



Current smoking and quit-attempts among US adults following Medicaid expansion

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ABSTRACT

The objective of this study was to estimate the influence of the Affordable Care Act (ACA) Medicaid Expansion on current smoking and quit attempts in expanded and non-expanded states. We analyzed data from the Behavioral Risk Factor Surveillance System (BRFSS) between 2003 through 2015 to evaluate changes in current smoking and quit attempts using multivariable logistic regression and generalized estimating equations (GEE), adjusting for socioeconomic factors. Time periods evaluated were: 2003–2009 (pre-expansion) and 2011–2015 (post-expansion), and in supplemental analysis, also 2011–2017. Overall, smoking prevalence among adults in expanded and non-expanded states were 16% and 17% ($p < 0.001$), respectively, and quit attempt prevalence for expanded and non-expanded states were 56% and 57% ($p = 0.05$), respectively. In adjusted models comparing post- versus pre- expansion periods, current smoking declined by 6% in both expanded (RR: 0.94, 95% CI: 0.93–0.94) and non-expanded (RR: 0.94, 95% CI: 0.94–0.95) states. Quit attempts increased by 4% (RR: 1.04, 95% CI: 1.04–1.05) in expanded states, and by 3% (RR: 1.03, 95% CI: 1.02–1.03) in non-expanded states. States that imposed barriers to utilization of smoking cessation services e.g. prior authorization, saw only a 3% increase in quit attempts regardless of expansion status, while expanded states that did not impose barriers experienced a 6% (RR: 1.06, 95% CI: 1.05–1.06) increase in quit attempts. Reducing administrative barriers to smoking cessation programs may enhance further declines in smoking rates among US adults.

1. Introduction

Cigarette smoking is the leading cause of preventable morbidity and mortality in the United States and accounts for approximately 480,000 deaths each year (National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health, 2014; Smoking and Mortality - Beyond Established Causes, 2016). There have been significant declines in cigarette smoking, from 42% in 1965 to 15% in 2015 (Drope et al., 2018). However, current smoking remains disproportionately higher among low-income (30%) and uninsured (28%) individuals (Jamal et al., 2016).

The Affordable Care Act (ACA), introduced in 2010, addressed provisions for healthcare coverage denial due to pre-existing conditions, provided tax-credits and subsidies to purchase health insurance and access to free preventive care, and expanded insurance coverage to include non-disabled single childless adults (Gostin and Garcia, 2012; Manchikanti et al., 2011; Sheen, 2012). As part of the ACA provision, childless adults could be Medicaid eligible at or below 133% federal

poverty level (FPL) (Sheen, 2012). A total of 30 US states including the District of Columbia had expanded Medicaid as part of the ACA by December 31, 2015, however in March 2010, six states and jurisdictions—California, Connecticut, the District of Columbia, Minnesota, New Jersey, and Washington—enacted Medicaid expansion among low-income groups due to the provisions in the ACA (Sommers et al., 2013).

Prior to the ACA, low-income adults without Medicaid coverage had few available choices for accessing smoking cessation services and states had flexibility in types of smoking cessation services offered through Medicaid (Singleterry et al., 2015). However, following the implementation of the ACA, state Medicaid programs were required to cover smoking cessation services among newly eligible adults (McAfee et al., 2015), leading to expanded coverage of evidence-based smoking cessation treatments. Previous studies have evaluated the impact of ACA expansion on quit attempts and current smoking, however prior studies have only evaluated annual trends, focused on a single or few US states, or did not account for baseline differences in states Medicaid

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expansion status (Brown et al., 2018; Koma et al., 2017; Ku et al., 2016; Greene et al., 2014). The purpose of this study is to evaluate the impact of the ACA expansion on current smoking and quit attempts among expanded and non-expanded US states, to evaluate the impact among low-income individuals, and to account for state-level barriers to smoking cessation services.

2. Methods

2.1. Data source

Data were obtained from the Behavioral Risk Factor Surveillance System (BRFSS) for adults 18 years and older surveyed between 2003 and 2017 (Centers for Disease Control and Prevention, n.d). The BRFSS collects nationally representative data annually on randomly selected land-line and cell-phone telephone numbers on over 400,000 adults in all 50 states, including three U.S. territories and the District of Columbia (Iachan et al., 2016). The annual telephone survey obtains information on health related risk behaviors, chronic health conditions and use of preventive services. The BRFSS median response rate over the study period ranged from 53% in 2003 to 47% in 2015 (Centers for Disease Control and Prevention, n.d). In the current analyses, data on socio-demographics, current smoking and quit attempts were obtained from the BRFSS, and data on Medicaid expansion status and year of expansion by state was obtained from the Kaiser Family Foundation State Health Facts (Medicaid Expansion Enrollment, 2017).

2.2. Study variables

Outcome variables of interest were current smoking and quit-attempts in the past year among smokers. Current smokers were defined as participants who indicated that they currently smoked every day or some days, or that they had smoked a cigarette within the past month. Quit-attempts among smokers was defined as having a quit-attempt in the preceding 12 months for one day or longer. Current smoking was defined using the 'computed smoking status' variable, while quit-attempts was defined using the variable '_STOPSMK2' in the past year among current smokers. Sociodemographic characteristics, including age, sex, race/ethnicity, education, employment status, and annual household income were obtained, and data on availability of regular healthcare providers and health care coverage were included to examine access to healthcare. Age variable was classified in three groups; 18–49, 50–79, and 80+ years of age; annual household income variable was categorized into four groups - < \$10,000, \$10,000– < \$20,000, \$20,000– < \$50,000, and ≥ \$50,000; race was identified using the five level race/ethnicity variable and classified into White, Black, Hispanic, and Other categories; education was categorized into < high school, high school graduate, and some college or higher. Healthcare coverage was ascertained as having any kind of coverage, including health insurance, prepaid plans such as Health Maintenance Organizations (HMOs), or government plans like Medicare, or Indian Health Service. To evaluate the impact of state-level barriers to utilization of smoking cessation services, data on two state-level barrier variables – prior authorization before smoking cessation treatment and copayments- were obtained from the American Lung Association for 2010, dichotomized as yes/no (Centers for Disease Control and Prevention, n.d).

2.3. Study periods

The two study periods, pre-expansion (2003–2009) and post-expansion (2011–2015), were defined based on states' Medicaid expansion status during the study period. Five states and the District of Columbia expanded eligibility as early as 2010 by taking advantage of provisions in the ACA and Medicaid waivers (Sheen, 2012; Sommers et al., 2013), therefore we considered the year 2010 as the washout

period. By 2015, the following states had expanded Medicaid as part of the ACA; Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, West Virginia, and District of Columbia. To evaluate more recent trends in current smoking and smoking cessation, we also examined BRFSS data from 2011 to 2017; comparing 2011–2013 and 2015–2017 time periods.

2.4. Statistical analysis

Weighted analyses for descriptive variables by expansion status using chi-square tests, were evaluated for current smoking and quit attempts by socio-demographic variables and expansion status. We assessed annual trends in current smoking and quit attempts by expansion status, and utilized multivariable adjusted logistic regression and generalized estimating equations (GEE) to assess current smoking and quit attempts in the past year in non-expanded versus expanded states for each time period. Due to the high prevalence of current smoking and quit attempts in the past year, we interpret estimates from GEE models as relative risks (RRs) instead of odds ratios (ORs) (Dicker et al., 2006). To examine the secular time trends in the prevalence of current smoking and quit-attempt status among adults in the two time periods, we assessed for linear and quadratic changes adjusting for socio-demographic and socio-economic predictors in pre-expansion (2003–2009) and post-expansion (2011–2015) periods. Similar analyses were conducted for 2011–2013 versus 2015–2017 (Supplemental tables). We also assessed for interactions between expansion status and time periods in prevalence of current smoking and quit-attempts. Furthermore, we evaluated whether the association between expansion and smoking cessation varied by state-level barriers such as prior authorization and co-payments for smoking cessation treatment. All analyses were carried out using SAS version 9.4 (SAS Institute, Inc., Cary, NC; USA) accounting for the complex sample survey design; statistical significance levels were determined based on p -values < 0.05.

3. Results

By December 31, 2015, 30 states and DC had implemented Medicaid expansion, while 21 states had not implemented the policy. A total of 5,311,872 participants were included in this analysis, 2,289,033 (43%) were in non-expanded states and 3,022,839 (57%) were in expanded states (Table 1). Table 1 shows the baseline characteristics of the study participants overall and by Medicaid expansion status. Participants in expanded vs. non-expanded states were less likely to be Black (7% vs. 10%), more likely to be Hispanic (7% vs. 5%), have at least some college education (64% vs. 60%), have an average annual household income of > \$50,000 (47% vs. 41%), more likely to have health insurance coverage (91% vs. 88%) and at least one regular healthcare provider (86% vs. 84%).

Overall, 16% of participants residing in expanded states were current smokers, compared with 17% of participants in non-expanded states (Table 2; $p < 0.001$). The prevalence of current smoking in the expanded states declined from 23% to 14%, and in the non-expanded states reduced from 22% to 15% between 2003 and 2015 (Fig. 1). For quit attempts, prevalence in expanded states increased from 53% to 57%, and in the non-expanded states it increased from 51% to 58% (Fig. 2). Current smoking was lower in expanded vs. non-expanded states, especially among participants aged 18–34 (22% vs. 23%), those without health insurance coverage (31% vs. 33%), those with an annual household income less than \$10,000 (31% vs. 32%) and those who were unemployed (30% vs. 34%). The prevalence of current smoking in the expanded states declined from 23% to 14%, and in the non-expanded states reduced from 22% to 15% between 2003 and 2015

Table 1
Baseline characteristics of study population by Medicaid expansion status, BRFSS 2003–2015 (unweighted).

Characteristics	Expansion			p value
	Total (N = 5,311,872)	Non-expanded States (21) (N = 2,289,033)	Expanded States (30) (N = 3,022,839)	
Age				
18–34	796,657 (14.49)	345,041 (14.57)	451,616 (14.42)	< 0.0001
35–49	1,219,456 (21.20)	509,427 (20.57)	710,029 (21.70)	
50–64	1,642,264 (31.84)	701,298 (31.41)	940,966 (32.17)	
65–79	1,199,499 (24.25)	536,075 (25.0)	663,424 (23.68)	
≥80	403,594 (8.19)	178,504 (8.43)	225,090 (8.02)	
Sex				
Male	2,086,990 (39.98)	888,554 (39.46)	1,198,436 (40.36)	< 0.0001
Female	3,224,809 (60.02)	1,400,434 (60.54)	1,824,375 (59.64)	
Race				
White	4,176,702 (79.36)	1,814,675 (80.08)	2,362,027 (78.81)	< 0.001
Black	429,021 (8.18)	225,859 (9.92)	203,162 (6.84)	
Other race	301,577 (5.87)	102,984 (4.56)	198,593 (6.88)	
Hispanic	336,421 (6.57)	118,687 (5.42)	217,734 (7.45)	
Education				
< High school	492,197 (8.78)	237,869 (9.80)	254,328 (7.99)	< 0.001
High school grad	1,576,718 (29.34)	492,197 (30.66)	710,105 (28.33)	
Some college or higher	3,222,435 (61.87)	1,333,728 (59.53)	1,888,707 (63.66)	
Income level				
< \$10,000	247,936 (5.38)	114,579 (5.73)	133,357 (5.11)	< 0.001
\$10,000– < \$20,000	637,669 (13.89)	299,939 (15.15)	337,730 (12.93)	
\$20,000– < \$50,000	1,717,152 (36.54)	778,781 (38.59)	938,371 (34.97)	
≥ 50,000	1,947,866 (44.17)	762,843 (40.51)	1,185,023 (46.98)	
Employment				
Employed	2,296,526 (42.05)	962,264 (40.73)	1,334,262 (43.07)	< 0.001
Self-employed	452,022 (8.39)	199,625 (8.63)	252,397 (8.21)	
Unemployed	257,218 (5.03)	102,243 (4.64)	154,975 (5.32)	
Student/homemaker/retired	1,073,783 (37.35)	843,350 (38.12)	1,073,783 (36.75)	
Unable to work	189,519 (7.16)	170,996 (7.86)	189,519 (6.62)	
Marital status				
Married	2,878,492 (53.94)	1,273,187 (55.28)	1,605,305 (52.91)	< 0.001
Divorced/widowed/separated	1,557,951 (29.61)	687,999 (30.28)	869,952 (29.10)	
Never married/unmarried couple	847,402 (16.44)	317,997 (14.43)	529,405 (17.97)	
Healthcare coverage ^a				
Yes	4,718,672 (89.74)	1,996,128 (88.09)	2,722,544 (91.00)	< 0.001
No	576,588 (10.25)	285,477 (11.90)	291,111 (8.92)	
Healthcare providers ^b				
At least one	4,523,661 (85.45)	1,925,100 (84.30)	2,598,561 (86.34)	< 0.001
No	769,281 (14.54)	357,067 (15.70)	412,214 (13.65)	

(O) Denotes column percentage. Sample sizes are unweighted; percentages are weighted to adjust for sampling and post-stratification.

^a Healthcare coverage is defined as having any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare.

^b Healthcare providers is defined as personal doctor or health care provider.

(Fig. 1). For quit attempts, prevalence in expanded states increased from 53% to 57%, and in the non-expanded states it increased from 51% to 58% (Fig. 2).

In models adjusted for sex, race, income, and education, and comparing non-expanded versus expanded states (Table 3), current smoking increased by 2% (RR: 1.02, 95% CI: 1.02–1.03) in the pre-expansion period (2003–2009), but no significant difference was found post-expansion (RR: 0.99, 95% CI: 0.99–1.00). In addition, quit attempts declined by 2% pre-expansion (RR: 0.98, 95% CI: 0.98–0.99), and increased by 1% (RR: 1.01, 95% CI: 1.01–1.02) post-expansion. In Table 4, comparing post- versus pre-expansion periods, current smoking declined by 6% in both expanded (RR: 0.94, 95% CI: 0.93–0.94) and non-expanded (RR: 0.94, 95% CI: 0.94–0.95) states. Quit attempts increased by 4% (RR: 1.04, 95% CI: 1.04–1.05) in expanded states post-versus pre-expansion, and by 3% (RR: 1.03, 95% CI: 1.02–1.03) in non-expanded states. When focused on low income individuals (annual household income < \$20,000), there was no significant change in current smoking post versus pre-expansion in either expanded or non-expanded states, but there quit attempts increased by 5% (RR: 1.05, 95% CI: 1.05–1.06) in expanded states and by 4% (RR: 1.04, 95% CI: 1.04–1.05) in non-expanded states. More modest associations were

observed in more recent BRFSS years (2011–2017); current smoking declined by 1% (RR: 0.99, 95% CI: 0.99–0.99) in 2011–2013, and increased by 1% (RR: 1.01, 95% CI: 1.01–1.01) in 2015–2017. Quit attempts increased by 0.6% (RR: 1.006, 95% CI: 1.006–1.007) in 2011–2013 period, and by 1% (RR: 1.01, 95% CI: 1.01–1.01) in 2015–2017 (Supplemental Tables 1–2).

We further examined the association between Medicaid expansion and current smoking or quit attempts varied by state-level prior authorization and co-payment barriers. Among states that required prior authorization (Table 5), quit attempts increased by 3% (RR: 1.03, 95% CI: 1.02–1.03) in the post versus pre-expansion period in both expanded and non-expanded states. However, among states that did not require prior authorization for smoking cessation, quit attempts increased by 6% (RR: 1.06, 95% CI: 1.05–1.06) in expanded states, and increased by 3% (RR: 1.03, 95% CI: 1.02–1.03) in non-expanded states. Among states that required co-payments for smoking cessation services (Table 6), quit attempts increased by 3% (RR: 1.03, 95% CI: 1.02–1.03) in expanded states, and by 2% (RR: 1.02, 95% CI: 1.02–1.03) in non-expanded states. Among states that did not require copayments, quit attempts increased by 7% (RR: 1.07, 95% CI: 1.06–1.07) in expanded states, and by 3% in non-expanded states (RR: 1.03, 95% CI:

Table 2
Smoking Status by study period in the expanded and non-expanded states, BRFSS 2003–2015 (N = 5,311,799).

Characteristics	Smoking status					
	Current smoker ^a			Quit attempts		
	Non-expanded	Expanded	p value	Non-expanded	Expanded	p value
Overall	398,437 (16.6)	499,893 (15.90)	< 0.0001	219,367 (56.61)	275,150 (56.38)	0.05
Socio-demographics						
Age						
18–34	79,937 (22.46)	100,966 (21.56)	< 0.0001	51,018 (65.40)	63,752 (64.19)	< 0.0001
35–49	113,117 (20.99)	145,667 (19.56)		62,426 (57.16)	81,325 (57.44)	
50–64	138,497 (19.45)	172,103 (18.15)		74,064 (54.76)	92,100 (54.70)	
65–79	58,565 (10.81)	69,600 (10.46)		29,223 (50.78)	34,515 (50.38)	
≥ 80	6264 (3.46)	8242 (3.59)		2636 (42.73)	3458 (42.43)	
Sex						
Male	169,434 (18.32)	213,833 (17.27)	< 0.0001	89,239 (53.96)	114,084 (54.54)	< 0.0001
Female	229,003 (15.58)	286,060 (14.98)		131,173 (58.60)	162,750 (57.84)	
Race						
White	307,000 (16.07)	384,156 (15.52)	< 0.0001	161,934 (53.97)	204,189 (54.01)	< 0.0001
Black	42,342 (18.60)	39,288 (19.40)		28,883 (69.41)	26,314 (68.15)	
Other race	27,570 (26.12)	37,223 (18.16)		16,461 (60.68)	21,917 (59.81)	
Hispanic	17,545 (14.21)	33,257 (14.95)		10,985 (64.08)	21,133 (64.63)	
Healthcare access						
Healthcare coverage						
Yes	303,125 (14.50)	407,772 (14.46)	< 0.0001	166,624 (56.20)	225,751 (56.33)	< 0.0001
No	94,210 (32.70)	90,653 (30.53)		53,169 (57.82)	50,266 (56.44)	
Healthcare providers						
At least one	300,058 (14.80)	391,389 (14.31)	< 0.0001	169,097 (57.58)	220,773 (57.35)	< 0.0001
No	97,212 (26.66)	106,253 (25.26)		50,706 (53.66)	54,876 (52.73)	
Socio-economic status						
Income level						
< \$10,000	36,174 (32.02)	41,227 (31.16)	< 0.0001	22,212 (62.81)	24,599 (60.78)	< 0.0001
\$10,000– < \$20,000	76,965 (25.50)	86,079 (25.47)		45,485 (60.52)	50,089 (59.40)	
\$20,000– < \$50,000	151,150 (18.48)	182,850 (18.68)		82,335 (55.77)	10,611 (55.92)	
≥ \$50,000	88,676 (10.75)	133,184 (10.47)		46,089 (52.77)	71,597 (54.42)	
Education						
< High school	64,218 (27.0)	67,379 (26.58)	< 0.0001	37,016 (59.12)	37,967 (57.37)	< 0.0001
High school grad	154,172 (21.12)	190,719 (21.51)		83,566 (55.53)	103,138 (54.98)	
Some college or higher	179,344 (12.70)	240,561 (12.12)		99,466 (56.63)	135,099 (57.16)	
Employment						
Employed	180,242 (17.60)	230,795 (16.26)	< 0.0001	97,836 (55.54)	126,946 (56.08)	< 0.0001
Self-employed	32,272 (15.02)	38,167 (14.29)		16,554 (52.26)	19,985 (53.18)	
Unemployed	34,859 (33.66)	47,899 (30.40)		20,970 (61.51)	28,317 (60.07)	
Student/homemaker/retired	93,249 (10.60)	115,721 (10.42)		48,573 (52.84)	60,191 (52.46)	
Unable to work	56,559 (33.14)	65,265 (34.51)		35,837 (64.55)	40,344 (62.78)	

Quit attempts is defined as stopped smoking for one day or longer because of trying to quit smoking.

Expanded states include AK, AR, AZ, CA, CO, CT, DE, HI, IA, IL, IN, KY, MD, MA, MI, MN, NV, NH, NJ, NM, NY, ND, OH, OR, PA, RI, VT, WA, WV, and DC which expanded Medicaid under the ACA between 2010 and 2015.

Non-Expanded states did not expand Medicaid under the ACA till the end of 2015.

^a Current smoker is defined as every day or someday smoker who smoked at least 100 cigarettes in their lifetime.

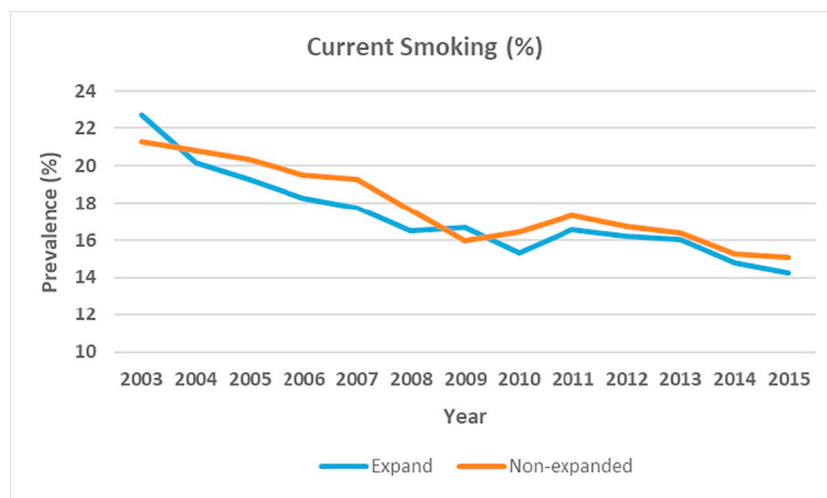


Fig. 1. Prevalence of current smoking in the expanded vs. non-expanded states – BRFSS, United States, 2003–2015.

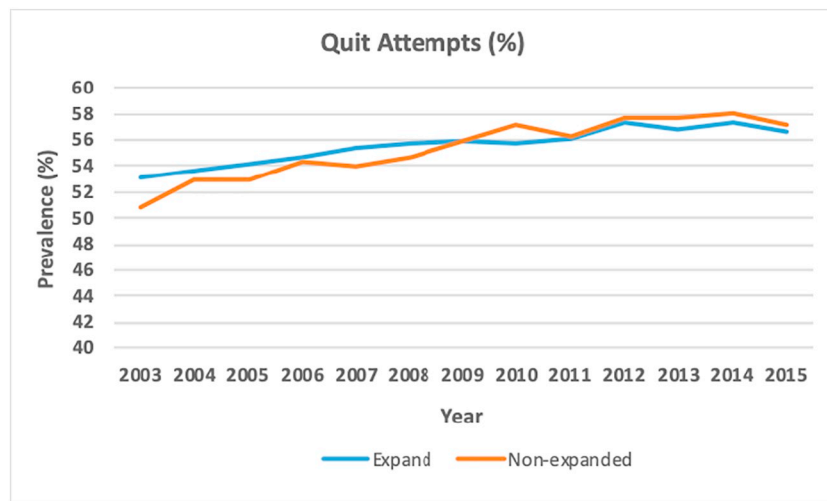


Fig. 2. Prevalence of adult smokers reporting a quit attempt during the previous year in the expanded vs. non-expanded states – BRFSS, United States, 2003–2015.

1.03–1.04).

4. Discussion

In a large nationally representative study population of US adults, we examined the impact of the ACA expansion on current smoking and quit attempts in pre-expansion and post-expansion time periods. Overall, current smoking was 2% higher in the non-expanded versus expanded states in the pre-expansion period, but 1% lower post-expansion. However, in both expanded and non-expanded states, there was a 6% decline in current smoking post- versus pre-expansion, and a 3–4% increase in quit attempts. There was no significant change in current smoking among participants with an annual household income of ≤\$20,000, but a 4–5% increase in quit attempts was observed in this group. These results indicate that while non-expanded states had higher current smoking rates compared with expanded states pre-expansion, following implementation of the ACA Medicaid expansion policy, both expanded and non-expanded states experienced significant improvements in declining current smoking rates and higher quit attempts. However, expanded states that introduced barriers to accessing evidence based smoking cessation services, specifically prior authorization

and co-payments, experienced very modest increases in quit attempts post- versus pre-expansion, compared with states that did not institute such barriers, while such barriers made no difference in non-expanded states.

Prior studies have analyzed the impact of Medicaid expansion on current smoking and quit attempt rates among US adults (Smoking and Mortality - Beyond Established Causes, 2016; Land et al., 2010; Naavaal et al., 2018; Pernenkil et al., 2017; Simon et al., 2017; Young-Wolff et al., 2017). The majority of those studies observed that following the implementation of Medicaid expansion as part of the Affordable Care Act, current smoking rates declined modestly (Smoking and Mortality - Beyond Established Causes, 2016; Land et al., 2010; Pernenkil et al., 2017; Simon et al., 2017) while quit attempts increased (Smoking and Mortality - Beyond Established Causes, 2016; Naavaal et al., 2018; Young-Wolff et al., 2017). Three studies utilized data from BRFSS to evaluate differences in current smoking post- versus pre-expansion and observed declines in current smoking ranging from 15% (Land et al., 2010) and 7% (Pernenkil et al., 2017) to 0.06% (Simon et al., 2017). Other studies have evaluated differences in prevalence of current smoking comparing trends over time (Smoking and Mortality - Beyond Established Causes, 2016; Land et al., 2010; Naavaal et al., 2018; Simon

Table 3

Relative risks for current smoking and quit attempts by ACA expansion status and age-group, US BRFSS 2003–2015.

Year	Current smokers (%)		Quit attempts (%)	
	2003–2009*	2011–2015†	2003–2009†	2011–2015†
Overall US				
Expanded	262,751 (17.22)	200,030 (16.07)	143,057 (55.31)	113,123 (56.86)
Non-expanded	205,078 (18.28)	160,235 (15.46)	110,105 (54.59)	91,410 (57.34)
	RR = 1.02 (1.02–1.03)	RR = 0.99 (0.99–1.00)	RR = 0.98 (0.98–0.99)	RR = 1.01 (1.01–1.02)
18–49 years				
Expanded	142,484 (21.61)	88,645 (19.79)	81,926 (58.52)	53,845 (61.14)
Non-expanded	108,863 (23.19)	70,683 (20.84)	61,681 (57.86)	43,527 (61.98)
	RR = 1.02 (1.01–1.02)	RR = 1.01 (1.01–1.02)	RR = 0.99 (0.99–1.00)	RR = 1.01 (1.01–1.02)
50–79 years				
Expanded	114,680 (15.45)	106,501 (14.68)	58,669 (52.42)	57,077 (53.83)
Non-expanded	92,283 (16.45)	85,935 (15.27)	46,729 (51.76)	46,245 (54.02)
	RR = 1.02 (1.02–1.03)	RR = 0.98 (0.98–0.99)	RR = 0.98 (0.98–0.99)	RR = 0.99 (0.99–1.00)
≥ 80 years				
Expanded	3843 (3.87)	3613 (3.46)	1594 (41.74)	1538 (42.85)
Non-expanded	2766 (3.79)	2895 (3.37)	1128 (41.05)	1241 (43.04)
	RR = 0.96 (0.96–0.97)	RR = 0.99 (0.99–1.00)	RR = 0.96 (0.96–0.97)	RR = 1.02 (1.02–1.03)

Reference = expanded; RR = relative risk. RRs for age categories have been adjusted for sex, race, annual household income, and educational status using Proc Genmod. Excluded 2010 data as the wash-out period.

* Linear trend $p = 0.13$; quadratic trend $p < 0.0001$.

† Linear trend $p < 0.0001$.

Table 4
Relative risks for current smokers and quit attempts by expansion and time period, US BRFSS 2003–2015.

	Overall		Low income (≤\$20,000) ^a	
	Current smoking [*]	Quit attempts [*]	Current smoking [†]	Quit attempts [*]
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Expanded				
Pre-expansion (2003–2009)	Ref	Ref	Ref	Ref
Post-expansion (2011–2015)	0.94 (0.93–0.94)	1.04 (1.04–1.05)	0.99 (0.99–1.00)	1.05 (1.05–1.06)
Non-expanded				
Pre-expansion (2003–2009)	Ref	Ref	Ref	Ref
Post-expansion (2011–2015)	0.94 (0.94–0.95)	1.03 (1.02–1.03)	0.99 (0.99–1.00)	1.04 (1.04–1.05)

Note: Relative risks were adjusted for sex, race, annual household income, educational status including interaction terms for expansion status and time periods of pre- and post-expansion using Proc Genmod. Excluded 2010 data as the wash-out period.

P-value for expand × period interaction: * < 0.0001; † 0.0019.

^a Annual household income ≤ \$20,000.

et al., 2017), a study using the National Health Interview Survey (NHIS) observed that current smoking prevalence was 21% in 2005 and 15% in 2015 (Jamal et al., 2016), while a state-based study using the Massachusetts BRFSS observed that smoking prevalence decreased from 38% in 1999 to 28% in 2008 (Land et al., 2010). Two studies using the BRFSS evaluated the effect of Medicaid expansion on quit attempts in the pre- versus post-expansion period, and observed that the odds of smoking cessation increased by 21% among US adults (Pernenkil et al., 2017), while the other study observed that non-expanded Medicaid enrollees had a 5% lower odds of quit attempts compared with enrollees (Young-Wolff et al., 2017). Other studies have utilized data from specific states to evaluate expansion and quit attempts. For instance, a study of Medicaid enrollees in Alabama, Georgia, and Maine observed that the odds of quit attempts increased by 60% after the Medicaid expansion (Athar et al., 2016), while a study from northern California showed a 49% increase among Medicaid enrollees compared to those on commercial insurance (Young-Wolff et al., 2017). There are several potential reasons for the differences between these prior studies and our findings.

Compared with other studies (Smoking and Mortality - Beyond Established Causes, 2016; Land et al., 2010; Pernenkil et al., 2017; Simon et al., 2017), we observed a more modest 6% decline in current smoking among US adults in both expanded and non-expanded states comparing post- and pre-expansion periods. That is, regardless of whether a state expanded Medicaid as part of the Affordable Care Act, current smoking declined by 6%, while quit attempts increased by 3–4%. Among low-income individuals, we did not observe a significant decline in current smoking, but did observe a 4–5% increase in quit attempts. This is similar to a 2% increase in quit attempts observed by a separate study (Koma et al., 2017) using the BRFSS dataset. Our findings of current smoking prevalence of 26% in the non-expanded and 18% in the expanded states for participants of Other races (includes

multiracial, American Indian/Alaska Native, and Asians) are also comparatively lower compared to a previous study (Jamal et al., 2016) using the NHIS that had a prevalence of 32% among American Indian/Alaska Natives. The lower rates could be due to the combination of racial groups i.e. American Indian/Alaska Natives and Asians with significantly different current smoking rates. Moreover, our results are based on an overall population average for 2003 to 2015, while the NHIS study reported cross-sectional results for 2015 (Jamal et al., 2016).

The modest findings in our study may be explained by several possible reasons. First, in contrast to other studies, our analytic approach did not assume that states that expanded Medicaid as part of the Affordable Care Act were similar to states that did not expand at baseline. For instance, individuals in expanded states were younger, less likely to be Black, and had higher annual household incomes on average compared with individuals in states that did not expand. To account for these baseline differences, we estimated the risks of current smoking and smoking cessation in pre- versus post-expansion separately in expanded and non-expanded states, and statistically adjusted for these demographic differences.

Second, the modest declines in current smoking observed may be due to administrative and/or logistical barriers in accessing smoking cessation services that remained unaddressed or were newly implemented in some states after Medicaid expansion, a factor that was not directly considered in other studies. For instance, of the 31 states and jurisdictions that expanded Medicaid, only 19 states covered all the FDA-approved medications, while only 17 covered individual and 11 covered group counseling (DiGiulio et al., 2016). Furthermore, some of the expanded states established administrative barriers such as co-payments and prior authorization for available treatments, therefore limiting access for cessation programs (DiGiulio et al., 2018). In addition, prior to 2015, 48 states covered some cessation treatments, but by

Table 5
Relative risks for quit attempts by expansion and time period by prior authorization, US BRFSS 2003–2015.

	Quit attempts		Prior authorization	
	Overall	Yes	No	
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Expanded				
Pre-expansion (2003–2009)	Ref	Ref	Ref	Ref
Post-expansion (2011–2015)	1.04 (1.04–1.05)	1.03 (1.02–1.03)	1.06 (1.05–1.06)	
Non-expanded				
Pre-expansion (2003–2009)	Ref	Ref	Ref	Ref
Post-expansion (2011–2015)	1.03 (1.02–1.03)	1.03 (1.02–1.03)	1.03 (1.02–1.03)	

Note: Relative risks were adjusted for sex, race, annual household income, educational status including interaction terms for expansion status and time periods of pre- and post-expansion using Proc Genmod. Excluded 2010 data as the wash-out period.

Prior authorization required for smoking cessation among states include: AK, AL, AR, CO, DE, HI, IA, ID, MA, ME, MI, MO, MT, ND, NE, NV, OK, RI, TN, UT, VT, WA, and WV (23 states).

Table 6
Relative risks for quit attempts by expansion and time period by co-payment, US BRFSS 2003–2015.

	Quit attempts	Co-payments	
	Overall	Yes	No
Expanded	RR (95% CI)	RR (95% CI)	RR (95% CI)
Pre-expansion (2003–2009)	Ref	Ref	Ref
Post-expansion (2011–2015)	1.04 (1.04–1.05)	1.03 (1.02–1.03)	1.07 (1.06–1.07)
Non-expanded			
Pre-expansion (2003–2009)	Ref	Ref	Ref
Post-expansion (2011–2015)	1.03 (1.02–1.03)	1.02 (1.02–1.03)	1.03 (1.03–1.04)

Note: Relative risks were adjusted for sex, race, annual household income, educational status including interaction terms for expansion status and time periods of pre-and post-expansion using Proc Genmod. Excluded 2010 data as the wash-out period.

Co-payments required for smoking cessation among states include: AK, CA, CO, DE, IA, IL, IN, KS, LA, MA, ME, MN, MS, MT, NC, ND, NE, NH, NV, OH, OK, OR, PA, SD, TX, UT, VA, VT, WI, WV, and, WY (31 states).

June 2017, all of the 50 states and DC covered some form of tobacco cessation treatments (DiGiulio et al., 2018). These may explain our observation of similar declines in current smoking and quit attempt rates between expanded and non-expanded states. That is, the added benefit of Medicaid expansion in improving access to smoking cessation services and hence reducing smoking rates may have been muted by accessibility barriers in expanded states, and provision of at least some smoking cessation services in non-expanded states. Based on our analyses, expanded states that had no barriers to smoking cessation treatments had a 7% increase in quit-attempts compared to a 3% increase among expanded states that had barriers in the post-expansion period. However, it is important to evaluate changes over time as benefits included in Medicaid coverage can change over time, for example North Dakota and Pennsylvania initially covered all cessation treatments, but no longer did so by June 2017 (DiGiulio et al., 2018).

Third, provision of smoking cessation services without other health policies such as indoor smoking bans, cigarette excise taxes and stricter age-limits, are likely to have limited the effectiveness of Medicaid expansion on smoking cessation. As of Jan 2018, only 28 states and D.C. have instituted a statewide smoking ban policy, and 47 states have increased cigarette taxes with an average state tax of \$1.69 per pack, ranging from \$0.33 to \$5.1 (Tobacco Facts, n.d.). A 15% decline in current smoking was reported in Massachusetts (Land et al., 2010), the first state to establish a Medicaid expansion program for low-income individuals. The program also provided fewer restrictions to participants, including lower administrative barriers to cessation services, and simultaneously implemented other smoking cessation policies such as indoor bans and higher excise taxes that likely contributed to its success (Land et al., 2010). Treatment effectiveness may also vary - one study (Lindson-Hawley et al., 2016) compared success rates in quitting gradually vs. abruptly found a significant quit rate (15% vs. 22%) at the end of six months in primary care clinics in England when included with behavioral support and nicotine replacement. A prior study has also reported that almost 85% of smokers quit smoking abruptly (Fiore et al., 1990). We were unable to ascertain if our rates of quit attempts were based on counseling and nicotine replacement or just quit 'cold-turkey' as the BRFSS participants were not asked regarding cessation treatments.

Fourth, Medicaid expansion was designed to increase insurance coverage for low-income individuals. Our study found no significant difference in current smoking in both the expanded and non-expanded states among low-income adults. This may be partly due to the increase in the Medicaid population over time; in 1997 low-income adults represented 8% of the US adult population, but by 2013 it had doubled almost to almost 17 (Zhu et al., 2017). In addition, many low-income individuals initiate smoking due to intense exposure to advertising, and personal psychosocial factors such as stress, financial burdens, and lack of social support (Boen and Yang, 2016; Echer and Barreto, 2008; Golden and Perreira, 2015). Medicaid expansion by itself is unlikely to address all these issues, and states may need to enhance tobacco

cessation programs with other strategies including advertising restrictions especially for younger individuals, free or low-cost counseling and policies to further limit exposure to cigarettes. Current smoking was higher among 18–49-year olds in our study in non-expanded (21%) and expanded (20%) states compared with other age-groups evaluated, highlighting the need for greater access to comprehensive smoking cessation services with limited financial and logistical barriers to utilization among younger adults.

The strengths of our study are the use of a nationally representative non-institutionalized population of US adults across a wide range of racial, and socio-economic age groups. Our study estimates are reliable due to the large sample size across all sub-populations that provided adequate statistical power for the analysis. Also, we were able to assess study outcomes specifically among low-income individuals, since Medicaid expansion was designed to improve insurance coverage in this sub-population. There are also certain limitations relevant to our study. First, we relied on self-reported data on smoking status and quit attempts, however, self-reports of these variables have been validated previously (Binnie et al., 2004). Second, measuring the impact of a general policy on individuals is vulnerable to ecological bias. Studies of low-income individuals comparing those enrolled in Medicaid as part of the Affordable Care Act with those who remained uninsured can provide better estimates of the direct association between expansion and smoking outcomes. We did not account for the time-varying nature of state-level barriers across the study period, but obtained data on barriers for the calendar year 2010. Lastly, the weighting methodology for BRFSS changed in 2010, thus estimates after 2011 were not comparable to previous years (Centers for Disease Control and Prevention (CDC), 2012). To account for this, we examined the trends in the pre-expansion period (2003–2009) and post-expansion periods (2011–2015) by categorizing expanded and non-expanded states, and examined the trends while considering calendar year 2010 as our wash-out period.

5. Conclusion

In summary, our findings provide evidence that current smoking rates declined and quit attempts increased post-Medicaid expansion period; however, these trends were observed in both expanded and non-expanded states and were significantly influenced by state-level barriers to access smoking cessation services. Eliminating financial and logistical barriers to cessation services among Medicaid enrollees, and implementation of smoking related policies such as the indoor smoking ban and excise taxes may help to further reduce current smoking rates among US adults.

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Declaration of Competing Interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2019.100923>.

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