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Trends in impact of Medicaid expansion on use of clinical preventive services

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Abstract

Introduction: This study aimed to evaluate the trends in the impact of Medicaid expansion on the use of selected recommended clinical preventive services (CPSs) and examine differences in use by income level over time.

Methods: The data were obtained from the 2011–2019 Behavioral Risk Factor Surveillance System and were analyzed in 2021. This study conducted a difference-in-differences analysis of the association between Medicaid expansion and the use of five CPSs, including colon/breast/cervical cancer screenings, HIV testing and influenza vaccination. Annual percent change was applied to assess the trends in the impact of Medicaid expansion on the use of CPSs.

Results: The use of all five CPSs varied over time. In almost every year, the use of four CPSs (all but HIV testing) among Medicaid expansion states was higher than that among the non-expansion states. People with lower income used four CPSs (all but HIV testing) less frequently than those with higher income, regardless of their residence in expansion or non-expansion groups. Among the lower-income group, the use of five CPSs increased after Medicaid expansion almost every year with the use of colon cancer screening and HIV testing reaching statistical significance, and the impact of Medicaid expansion in the use of each CPS kept stable from 2014–2019.

Conclusions: Our findings provide evidence that Medicaid expansion may be associated with sustainably increased use of the selected recommended CPSs among the lower-income population and that Medicaid expansion to reduce financial barriers may be an effective strategy to improve population health.

Keywords

Medicaid expansion; clinical preventive services; utilization; impact

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Introduction

Clinical preventive services (CPSs) are essential components of healthcare services. About 100,000 deaths each year in the US could be prevented with the recommended use of CPSs.[1,2] Specifically, CPSs are associated with preventing nine of the ten leading causes of death in the US, including cancer and influenza deaths, etc.[1,2] However, the use of preventive services remains below Healthy People 2020 targets, especially among those with no insurance coverage or lower income.[3,4]

As of December 31, 2019, 33 states and DC adopted Medicaid expansion to expand the eligibility so as to increase the health insurance coverage.[5] 26 of 33 states and DC implemented expansion in 2014; Alaska, Indiana, and Pennsylvania implemented expansion in 2015; Louisiana and Montana implemented expansion in 2016; Virginia and Maine implemented expansion in 2019. 17 states had not adopted Medicaid expansion before the end of 2019, including AL, FL, GA, ID, KS, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, WI, and WY.[5] The states that have opted into Medicaid expansion provide coverage for individuals, including those with incomes at or below 138% of the federal poverty level (FPL).[6] Besides the expanded health insurance eligibility, as of September 2010, the Patient Protection and Affordable Care Act (ACA), requires many health plans to cover certain CPSs without cost-sharing when provided in-network.[1] This CPS coverage requirement applies to coverage provided to enrollees in Medicaid expanded under the ACA.[1] The qualifying services are those recommended by the US Preventive Services Task Force with grades A or B, the Advisory Committee on Immunization Practices, and the Health Resources and Services Administration.

Recent analyses have shown that Medicaid expansion is associated with improved health insurance coverage and increased access to certain preventive services in the US, but most studies have focused only on a limited number of preventive services, such as HIV testing[7] or certain type(s) of cancer screening(s).[8–14] Several studies assessed the impact on multiple preventive services, but the majority of them used a limited number of time points after Medicaid expansion, e.g. two years of post-intervention data.[15–18] Studies analyzing more recent data included only a small number of states[19] with some excluding the five states that implemented Medicaid expansion during 2015–2016.[12,13,17,20] Furthermore, the observed impact of Medicaid expansion on CPSs has not been consistent across studies, perhaps because of variation in study periods, population groups, etc.[13,20] For example, Hendryx et al found an increase in the use of colorectal (colon) and cervical cancer screenings after Medicaid expansion, while Tummalapalli's study reported that Medicaid expansion was not significantly associated with increased use of either cancer screening service.[13,20]

This study selected five recommended CPSs, including colon, breast and cervical cancer screenings, HIV testing, and influenza vaccination. Evaluating the impact of Medicaid expansion on multiple CPSs may provide insights into utilization patterns of different types of recommended preventive services that could help inform how effective interventions for increasing health insurance coverage and the access to CPSs can be tailored to different conditions or context. Inclusion of data through 2019 offers a longer follow-up period which provides opportunities to investigate the trends in the impact of Medicaid expansion on

the use of preventative care. Examining the population as defined in recommendations and guidelines among all states likely could improve the understanding of utilization among at-risk populations and inform the design and implementation of strategies to increase the use of CPSs. As the eligibility of Medicaid expansion is based on FPL[6] and insurance status and income level are two important factors associated with the use of CPSs[21–23], assessing the impact of Medicaid expansion by income status may assist in analyzing the disparities in the use of CPSs among people with different income level, and in comparing the effectiveness of expansion between targeted population and others.

To address these challenges, this study aimed to evaluate the trends in the impact of Medicaid expansion on the use of selected recommended CPSs in the United States and to identify potential disparities in CPS utilization by income status over time.

Methods

The data were obtained from the 2011–2019 Behavioral Risk Factor Surveillance System (BRFSS), which is an annual nationwide survey conducted by the US Centers for Disease Control and Prevention, and were analyzed in 2021. Among the participants, landline and cellular phone combined sample sizes ranged from 418,461 (2019) to 506,467 (2011), with the response rates ranging from 45.2% (2012) to 49.9% (2018). The analysis included all 50 states and DC.

To more accurately create a category of participants for which this study could stratify by income status in a way meaningful to Medicaid expansion eligibility limits, given the formatting of questions in BRFSS, the study sample was limited to respondents aged 18 to 64 years with no dependent children in the household.[13,18] BRFSS collected annual household income categories instead of the precise estimate of income, making it difficult to accurately calculate the individual level FPL. As childless households would likely have only one or two members, qualifying poverty levels of one or two persons were applied to the childless households.[13,18] This study defined persons with a childless household income of less than $20,000 as the lower-income group, which was the closest category available in BRFSS compared to Medicaid expansion eligibility limit (in 2019, 138% FPL was $17,236.2 and $23,335.8 for a household of one or two people respectively).[13,15,18,24] The higher-income group was defined as the persons who lived in a household with an income ≥$20,000.

The outcome variables were responses to each of the five covered recommended services. The definitions and study years of selected CPSs are shown in Supplementary Table S1. These five services were all services included in both BRFSS questions and consistent recommendations/guidelines during 2011–2019.

Covariates included age, sex, race/ethnicity, education level and health status. Age was defined as a continuous variable. Sex was dichotomized and was not included in the analysis for breast and cervical cancer screenings. Race/ethnicity was categorized into four groups including white non-Hispanic, black non-Hispanic, other non-Hispanic, and Hispanic. Education level and health status were dichotomized into high school graduation

or less versus some college or more, and self-reported health status as fair and poor versus good/very good/excellent, respectively.

In the statistical analysis, the final weight provided in BRFSS (shown in _LLCPWT variable) was assigned to each respondent, considering gender, age group, race/ethnicity, education, marital status, tenure and phone ownership.[25,26] Multiple groups and time periods difference-in-differences (DID) analyses were conducted with logit regressions estimating the marginal effects to examine the impact of Medicaid expansion on selected CPS use, comparing the gap in use of CPS between expansion states and non-expansion states after Medicaid expansion with that gap before Medicaid expansion.[27–31] The logit regression included a group variable, a time variable, an interaction term between group and time, and covariates.[30,31] In the group variable, the expansion group (treatment group) was consist of the 33 states and DC that implemented Medicaid expansion between 2014 and 2019, and the non-expansion group (control group) was composed of the 17 states that did not adopt Medicaid expansion as of December 31, 2019.[30,31] The time variable was equal to 1 in an expansion state during the years Medicaid expansion being effective, and was coded as 0 in a year in which Medicaid expansion was not in effect among the expansion states and was equal to 0 every year among the non-expansion states.[30,31] The coefficient of the interaction term estimated the impact of Medicaid expansion on CPS use.[30,31] To investigate how the effects have evolved over time, the impact of Medicaid expansion was assessed every year from 2014–2019, and the trends in the effect were estimated in JoinPoint (version 4.7.0.0), which directly provided the annual percent changes (APCs) calculated by the slopes relative to the utilization from the log-linear model.[32,33] To increase the credibility of DID analysis, we also tested the parallel trends in each CPS use among expansion states and non-expansion states and for both the higher- and lower-income groups before Medicaid expansion (Supplementary Table S3), reporting that, without Medicaid expansion, use of each CPS trended similarly in each group prior to the expansion, except for the use of breast and cervical cancer screenings among higher-income group.

All analyses used BRFSS sampling weights and survey specification variables. All data analyses were conducted in STATA/MP software version 16.0. Two-sided $P < 0.05$ indicated significance.

Results

Table 1 presents a descriptive summary of study variables by household income level for Medicaid expansion and non-expansion states before and after Medicaid expansion. Respondents with a household income ≥$20,000 accounted for about 80% in both expansion and non-expansion groups. They on average were more likely to be female, non-Hispanic White, and have self-reported good health status in both expansion and non-expansion groups. Among higher-income groups, respondents were more likely to have a higher education level of some college or more (46.66 and 40.66 percentage points higher than people with a lower education level in expansion and non-expansion states, respectively). Respondents in lower-income groups were more likely to have had no more than high school education. Similar patterns in these study variables were observed in each group before and after Medicaid expansion.

Figure 1 and Supplementary Table S2 show the weighted use of each CPS among Medicaid expansion and non-expansion states by year. The use of three CPSs (colon cancer screening, HIV testing and influenza vaccination) increased from 2011–2019 in both expansion and non-expansion groups, ranging from 3.19 percentage points (colon cancer screening among non-expansion group) to 9.12 percentage points (colon cancer screening among expansion group). The use of cervical cancer screening decreased 5.46 and 5.43 percentage points over time in expansion and non-expansion groups, respectively. The use of breast cancer screening seemed to be constant over time. With the exception of HIV testing, in almost every year, the use of the other four CPSs among Medicaid expansion states was higher than that among the non-expansion states. People living in the expansion states used HIV testing less frequently each year (except for 2018) from 2011–2019, compared to those living in the non-expansion states.

Figure 2 shows the weighted use of each CPS by income level and by Medicaid expansion and non-expansion states. Among childless adults aged 18–64 years, people with lower income used four CPSs (all but HIV testing) less frequently than those with higher income, regardless of their residence in Medicaid expansion or non-expansion states. The use of HIV testing was less among people with higher income, compared to those with lower income. Among either income group, the use of all selected CPSs (except for HIV testing) among Medicaid expansion states was higher than that among the non-expansion states.

Table 2 presents the impact of Medicaid expansion by income level over time. Among the lower-income group, the gap in utilization between people living in expansion and non-expansion states widened every year after Medicaid expansion among all five CPSs with two reaching statistical significance: colon cancer screening and HIV testing, indicating that lower-income people exposed to Medicaid expansion had a significantly increased use of these two CPSs from pre-expansion to post-expansion. Specifically, in 2019, the adjusted use of colon cancer screening and HIV testing significantly increased 2.45 (95% CI=0.91–3.98) and 2.39 (95% CI=1.56–3.22) percentage points, respectively, after Medicaid expansion; the use of the other three services also increased, but didn't reach statistical significance. Among the higher-income group, people living in expansion states significantly increased the use of colon cancer screening, HIV testing and influenza vaccination from pre-expansion to post-expansion almost every year. The increase in the use of those three CPSs ranged from 0.58 (95% CI=0.23–0.93) percentage points for HIV testing to 0.91 (95% CI=0.55–1.27) percentage points for influenza vaccination in 2019. The widened gap of use between expansion and non-expansion states after Medicaid expansion was significantly larger among the lower-income group than that among the higher-income group for HIV testing after 2016, since the two CIs were not overlapped. In terms of the trends, among the lower-income group, the impact of Medicaid expansion in the use of each CPS didn't change significantly, which was shown by the insignificant APCs; among the higher-income group, the impact of Medicaid expansion significantly decreased over time for colon cancer screening (APC= −13.37, 95% CI=−23.27, −2.19) and HIV testing (APC= −19.65, 95% CI=−35.17, −0.42).

Discussion

This study uses comprehensive, nationwide BRFSS data to provide empirical evidence that Medicaid expansion may have increased the use of all five selected recommended CPSs through six years post-expansion. Given that increased health insurance coverage and decreased cost-sharing have been associated with more adherence to recommended healthcare service use and increased utilization of healthcare services[34,35], our findings suggest that Medicaid expansion has the potential to sustainably reduce the financial barriers to and increase the utilization of most selected recommended CPSs, especially among populations with lower income.

The use of all five CPSs varied over time—increasing in use of colon cancer screening, HIV testing and influenza vaccination, constant in use of breast cancer screening and decreasing in use of cervical cancer screening and, which aligns with previous studies.[13,26] Reasons for the declining trend in cervical cancer screening are not clear. One possible reason may be that the screening (Pap smear) is also recommended in a less frequent way (five years) if women are receiving it together with human papillomavirus screening.[4,13,26] The use of four CPSs (all but HIV testing) among people with higher income or among Medicaid expansion states was higher than that among people with lower income or among the non-expansion states, which aligns with the previous studies as well.[13,21,22,26,36] The use of HIV testing showed a reverse result, higher use among people with lower income or among the non-expansion group, which is also consistent with previous findings.[7,21,23,26] This finding might reflect the success of a testing strategy that focused HIV screening efforts in communities that are disproportionately comprised of persons of lower income.[37]

This study found that, among the lower-income group, Medicaid expansion was associated with an increase in the use of all five CPSs with the use of colon cancer screening and HIV testing reaching statistical significance from 2014–2019, which were consistent with previous studies.[7,10,13,15,18,20,36] Respondents in expansion states on average had disproportionately higher education and income levels and more people reported good health status, suggesting that differences in health awareness, economic access to health care, self-recognition in health or other factors may be associated with the use of CPSs in the expansion states.[16] Among the higher-income group, Medicaid expansion was also observed to be associated with the increased use of three CPSs[38], which may result from a spillover effect following Medicaid expansion. Changes in the health insurance have had spillover effects on persons with other types of insurance who are not targeted by reform[39], so, our findings suggest a similar effect may have occurred in an entire state population even if only a portion of that population was targeted by the expansion. Another reason for the significant effect among higher-income group may lie in the expansion in private insurance at the similar time with Medicaid expansion, January 2014. The expansion in private insurance enacted through the premium tax credit for those with a household income of 100–400% FPL who are not eligible for Medicaid, to subsidize premiums for purchasing private insurance on newly established insurance exchanges.[40,41] It is worth noting that the impact of Medicaid expansion in the use of each CPS kept stable among the lower-income group, while that impact significantly decreased over time for colon cancer screening and HIV testing among the higher-income group, indicating that Medicaid expansion exerted

a sustainable effect for six years among the targeted population and the spillover effect reduced over time among the untargeted population.

We also found that the increase of use of HIV testing was significantly higher among the lower-income group than that among the higher-income group, suggesting that Medicaid expansion potentially had a larger effect among the intended population, i.e., people with lower income. Conversely, the widened gap of use of influenza vaccination was larger among the higher-income group than that among the lower-income group but didn't reach statistical significance. The possible reason could be that the people with higher income may have more frequent access to such service[21,23], since the use of influenza vaccination is recommended annually.

Insurance coverage and income are some of the strongest factors associated with CPS use[21–23,26]; yet, many people regardless of income level didn't use CPSs as recommended even after Medicaid expansion, suggesting a more complex interaction of factors that influence the use of CPS. Other potential barriers, such as lack of paid sick leave, may deter accessing healthcare services, even when CPSs are offered without cost-sharing.[42–45] Further studies are needed to improve the use of preventive services.

Limitations

This study is subject to four limitations. First, self-reported data were used in this study, which could result in recall and social desirability bias, especially for reported income and for use of some services recommended to be done over a long period of time. In addition, there could be misreporting for services associated with stigma, such as HIV testing. Second, health insurance type dictates whether CPSs are covered in-network with no cost-sharing, but this variable was not provided in BRFSS. Third, because BRFSS uses a categorical rather than a precise estimate of household income, FPL cannot be calculated precisely. Also, the number of adults in the household answered by cell phone was not reported from 2011–2013, so FPL cannot be estimated among these respondents. Thus, this study only focused on childless adults, which may reduce the sample size. However, this study has already included 1,414,733 respondents, which could provide representativeness. Finally, questions for three cancer screenings were asked of all 50 states and DC every other year, which prevents an estimate of a nationwide utilization prevalence for odd-numbered years.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Public Health Implication

This study highlights the potential of Medicaid expansion to sustainably increase access to no cost-sharing CPSs as an effective tool to increase the use of CPSs and suggests that the Medicaid expansion designed to improve the health of specific at-risk populations could reduce health disparities.

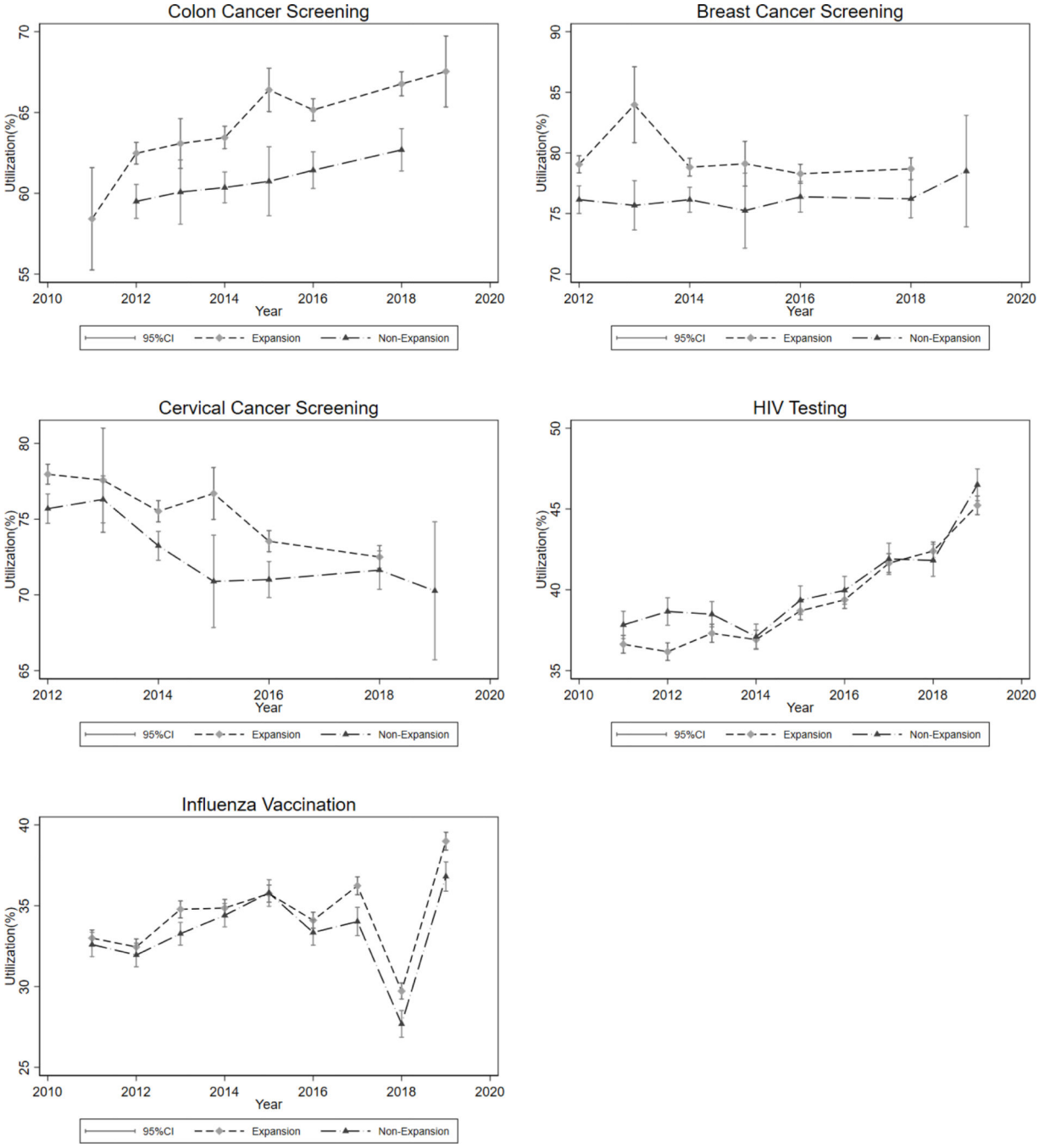

Figure 1.

Weighted use of clinical preventive services among Medicaid expansion and non-expansion states from 2011–2019

Abbreviations: HIV=human immunodeficiency virus; 95%CI=95% confidence interval.

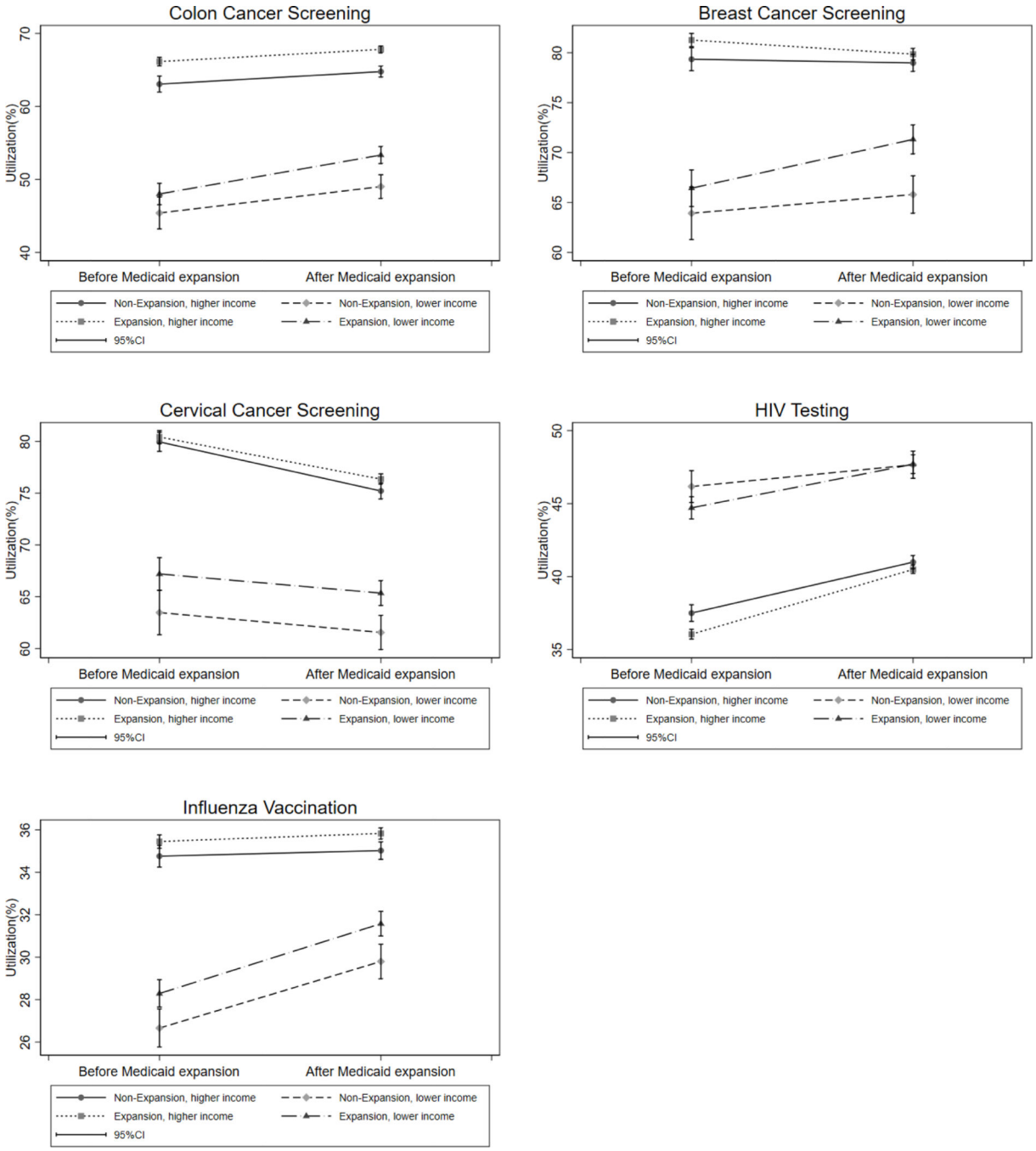

Figure 2.

Weighted clinical preventive service use before and after Medicaid expansion by states and household income level

Abbreviations: HIV=human immunodeficiency virus; 95%CI=95% confidence interval.

Table 1.

Descriptive summary of study variables

	Expansion states (33 states and DC) [a]									Non-expansion states (17 states) [b]								
	Before Medicaid expansion, (%)			After Medicaid expansion, (%)			Total, (%)			Before Medicaid expansion, (%)			After Medicaid expansion, (%)			Total, (%)		
	Household income≥$20,000	Household income<$20,000	Total	Household income≥$20,000	Household income<$20,000	Total	Household income≥$20,000	Household income<$20,000	Total	Household income≥$20,000	Household income<$20,000	Total	Household income≥$20,000	Household income<$20,000	Total	Household income≥$20,000	Household income<$20,000	Total
N	320393	74073	394466	446627	93453	540080	767020	167526	934546	144028	39237	183265	239928	56994	296922	383956	96231	480187
	(81.22)	(18.78)	(100)	(82.70)	(17.30)	(100)	(82.07)	(17.93)	(100)	(78.59)	(21.41)	(100)	(80.81)	(19.19)	(100)	(79.96)	(20.04)	(100)
Sex																		
Male	144998	32889	177887	218316	44614	262930	363314	77503	440817	64244	16752	80996	117509	25976	143485	181753	42728	224481
	(45.26)	(44.40)	(45.10)	(48.90)	(47.77)	(48.71)	(47.38)	(46.28)	(47.18)	(44.61)	(42.69)	(44.20)	(48.98)	(45.59)	(48.33)	(47.34)	(44.41)	(46.75)
Female	175387	41179	216566	228099	48770	276869	403486	89949	493435	79784	22485	102269	122380	31002	153382	202164	53487	255651
	(54.74)	(55.60)	(54.90)	(51.10)	(52.23)	(51.29)	(52.62)	(53.72)	(52.82)	(55.39)	(57.31)	(55.80)	(51.02)	(54.41)	(51.67)	(52.66)	(55.59)	(53.25)
Race/ethnicity																		
White, non-Hispanic	263357	49136	312493	352588	58211	410799	615945	107347	723292	119001	24629	143630	192691	34683	227374	311692	59312	371004
	(82.98)	(67.32)	(80.05)	(79.98)	(63.47)	(77.14)	(81.24)	(65.18)	(78.37)	(83.40)	(63.71)	(79.20)	(81.19)	(61.83)	(77.49)	(82.02)	(62.60)	(78.14)
Black, non-Hispanic	20125	9516	29641	27606	10808	38414	47731	20324	68055	12270	8146	20416	20300	11226	31526	32570	19372	51942
	(6.34)	(13.04)	(7.59)	(6.26)	(11.79)	(7.21)	(6.30)	(12.34)	(7.37)	(8.60)	(21.07)	(11.26)	(8.55)	(20.01)	(10.74)	(8.57)	(20.45)	(10.94)
Other, non-Hispanic	19592	6987	26579	33304	10490	43794	52896	17477	70373	5752	2884	8636	10924	4473	15397	16676	7357	24033
	(6.17)	(9.57)	(6.81)	(7.55)	(11.44)	(8.22)	(6.98)	(10.61)	(7.63)	(4.03)	(7.46)	(4.76)	(4.60)	(7.97)	(5.25)	(4.39)	(7.76)	(5.06)
Hispanic	14293	7354	21647	27353	12200	39553	41646	19554	61200	5663	2997	8660	13427	5710	19137	19090	8707	27797
	(4.50)	(10.07)	(5.55)	(6.20)	(13.30)	(7.43)	(5.49)	(11.87)	(6.63)	(3.97)	(7.75)	(4.78)	(5.66)	(10.18)	(6.52)	(5.02)	(9.19)	(5.85)
Education																		
High school graduation or less	88139	40482	128621	116187	50895	167082	204326	91377	295703	43290	22799	66089	70537	32679	103216	113827	55478	169305
	(27.53)	(54.76)	(32.64)	(26.04)	(54.61)	(30.98)	(26.67)	(54.68)	(31.68)	(30.08)	(58.20)	(36.09)	(29.42)	(57.45)	(34.80)	(29.67)	(57.76)	(35.29)
Some college or more	232004	33440	265444	329938	42302	372240	561942	75742	637684	100641	16376	117017	169187	24201	193388	269828	40577	310405
	(72.47)	(45.24)	(67.36)	(73.96)	(45.39)	(69.02)	(73.33)	(45.32)	(68.32)	(69.92)	(41.80)	(63.91)	(70.58)	(42.55)	(65.20)	(70.33)	(42.24)	(64.71)
Health status																		
Good	281292	42468	323760	390729	53309	444038	672021	95777	767798	124847	21420	146267	207214	30791	238005	332061	52211	384272
	(87.98)	(57.63)	(82.30)	(87.58)	(57.24)	(82.34)	(87.75)	(57.41)	(82.32)	(86.88)	(54.92)	(80.05)	(86.52)	(54.33)	(80.36)	(86.65)	(54.57)	(80.24)
Poor or fair	38431	31221	69652	55397	39821	95218	93828	71042	164870	18860	17583	36443	32296	25881	58177	51156	43464	94620
	(12.02)	(42.37)	(17.70)	(12.42)	(42.76)	(17.66)	(12.25)	(42.59)	(17.68)	(13.12)	(45.08)	(19.95)	(13.48)	(45.67)	(19.64)	(13.35)	(45.43)	(19.76)

[a] States that had implemented Medicaid expansion as of December 31, 2019, including AK, AR, AZ, CA, CO, CT, DC, DE, HI, IA, IL, IN, KY, LA, MA, MD, ME, MI, MN, MT, ND, NH, NJ, NM, NV, NY, OH, OR, PA, RI, VA, VT, WA, WN.

[b] States that had not implemented Medicaid expansion as of December 31, 2019, including AL, FL, GA, ID, KS, MS, MO, NE, NC, OK, SC, SD, TN, TX, UT, WI, and WY.

Table 2.

Impact of Medicaid expansion on use of clinical preventive services by income level over time

	2014		2015		2016		2017		2018		2019		APC[b]	
Marginal difference[a]	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**	**Lower-income**	**Higher-income**
Colon cancer screening														
Before	3.16**	2.47**	3.16**	2.46**	3.39**	2.69**	3.39**	2.69**	3.81**	2.86**	3.81**	2.86**	4.44**	3.41**
(95% CI)	(1.90, 4.42)	(1.94, 3.01)	(1.91, 4.42)	(1.92, 2.99)	(2.14, 4.63)	(2.16, 3.21)	(2.14, 4.63)	(2.16, 3.21)	(2.57, 5.05)	(2.34, 3.38)	(2.57, 5.05)	(2.34, 3.38)	(2.33, 6.60)	(1.80, 5.04)
After	5.95**	3.79**	5.74**	4.10**	5.70**	3.71**	5.70**	3.71**	6.11**	3.66**	6.26**	3.66**	1.88	−1.49
(95% CI)	(4.31, 7.58)	(3.15, 4.44)	(4.25, 7.23)	(3.51, 4.68)	(4.61, 6.79)	(3.28, 4.14)	(4.61, 6.79)	(3.28, 4.14)	(5.18, 7.03)	(3.30, 4.03)	(5.33, 7.18)	(3.30, 4.02)	(−0.45, 4.26)	(−3.68, 0.74)
DID	2.78**	1.34**	2.57**	1.67**	2.31**	1.05**	2.31**	1.05**	2.29**	0.82*	2.45**	0.82*	−2.44	−13.37*
(95% CI)	(0.73, 4.83)	(0.51, 2.18)	(0.63, 4.51)	(0.88, 2.46)	(0.67, 3.96)	(0.37, 1.73)	(0.67, 3.96)	(0.37, 1.73)	(0.75, 3.83)	(0.19, 1.46)	(0.91, 3.98)	(0.19, 1.46)	(−6.47, 1.75)	(−23.27, −2.19)
Breast cancer screening[c]														
Before	5.98**	NA	6.02**	NA	6.12**	NA	6.12**	NA	6.24**	NA	6.24**	NA	0.92**	NA
(95% CI)	(4.40, 7.56)		(4.44, 7.60)		(4.56, 7.69)		(4.56, 7.69)		(4.68, 7.79)		(4.69, 7.80)		(0.59, 1.25)	
After	8.90**	NA	8.44**	NA	7.61**	NA	7.61**	NA	8.09**	NA	8.02**	NA	−1.17	NA
(95% CI)	(6.88, 10.92)		(6.50, 10.38)		(6.22, 9.00)		(6.22, 9.00)		(6.91, 9.28)		(6.85, 9.20)		(−4.72, 2.51)	
DID	2.90*	NA	2.40	NA	1.47	NA	1.47	NA	1.85	NA	1.78	NA	−9.63	NA
(95% CI)	(0.35, 5.45)		(−0.08, 4.88)		(−0.61, 3.56)		(−0.61, 3.56)		(−0.09, 3.80)		(−0.16, 3.72)		(−20.07, 2.17)	
Cervical cancer screening[c]														
Before	5.14**	NA	5.13**	NA	5.00**	NA	5.00**	NA	4.91**	NA	4.91**	NA	−1.03**	NA
(95% CI)	(3.81, 6.48)		(3.80, 6.46)		(3.68, 6.32)		(3.68, 6.32)		(3.60, 6.22)		(3.60, 6.23)		(−1.46, −0.59)	
After	7.05**	NA	6.86**	NA	6.18**	NA	6.18**	NA	6.35**	NA	6.36**	NA	−1.60	NA
(95% CI)	(5.33, 8.78)		(5.21, 8.51)		(4.99, 7.38)		(4.99, 7.38)		(5.33, 7.36)		(5.35, 7.37)		(−4.42, 1.30)	
DID	1.90	NA	1.72	NA	1.18	NA	1.18	NA	1.44	NA	1.45	NA	−5.24	NA

Marginal difference[a]	2014		2015		2016		2017		2018		2019		APC[b]	
	Lower-income	Higher-income	Lower-income	Higher-income	Lower-income	Higher-income	Lower-income	Higher-income	Lower-income	Higher-income	Lower-income	Higher-income	Lower-income	Higher-income
(95% CI)	(−0.26, 4.07)		(−0.39, 3.83)		(−0.59, 2.95)		(−0.59, 2.95)		(−0.21, 3.09)		(−0.20, 3.10)		(−14.46, 4.97)	
HIV testing														
Before	2.58**	3.67**	2.60**	3.74**	2.68**	3.86**	2.76**	3.99**	2.84**	4.12**	2.85**	4.14**	2.28**	2.67**
(95% CI)	(1.94, 3.21)	(3.40, 3.94)	(1.97, 3.23)	(3.47, 4.01)	(2.05, 3.31)	(3.59, 4.13)	(2.13, 3.38)	(3.73, 4.26)	(2.21, 3.46)	(3.85, 4.38)	(2.22, 3.47)	(3.87, 4.40)	(1.66, 2.91)	(2.05, 3.29)
After	4.59**	5.05**	5.07**	5.16**	4.56**	4.31**	4.31**	4.40**	5.33**	4.80**	5.24**	4.78**	3.08	−0.34
(95% CI)	(3.33, 5.86)	(4.54, 5.55)	(4.14, 5.99)	(4.80, 5.52)	(3.82, 5.31)	(4.02, 4.61)	(3.66, 4.96)	(4.14, 4.66)	(4.75, 5.92)	(4.56, 5.04)	(4.70, 5.79)	(4.56, 5.00)	(−3.08, 9.63)	(−5.22, 4.78)
DID	2.02**	1.37**	2.47**	1.40**	1.88**	0.42*	1.55**	0.37	2.49**	0.63**	2.39**	0.58**	2.83	−19.65*
(95% CI)	(0.61, 3.43)	(0.80, 1.94)	(1.35, 3.58)	(0.95, 1.85)	(0.91, 2.85)	(0.02, 0.82)	(0.65, 2.45)	(−0.01, 0.74)	(1.63, 3.35)	(0.27, 0.98)	(1.56, 3.22)	(0.23, 0.93)	(−9.05, 16.26)	(−35.17, −0.42)
Influenza vaccination														
Before	1.55**	−0.60**	1.59**	−0.53**	1.61**	−0.52**	1.64**	−0.47**	1.53**	−0.58**	1.53**	−0.59**	−0.47	NA
(95% CI)	(0.95, 2.15)	(−0.89, −0.31)	(0.99, 2.19)	(−0.82, −0.24)	(1.01, 2.21)	(−0.81, −0.23)	(1.05, 2.24)	(−0.75, −0.18)	(0.93, 2.12)	(−0.86, −0.29)	(0.93, 2.12)	(−0.88, −0.31)	(−2.55, 1.67)	
After	2.10**	0.21	1.58**	−0.28	2.04**	−0.01	2.38**	0.26	2.13**	0.05	2.24**	0.32**	2.98	10.04
(95% CI)	(0.90, 3.30)	(−0.34, 0.76)	(0.69, 2.47)	(−0.67, 0.12)	(1.33, 2.75)	(−0.33, 0.30)	(1.76, 2.99)	(−0.02, 0.53)	(1.58, 2.68)	(−0.20, 0.29)	(1.73, 2.75)	(0.10, 0.55)	(−4.75, 11.34)	(−32.76, 80.08)
DID	0.55	0.81*	−0.01	0.25	0.43	0.50*	0.74	0.72**	0.60	0.62**	0.72	0.91**	6.31	6.77
(95% CI)	(−0.79, 1.89)	(0.19, 1.43)	(−1.08, 1.06)	(−0.24, 0.74)	(−0.49, 1.35)	(0.08, 0.93)	(−0.12, 1.59)	(0.33, 1.12)	(−0.20, 1.41)	(0.25, 0.99)	(−0.06, 1.50)	(0.55, 1.27)	(−11.70, 28.00)	(−11.13, 28.27)

*p<0.05;

**p<0.01.

Abbreviations: DID=Difference-in-differences; HIV=human immunodeficiency virus; 95% CI=95% confidence interval; APC=annual percent change.

Note: Lower-income group: household income<$20,000; Higher-income group: household income≥$20,000. Adjusted by age, sex, race/ethnicity, education level, marital status and health status. For sex-related services (breast cancer screening and cervical cancer screening), sex was not included for adjusting.

[a]The marginal difference refers to the difference between Expansion states and Non-expansion states.

[b]The annual percent change (APC) was tested in JoinPoint, which assumes that change at a constant percentage every year change linearly on a log scale.

[c]The results in breast and cervical cancer screenings among higher-income group were not shown, because of the violations of parallel trends before Medicaid expansion.