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ORIGINAL PAPER

Impact of Medicaid Expansion on PrEP Utilization in the US: 2012–2018

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Abstract

We investigated the impact of Medicaid expansions made possible by the 2010 Affordable Care Act on HIV Pre-Exposure Prophylaxis (PrEP) utilization in the US over the period 2012–2018. We used data on PrEP utilization from Symphony Health in a difference-in-differences regression analysis with bootstrapped standard errors. We found that Medicaid Expansion resulted on average in 7.78 additional estimated PrEP users per 100,000 population on a yearly basis ($z = 2.72$; $p = 0.007$). When restricting the sample to males, Medicaid Expansion resulted in 14.67 additional PrEP users per 100,000 population each year ($z = 2.5$; $p = 0.012$). People in the age group 25–34 were those who benefitted the most from Medicaid Expansion with 16.95 additional PrEP users per 100,000 population per year attributable to Medicaid Expansion ($z = 3.2$; $p < 0.001$). States that are considering expanding Medicaid may recognize the benefits in PrEP utilization we document here.

Keywords Affordable care act · Medicaid expansion · HIV · PrEP

Background

The Patient Protection and Affordable Care Act (ACA) was signed into law in 2010 and included funding for states to expand Medicaid to those with income up to 133% of the federal poverty level [1]. District of Columbia and twenty-four states adopted ACA and expanded Medicaid on January 1, 2014, while seven other states did so before December 2016; all other states did not expand Medicaid as of December 31, 2018. The effects of the policy in increasing access to care have been extensively documented in several healthcare domains: among others, Medicaid expansion was found to be associated with 11 pp increase in the likelihood of having annual check-up [2], 14 pp increase in receipt of prenatal vitamins for first-time mothers [3], 5.7 pp increase in the likelihood of having a high cholesterol diagnosis [4], 1.4 pp in the likelihood of colon cancer screening [5], and with 7.4 pp increase in discharge from hospital to rehabilitation among adult trauma patients [6].

In 2018, there were 36,400 new estimated HIV infections in the United States [7]. Of these, the 25–34 age group accounted for 14,400 new infections and males accounted for 29,700 new infections. The first drug approved by FDA for HIV Pre-exposure Prophylaxis (PrEP) was Truvada (emtricitabine and tenofovir disoproxil fumarate), in 2012. PrEP is indicated as a preventive medication for people who consider themselves at higher risk of being exposed to HIV. Early clinical trials showed PrEP's efficacy in men who have sex with men (MSM) [8] as well as in heterosexual men and women [9, 10], heterosexual couples [11] and people who inject drugs [12]. PrEP utilization increased steadily since its introduction and in 2018 there were more than 130,000 PrEP users in the US alone [13]. Nevertheless, a 2018 CDC analysis [14] reported that in 2015 approximately 1.1 million Americans overall were at substantial risk for HIV and should have been offered PrEP. However, only 90,000 PrEP prescriptions were filled in commercial pharmacies in the year examined.

An increase in PrEP utilization is considered vital to combat the HIV epidemic in the US, but its cost, amounting to up to $22,000 a year [15], has constituted a barrier to access and is considered to be a major factor determining the course of the epidemic [16]. Moreover, additional costs associated with PrEP utilization, such as HIV and STDs testing, serum

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creatinine and creatinine clearance may further exacerbate the service provision gap.

Associations between insurance status and PrEP utilization have previously been described [17], suggesting the presence of cost barriers to accessing PrEP for the uninsured; the ACA is one policy with a potentially large impact in overcoming this cost barrier to more widespread PrEP adoption; however, to date no evaluation has been conducted to rigorously estimate the causal effect of Medicaid expansions as the result of the ACA on PrEP uptake in the US.

In this paper, we aimed to determine the effect of Medicaid expansion on PrEP utilization in the US over the period 2012–2018 using a difference-in-differences approach.

Methods

Data

We use AIDSVu publicly available data from Symphony Health as maintained by Emory University's Rollins School of Public Health in partnership with Gilead Sciences, Inc. and the Center for AIDS Research at Emory University (CFAR) [13]. In the data, PrEP users represent the number of people who had at least 1 day of prescribed TDF/FTC for PrEP in a calendar year from 2012 to 2018 and in particular PrEP utilization rate is expressed as the number of PrEP users per 100,000 people in the population. State-level data on total population for the years 2012–2018 were obtained from the American Community Survey (ACS). State-year control variables were also obtained from the ACS and include percentages of the state population that were living in rural areas, Black, below the federal poverty level. We also include population median income. Medicaid expansion dates were obtained from states' online legislative reference libraries. We start our analysis in 2012, the year when PrEP received FDA approval. We organize our data into year by state cells.

Statistical Analysis

We fit a difference-in-differences regression analysis to estimate the causal effect of Medicaid expansion policy on PrEP utilization rate. The estimating equation is defined as follows:

$$y_{it} = \alpha + \beta T_{it} + \gamma_i + \delta_t + \zeta_{it} + \varepsilon_{it} \quad (1)$$

where β is the coefficient of interest and gives the impact of Medicaid expansion on PrEP utilization rates. The variable T_{it} gives the portion of a particular year that states had a Medicaid expansion in effect (e.g. this will take the value zero in years that states had not yet expanded Medicaid, take the value one in years after states expanded Medicaid, and reflect the proportion of the year an expansion was in effect during the year of expansion itself). The outcome is PrEP users per 100,000 people in the population and y_{it} is the outcome for state i at year t; i is state and γ_i is the state-level fixed effect; t is year and δ_t is the year-level fixed effect; ζ_{it} is the controls vector for state i at year t; and ε_{it} is the error term. Years included in the model are 2012–2018. Standard errors are clustered at state level and estimates are obtained with 5000 bootstrap iterations.

One of the key assumptions in a difference-in-differences statistical model is that the control group (non-expansion states) serve as good counterfactuals for the treated group (states that expanded Medicaid). While we cannot test this directly, we can test if the trends in the two groups were parallel before the policy was implemented. We test this assumption of parallel pre-trends between the two groups using an event study analysis with balanced time periods. The estimated coefficients represent the outcome mean relative to the omitted category, which is the outcome value one year prior to policy implementation, and are calculated using the specification:

$$y_{it} = \sum_{\substack{j=-s \\ j \neq -1}}^{s} \alpha_j * treat_{it} * I\left[\left(t - T_i\right) = j\right] + \gamma_i + \delta_t + \zeta_{it} + \varepsilon_{it} \quad (2)$$

where α_j are a series of relative time fixed effects; s is the maximum number of pre- and post-policy time periods and is equal to 3; T_i is the year of policy change in state i; $I(\cdot)$ denotes the indicator function, which takes a value of 1 when the difference between the year of policy change in state i and year t is equal to j, and 0 otherwise; γ_i are state fixed effects, δ_t represents year fixed effects and ζ_{it} is the controls vector for state i at year t as defined in our main differences-in-differences estimation. To pass the parallel pre-trends test the relative time effects (α_j) should be statistically indistinguishable from zero at the 5% significance level in the pre-expansion periods.

Results

Analytical sample means and standard deviations are presented in Table 1, distinguishing between states that expanded Medicaid and those that never adopted the policy. PrEP users per 100,000 people in the population averaged 12.52 (SD = 10.79) per year in the states that never expanded and 24.84 (SD = 41.73) in the states that adopted Medicaid expansion. States that expanded Medicaid were composed of a lower percentage of Black population (μ = 10.11; SD = 10.25) than those that never expanded Medicaid

Table 1 Sample means and standard deviations. State-level yearly data 2012–2018

	Never expanded medicaid	Expanded medicaid
PrEP users per 100,000 population	12.52	24.84
	(10.79)	(41.73)
Total population average	6,507,093	6,164,685
	(6,699,456)	(7,366,905)
Median income	52,241	59,233
	(6936)	(10,786)
Percent below federal poverty level	14.80	13.78
	(2.95)	(3.28)
Percent of Black population	13.17	10.11
	(11.24)	(10.25)
Percent of urban population	68.90	77.20
	(12.47)	(15.16)

N = 357

(μ = 13.17; SD = 11.24). Finally, states that expanded Medicaid had a higher median population income (μ = 59,233; SD = 10,786) and a lower percentage of population below the federal poverty level (μ = 13.78; SD = 3.28) than those that never expanded.

Table 2 shows the results of the difference-in-differences regression analysis. Medicaid expansion resulted in 7.78 (z = 2.72; p = 0.007) additional PrEP users per 100,000 people in the population every year. Every additional percentage point of Black population proportion decreased PrEP users by 39.63 (z = -3.37; p < 0.001) on a yearly basis. A percentage point increase in the total proportion of people below the federal poverty level resulted in 7.08 (z = 3.25; p = 0.002) additional PrEP users per 100,000 population on average: as expected, this parameter has the same sign as the policy parameter of interest. When the sample is restricted to males only, the apparent benefits of the policy are even more tangible: Medicaid expansion translated into 14.67 (z = 2.5; p = 0.012) additional male PrEP users per 100,000 male population.

Finally, subgroup analyses highlight that age groups 25–34 and 35–44 benefitted the most from Medicaid expansion, with 16.95 (z = 3.2; p < 0.001) and 12.74 (z = 2.87; p = 0.004) additional PrEP users per 100,000 population,

Table 2 Difference-in-Differences regression coefficients with bootstrapped test statistic and p-values

Outcome (PrEP users per 100,000 pop.) Correlate	Overall	Male	Female	Age < 25	Age25–34	Age35–44	Age45–54	Age ≥ 55
Medicaid expansion	7.78***	14.67**	1.38***	5.81***	16.95***	12.74***	7.97**	1.86**
	z = 2.72 p = 0.007	z = 2.5 p = 0.012	z = 3.74 p < 0.001	z = 3.67 p < 0.001	z = 3.2 p < 0.001	z = 2.87 p = 0.004	z = 2.21 p = 0.027	z = 2.2 p = 0.027
Total population (per 100,000)	0.1	0.13	0.01	− 0.16	− 0.02	0.06	0.38	0.13
	z = 0.21 p = 0.831	z = 0.12 p = 0.897	z = 0.08 p = 0.941	z = − 0.58 p = 0.564	z = − 0.03 p = 0.986	z = 0.08 p = 0.932	z = 0.68 p = 0.496	z = 0.98 p = 0.328
Median income (thousands $)	5.67***	12.03***	− 0.11	2.80***	10.33***	8.31***	6.81***	1.69***
	z = 4.63 p < 0.001	z = 4.75 p < 0.001	z = − 0.67 p = 0.505	z = 5.29 p < 0.001	z = 5.15 p < 0.001	z = 4.54 p < 0.001	z = 4.3 p < 0.001	z = 3.83 p < 0.001
Percent below FPL	7.08***	15.01***	− 0.09	3.32***	12.62***	10.27***	8.27***	2.16***
	z = 3.25 p = 0.002	z = 3.28 p < 0.001	z = − 0.43 p = 0.664	z = 3.24 p < 0.001	z = 3.56 p < 0.001	z = 2.95 p = 0.003	z = 2.82 p = 0.005	z = 3.29 p < 0.001
Percent of Black population	− 39.63***	− 81.14***	− 3.40***	− 14.77***	− 58.01***	− 56.51***	− 53.04***	− 12.96***
	z = − 3.37 p < 0.001	z = − 3.33 p < 0.001	z = − 3.1 p = 0.002	z = − 3.47 p < 0.001	z = − 3.29 p < 0.001	z = − 3.21 p < 0.001	z = − 3.38 p < 0.001	z = − 3.02 p = 0.002
Percent of urban population	− 18.56	− 38.68	− 0.55	− 10.53	− 38.43	− 28.51	− 19.25	− 4.56
	z = − 0.95 p = 0.345	z = − 0.97 p = 0.329	z = − 0.27 p = 0.786	z = − 0.73 p = 0.463	z = − 0.73 p = 0.462	z = − 0.87 p = 0.383	z = − 1.12 p = 0.265	z = − 1.12 p = 0.261
Mean	20.25	37.15	4.34	13.58	45.64	32.85	22.14	4.93
% Impact	38.43	39.5	31.77	42.79	37.13	38.78	36.02	37.68
Obs	357	357	357	357	357	357	357	357

(N = 357)

Year- and time- fixed effects coefficients included in the difference-in-difference analysis are not shown

***p < 0.01, **p < 0.05, *p < 0.1

respectively. No specific state alone is driving the results, which are robust to pass the sensitivity analysis—where one state at a time is left out from the regression—at 95% confidence level (Appendix, Table 3).

Finally, coefficients calculated as per Eq. (2) are plotted in Fig. 1. The event study graphs show no evidence of pre-policy unparallel trends in any population. As expected, the male population and the 25–34 population show the most substantive and steepest increase in PrEP users as a consequence of Medicaid expansion; though sustained, statistically significant increases in PrEP use are seen across all age groups. PrEP utilization in the female population, however, was not significantly impacted by the policy (Fig. 1).

Discussion

This study is the first to assess the effect of Medicaid expansion on PrEP utilization in the US during the period 2012–2018. Medicaid expansion positively and significatively affected PrEP uptake. The findings of this paper add on to the established impact of Medicaid expansion in increasing access to healthcare services in the states that adopted the policy, and provide further evidence on the likely willingness to use PrEP among populations that currently face cost barriers in states that never adopted the policy. The importance of this evaluation lies in the fact that PrEP, which is very effective at preventing HIV transmission, has been underutilized. Using a difference-in-differences methodology supported by event study graphs, this analysis establishes a causal relation between Medicaid expansion and PrEP utilization in the US, which corroborates previous findings describing associations between insurance status and PrEP; furthermore, the findings of this study have important policy implications as they suggest improved access to PrEP through reduced cost barriers in the states that adopted Medicaid. The findings of this analysis align with previous studies linking Medicaid expansion to increased access to healthcare services and suggest that Medicaid expansion facilitated by the ACA significantly increased access to PrEP. Furthermore, these finding provide evidence of an increasing trend in PrEP utilization made possible by Medicaid expansion, in particular for males in the 25–34 age group.

With 14,400 new infections in 2018, the 25–34 age group was the one with the highest estimated HIV incidence in the United States, accounting for 39.6% of the total new infections in 2018 [8]. Our findings suggest that the population

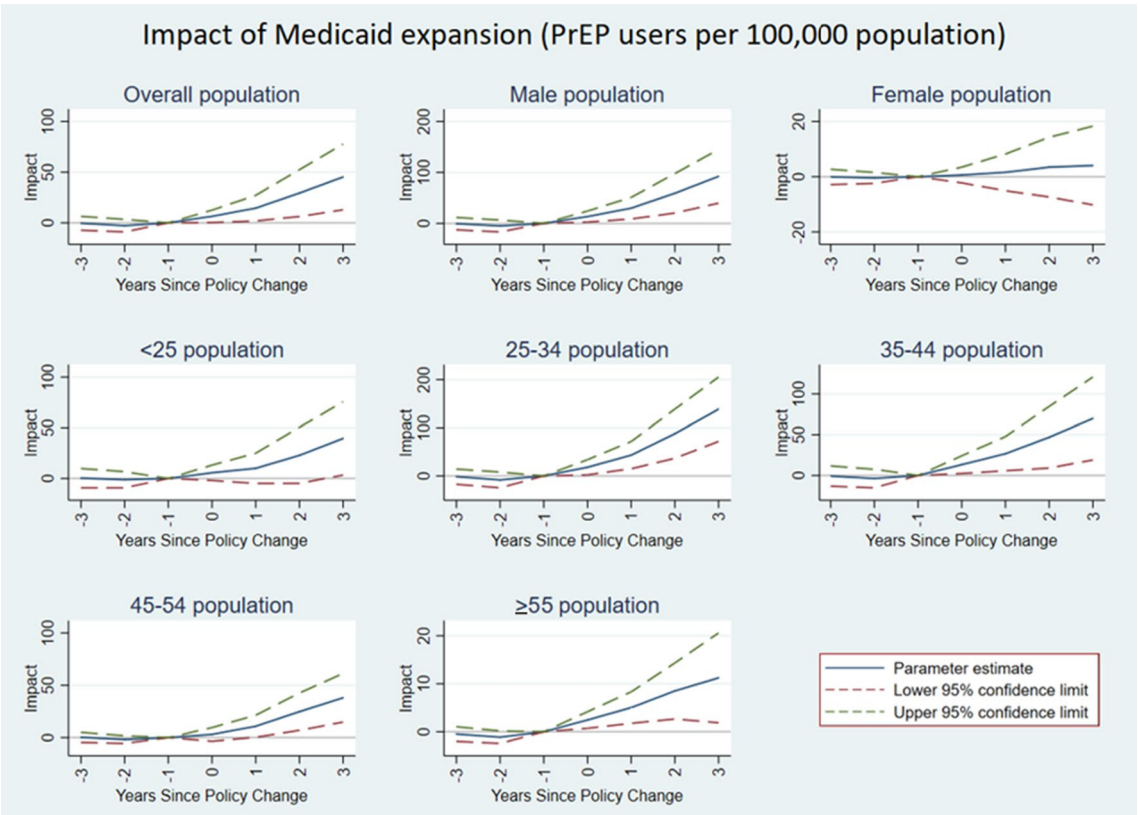

Fig. 1 Event study graph of Medicaid expansion effect on PrEP utilization. Only balanced graphs where Eq. (2) *j* parameter = 3 are shown

belonging to this age group significantly increased utilization of PrEP after Medicaid expansion. This has important implications. First, the increased utilization of PrEP among the population presenting the highest incidence suggests a certain degree of risk self-awareness among this population; growing awareness and increased access to PrEP may be expected to decrease HIV incidence in this age group in the foreseeable future. Second, our findings suggest the presence of a significant number of people who were not able to access PrEP because the state they lived in had not adopted Medicaid expansion; this may be particularly worrisome for those states whose estimated HIV incidence is above national average, and where Medicaid expansion, as of July 2020, has not been adopted, such as Florida or Georgia. Third, there exists a well-documented coverage gap [18] by which millions of Americans who remain ineligible for Medicaid do not have the financial means for a private health insurance, and are therefore uninsured: among these, those who want to access PrEP may still face cost barriers even in the states that adopted Medicaid expansion; urgent and specific solutions should be implemented to address the needs of this particular population. Finally, although Medicaid expansion increased PrEP utilization, the effect of the cost of medical visits and laboratory tests, recommended by the CDC for ongoing PrEP users, likely contributed to lowering the overall observed effect.

Medicaid expansion was previously found to be associated with an increase in access to primary care and with an increase in the likelihood of having annual check-up [2, 3], both of which may be on the pathway between the ACA and PrEP use: a mediation analysis investigating these relations may constitute the object of future research.

The described strengths of this study are accompanied by several limitations. First, data are derived from prescriptions to unique people; however, not everyone who fills a prescription uses it, which implies that the reported number of PrEP users in the US may be overestimated. Second, AIDSVu's PrEP data originate from Source Healthcare Analytics (SHA) which collects data from over 54,000 pharmacies, 1500 hospitals, 800 outpatient facilities, and 80,000 physician practices across the US; however, SHA's dataset excludes entities that do not make their data available, the amount of which is not quantifiable: as a result, the dataset used underestimates the total number of PrEP users in the US [13]. Finally, PrEP data could not be stratified by race or ethnicity and therefore it is not possible to estimate the effect of Medicaid expansion on PrEP uptake among Blacks or Whites: because the unmet HIV prevention needs are particularly relevant among African American and Hispanic populations [14], being able to stratify the results by race or ethnicity would have been desirable, and further research should be conducted to investigate whether there exist significant race-based disparities in PrEP utilization among Medicaid beneficiaries. These data limitations may result in information bias, which could itself generate measurement errors and estimates that differ from the true population parameters. These effects may balance each other; however, it is unknown whether any of the two effects prevails and the direction of the bias cannot be determined.

This study investigated the effect of Medicaid expansion on PrEP utilization in the United States over the period 2012–2018. The findings of this study suggest that males in the 25–34 age group were the population that more than others increased their access to PrEP after Medicaid expansion. This has important policy implications as thirteen states have not yet adopted Medicaid expansion. States that have not expanded Medicaid that are in need of controlling the HIV epidemic may consider the benefits of a policy change.

Compliance with Ethical Standards

Ethical Approval This research was not supported by grants or dedicated funding. Aggregated, state-level, de-identified, publicly available, secondary data were used for this research. The authors declare no competing interests in activities that would be affected by this research.

Appendix

See Table 3.

Table 3 Sensitivity analysis—leave one state out at a time

Left-out state	AL	AK	AZ	AR	CA	CO	CT	DE	DC	FL
Medicaid expansion	8.11***	8.78***	7.87***	8.20***	8.73***	8.26***	7.80***	7.77***	6.27***	8.09***
(*z* =)	2.82	3.05	2.72	2.84	3.01	2.85	2.73	2.72	4.17	2.84
(*p* =)	0.005	0.002	0.006	0.004	0.003	0.004	0.006	0.006	0.000	0.005
Total population (per 100,000)	0.12	0.15	0.11	0.06	0.5	0.12	0.12	0.1	0.48	− 0.24
(*z* =)	0.26	0.32	0.22	0.13	1.25	0.25	0.25	0.2	1.51	− 0.37
(*p* =)	0.795	0.751	0.826	0.895	0.211	0.801	0.806	0.839	0.131	0.715
Median income (thousands $)	5.70***	5.67***	5.65***	5.42***	6.00***	5.86***	5.65***	5.71***	2.22***	5.80***
(*z* =)	4.59	4.66	4.58	4.56	4.71	4.65	4.58	4.65	5.18	4.58
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent below FPL	7.11***	8.13***	7.24***	6.66***	7.12***	6.93***	6.84***	6.77***	1.51**	7.04***
(*z* =)	3.3	3.57	3.25	3.17	3.33	3.28	3.21	3.13	2.35	3.22
(*p* =)	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.002	0.019	< 0.001
Percent of Black population	− 39.74***	− 40.78***	− 39.87***	− 40.68***	− 39.69***	− 39.53***	− 40.00***	− 40.51***	0.95	− 39.45***
(*z* =)	− 3.4	− 3.51	− 3.4	− 3.45	− 3.45	− 3.42	− 3.43	− 3.46	0.42	− 3.28
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.676	< 0.001
Percent of urban population	− 18.6	− 19.04	− 18.63	− 18.51	− 12.89	− 19.15	− 18.42	− 18.44	− 10.21	− 20.76
(*z* =)	− 0.92	− 0.97	− 0.93	− 0.93	− 0.65	− 0.96	− 0.91	− 0.91	− 0.5	− 0.87
(*p* =)	0.357	0.334	0.354	0.354	0.519	0.337	0.361	0.360	0.616	0.386
Mean	20.41	20.46	20.35	20.45	20.19	20.3	20.12	20.19	17.07	20.15
% Impact	39.73	42.91	38.66	40.09	43.22	40.71	38.78	38.46	36.73	40.14
Obs	350	350	350	350	350	350	350	350	350	350
Left-out state	GA	HI	ID	IL	IN	IA	KS	KY	LA	ME
Medicaid expansion	8.81***	8.19***	7.61***	7.68***	8.04***	7.85***	7.62***	7.96***	6.85**	7.76***
(*z* =)	3.09	2.83	2.63	2.66	2.75	2.73	2.63	2.78	2.41	2.68
(*p* =)	0.002	0.005	0.009	0.008	0.006	0.006	0.008	0.006	0.016	0.007
Total population (per 100,000)	0.1	− 0.03	0.09	0.13	0.1	0.11	0.08	0.09	0.08	0.1
(*z* =)	0.2	− 0.06	0.19	0.27	0.22	0.23	0.18	0.2	0.18	0.22
(*p* =)	0.841	0.954	0.848	0.783	0.822	0.818	0.855	0.843	0.856	0.824
Median income (thousands $)	5.69***	6.10***	5.69***	5.68***	5.65***	5.67***	5.63***	5.62***	5.92***	5.71***
(*z* =)	4.57	4.73	4.46	4.5	4.45	4.49	4.46	4.45	4.59	4.51
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent below FPL	7.69***	7.37***	7.08***	7.14***	7.04***	7.01***	7.05***	7.01***	7.16***	7.12***
(*z* =)	3.32	3.34	3.12	3.27	3.18	3.19	3.21	3.18	3.22	3.19
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent of Black population	− 40.54***	− 39.98***	− 39.63***	− 39.62***	− 39.69***	− 39.84***	− 39.74***	− 39.77***	− 39.44***	− 39.73***
(*z* =)	− 3.35	− 3.39	− 3.29	− 3.23	− 3.28	− 3.28	− 3.29	− 3.29	− 3.28	− 3.28

Table 3 (continued)

Left-out state	GA	HI	ID	IL	IN	IA	KS	KY	LA	ME
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent of urban population	− 18.25	− 18.89	− 18.66	− 20.79	− 18.59	− 18.49	− 18.47	− 18.65	− 18.61	− 18.44
(*z* =)	− 0.9	− 0.95	− 0.93	− 0.78	− 0.93	− 0.92	− 0.93	− 0.93	− 0.92	− 0.92
(*p* =)	0.368	0.342	0.353	0.435	0.353	0.357	0.355	0.351	0.357	0.357
Mean	20.28	20.41	20.5	20.05	20.39	20.36	20.44	20.46	20.3	20.41
% Impact	43.44	40.14	37.11	38.3	39.44	38.55	37.27	38.92	33.76	38.03
Obs	350	350	350	350	350	350	350	350	350	350
Left-out state	MD	MA	MI	MN	MS	MO	MT	NE	NV	NH
Medicaid expansion	7.81***	7.68***	8.28***	7.44***	8.39***	7.92***	9.00***	7.21**	6.98**	8.07***
(*z* =)	2.71	2.69	2.85	2.59	2.87	2.72	3.08	2.49	2.46	2.76
(*p* =)	0.007	0.007	0.004	0.010	0.004	0.007	0.002	0.013	0.014	0.006
Total population (per 100,000)	0.11	0.1	0.07	0.12	0.23	0.11	0.06	0.05	0.12	0.07
(*z* =)	0.23	0.23	0.14	0.25	0.5	0.23	0.14	0.12	0.25	0.14
(*p* =)	0.816	0.821	0.886	0.800	0.614	0.821	0.892	0.908	0.800	0.885
Median income (thousands $)	5.65***	5.43***	5.58***	5.48***	5.87***	5.65***	5.68***	5.74***	5.76***	5.79***
(*z* =)	4.41	4.22	4.49	4.51	4.49	4.5	4.46	4.51	4.53	4.53
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent below FPL	7.06***	6.75***	6.78***	6.90***	7.88***	7.05***	6.86***	7.13***	7.58***	7.18***
(*z* =)	3.14	3.06	3.13	3.18	3.26	3.21	3.05	3.22	3.29	3.22
(*p* =)	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Percent of Black population	− 39.81***	− 40.38***	− 40.00***	− 41.08***	− 39.80***	− 39.76***	− 39.75***	− 39.62***	− 40.76***	− 39.36***
(*z* =)	− 3.29	− 3.33	− 3.31	− 3.32	− 3.3	− 3.28	− 3.31	− 3.29	− 3.34	− 3.26
(*p* =)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Percent of urban population	− 18.47	− 18.19	− 18.75	− 18.41	− 18.77	− 18.47	− 18.82	− 18.46	− 18.38	− 18.62
(*z* =)	− 0.92	− 0.9	− 0.94	− 0.91	− 0.93	− 0.92	− 0.95	− 0.93	− 0.91	− 0.93
(*p* =)	0.358	0.367	0.347	0.364	0.352	0.356	0.345	0.353	0.365	0.351
Mean	20.17	19.71	20.39	20.25	20.47	20.34	20.52	20.47	20.32	20.34
% Impact	38.71	39	40.64	36.75	40.97	38.95	43.87	35.22	34.36	39.68
Obs	350	350	350	350	350	350	350	350	350	350
Left-out state	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI
Medicaid expansion	8.05***	7.63***	7.14**	7.86***	7.72***	7.70***	7.68***	7.88***	8.34***	7.46***
(*z* =)	2.75	2.64	2.56	2.73	2.7	2.67	2.64	2.7	2.86	2.6
(*p* =)	0.006	0.008	0.010	0.006	0.007	0.008	0.008	0.007	0.004	0.009
Total population (per 100,000)	0.07	0.11	0.23	0.12	0.15	0.11	0.1	0.09	0.15	0.1
(*z* =)	0.15	0.24	0.56	0.26	0.33	0.24	0.22	0.2	0.31	0.22
(*p* =)	0.883	0.808	0.574	0.793	0.739	0.813	0.825	0.845	0.757	0.825

Table 3 (continued)

Left-out state	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI
Median income (thousands $)	5.93***	5.89***	5.48***	5.66***	5.62***	5.70***	5.64***	5.73***	5.70***	5.69***
(*z* =)	4.47	4.48	4.24	4.44	4.6	4.47	4.42	4.41	4.47	4.37
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent below FPL	7.53***	7.32***	7.10***	6.99***	6.74***	7.11***	7.11***	7.02***	7.09***	6.96***
(*z* =)	3.26	3.23	3.17	3.14	3.21	3.21	3.2	3.15	3.19	3.11
(*p* =)	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.002
Percent of Black population	− 39.72***	− 39.61***	− 39.90***	− 39.79***	− 42.57***	− 39.68***	− 39.72***	− 39.59***	− 39.73***	− 39.84***
(*z* =)	− 3.32	− 3.3	− 3.23	− 3.3	− 3.24	− 3.28	− 3.29	− 3.29	− 3.3	− 3.26
(*p* =)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Percent of urban population	− 18.86	− 18.85	− 9.06	− 18.53	− 19.14	− 18.65	− 18.55	− 18.66	− 37.83	− 18.4
(*z* =)	− 0.95	− 0.94	− 0.74	− 0.93	− 0.94	− 0.94	− 0.94	− 0.94	− 1.35	− 0.92
(*p* =)	0.343	0.350	0.460	0.350	0.345	0.348	0.348	0.346	0.178	0.360
Mean	20.21	20.41	19.51	20.39	20.51	20.26	20.47	20.24	20.25	19.87
% Impact	39.81	37.38	36.62	38.58	37.64	38.02	37.53	38.95	41.2	37.53
Obs	350	350	350	350	350	350	350	350	350	350

Left-out state	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
Medicaid expansion	6.72**	7.08**	7.41***	7.93***	7.46***	7.93***	6.51**	7.98***	7.46***	7.35**	6.72**
(*z* =)	2.41	2.44	2.58	2.77	2.61	2.75	2.31	2.72	2.6	2.54	2.35
(*p* =)	0.016	0.015	0.010	0.006	0.009	0.006	0.021	0.006	0.009	0.011	0.019
Total population (per 100,000)	0.11	0.08	0.09	− 0.41	0.08	0.1	0.12	0.12	0.1	0.06	0.09
(*z* =)	0.25	0.16	0.2	− 0.48	0.16	0.22	0.27	0.25	0.21	0.13	0.19
(*p* =)	0.800	0.873	0.840	0.632	0.869	0.829	0.789	0.803	0.834	0.893	0.849
Median income (thousands $)	5.37***	5.77***	5.66***	5.77***	5.79***	5.70***	5.88***	5.77***	5.75***	5.70***	5.46***
(*z* =)	4.51	4.46	4.45	4.37	4.43	4.43	4.47	4.18	4.34	4.45	4.41
(*p* =)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent below FPL	6.52***	7.35***	7.02***	6.82***	7.04***	7.39***	7.70***	7.11***	7.04***	7.08***	7.54***
(*z* =)	3.1	3.26	3.17	3.13	3.18	3.23	3.3	3.18	3.15	3.2	3.3
(*p* =)	0.002	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Percent of Black population	− 41.95***	− 39.57***	− 39.77***	− 39.65***	− 39.49***	− 39.73***	− 39.79***	− 39.57***	− 39.75***	− 39.60***	− 40.75***
(*z* =)	− 3.42	− 3.27	− 3.29	− 3.3	− 3.29	− 3.31	− 3.33	− 3.3	− 3.28	− 3.3	− 3.37
(*p* =)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Percent of urban population	− 18.97	− 18.7	− 18.64	− 17.48	− 18.77	− 18.72	− 18.85	− 18.76	− 18.5	− 18.63	− 18.59
(*z* =)	− 0.95	− 0.94	− 0.93	− 0.8	− 0.94	− 0.94	− 0.95	− 0.94	− 0.92	− 0.94	− 0.94
(*p* =)	0.342	0.348	0.351	0.425	0.348	0.349	0.342	0.349	0.357	0.350	0.348
Mean	20.47	20.51	20.39	20.31	20.33	20.45	20.34	20.03	20.48	20.44	20.57

Table 3 (continued)

Left-out state	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
% Impact	32.83	34.54	36.36	39.06	36.69	38.79	32	39.85	36.42	35.95	32.65
Obs	350	350	350	350	350	350	350	350	350	350	350

Outcome: overall PrEP users per 100,000 population

Year- and time- fixed effects coefficients included in the difference-in-difference analysis are not shown

***p < 0.01, **p < 0.05, *p < 0.1

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