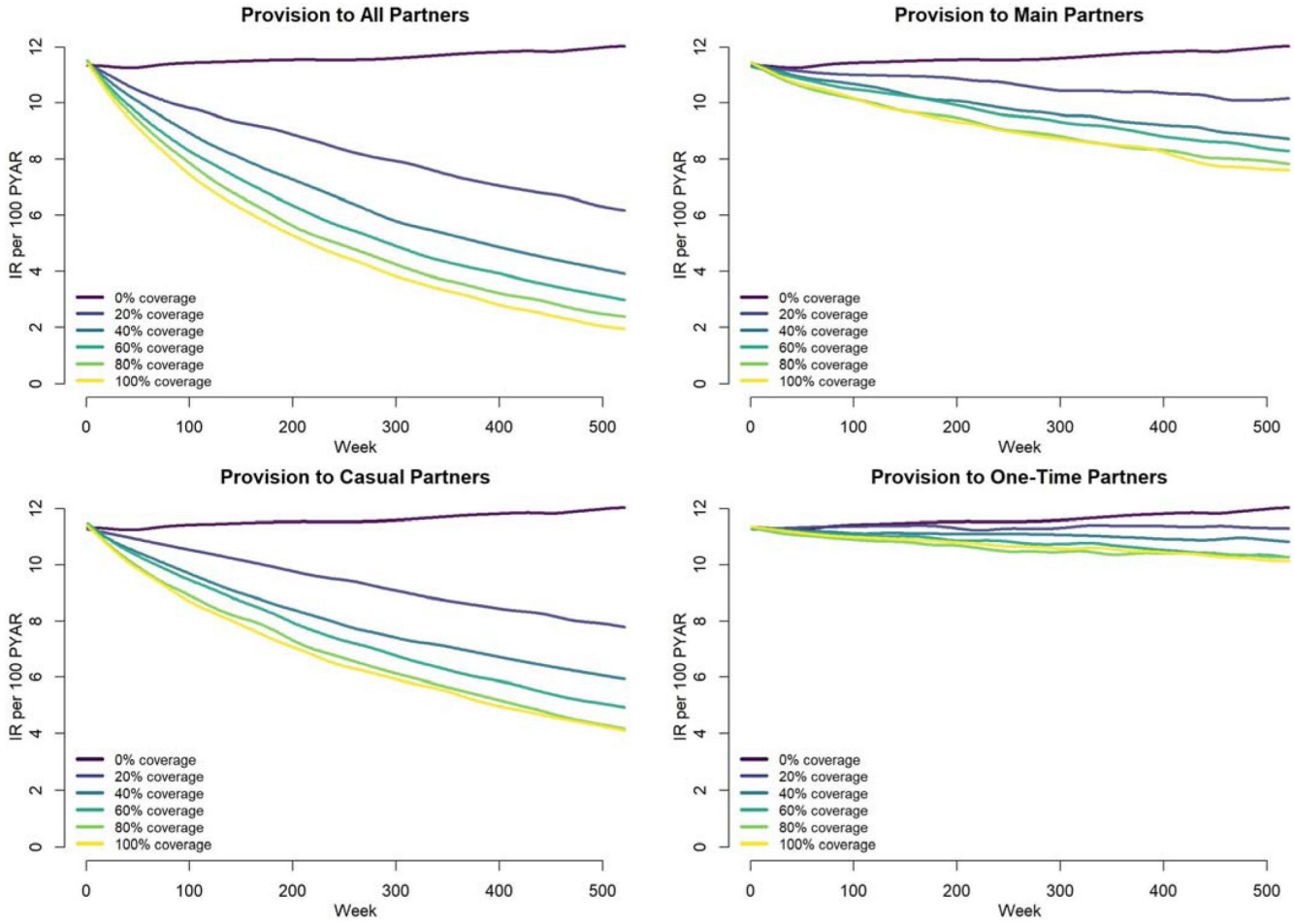

Figure 2:
Incidence Rates (IR) by EPT Coverage with Provision Limited by Type of Partnerships

Table 1.

Model Parameters for Sexually Transmitted Infection (STI) Screening and Expedited Partner Therapy (EPT) Continuum Steps for Reference (No Intervention), Base Intervention, and Counterfactual Scenarios

Continuum Step	Reference Model	Base Intervention Values*	Counterfactual Scenarios
NG/CT Screening (Past Year)	HIV−: 45% HIV+: 61%	HIV−: 45% HIV+: 61%	HIV−: 45% HIV+: 61%
Coverage for Index Patients	0%	20%	10–100%
EPT Partnership Window	--	2 months	1–6 months
Provision of EPT to Partners	--	50% (Main Partner, Ongoing) 40% (Main Partner, Ended) 40% (Casual Partner, Ongoing) 30% (Casual Partner, Ended) 20% (One-Time Partner)	0–50% relative increase
Uptake of EPT by Partners	--	80% (Main Partner) 80% (Casual Partner) 80% (One-Time Partner)	0–20% relative increase
EPT Success for Partners	--	100%	100%

*Base values for each parameter, unless otherwise noted, are held fixed at base intervention values when varying the value of another parameter

Table 2.

Combined Gonorrhea and Chlamydia (NG/CT) Incidence, Proportion of Infections Averted (PIA), Per-Capita Number of Times Infected, and Proportion of Partners Provided with EPT Medication Who Have an Undiagnosed HIV Infection and Did Not Have Prevalent NG/CT Infection Across EPT Continuum Steps among Men Who Have Sex with Men

	Incidence *(Median, IQR)*	**Cumulative PIA** *(Median, IQR)*	**Per-Capita Times Infected** *(Median, IQR)*	**Percent of Partners Provided with Undiagnosed HIV** *(Median, IQR)*	**Percent of Partners Provided Without STI** *(Median, IQR)*
Reference Model	11.46 (9.55, 14.17)	---	1.18 (1.05, 1.34)	---	---
Coverage for Index Patients					
10%	7.82 (6.15, 9.41)	0.20 (0.02, 0.30)	0.98 (0.87, 1.09)	4.18 (3.71, 4.89)	51.78 (50.35, 53.32)
20%	6.05 (4.79, 7.73)	0.27 (0.13, 0.39)	0.87 (0.79, 1.00)	4.16 (3.65, 4.66)	53.57 (52.39, 54.80)
30%	4.94 (3.87, 6.25)	0.35 (0.23, 0.45)	0.79 (0.70, 0.89)	4.13 (3.65, 4.61)	55.20 (53.89, 56.39)
40%	3.93 (3.05, 4.91)	0.41 (0.32, 0.50)	0.71 (0.63, 0.79)	4.15 (3.76, 4.54)	56.85 (55.68, 57.83)
50%	3.58 (2.67, 4.51)	0.44 (0.33, 0.53)	0.68 (0.60, 0.75)	4.03 (3.58, 4.44)	57.88 (57.01, 58.89)
60%	3.05 (2.38, 3.92)	0.48 (0.39, 0.56)	0.63 (0.57, 0.70)	4.06 (3.66, 4.48)	59.20 (58.13, 60.11)
70%	2.68 (1.95, 3.40)	0.52 (0.42, 0.60)	0.59 (0.53, 0.66)	3.98 (3.56, 4.47)	60.17 (59.16, 61.09)
80%	2.34 (1.77, 3.12)	0.54 (0.45, 0.61)	0.57 (0.50, 0.65)	4.02 (3.50, 4.44)	61.12 (60.22, 62.15)
90%	2.10 (1.62, 2.80)	0.55 (0.46, 0.62)	0.54 (0.49, 0.60)	3.98 (3.51, 4.39)	61.67 (60.76, 62.62)
100%	1.98 (1.43, 2.62)	0.56 (0.49, 0.63)	0.53 (0.48, 0.60)	3.95 (3.52, 4.33)	62.61 (61.66, 63.50)
EPT Partnership Window					
1 month (28 days)	6.28 (5.05, 7.85)	0.26 (0.14, 0.38)	0.88 (0.78, 0.99)	4.31 (3.81, 4.88)	49.72 (48.35, 50.87)
3 months (91 days)	5.91 (4.75, 7.42)	0.30 (0.15, 0.40)	0.86 (0.76, 0.97)	4.11 (3.50, 4.62)	56.65 (55.46, 57.83)
4 months (119 days)	6.20 (4.78, 8.00)	0.27 (0.15, 0.39)	0.87 (0.78, 0.97)	4.03 (3.52, 4.54)	58.86 (57.91, 60.04)
5 months (154 days)	6.03 (4.75, 7.38)	0.27 (0.16, 0.39)	0.88 (0.77, 0.97)	3.93 (3.54, 4.40)	61.56 (60.37, 62.81)
6 months (182 days)	6.15 (4.92, 7.29)	0.26 (0.13, 0.39)	0.88 (0.78, 0.96)	3.83 (3.46, 4.20)	63.75 (62.61, 64.65)
Provision of EPT to Partners					
Base values + 10%	6.09 (4.62, 7.38)	0.29 (0.17, 0.40)	0.85 (0.76, 0.96)	4.16 (3.70, 4.77)	53.41 (52.27, 54.58)
Base values + 20%	5.55 (4.30, 6.89)	0.32 (0.20, 0.41)	0.83 (0.73, 0.91)	4.10 (3.57, 4.72)	53.46 (52.09, 54.55)
Base values + 30%	5.29 (4.05, 6.44)	0.32 (0.21, 0.43)	0.81 (0.73, 0.90)	4.13 (3.67, 4.62)	53.27 (52.19, 54.43)
Base values + 40%	4.81 (3.82, 5.91)	0.38 (0.24, 0.46)	0.78 (0.69, 0.86)	4.12 (3.74, 4.54)	53.09 (52.04, 54.37)
Base values + 50%	4.37 (3.43, 5.54)	0.37 (0.27, 0.47)	0.75 (0.67, 0.84)	4.19 (3.71, 4.65)	53.04 (52.08, 54.16)
Uptake of EPT by Partners					
Base values + 10%	5.65 (4.55, 7.07)	0.30 (0.17, 0.39)	0.85 (0.76, 0.96)	4.14 (3.61, 4.73)	53.72 (52.51, 55.06)
Base values + 20%	5.39 (4.43, 6.69)	0.32 (0.20, 0.43)	0.82 (0.74, 0.91)	4.05 (3.52, 4.62)	53.77 (52.51, 54.89)

IQR: interquartile range (25% and 75% percentiles) of the simulation outcomes; Incidence expressed per 100 person-years at risk at final year of simulation; All outcomes are compared to the reference model.

Table 3.

Combined Gonorrhea and Chlamydia (NG/CT) Incidence, Proportion of Infections Averted (PIA), Expedited Partner Therapy (EPT) Doses Taken by Partners, and Per-Capita Number of Times Infected Across EPT Coverage (Provision to Index) Levels, Limited by Partnership Type, among Men Who Have Sex with Men

	Incidence *(Median, IQR)*	**Cumulative PIA** *(Median, IQR)*	**Total EPT Doses Taken** *(Median, IQR)*	**Per-Capita Times Infected** *(Median, IQR)*
Reference Model	11.46 (9.55, 14.17)	---	---	1.18 (1.05, 1.34)
Coverage for Index Patients (Provision to Main Partners Only) *				
10%	10.43 (8.58, 12.51)	0.05 (−0.13, 0.20)	120 (102, 133)	1.13 (1.01, 1.26)
20%	9.83 (7.87, 11.94)	0.07 (−0.12, 0.23)	207 (184, 238)	1.09 (0.97, 1.23)
30%	9.08 (7.22, 10.93)	0.12 (−0.05, 0.28)	282 (243, 322)	1.06 (0.92, 1.19)
40%	8.56 (6.94, 10.25)	0.14 (0.00, 0.28)	346 (316, 396)	1.02 (0.92, 1.13)
50%	8.21 (6.64, 10.41)	0.17 (0.00, 0.31)	412 (363, 466)	1.00 (0.90, 1.14)
60%	8.25 (6.54, 10.03)	0.17 (0.01, 0.32)	467 (415, 531)	0.99 (0.88, 1.13)
70%	7.51 (5.77, 9.39)	0.20 (0.06, 0.33)	492 (438, 559)	0.95 (0.84, 1.08)
80%	7.62 (6.06, 9.39)	0.22 (0.05, 0.34)	542 (486, 620)	0.94 (0.84, 1.08)
90%	7.20 (5.80, 9.05)	0.22 (0.09, 0.35)	585 (518, 661)	0.94 (0.83, 1.06)
100%	7.34 (5.69, 9.17)	0.23 (0.07, 0.33)	641 (565, 708)	0.95 (0.84, 1.06)
Coverage for Index Patients (Provision to Casual Partners Only) *				
10%	9.19 (7.63, 11.00)	0.11 (−0.05, 0.25)	310 (265, 347)	1.05 (0.94, 1.19)
20%	7.55 (5.95, 9.39)	0.18 (0.04, 0.31)	540 (467, 598)	0.99 (0.86, 1.11)
30%	6.76 (5.13, 8.44)	0.24 (0.09, 0.36)	714 (610, 816)	0.91 (0.80, 1.05)
40%	5.79 (4.83, 7.23)	0.30 (0.19, 0.41)	832 (745, 920)	0.84 (0.76, 0.92)
50%	5.61 (4.52, 6.90)	0.29 (0.19, 0.41)	995 (873, 1120)	0.84 (0.75, 0.94)
60%	5.00 (3.87, 6.11)	0.34 (0.22, 0.45)	1084 (947, 1209)	0.80 (0.70, 0.88)
70%	4.50 (3.57, 5.73)	0.38 (0.25, 0.47)	1158 (1023, 1315)	0.75 (0.66, 0.86)
80%	4.24 (3.43, 5.11)	0.40 (0.28, 0.50)	1222 (1118, 1359)	0.72 (0.66, 0.81)
90%	4.25 (3.20, 5.30)	0.39 (0.28, 0.48)	1348 (1216, 1494)	0.74 (0.66, 0.82)
100%	4.12 (3.23, 5.30)	0.41 (0.32, 0.50)	1401 (1270, 1571)	0.72 (0.65, 0.80)
Coverage for Index Patients (Provision to One-Time Partners Only) *				
10%	11.11 (8.71, 13.19)	0.02 (−0.14, 0.19)	115 (101, 135)	1.14 (1.02, 1.31)
20%	11.02 (9.03, 13.28)	0.03 (−0.17, 0.17)	223 (197, 255)	1.17 (1.04, 1.31)
30%	10.63 (8.73, 12.51)	0.05 (−0.12, 0.19)	308 (275, 342)	1.14 (1.02, 1.25)
40%	10.44 (8.57, 13.18)	0.04 (−0.12, 0.19)	398 (351, 451)	1.14 (1.03, 1.27)
50%	10.69 (8.68, 12.79)	0.03 (−0.13, 0.18)	482 (424, 533)	1.15 (1.01, 1.29)
60%	10.14 (8.19, 12.20)	0.06 (−0.12, 0.22)	548 (487, 610)	1.11 (1.00, 1.25)
70%	10.41 (8.58, 12.41)	0.05 (−0.13, 0.20)	620 (537, 686)	1.13 (1.00, 1.26)
80%	10.17 (7.99, 11.82)	0.08 (−0.07, 0.23)	657 (598, 727)	1.09 (0.98, 1.22)
90%	10.00 (8.12, 12.07)	0.08 (−0.12, 0.21)	732 (659, 815)	1.10 (0.99, 1.25)
100%	9.80 (7.90, 12.39)	0.07 (−0.07, 0.21)	775 (697, 867)	1.10 (0.98, 1.24)

IQR: interquartile range (25% and 75% percentiles) of the simulation outcomes; Incidence expressed per 100 person-years at risk at final year of simulation; All outcomes are compared to the reference model;

* 0% Provision to Other Partnership Types

Table 4.

Combined Gonorrhea and Chlamydia (NG/CT) Incidence, Proportion of Infections Averted (PIA), Expedited Partner Therapy (EPT) Doses Taken by Partners, and Per-Capita Number of Times Infected Across EPT Provision (Distribution to Partner) Levels, Limited by Partnership Type, among Men Who Have Sex with Men

	Incidence *(Median, IQR)*	**Cumulative PIA** *(Median, IQR)*	**Total EPT Doses Taken** *(Median, IQR)*	**Per-Capita Times Infected** *(Median, IQR)*
Reference Model	11.46 (9.55, 14.17)	---	---	1.18 (1.05, 1.34)
Provision to Main Partners *				
50%	9.46 (7.61, 11.17)	0.10 (−0.07, 0.25)	208 (181, 237)	1.06 (0.94, 1.19)
60%	9.11 (7.64, 11.69)	0.09 (−0.07, 0.25)	256 (221, 297)	1.08 (0.94, 1.23)
70%	8.82 (7.39, 10.77)	0.13 (−0.03, 0.27)	280 (253, 323)	1.03 (0.93, 1.16)
80%	8.78 (6.71, 10.43)	0.16 (−0.03, 0.29)	320 (286, 363)	1.02 (0.91, 1.15)
90%	8.47 (6.76, 10.16)	0.15 (−0.01, 0.30)	361 (316, 406)	1.02 (0.90, 1.11)
100%	8.17 (6.52, 9.77)	0.16 (−0.02, 0.30)	401 (348, 449)	1.00 (0.88, 1.12)
Provision to Casual Partners *				
50%	6.51 (5.34, 8.35)	0.24 (0.12, 0.37)	638 (564, 724)	0.90 (0.80, 1.02)
60%	6.19 (4.87, 7.66)	0.28 (0.13, 0.39)	740 (651, 838)	0.88 (0.77, 0.98)
70%	5.93 (4.66, 7.27)	0.29 (0.19, 0.40)	858 (749, 948)	0.86 (0.76, 0.94)
80%	5.11 (4.19, 6.32)	0.34 (0.21, 0.45)	905 (814, 1018)	0.80 (0.73, 0.89)
90%	4.67 (3.78, 5.77)	0.38 (0.26, 0.45)	973 (888, 1082)	0.76 (0.69, 0.85)
100%	4.32 (3.35, 5.41)	0.39 (0.29, 0.49)	1033 (932, 1181)	0.74 (0.65, 0.83)
Provision to One-Time Partners *				
50%	10.02 (8.02, 11.80)	0.08 (−0.09, 0.22)	524 (453, 600)	1.11 (0.97, 1.25)
60%	9.43 (7.54, 11.41)	0.10 (−0.06, 0.24)	602 (530, 684)	1.07 (0.95, 1.19)
70%	9.62 (7.62, 11.94)	0.08 (−0.09, 0.23)	730 (628, 828)	1.10 (0.97, 1.23)
80%	9.62 (7.84, 11.16)	0.08 (−0.07, 0.24)	831 (732, 934)	1.10 (0.97, 1.22)
90%	9.12 (7.22, 11.22)	0.09 (−0.06, 0.25)	906 (790, 1026)	1.07 (0.94, 1.20)
100%	8.78 (7.39, 10.59)	0.13 (−0.04, 0.27)	980 (877, 1125)	1.05 (0.93, 1.19)

IQR: interquartile range (25% and 75% percentiles) of the simulation outcomes; Incidence expressed per 100 person-years at risk at final year of simulation; All outcomes are compared to the reference model;

* 0% Provision to Other Partnership Types