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Original Articles Expanding Medicaid to Reduce Human Immunodeficiency Virus Transmission in Houston, Texas: Insights From a Modeling Study

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Abstract

Context: Medicaid expansion has been nationally shown to improve engagement in the HIV treatment and prevention continua, which are vital steps to stopping the HIV epidemic. New HIV infections in the U.S. are disproportionately concentrated among young Black men who have sex with men (YBMSM). Houston, TX, is the most populous city in the Southern U.S. with a

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Conflicts of Interest
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racially/ethnically diverse population that is located in one of eleven U.S. states that have not yet expanded Medicaid coverage as of 2021.

Methods: An agent-based model that incorporated the sexual networks of YBMSM was employed to simulate improved ART and PrEP engagement through Medicaid expansion in Houston, TX. Analyses considered the HIV incidence (number of new infections and as a rate metric) among YBMSM over the next 10 years under Medicaid expansion as the primary outcome. Additional scenarios, involving viral suppression and PrEP uptake above the projected levels achieved under Medicaid expansion, were also simulated.

Results: The baseline model projected an HIV incidence rate of 4.96 per 100 person years (py) and about 368 new annual HIV infections in the tenth year. Improved HIV treatment and prevention continua engagement under Medicaid expansion resulted in a 14.9% decline in the number of annual new HIV infections in the tenth year. Increasing viral suppression by an additional 15% and PrEP uptake by 30% resulted in a 44.0% decline in new HIV infections in the tenth year, and a 27.1% decline in cumulative infections across the ten years of the simulated intervention.

Findings: Simulation results indicate that Medicaid expansion has the potential to reduce HIV incidence among YBMSM in Houston. Achieving HIV elimination objectives, however, might require additional effective measures to increase ART and PrEP uptake beyond the projected improvements under expanded Medicaid.

Keywords

HIV; pre-exposure prophylaxis; computer simulation; data mining; sexual and gender minorities; preventive medicine

INTRODUCTION

The Center for Medicare and Medicaid (CMS) services is the largest single provider of health insurance in the United States (U.S.), with 90 million Americans benefiting through its programs.[1] Under the Patient Protection and Affordable Care Act (ACA), Medicaid coverage was expanded to 138% of the federal poverty level in states that opted for expansion.[2] As of April 2021, Medicaid expansion was yet to be adopted by 11 states, including Texas; two others (OK, MO) had adopted but not yet implemented Medicaid expansion.[3]

The most populous city in the Southern U.S., Houston, Texas, is home to over 2.3 million people. A racially/ethnically diverse population with a growing influx of immigrants and younger cohorts,[4] Houston is the principal city of Harris County, which includes 4.7 million residents,[5] and is a microcosm of Texas, the state with the highest uninsured rate in the country: of Texas adults under 65 years of age, nearly 25% are uninsured and less than 7% are covered by Medicaid.[6] Despite proposals to create a state-tailored expansion, legislative debate in 2021 was short-lived,[7] leaving Texas and major cities such as Houston with no end in sight to massive coverage gaps that disproportionately burden people of color.[8] This disparity in medical access intersects with existing health disparities in disease burden and health inequities, a potential driver for sustained transmission of conditions such as HIV among groups that have been marginalized.

As of a recent CDC report, the Houston metropolitan area ranked ninth nationally in rate of new HIV diagnoses[9] and reports lower rates of retention in HIV care and viral suppression than the U.S. overall.[10]Of all new diagnoses in 2019, men who have sex with men (MSM) are believed to have constituted nearly 71% of diagnoses in Houston/Harris County. Among MSM 18-34 years of age, the highest burden was among young, Black MSM (YBMSM) who made up 19% of all new diagnoses per internal calculations from the Houston Health Department whereby missing risk group information was imputed.[11] Contributing factors to continued HIV transmission, especially in the South, may include intersectional stigma of race and sexual identity in geographic regions perceived as oppressive and the medical distrust that results from this and other forces.[12]Expectations around masculinity and religious ideals that are common among Black communities lead some YBMSM to experience “potentially irreconcilable beliefs surrounding race and its interplay with… sexual identity”.[13] Social isolation resulting from such perceptions and experiences of homophobia dissuade engagement in HIV prevention and care services. A further barrier to services includes insurance coverage; MSM in non-expansion states are more likely to be uninsured and less likely to utilize preexposure prophylaxis (PrEP) than their counterparts residing in expansion states.[2]Furthermore, research demonstrates that lacking health insurance is associated with lengthy delays in the initiation of PrEP care among interested YBMSM[14]and may be related to lower PrEP care retention.[15-19]Medicaid expansion has been shown to improve engagement in both the ART and PrEP continua.[20-22] A number of empirical and simulation studies have projected declines in downstream HIV incidence due to improved ART and PrEP continuum engagement.[23]

However, little is known about how Medicaid expansion is likely to impact downstream HIV incidence, particularly in Houston, which remains among the urban epicenters of HIV in the southern US. Estimating the population health impacts of policy reforms is difficult because the effects of such policies may be realized over time periods that are longer than the duration of most empirical studies. Second, these impacts occur at a multitude of scales, starting from the micro-level individual, to the meso-level networks, and the macro-level population or community impacts. Computational modeling allows for the investigation of the impact of policy interventions prior to their real-world implementation and provides rigorous methods to quantify uncertainties given that data on relevant parameters are sometimes parse, uncertain, or unavailable.

This study takes a simulation approach to investigate the impact of Medicaid expansion strategies on HIV incidence among YBMSM in the context of Houston, TX. This simulation study is grounded on the modeling framework of a previously developed and calibrated agent-based network model (ABNM) and relies on empirically defined parameter estimates.[23] ABNMs are a complex systems modeling technique that provide the flexibility to model individual persons and members of their community networks as "agents" and the social network structures that connect them as "ties". The co-evolution of agents and networks provides practical insight into the impacts of health policy implementations.[24] The goal is to study the population-health impacts of Medicaid expansion strategies that have shown promise at the individual-level in improving engagement across the ART and PrEP continua.[20-22,25] To our knowledge, the impact of the resulting population-level improvements in ART and PrEP continua engagement on downstream HIV incidence have not yet been estimated.

The ABNM is deployed here as a tool to estimate how Medicaid expansion might impact HIV incidence in Houston in the next decade. Quantifying any projected gaps between the estimated declines in HIV incidence and the levels required to achieve a "functional zero" incidence (i.e., a level at which the projected number of new HIV infections is below the threshold needed to sustain the epidemic) can help guide intervention planning tailored for the YBMSM population at this important juncture.[26]

METHODS

Agent-Based Network Model (ABNM) Development

The ABNM combines an agent-based simulation approach with modeling of a sexual network structure and includes a number of processes that impact HIV transmission (described below). The sexual network structure was estimated using exponential random graph models (ERGMs)[27]; this approach is consistent with the methodology deployed in recent work across U.S. urban areas.[28-30] The ABNM presented here was implemented using the *statnet*[31] suite of packages in the R programming language to simulate dynamic networks. The ABM components were developed with the C++-based Repast HPC ABM toolkit.[32-34]

Demographic, Network, Behavioral and Biological Data

The demographic, clinical, and behavioral parameters of the ABNM was estimated using data sources that were representative of YBMSM in Houston, TX. Primarily, these were: a population-based cohort data from the Young Men's Affiliation Project (YMAP)[35] and the National HIV Behavioral System (NHBS).[36] The biological parameters were obtained from published data sources; data sources for all key parameters are provided in Table A.3. Procedures and protocols were approved by relevant institutional review boards.

Baseline Model

Baseline HIV transmission was simulated to capture existing epidemic features among adolescents and young adults (age 18-34 years), populated with 10,000 individuals at the start of the dynamic simulations. Population-based cohort data for YBMSM living in Houston were used to identify a calibration target of about 32%.[35] An empirical HIV incidence rate of approximately 4 per 100 person years was computed using the same cohort data (though this estimate was not published). Simulations proceeded in daily time steps. The substantive model components included agent arrival into the model ("aging in"), departures (agents "aging out" or experiencing mortality), dynamic sexual network structure, the temporal evolution of CD4 counts and HIV RNA ("viral load"), HIV testing and diagnosis, dynamics of ART and PrEP use, external HIV infections, and HIV transmission dynamics. These processes are described in greater detail in Section A.4 of the Appendix.

The baseline model was simulated 30 times to assess to assess the inherent (aleatory) variability in model outputs for each parameter set (Appendix Section A.6). The mean HIV prevalence rate across the 30 runs was 30.5 (S.D. 0.80) and the mean HIV incidence rate was 4.1 per 100 py (S.D. 0.37). For computational feasibility and since the replicates did not differ meaningfully from each other, we chose one out of the 30 replicates for the subsequent analyses to assess the difference between the baseline model and the Medicaid Expansion intervention scenarios.

Modeling Medicaid Expansion Interventions

The Medicaid Expansion scenario was modeled by assuming a 5% increase in HIV testing rates, in accordance with recent data,[20] a 2% increase in the proportion of HIV-negative persons using PrEP,[21,37] and a 17% improvement in ART adherence[20,38]. Using this scheme, three Medicaid expansion policy scenarios were simulated: (a) Medicaid Expansion (ME1), as described above (Table 1); (b) ME1 plus a 20% increase in PrEP uptake and an increased ART uptake for 15% or persons on it (ME 2); and, (c) ME1 plus 30% PrEP uptake and 15% ART uptake (ME 3). The ART and PrEP uptake expansion rates in scenarios (b) and (c) were selected based on the study team's results on achieving HIV elimination targets when applying this model to a YBMSM population in another large US city.[26] The PrEP increase was simulated to uniformly achieve the targets uptake level over the 10-year intervention period. Improvement in the HIV testing, time between diagnosis and ART initiation, and ART adherence and linkage parameters were set at the start of the intervention period, and the consequent improvement in ART uptake was achieved over the ten years of the intervention.

Outcomes

The control setting and interventions were each simulated 30 times. The primary outcome was the HIV incidence rate ten years after the start of implementation, averaged over the 30 model simulations. The annual incidence rate in the tenth year under the ME1, ME2, and ME3 scenarios were computed, and compared with the control scenario where levels of engagement in the HIV prevention and treatment continua were held constant at levels consistent with the Baseline Model throughout the 10-year intervention period. Additionally, the cumulative number of new infections averted in each year of ME 1, ME 2 and ME 3 are reported, relative to the control scenario.

Uncertainty in the incidence projection estimates was quantified by using bootstrap estimates derived via simulation. To do this, the 30 simulation runs for each policy scenario at each time point were sampled 1000 times with replacement. The mean for each of the resampled datasets was computed, and the 2.5% and 97.5% quantile of these means were taken to obtain the 95% bootstrap simulation interval (SI) around the mean.

RESULTS

Table 3 provides the mean tenth year incidence rate (per 100 person years), the mean number of HIV infections in the tenth year, and the mean HIV prevalence at the end of the ten years of the simulation period. Figure 1 displays the average annual incidence rates, Figures 1 and 2 display simulated data for the HIV incidence rate (per 100 py) and the annual mean number of new HIV infections under all four scenarios, with color bands that demonstrate the bootstrap SIs. Table 4 provides the cumulative number of new infections averted in each year of ME 1, ME 2 and ME 3, relative to the control scenario.

A considerable decline in the HIV incidence rate and the projected mean number of new HIV infections is observed under all three Medicaid expansion scenarios. The ME1 scenario resulted in a 17.5% reduction in the HIV incidence rate and about a 14.9% decline in the number of infections in the tenth year of the intervention versus baseline. ME2 yielded tenth-year declines of 42.3% in the HIV incidence rate and 37.8% in mean number of new infections. ME3 yielded reductions of 48.7% in the HIV incidence rate and 44.0% in the number of new infections in the tenth year.

Cumulatively, the 30 simulation runs of the control scenario produced a mean of 3699 new infections across the 10th year. In contrast, ME1, ME2 and ME3 respectively yielded 3358, 2837, and 2698 cumulative infections, corresponding to declines of 9.2%, 14.1%, and 27.1%, relative to the control scenario.

DISCUSSION

In this study, we explored the impact that Medicaid expansion might have on HIV incidence among YBMSM in Houston. We observe that Medicaid expansion can make a sizeable impact on HIV incidence. In addition, increasing PrEP and ART uptake beyond the projected increases under Medicaid expansion, can yield further decreases in the rate of new cases. An increase in ART and PrEP uptake, beyond the levels projected under Medicaid expansion, might be necessary to eliminate HIV transmission in the next decade. For example, drug assistance programs (DAP) in combination with Medicaid expansion, have been associated with 99% increase in PrEP use,[39] and may prove effective in increasing uptake. While Medicaid expansion alone may not get Houston to the goal of zero incidence, expanding PrEP and ART interventions in combination may help achieve this goal.

Previous work in Chicago, with a comparably sized HIV epidemic, has suggested that increasing ART and PrEP uptake to 30% above current levels would lower incidence to about 200 new infections per year among YBMSM, reaching a “functional zero” transmission rate.[26] Simulated data presented in this study indicate some similarity between the two cities, with comparably sized populations of YBMSM, where about a 30% increase in PrEP uptake and a 15% increase in ART use is projected to result in 205 new HIV infections per year among YBMSM in Houston.

With the Texas legislature’s decision not to expand Medicaid in April 2021,[7] there is little evidence that widespread coverage gaps will soon be mitigated through this avenue. However, Houston has made substantial strides to increase PrEP and ART uptake that may bring the city closer to HIV Ending the Epidemic goals. In 2019, the Houston Health Department (HHD) initiated a locally-driven awareness campaign with residents from the LGBTQ community serving as ambassadors. Branded *I am Life*, the campaign focused on PrEP and treatment as prevention (TasP) messages among the populations most impacted in

Houston—Black and Hispanic MSM and transgender individuals.[40] Complementing work to increase demand for PrEP, the HHD simultaneously increased availability by expanding hours/days of operation at PrEP-specific clinics.

In order to promptly disrupt onward transmission, Houston also continues to expand rapid initiation of ART. Just one of fifteen grantees, a Houston community-based organization was awarded new federal funding in 2020 to build capacity for rapid ART implementation.[41,42] The Houston jurisdiction's Ryan White Grant Administration additionally scaled up rapid start as part of their Ending the HIV Epidemic initiative. Over the period of 2020 to 2021, they have provided over $3.7 million to initiate or enhance rapid start in five provider locations in the Houston area (personal communication, Carin Martin).

There are several limitations in this study. The external transmission from Black MSM older than 34 years, women, and non-Black MSM were not included in the model. This is due to limited evidence that supports infections among YBMSM originating from these populations and high levels of racial homophily among Black MSM,[43,44] although results are somewhat mixed.[45] Ongoing extensions to the model are expanding the representation of race/ethnicities, gender identities, and age groups included. Another limitation is that the target for a functional zero is not precisely defined yet. Research on a precise statistical definition of a functional zero is underway, and such a definition will help in planning better focused policy prescriptions. We also did not have data on the frequency of anal sex among YBMSM in Houston. We did, however, have comparable information for a similar population (younger Black MSM between 18-34 years of age) in Chicago. This frequency of anal sex produced calibration outcomes that were consistent with our Houston targets. Further research on estimating this parameter in Houston could help address this gap. Additionally, our model does not take into account expanded coverage that may exist from local safety-net programs, such as financial assistance or sliding scale medical care through Federally Qualified Health Centers (FQHC) or Harris Health System's Financial Assistance Program.[46]

Improved ART and PrEP engagement have shown promise in reducing HIV transmission in a number of U.S. populations that bear a disproportionate burden of the epidemic. Expanding Medicaid, as a number of states have already done, may help substantially reduce the burden of HIV among underserved populations in Houston and throughout Texas. Recently announced, the federal mandate that nearly all medical insurers must eliminate cost sharing for PrEP,[47] may prompt substantial acceleration toward the goal of HIV elimination; however, without concerted efforts to reach the uninsured, this change has the potential to increase rather than to decrease the disparities in HIV incidence that disproportionately affects Black MSM. Modeling studies can continue to provide insight as updates to policies are planned and implemented.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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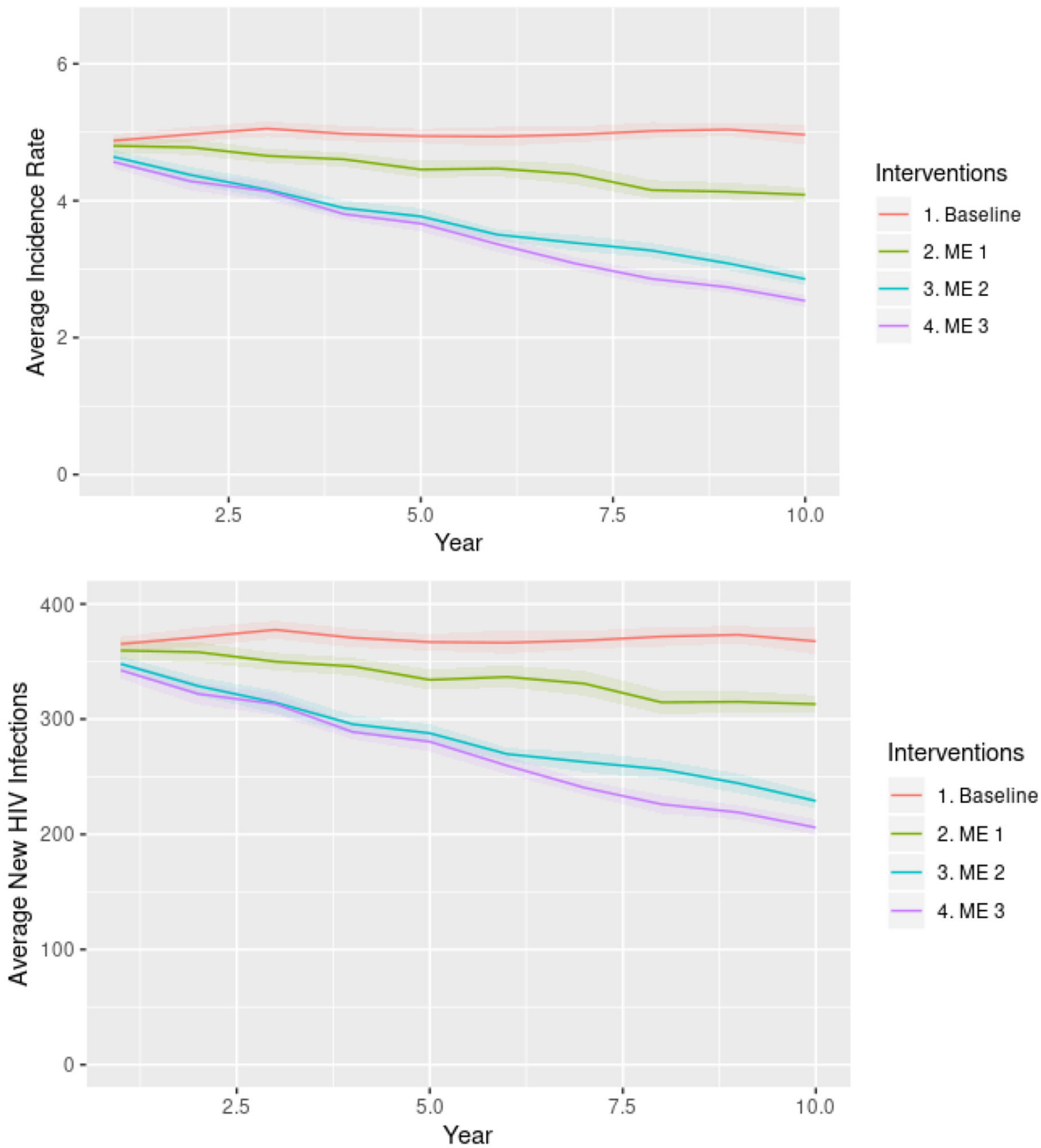

Figure 1: Simulated annual mean incidence rates (top) and number of new HIV infections (bottom), under different policy scenarios. Baseline: Control scenario, no Medicaid Expansion

ME1: Medicaid Expansion, including a 2% increase in PrEP uptake and a 17% improvement in viral suppression

ME2: ME1 plus a 20% increase in PrEP uptake and a 15% increase in ART uptake

ME3: ME1 plus a 30% increase in PrEP uptake and a 15% increase in ART uptake

Table 1:

Evidence Supporting Parameterization of Medicaid Expansion (ME) Scenario I.

Parameter	Reference	Study Setting	Summary of Conclusions	Impact on Medicaid Expansion (ME) Model	Comments on Validity
HIV testing rates	Simon et al. (2017)[1]	Behavioral Risk Factor Surveillance System (BRFSS) data from all 50 states and District of Columbia, restricted to adults <65 years of age with household incomes below 100% federal poverty level; compared states with ME versus states without ME.	ME increased the probability of receiving an HIV test by 5%.	HIV testing rate improved by 5% in the presence of ME.	BRFSS “designed to be representative of the non-institutionalized adult population in the United States”; difference-in-differences methodology used with differences in outcomes before/after ME computed and comparison made of differences between control and treatment states; sensitivity analyses included no violation of parallel trends assumption (i.e., without treatment, outcomes in treatment group follow same trend as control) and robustness of results to variation in sample and model specification
ART adherence	Furl et al. (2018)[2] and Adamson et al (2019)[3]	AIDS Drug Assistance Program participants recruited for insurance enrollment in Nebraska.	Affordable Care Act (ACT) enrollment associated with a 17.2% increase in proportion of days covered by HIV medication refill (refill ratio/year).	17% improvement in ART adherence under ME	Electronic medical records, pharmacy, and Ryan White program databases utilized; pharmacy database for claims used to validate proportion of days covered
PrEP uptake	Farkhad et al. (2021)[4]	32 US states and District of Columbia with ME versus 18 states without ME.	ME increased the rate of PrEP use in the general population by a small amount (2.643/100,000 population).	PrEP use expansion is negligible in terms of increase in proportion of HIV-negative persons using PrEP with ME.	Difference-in-differences methodology used with differences in outcomes before/after ME computed and comparison made of differences between control and treatment counties; sensitivity analyses included state-specific time trends and no violation of parallel trends assumption (i.e., without treatment, outcomes in treatment group follow same trend as control)
	Siegler 2020[5]	National dataset of PrEP users data from claims data aggregator used to develop county-level estimates of PrEP use in 2018. Regression used to explore associations of state Medicaid expansion policies and PrEP assistance programs with rates of PrEP use.	PrEP prevalence increases by 25% in states with ME.	PrEP use rate in our population would increase to about 25% with ME (compared to 20% without, see Table 1). We took the average of the two studies (Farkhad et al. (2021)[4] and Siegler 2020[5]) to estimate an approximate 2% increase in PrEP uptake with Medicaid Expansion.	PrEP use method determination validated in previous studies[6,7], including use of national pharmacy data regardless of payer source and validated against medical claims; sensitivity analysis accounting for missing data used to select national best estimate.

Table 2:

Parameters in Policy Scenarios

	Medicaid Expansion Scenarios		
Parameters	**ME1**	**ME2**	**ME3**
HIV Testing Frequency	20% decline in proportion of persons with least frequent HIV testing (1-2 tests in previous 2 years)**	30% decline in proportion of persons with least frequent HIV testing (1-2 tests in previous 2 years)**	Same as ME2
Time between HIV diagnosis and ART initiation	Same as Baseline	60% increase in HIV initiations within 1 week after diagnosis**	Same as ME2
Distribution of ART adherence	17% increase in always adherent persons**	Same as ME1	Same as ME1
Number of PrEP users	2% increase relative to Baseline**	20% increase relative to ME1, distributed uniformly over the 10 years of intervention**	30% increase relative to ME1, distributed uniformly over the 10 years of intervention**

Baseline: Control scenario, no Medicaid Expansion. Parameters listed in Table 1.

ME1: Medicaid Expansion, including a 2% increase in PrEP uptake and a 17% improvement in viral suppression

ME2: ME1 plus a 20% increase in PrEP uptake and a 15% increase in ART uptake

ME3: ME1 plus a 30% increase in PrEP uptake and a 15% increase in ART uptake

** Full parameterization details are given in the Appendix

Table 3:

Mean incidence rate, HIV prevalence, and the number of new HIV diagnoses for each policy scenario in the tenth year of the simulation

Policy Scenario	Incidence Rate (per 100 persons years)	New HIV Infections	Absolute (%) difference between new infections in tenth year and functional zero[†] Target
Baseline	4.96 (4.82,5.11)[*]	367 (356, 379)	167 (83.5)
ME1	4.09 (3.99,4.19)	313 (305, 320)	113 (56.5)
ME2	2.86 (2.76, 2.94)	229 (222, 236)	29 (14.5)
ME3	2.54 (2.45, 2.62)	205 (199, 213)	5 (2.5)

Baseline: Control scenario, no Medicaid Expansion

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ME3: ME1 plus a 30% increase in PrEP uptake and a 15% increase in ART uptake

[†]The "functional zero target" is 200 new infections per year

[*]The uncertainty is given by the bootstrap simulation interval (SI) across 1000 replicates.

Table 4:

Cumulative Infections in Each Year averaged across the 30 simulations

Year	Base	ME1	ME2	ME3
1	365	359	348	342
2	736	717	676	665
3	1,114	1,067	991	978
4	1,485	1,413	1,286	1,267
5	1,852	1,747	1,574	1,547
6	2,218	2,084	1,844	1,807
7	2,587	2,415	2,107	2,047
8	2,959	2,730	2,364	2,273
9	3,332	3,045	2,608	2,492
10	3,699	3,358	2,837	2,698
Absolute (%) difference in Cumulative Infections between Baseline and the Medicaid Expansion Scenarios				
		ME1	**ME2**	**ME3**
1	--	5.79 (1.6)	11.52 (3.2)	22.7 (6.2)
2	--	19.06 (2.6)	41.01 (5.6)	71.77 (9.7)
3	--	46.68 (4.2)	76.55 (6.9)	136.23 (12.2)
4	--	71.63 (4.8)	126.69 (8.5)	218.07 (14.7)
5	--	104.38 (5.6)	172.95 (9.3)	304.78 (16.5)
6	--	134.36 (6.1)	240.07 (10.8)	411.75 (18.6)
7	--	171.82 (6.6)	307.96 (11.9)	539.52 (20.9)
8	--	229.02 (7.7)	366.07 (12.4)	685.39 (23.2)
9	--	287.10 (8.6)	436.57 (13.1)	839.39 (25.2)
10	--	341.75 (9.2)	520.31 (14.1)	1001.11(27.1)

Baseline: Control scenario, no Medicaid Expansion

ME1: Medicaid Expansion, including a 2% increase in PrEP uptake and a 17% improvement in viral suppression

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ME3: ME1 plus a 30% increase in PrEP uptake and a 15% increase in ART uptake