The Impact of Medicaid Expansion on Breast and Cervical Cancer Screening Rates

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Abstract

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Background: Screenings are an important public health intervention to prevent breast and cervical cancer. Previous studies have indicated a relationship between Medicaid expansion under the Affordable Care Act (ACA) and breast and cervical cancer screenings, but the results have been mixed and inconclusive. We examined the relationship between Medicaid expansion and breast and cervical cancer screenings among low-income women. In our secondary analyses, we assessed if this association was modified by race/ethnicity or rural residence status.

Methods: We used data from the Behavioral Risk Factor Surveillance System from 2012-2019, excluding 2017. States that expanded Medicaid before the ACA were excluded. A total of 27 states were considered Medicaid expansion states and 17 were considered non-expansion states. Participants included women with incomes up to 138% of the Federal Poverty Level (FPL) without

a previous cancer diagnosis, excluding Medicare-eligible ages. Using a difference-in-difference time series event design, this study compared the odds ratio of breast and cervical cancer screenings for a total of 8 years pre- and post-Medicaid expansion controlling for age, race/ethnicity, education, income, employment, having a regular healthcare provider, rurality, and year and state fixed effects. Dummy variables on years from expansion were created from 7 years before expansion up to 5 years after expansion, including a dummy variable indicating the expansion year. The expansion year dummy variable was coded as 1 if the year of observation was equivalent to the year when the state expanded Medicaid and 0 otherwise. Stratified analyses were used to test if there was an interaction at the multiplicative level by race/ethnicity or rurality.

Results: Among 27,290 women aged 40-64, 76.4% of the women residing in expansion states reported having an up-to-date breast cancer screening compared to 70.8% of women residing in non-expansion states. Among 30,808 women aged 18-64, 82.3% of the women residing in expansion states reported having an up-to-date cervical cancer screening compared to 79.9% of women residing in non-expansion states. Medicaid expansion was associated with 2.89-fold higher rate of up-to-date breast cancer screenings 1 year post-expansion (aOR 2.89; 95% CI: 1.34, 6.23). The odds ratios relating Medicaid expansion and up-to-date cervical cancer screenings during the expansion year and 4 years post-expansion were 1.35 (95% CI: 1.14, 1.61) and 1.37 (95% CI: 1.01, 1.85), respectively. The associations were stronger among White non-Hispanic, Black non-Hispanic women, and urban women for both breast and cervical cancer screenings.

Discussion: Medicaid expansion led to higher rates of up-to-date breast and cervical cancer screenings during some years pre- and post-expansion. These associations were modified by race/ethnicity and rurality. Future research should control for baseline rates of up-to-date breast and cervical cancer screening rates. A longitudinal study should be conducted to further control

for time-varying confounders. Findings support adoption of Medicaid expansion should be adopted by all states to improve breast and cervical cancer screening rates for low-income women.

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1. INTRODUCTION

In March of 2010, the Patient Protection and Affordable Care Act (ACA) was enacted, which contains many separate provisions regarding rules and guidelines on administering healthcare coverage in the United States (U.S.).[1] The ACA made substantial changes to Medicaid, specifically the expansion of eligibility to adults with incomes up to 138% of the Federal Poverty Level (FPL).[1,2] However, as Medicaid, funded jointly by the state and federal government, is administered by the states themselves the option to expand Medicaid coverage has varied by state. As of 2021, 39 states, including the District of Columbia, have adopted Medicaid expansion (2 states have adopted but not implemented Medicaid expansion) and 12 states have not adopted Medicaid expansion (Appendix A).[3]

Studies have shown that Medicaid expansion is associated with increased insurance coverage rates and improved access to care.[4-8] Studies have also shown an association between Medicaid expansion and positive health outcomes, including women's health outcomes.[7,9-13] In addition to expanding coverage, the ACA requires that Medicare and Medicaid, as well as private insurance, must cover all 10 essential services defined by the act.[1] For women, this includes breast cancer mammography screenings without any out-of-pocket expense every 1-2 years for women over 40 and cervical cancer screenings (pap test and HPV test) every 3 years for women 21-65 years of age.[14,15] Breast and cervical cancer screening rates are low compared to targets for women across the U.S.[16,17] Lack of health insurance coverage is a major factor in using mammography and pap smear services.[18,19] Further, there are disparities in breast and cervical cancer screenings and diagnoses among women by income, health insurance status, education level, race/ethnicity, and rural residence, and, insurance coverage was shown to greatly attenuate disparities.[18-20]

Previous studies have found that Black women have lower rates of mammogram utilization and are more likely to develop breast cancer compared to other women.[18] Hispanic women have lower rates of pap test utilization and are more likely to develop cervical cancer compared to other women.[19,20] Before the passing of the ACA, more inclusive state Medicaid eligibility requirements were associated with higher breast and cervical cancer screening rates.[21]

There have been limited studies of the impact of Medicaid expansion on cervical and breast cancer screenings.[21-28] While the literature in this area is growing, relationships have not yet been thoroughly investigated. Further, the few available studies have reported mixed results.[21-28] Besides inconsistencies, most studies did not analyze data past 2016, failing to study the long-term effects of Medicaid expansion on screening. Finally, studies examining the impact of Medicaid expansion on screening did not assess potential differential impact by race/ethnicity or rural/urban residence.

This study uses a nationally representative survey to measure the impact of Medicaid expansion on breast and cervical cancer screening outcomes among low-income women. Besides expanding the years of assessment, this study assesses how the relationship between Medicaid expansion and cancer screening among low-income women is modified by an individual's race/ethnicity and rural resident status.

2. METHODS

2.1 STUDY DESIGN

Using a difference-in-difference time series event design, this study takes advantage of the state-level option to adopt and implement Medicaid expansion beginning in 2014 to create a natural experiment of the effect of this policy on breast and cervical cancer screenings. This is a repeated

cross-sectional study comparing the odds ratio of breast and cervical cancer screenings pre- and post-Medicaid expansion in years 2012-2019, using data from the CDC Behavioral Risk Factor Surveillance System (BRFSS) surveys and the Kaiser Family Foundation.[3] The time series event study design allows us to determine if there are differing effects of Medicaid expansion based on several years before or after expansion in a state, as the effects may not be seen instantaneously.

2.1 STUDY SETTING

The study analyzed data collected from 44 U.S states, of which 27 were considered Medicaid expansion states (Alaska, Arizona, Arkansas, Colorado, Delaware, Hawaii, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Michigan, Montana, Nevada, New Hampshire, New Mexico, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Virginia, West Virginia) and 17 (Alabama, Florida, Georgia, Idaho, Kansas, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Wisconsin, Wyoming) were considered non-expansion states as of 2019. Early Medicaid expansion states, those that chose to expand eligibility before the national expansion in 2014 to some or all low-income groups targeted under the act, were excluded from this study, as these states would complicate and effect the time series event study design and experience differing effects than non-early adopters. These early Medicaid expansion states, California, Connecticut, the District of Columbia, Minnesota, New Jersey, and Washington, experienced different effects than states that chose to adopt during the national expansion, subject to the states' baseline match rate (Federal Medical Assistance Percentage) rather than the 100% (90% in the long run) initial federal funding offered by the ACA for newly eligible adults in 2014.[29] Vermont was also excluded from the analysis as the state had ACA-level Medicaid eligibility requirements pre-ACA.[3]

2.2 Study Population

Figure 1 and Figure 2 illustrate the exclusion criteria used to determine the appropriate study population for both the breast and cervical cancer screening analyses respectively. Study population restrictions removed 544,366 observations from the analyses (Figure 1; Figure 2). The initial sample included all respondents of the BRFSS surveys in the years 2012-2019, excluding 2017 (N = 3,215,587). Respondents from early expansion states (California, Connecticut, District of Columbia, Minnesota, New Jersey, Washington) were then excluded from the sample (N = 2,671,221). The sample was further restricted to females, as this is the most prominent group to be affected by breast and cervical cancer (N = 1,538,448). It should be noted that BRFSS respondents do not self-identify their sex and gender identity. This classification is made by the BRFSS interviewer based on their personal assumptions, which can vary based on who is conducting the interview.[29] Household size (total number of adults and children in household) and income were used to determine a core group of individuals that were not eligible for Medicaid before expansion but became eligible after expansion. Individuals with a household size and income up to 138% of the FPL were included in this study (N = 150,561). Women with a previous cancer diagnosis were excluded from the study, as this group may be fundamentally different from those without a history of cancer (N = 121,852). Participants who were 65 years and older, Medicare-eligible ages, were excluded from the sample, as Medicaid expansion would not affect this group. To assess the association between Medicaid expansion and breast cancer screening, the data sample was limited to women ages 40-64 in accordance with mammography recommendations from the American Cancer Society (N = 52,184).[30] To assess the association between Medicaid expansion and cervical cancer screening, the data sample was limited to women ages 18-64 in accordance with pap smear recommendations from the American College of Obstetricians and Gynecologists (ACOG).[31]

Although ACOG recommends women aged 21-65 should have a pap smear every three years, because age is coded in five-year categories in BRFSS, 18-24-year-olds were included to capture the minimum age requirement for screening (N = 73,791). In the cervical cancer screening analysis, individuals who indicated history of hysterectomy were also excluded, as this group would not be at risk of cervical cancer (33,414). Participants were included if they had data on breast and cervical cancer screening (ascertained from self-report). The final analytic population consisted of 27,290 women for the breast cancer screening analyses and 30,808 women for the cervical cancer screening analyses. The University of Washington Institutional Review Board determined this analysis of previously collected BRFSS data did not require human subjects' approval.

2.3 Data Sources

This study uses cross-sectional data from the CDC BRFSS surveys for the years 2012-2019 (excluding 2017).[32-38] BRFSS is a nationally representative, health-related telephone survey consisting of more than 450,000 telephone surveys with adults aged 18 and older each year in the U.S. The BRFSS questionnaire consists of a core module of questions asked of each respondent, which includes questions on breast and cervical cancer screenings. BRFSS is weighted to ensure representation of all demographic groups, taking into consideration that not all U.S. residents have equal access to cellular devices.[39,40] BRFSS data before 2011 used post-stratification weighting, which is incompatible with the proportional fitting used in BRFSS surveys after 2011.[41] The BRFSS 2011 and 2017 do not contain questions about breast and cervical cancer screenings, so the analysis was limited to BRFSS 2012-2016, 2018, and 2019.[42,43] It should be noted that there were still BRFSS data on women in the year 2017 collected from the BRFSS 2016 survey. State

Medicaid expansion status was determined using data gathered from the Kaiser Family Foundation (Appendix A).[3]

2.4 EXPOSURE

The exposure of interest was the respondents Medicaid expansion status by state and year. Dummy variables on years from expansion were created from 7 years before expansion up to 5 years after expansion, including a dummy variable indicating the expansion year. The year of expansion dummy variable was coded as 1 if the year of observation was equivalent to the year when the state expanded Medicaid and 0 otherwise. Similarly, the 1 year pre-expansion dummy variable was coded as 1 if the year of observation was equivalent to one year before the expansion year, and so on. It is worth noting that some states expanded Medicaid during the middle of the year (Appendix A). These states were coded as adopting Medicaid expansion during that year. No state rescinded their vote to expand Medicaid, meaning that states were included in the Medicaid expansion group throughout the timeline of the analysis after Medicaid expansion was implemented. Missouri and Oklahoma have adopted Medicaid expansion but have failed to implement were coded as 0, as there have been no effects of the policy on residents of those states (Appendix A). The study excluded early Medicaid expansion states and states that had expanded Medicaid eligibility requirements to ACA levels and beyond before the passing of the ACA (California, Connecticut, the District of Columbia, Minnesota, New Jersey, Vermont, Washington). A total of 27 states were considered Medicaid expansion states and 17 (were considered non-expansion states as of 2019.

2.5 OUTCOMES

The primary outcomes of interest were up-to-date breast and cervical cancer screenings. An up-to-date breast cancer screening was defined as having a mammogram in the past 2 years among women ages 40-64, based on 2021 American Cancer Society recommendations.[30] Only women who answered the breast cancer screening question in the BRFSS survey were included in the breast cancer analysis. An up-to-date cervical cancer screening was defined as having a pap smear test in the past 3 years among women ages 18-64, based on 2021 ACOG recommendations.[31] Only women who answered the cervical cancer screening question in the BRFSS survey were included in the cervical cancer analysis. Individuals who refused to the answer the question or those who answered don't know/unsure were excluded. These questions were only asked if you were identified as female by the BRFSS interviewer, meaning men were automatically excluded.

2.6 COVARIATES

Based on previous literature, factors that we considered as confounders were age (categorized into 5-year age groups), race/ethnicity (White non-Hispanic, Black non-Hispanic, other race non-Hispanic, Hispanic), educational attainment level (some high school, high school graduate, some college, college graduate), income level, employment status (employed, not employed), having a regular personal doctor or healthcare provider (yes/no), rurality (indicated by metropolitan statistical area and coded as urban, suburban, and rural). It should be noted that metropolitan statistical area was only assessed by the interviewer for respondents using landline phones (as opposed to cell phones). Year and state fixed effects were also included in each statistical model.

2.7 Data Analysis

The distribution of demographic information was examined by determining the frequency and weighted percentages by Medicaid expansion status (Table 1A; Table 1B). Using a difference-in-difference design, multivariate logistic regression models were used to compute the odds of breast and cervical cancer screenings associated with Medicaid expansion. First, logistic regression was used to compute the odds of breast and cervical cancer screening associated with Medicaid expansion using a crude model with the exposure and the outcome. For the primary analysis, the study used a logistic regression analysis to estimate equations of the form:

$$UTD\_BC_{ist} = \alpha_s + \alpha_t + \sum_{j=-7}^{5} \beta_j T_{jst} + \mathrm{B}X_{ist} + \varepsilon_{ist} \quad (0.1)$$

$$UTD\_CC_{ist} = \alpha_s + \alpha_t + \sum_{j=-7}^{5} \beta_j T_{jst} + \mathrm{B}X_{ist} + \varepsilon_{ist} \quad (0.2)$$

where UTD_BC represented an up-to-date breast cancer screening for an individual i residing in state s at year t, UTD_CC represented an up-to-date cervical cancer screening for an individual i residing in state s at year t, j indicated the number of years before or after expansion state *s* was in year t, T_{jst} was an indicator for whether state *s* was *j* years before or after Medicaid expansion at year t, X was a vector of individual-level control variables, and ε was a normally distributed error term. The variable T_{jst} was coded as zero for states that never expand Medicaid. In this model, the coefficients β_j measured the impact of Medicaid expansion *j* years after it occurs for $j \geq 0$ and can be used to check for pre-expansion trends for $j < 0$. The second model for the primary analysis used a fully adjusted model using the covariates described above (age, race/ethnicity, educational attainment level, income level, employment status, having a regular personal doctor or healthcare provider, and rurality).

For the secondary analyses evaluating effect modification by race/ethnicity and rurality, stratified analyses were used. Stratified analyses by race/ethnicity and rurality were fit using

Equations 2.1 and 2.2 listed above. Statistical significance of effect modification was determined by comparing odds ratios and their 95% confidence intervals across stratum.

Sensitivity analyses was conducted on the primary model by varying the age of the women included (50-64 for breast cancer screening and 25-64 for cervical cancer screening), the states included (using a propensity score matched model), and the use of educational attainment level as a proxy for income (limiting the sample to individuals without college degrees).

To conduct the propensity score based sensitivity analyses on the states included in the model, a propensity score matched model was developed to reduce confounding and more accurately determine the effect of the Medicaid expansion on breast and cervical cancer screening rates. Using a regression model, Medicaid expansion in 2019 was predicted in all 50 states and the District of Columbia using baseline characteristics from the U.S. Census Bureau American Community Survey 2010 data, including percent of the population that identifies as Black, percent of the population that identifies as Hispanic/Latino, percent of the population that identifies as "other" race, percent of population with a Bachelor's degree, percent of the population below the federal poverty level, percent of population receiving public assistance income, percent of population unemployed, and percent of population in a rural area. These propensity scores, or predicted probabilities of Medicaid expansion, were used to identify a "common support" region to be included in the study, where states are comparable in terms of included demographic characteristics and vary by the expansion of Medicaid. The highest propensity score in states that did not adopt Medicaid expansion by 2019 formed the upper bound, and the lowest propensity score in states that did adopt Medicaid expansion by 2019 formed the lower bound (Appendix B). This region included the following 26 states: Louisiana, Mississippi, Alabama, West Virginia, Texas, South Carolina, Kentucky, Arkansas, Georgia, New Mexico, North Carolina, North Dakota,

Florida, Wyoming, Tennessee, Indiana, Missouri, Nebraska, Montana, Idaho, Wisconsin, Oklahoma, South Dakota, Iowa, Utah, and Kansas (Figure 3).

Survey weights and robust standard error estimates clustered by state were used in all analyses. Statistical significance was determined using the $p<0.05$ cut off. All analyses were completed using Stata 17.0 (College Station, TX).

3. RESULTS

In this study based on 2012-2019 BRFSS data (excluding 2017), a total of 27,290 women aged 40-64 were included in the breast cancer screening analysis, including 7,761 women (28.4%) residing in states during years when Medicaid was expanded and 19,529 women (71.6%) residing in states during years when Medicaid was not expanded (Table 1A). Women in expansion states and years were similar in age to women in non-expansion states and years. Non-expansion states/years tended to have more women of color, with over 25% of women in the non-expansion group identifying as Black, Non-Hispanic (vs 19.0% in the expansion group). The non-expansion group also had more women who were uninsured (32.8% vs 11.1% in the expansion group). Most women in both the expansion and non-expansion group were high school graduates. The two groups were comparable in terms of marital status, income level, and employment status. The expansion group was made up of more women residing in urban areas (48.6% vs 39.1% in the non-expansion group) and women who had a regular personal doctor or healthcare provider (88.7% vs 81.7% in the non-expansion group). Among the 7,761 women who resided in states during years of state Medicaid expansion in this study, 76.4% reported having an up-to-date breast cancer screening. Among the 19,529 women who resided in states and years where Medicaid was not expanded in this study, 70.8% reported having an up-to-date breast cancer screening.

In this study based on 2012-2019 BRFSS data (excluding 2017), a total 30,808 women aged 18-64 were included in the cervical cancer screening analysis, including 8,100 women (28.4%) residing in states during years when Medicaid was expanded and 22,708 women (73.7%) residing in states during years when Medicaid was not expanded (Table 1B). Women in the expansion group were similar in age to women in non-expansion group, with the expansion group

having a slightly higher percentage of older women (11.8% in the expansion group vs 9.3% in the non-expansion group for women aged 55-59 and 9.4% in the expansion group vs 8.4% in the non-expansion group for women aged 60-64). The non-expansion group had a higher percentage of women of color compared to the expansion group (23.7% vs 18.7% in the expansion group for Black non-Hispanic women and 22.8% vs 19.6% in the expansion group for Hispanic women), which had a higher percentage of white women (52.8% vs 47.3% in the non-expansion group). The expansion group had a higher percentage of insured women (85.6% vs 61.3% in the non-expansion group). Expansion and non-expansion groups were comparable in terms of education level, marital status, income level, and employment status. The expansion group had a slightly higher percentage of women residing in urban areas (46.7% vs 40.9% in the non-expansion group), whereas the non-expansion group had a higher percentage of women residing in suburban (32.9% vs 30.4% in the expansion group) and rural areas (25.5% vs 22.7% in the expansion group). The expansion group also had a substantially higher percentage of women that had indicated having a regular personal doctor or healthcare provider (81.5% vs 71.6% in the non-expansion group). Among the 8,100 women who resided in states during years of state Medicaid expansion in this study, 82.3% reported having an up-to-date cervical cancer screening. Among the 22,708 women who resided in states and years where Medicaid was not expanded in this study, 79.9% reported having an up-to-date cervical cancer screening.

Table 2 presents the results of the unadjusted and adjusted models of the breast and cervical cancer screening analyses. In the fully adjusted model, the results indicate that women in expansion states had higher odds of having up-to-date breast cancer screenings compared to non-expansion states for all years of the analysis (except 4 and 5 years post-expansion), with 7 years pre-expansion (aOR 3.65; 95% CI: 1.83, 7.29), 4 years pre-expansion (aOR 2.46; 95% CI: 1.99,

3.05), 3 years pre-expansion (aOR 2.10; 95% CI: 1.01, 4.37), 2 years pre-expansion (aOR 1.28; 95% CI: 1.04, 1.56), and 1 year post-expansion (aOR 2.89; 95% CI: 1.34, 6.23) being statistically significant at the 95% confidence level. In the fully adjusted model for the cervical cancer screening analysis, the results also indicate that women in expansion states had higher odds of having up-to-date cervical cancer screenings compared to non-expansion states for all years in the analysis (except 1 year-post expansion), with 4 years pre-expansion (aOR 1.80; 95% CI: 1.32, 2.47), the expansion year (aOR 1.35; 95% CI: 1.14, 1.61), and 4 years post-expansion (aOR 1.37; 95% CI: 1.01, 1.85) being statistically significant at the 95% confidence level.

Table 3A and Table 3B present the results from the stratified analyses of the breast and cervical cancer screenings by race/ethnicity, respectively. In the breast cancer screening analysis, there was evidence that the association of years from expansion and an up-to-date breast cancer screening differed according to race/ethnicity for 7 years pre-expansion, 5 years pre-expansion, 4 years pre-expansion, 3 years pre-expansion, 2 years pre-expansion, 1 year pre-expansion, the expansion year, 1 year post-expansion, and 2 years post-expansion for some racial/ethnic categories. There was a statistically significant positive association of 7 years pre-expansion and up-to-date breast cancer screenings for White non-Hispanic (aOR 5.57; 95% CI: 2.14, 14.44), Black non-Hispanic (aOR 3.71; 95% CI: 1.32, 10.40), and Hispanic women (aOR 1.48; 95% CI: 1.06, 2.06). There was also a statistically significant positive association of 1 year post-expansion and up-to-date breast cancer screenings for White non-Hispanic (aOR 2.35; 95% CI: 1.18, 4.67), Black non-Hispanic (aOR 4.14; 95% CI: 1.46, 11.74), and Hispanic women (aOR 79.44; 95% CI: 29.74, 212.27). In the cervical cancer screening analysis, there was evidence that the association of years from expansion and an up-to-date breast cancer screening differed according to race/ethnicity for 4 years pre-expansion, 3 years pre-expansion, 2 years pre-expansion, 1 year pre-

expansion, the expansion year, 1 year post-expansion, 2 years post-expansion, 3 years post-expansion, 4 years post-expansion, and 5 years post-expansion for some racial/ethnic categories. The associations of years from expansion and up-to-date cervical cancer screenings were mixed with some racial/ethnic categories having statistically significant positive associations and others have statistically significant negative associations. For example, 2 years post-expansion there was a statistically positive association of expansion and up-to-date cervical cancer screenings for White non-Hispanic women (aOR 1.68; 95% CI: 1.23, 2.29), but a statistically significant negative association for Black non-Hispanic (aOR 0.26; 95% CI: 0.11, 0.59) and other race non-Hispanic women (aOR 0.25; 95% CI: 0.10, 0.61). In both analyses, the 95% confidence intervals were large for some years due to low numbers in each stratum.

Table 4A and Table 4B present the results from the fully interacted models of the breast and cervical cancer screenings by rurality, respectively. In the breast cancer screening analysis, among urban women, there was a statistically significant positive association of up-to-date breast cancer screenings and 4 years pre-expansion (aOR 3.05; 95% CI: 2.04, 4.58) and 1 year post-expansion (aOR 4.18; 95% CI: 1.25, 12.92). Among suburban women, there was a statistically significant positive association of 4 years pre-expansion and up-to-date breast cancer screenings (aOR 2.42; 95% CI: 1.70, 3.46). Among rural women, there was a statistically significant negative association of up-to-date breast cancer screenings 2 years pre-expansion (aOR 0.73; 95% CI: 0.58, 0.93) and 5 years post-expansion (aOR 0.34; 95% CI: 0.16, 0.75). In the cervical cancer screening analysis, among urban women, there was a statistically significant negative association of up-to-date cervical cancer screenings and 2 years pre-expansion, the expansion year, 2 years post-expansion, and 4 years post-expansion. For suburban women, the results were mixed, with 7 years pre-expansion and 5 years pre-expansion having a statistically significant negative association with

up-to-date cervical cancer screenings and 4 years pre-expansion and 4 years post-expansion having a statistically significant positive association. Among rural women, 7 years pre-expansion and 4 years pre-expansion were associated with increased odds of up-to-date cervical cancer screenings.

The sensitivity analysis limiting to a common support region of states yielded similar findings to those reported above (Table 5), though 7 years and 5 years pre-expansion were omitted from the analysis. The sensitivity analysis restricting the age of women included in the analyses also yielded similar results to those above (Table 6). Estimates of associations from the sensitivity analysis using education as a proxy for income level were slightly attenuated for the fully adjusted models on breast and cervical cancer screenings (Table 7).

4. DISCUSSION

In the current study, Medicaid expansion was associated with higher odds of up-to-date breast cancer screenings 1 year after the expansion year. Similarly, Medicaid expansion was also associated with higher odds of up-to-date cervical cancer screenings the year of Medicaid expansion and 4 years after Medicaid expansion. We also observed that the expansion states had significantly higher odds of up-to-date breast and cervical cancer screenings in pre-expansion years. From these analyses, it appears that the difference in up-to-date breast cancer screenings wanes as the years post-expansion increase, while the difference is more stable for up-to-date cervical cancer screenings.

Previous literature on this topic has found that Medicaid expansion increased cervical cancer screenings but had insignificant effects on breast cancer screenings.[26] Yet another study found that in non-expansion states women were significantly less likely to receive recommended breast cancer screenings.[28] Our findings differ slightly from previous literature indicating that

expansion was associated with increased breast and cervical cancer screenings. However, our findings provide additional context via the time series event study design. From our study, we are able to analyze up-to-date breast and cervical cancer screening rates in relation to when a state decided to expand Medicaid. From our analyses, statistically significant positive associations of up-to-date breast and cervical cancer screenings in pre-expansion years could indicate potential uncontrolled confounding, meaning states that chose to adopt Medicaid may also have adopted other policies and programs that would improve cancer screening rates. This could mean that Medicaid expansion alone wouldn't have targeted women in these states, as additional state programs, policies, or other factors may have already targeted these women for cancer screenings. For Medicaid expansion states, expansion may not have had an impact on cancer screening rates as there were already policies in place that had preexisting impacts on health behaviors of women in the state. From the stratified analyses, it appears that the association of years from expansion and up-to-date breast and cervical cancer screenings was modified by race/ethnicity. There is also evidence that the association of years from expansion and up-to-date breast and cervical cancer screening was modified by rurality; however, this was less apparent than the modification seen by race/ethnicity. Previous studies have found that Black women have lower rates of mammogram utilization and are more likely to develop breast cancer compared to other women.[18] Hispanic women have lower rates of pap test utilization and are more likely to develop cervical cancer compared to other women.[19,20] Another found that there was an insignificant increase in the breast cancer screening rate.[27]

Although BRFSS is a national survey, there are inherent limitations when using this data in relation to this study. The breast and cervical cancer screening questions were not included in BRFSS 2017. Although some observations for 2017 were acquired through the BRFSS 2016

dataset, this does affect the longitudinal nature of the study. This study relied on self-reported breast and cervical cancer screening, as well as screening recency, making the ascertainment of the outcome vulnerable to social desirability bias and recall bias. An up-to-date breast cancer screening was coded as every 2 years, while an up-to-date cervical cancer screening was coded as every 3 years. If an individual responds they had their last screening in the past two years in a state that implemented Medicaid expansion that year, there could be misclassification bias of the outcome, as this scenario has nothing to do with the expansion of Medicaid in that individual's state, because the screening took place before expansion was implemented.

Additionally, in order for a difference-in-difference analysis to estimate a causal effect, various assumptions must hold including that Medicaid expansion was not determined by cervical and breast cancer screening rates, that the difference between the expansion and non-expansion states is constant over time (parallel trends assumption), and the composition of the expansion and non-expansion states are stable for repeated cross-sectional data. Additionally, difference-in-difference study designs only allow researchers to analyze the effect of a policy on complier states, those that adopt the policy. Therefore, we are limited in our understanding of how Medicaid expansion would affect non-complier states, those that have not expanded Medicaid. The trend of increased up-to-date breast and cervical cancer screenings seen in complier states may not be present in non-complier states, meaning that adopting Medicaid expansion in these states would have a great impact.

A longitudinal prospective cohort study would allow researchers to determine if Medicaid expansion increases health coverage and that health coverage increases preventative cancer screenings. Using this study design, researchers could also establish temporality and look at decisions made immediately following and longitudinally after a Medicaid expansion policy is

adopted in a state. Prospective studies focused on individuals who gain health coverage through a Medicaid expansion policy could help to clarify causality and eliminate confounders in the analysis. Understanding the impact of the ACA on health outcomes, such as cancer screenings, is crucial to informing ongoing debates about adoption, implementation, and areas for improvement. Gained knowledge will also help in the effort to address health inequity among rural women and women of color.

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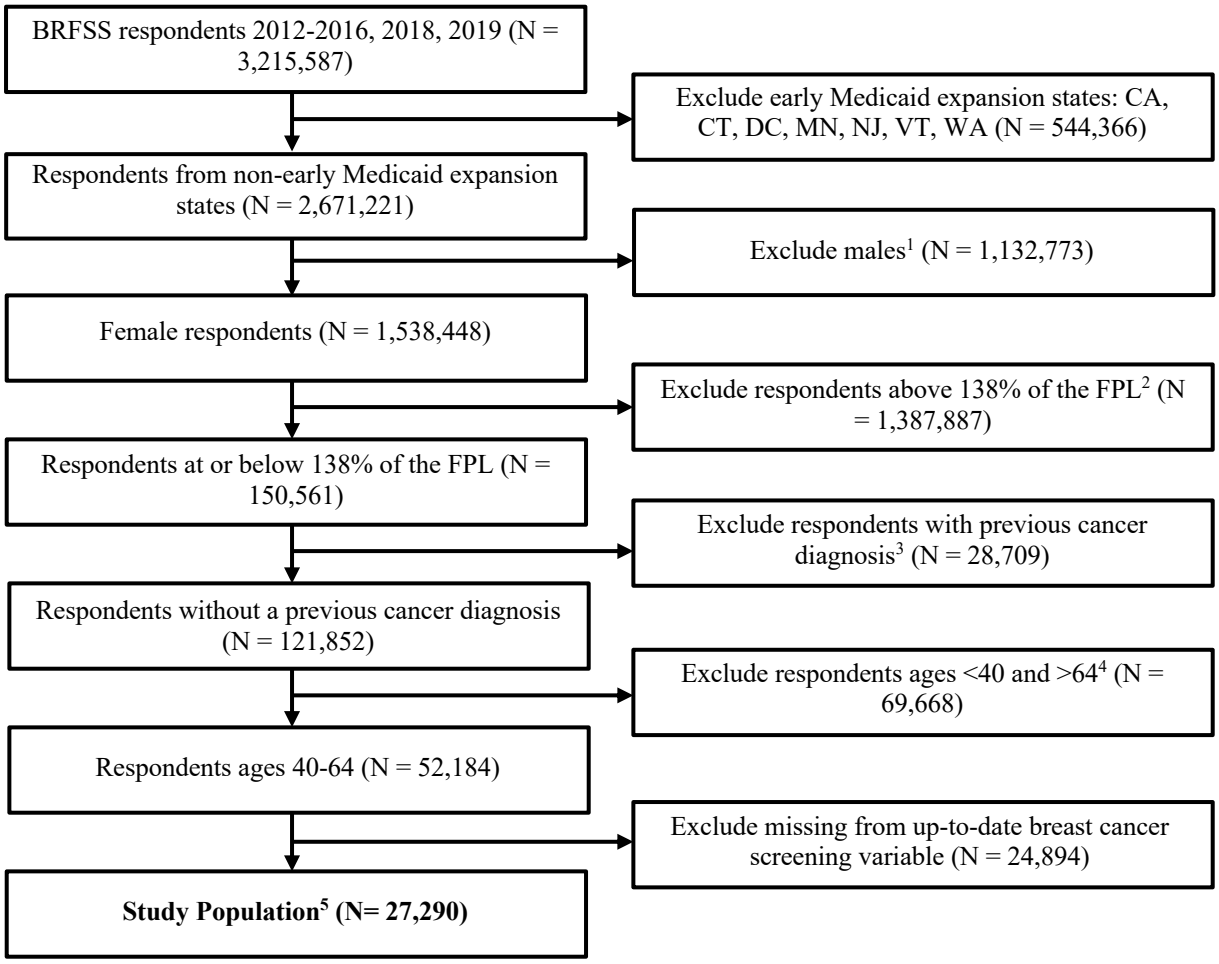
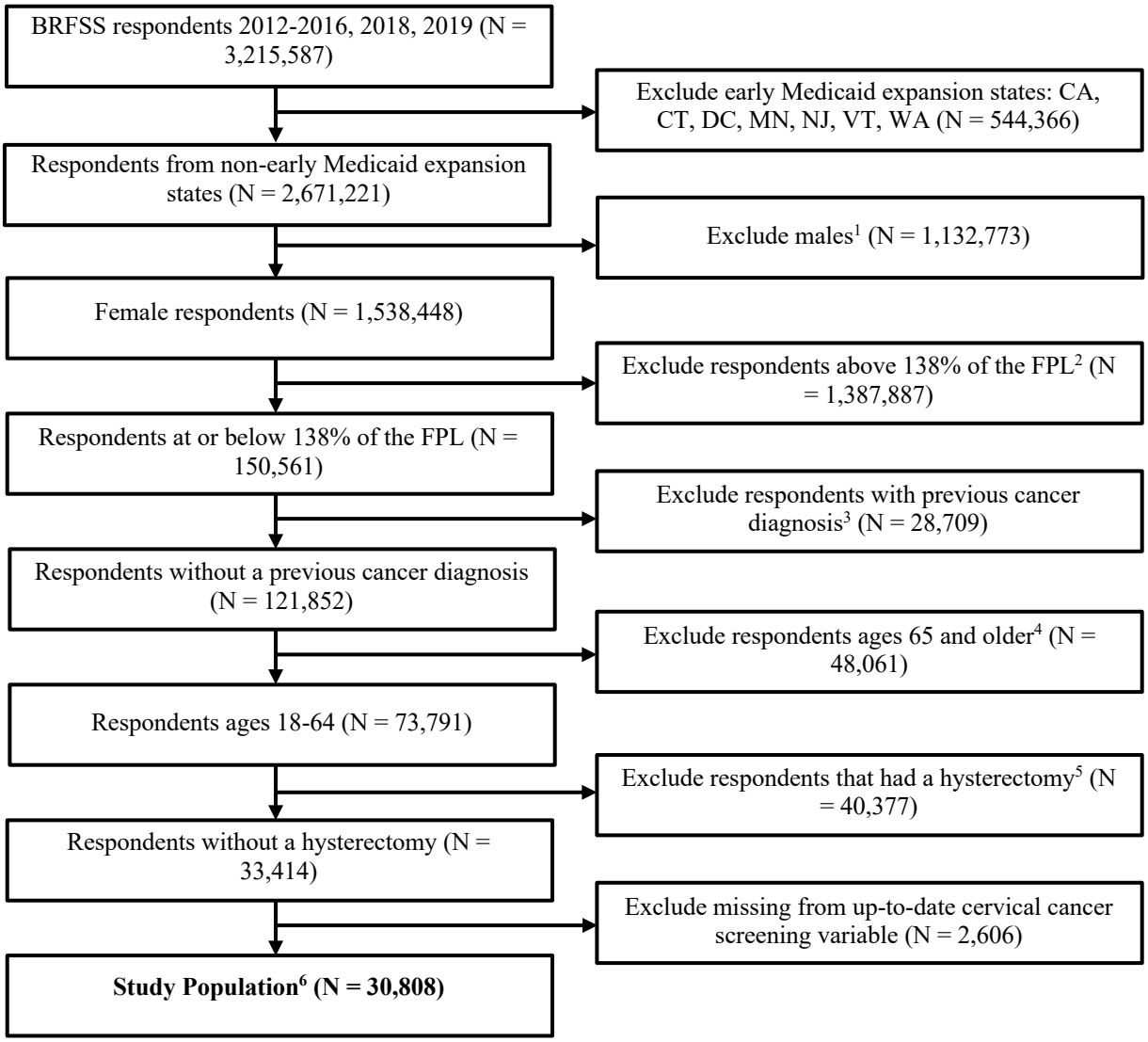
Figure 1. Sample population for breast cancer screening analyses



1. Also excludes don't know/refused and missing responses from *sex* variable.
2. Also excludes don't know/refused and missing responses from *children* and *numadult* variable.
3. Also excludes don't know/refused and missing responses from *chcocncr* and *chcscncr* variable.
4. Also excludes don't know/refused and missing responses from *age* variable.
5. Sample population includes 767 missing responses from covariates included in logistic regression models (education, employment, insurance, regular health care provider, marital status, mscode, and race/ethnicity).

Figure 2. Sample population for cervical cancer screening analyses



1. Also excludes don't know/refused and missing responses from *sex* variable.
2. Also excludes don't know/refused and missing responses from *children* and *numadult* variable.
3. Also excludes don't know/refused and missing responses from *chcocncr* and *chcscncr* variable.
4. Also excludes don't know/refused and missing responses from *age* variable.
5. Also excludes don't know/refused and missing responses from *hadhyst2* variable.
6. Sample population includes 815 missing responses from covariates included in logistic regression models (education, employment, insurance, regular health care provider, marital status, mscode, and race/ethnicity).

Figure 3. Comparison of predicted and actual state Medicaid expansion

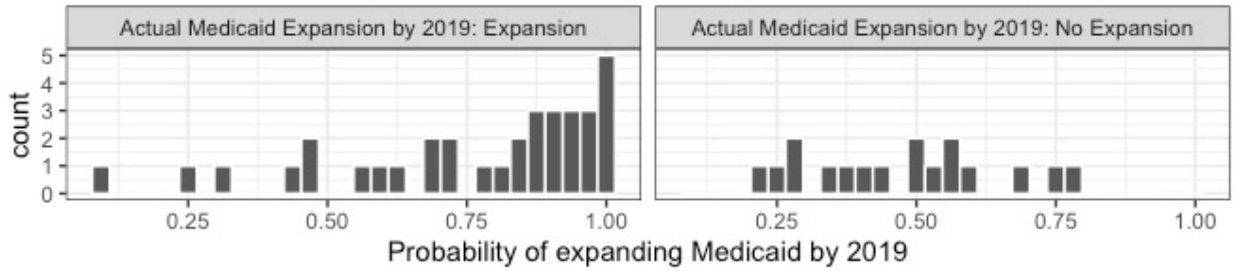


Table 1A. Selected characteristics of low-income women* ages 40-64 by state Medicaid expansion status, Behavioral Risk Factors Surveillance System, 2012-2019 (N = 27,290)**

	Expansion States/Years[1]		Non-Expansion States/Years	
Characteristics	**N = 7,761*** (unweighted)**	**% weighted[2]**	**N = 19,529*** (unweighted)**	**% weighted[2]**
Breast Cancer Screening				
Up-to-date[3]	5,806	76.4	13,890	70.8
Not up-to-date	1,955	23.6	5,639	29.2
Ages (years)				
40-44	763	16.8	2,068	15.9
45-49	1,154	15.8	2,970	17.5
50-54	1,645	22.7	4,274	23.7
55-59	2,075	24.5	4,996	21.6
60-64	2,124	20.2	5,221	21.2
Race/Ethnicity				
White only, Non-Hispanic	4,877	52.9	11,065	47.7
Black only, Non-Hispanic	1,088	19.0	4,874	26.6
Other race, Non-Hispanic	776	8.1	1,535	5.0
Hispanic	916	18.8	1,854	19.6
Health Insurance Coverage				
Insured[4]	6,996	88.7	13,919	66.9
Uninsured	748	11.1	5,549	32.8
Education Level				
Some high school	1,336	27.9	3,752	29.5
High school graduate	3,157	38.3	8,059	37.4
Some college[5]	2,249	26.1	5,397	25.6
College graduate[5]	1,013	7.7	2,302	7.4
Marital Status				
Married	2,219	38.7	5,603	38.1
Not currently married[6]	5,504	60.8	13,856	61.5
Household Income				
<$10,000	2,306	23.7	6,233	25.1

$10,000 - <$15,000	2,357	22.9	5,882	25.0
$15,000 - <$20,000	1,740	24.9	4,361	26.0
$20,000 - <$25,000	1,065	21.5	2,424	18.1
$25,000+	293	7.1	629	5.8
Employment				
Employed[7]	2,145	33.0	5,640	32.5
Not employed[8]	5,596	66.7	13,818	67.2
Rurality				
Urban[9]	2,759	48.6	5,736	39.1
Suburban[10]	2,126	30.0	5,202	32.9
Rural[11]	2,864	21.3	8,506	27.3
Regular Healthcare Provider				
Yes[12]	6,896	88.7	16,528	81.7
No	838	11.0	2,918	17.8

*Excludes women with incomes above 138% of the Federal Poverty Level and those with a previous cancer diagnosis.
**Excludes 2017 BRFSS dataset.
***Numbers may not add up due to missing data.
1. Excludes early expansion states: California, Connecticut, the District of Columbia, Minnesota, New Jersey, Vermont, and Washington.
2. Percentages weighted using final sample weights combining landline and cellphone data in BRFSS to account for survey sampling methods.
3. Defined as having a mammogram in the past 2 years (based on the American Cancer Society recommendations).
4. Includes both government and private insurance.
5. Includes both college and technical school.
6. Includes individuals that are divorced, separated, widowed, single, or in an unmarried partnership.
7. Includes individuals employed for wages and those that are self-employed.
8. Includes individuals that are out of work, those that are unable to work, retired, students, or homemakers.
9. Includes individuals residing in the center city of a metropolitan statistical area (MSA).
10. Includes individuals residing in the inside the county containing an MSA (but outside of the center city) or inside a suburban county containing an MSA.
11. Includes individuals not residing in an MSA.
12. Having one or more personal doctors or health care providers.

Table 1B. Selected characteristics of low-income women* ages 18-64 by state Medicaid expansion status, Behavioral Risk Factors Surveillance System, 2012-2019 (N = 30,808)**

	Expansion States/Years[1]		Non-Expansion States/Years	
Characteristics	**N = 8,100*** (unweighted)**	**% weighted[2]**	**N = 22,708*** (unweighted)**	**% weighted[2]**
Cervical Cancer Screening				
Up-to-date[3]	6,334	82.3	17,555	79.9
Not up-to-date	1,766	17.7	5,153	20.2
Ages (years)				
18-24	288	8.2	1,000	7.6
25-29	536	9.8	1,778	9.1
30-34	806	15.2	2,634	15.3
35-39	874	11.4	2,620	13.0
40-44	875	12.9	2,514	13.5
45-49	920	9.8	2,630	11.3
50-54	1,177	11.7	3,110	12.5
55-59	1,337	11.8	3,296	9.3
60-64	1,287	9.4	3,126	8.4
Race/Ethnicity				
White only, Non-Hispanic	4,907	52.8	12,618	47.3
Black only, Non-Hispanic	1,001	18.7	4,951	23.7
Other race, Non-Hispanic	966	7.8	1,936	5.2
Hispanic	1,145	19.6	2,992	22.8
Health Insurance Coverage				
Insured[4]	7,065	85.6	14,934	61.3
Uninsured	1,014	14.2	7,709	38.4
Education Level				
Some high school	1,338	25.4	4,026	27.3
High school graduate	3,148	36.3	8,889	35.6
Some college[5]	2,507	30.0	6,872	29.0
College graduate[5]	1,102	8.2	2,901	8.0
Marital Status				

Married	2,466	37.2	7,107	36.4
Not currently married[6]	5,597	62.5	15,531	63.2
Household Income				
<$10,000	2,126	22.0	6,009	20.8
$10,000 - <$15,000	2,047	19.1	5,555	20.1
$15,000 - <$20,000	1,873	24.8	5,424	26.2
$20,000 - <$25,000	1,483	23.6	4,128	23.2
$25,000+	571	10.5	1,592	9.8
Employment				
Employed[7]	2,955	40.5	8,709	39.8
Not employed[8]	5,111	59.0	13,906	59.8
Rurality				
Urban[9]	2,783	46.9	6,874	40.9
Suburban[10]	2,141	30.4	6,119	32.9
Rural[11]	3,163	22.7	9,619	25.5
Regular Healthcare Provider				
Yes[12]	6,664	81.5	17,158	71.6
No	1,406	18.2	5,468	27.9

*Excludes women with incomes above 138% of the Federal Poverty Level, those with a previous cancer diagnosis, and those that have had a hysterectomy.
**Excludes 2017 BRFSS dataset.
***Numbers may not add up due to missing data.
1. Excludes early expansion states: California, Connecticut, the District of Columbia, Minnesota, New Jersey, Vermont, and Washington.
2. Percentages weighted using final sample weights combining landline and cellphone data in BRFSS to account for survey sampling methods.
3. Defined as having a pap smear test in the past 3 years (based on ACOG recommendations).
4. Includes both government and private insurance.
5. Includes both college and technical school.
6. Includes individuals that are divorced, separated, widowed, single, or in an unmarried partnership.
7. Includes individuals employed for wages and those that are self-employed.
8. Includes individuals that are out of work, those that are unable to work, retired, students, or homemakers.
9. Includes individuals residing in the center city of a metropolitan statistical area (MSA).
10. Includes individuals residing in the inside the county containing an MSA (but outside of the center city) or inside a suburban county containing an MSA.
11. Includes individuals not residing in an MSA.
12. Having one or more regular personal doctors or health care providers.

Table 2. Associations of year of state Medicaid expansion with up-to-date breast and cervical cancer screening rates

	Up-to-date Breast Cancer Screening		Up-to-date Cervical Cancer Screening	
Medicaid Expansion	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
7 Years Pre-Expansion	**2.63** (1.34-5.18)**	**3.65** (1.83-7.29)**	0.90 (0.45-1.77)	1.75 (0.77-4.01)
6 Years Pre-Expansion	1.00 (*omitted)*	1.00 (*omitted)*	1.00 (*omitted)*	1.00 (*omitted)*
5 Years Pre-Expansion	0.85 (0.37-1.97)	1.16 (0.46-2.89)	0.74 (0.38-1.42)	1.14 (0.52-2.50)
4 Years Pre-Expansion	**1.76** (1.43-2.17)**	**2.46** (1.99-3.05)**	1.14 (0.85-1.52)	**1.80** (1.32-2.47)**
3 Years Pre-Expansion	1.56 (0.72-3.34)	**2.10* (1.01-4.37)**	0.74 (0.41-1.36)	1.05 (0.50-2.22)
2 Years Pre-Expansion	0.95 (0.81-1.12)	**1.28* (1.04-1.56)**	**0.76** (0.65-0.89)**	1.19 (0.99-1.44)
1 Year Pre-Expansion	1.00 (0.52-1.92)	1.42 (0.72-2.82)	1.00 (0.49-2.05)	1.37 (0.56-3.34)
Expansion Year	0.86 (0.60-1.23)	1.15 (0.81-1.64)	0.92 (0.79-1.07)	**1.35** (1.14-1.61)**
1 Year Post-Expansion	**2.19* (1.07-4.46)**	**2.89*** (1.34-6.23)**	0.80 (0.48-1.34)	0.99 (0.49-2.02)
2 Years Post-Expansion	1.06 (0.78-1.45)	1.47 (0.94-2.32)	**0.75** (0.60-0.93)**	1.02 (0.76-1.37)
3 Years Post-Expansion	1.07 (0.58-1.99)	1.33 (0.68-2.59)	1.34 (0.60-2.95)	1.91 (0.70-5.27)
4 Years Post-Expansion	0.76 (0.55-1.07)	0.99 (0.66-1.49)	0.91 (0.67-1.24)	**1.37* (1.01-1.85)**
5 Years Post-Expansion	0.84 (0.28-2.53)	0.94 (0.32-2.75)	0.89 (2.88-2.73)	1.42 (0.36-5.66)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age, race/ethnicity, educational attainment level, income level, employment status, having a regular healthcare provider, rurality, as well as state and year fixed effects.

Table 3A. Associations of year of state Medicaid expansion with up-to-date breast cancer screening rates, stratified by race/ethnicity

	Up-to-date Breast Cancer Screening, aOR (95% CI)			
	Race/Ethnicity			
Medicaid Expansion	**White, Non-Hispanic**	**Black, Non-Hispanic**	**Other race, Non-Hispanic**	**Hispanic**
7 Years Pre-Expansion	**5.57** (2.14-14.44)**	**3.71* (1.32-10.40)**	18.16 (0.61-544.44)	**1.48* (1.06-2.06)**
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.26 (0.52-3.05)	**4.96** (1.73-14.25)**	11.41 (0.34-387.69)	**9.19e+6 (2.65e+6-3.19e7)**
4 Years Pre-Expansion	**3.37** (2.65-4.30)**	**2.95** (1.69-5.17)**	0.33 (0.07-1.64)	3.54 (0.12-101.12)
3 Years Pre-Expansion	1.88 (0.98-3.62)	**4.17* (1.35-12.89)**	1.92 (0.15-25.00)	**5.52** (2.44-12.51)**
2 Years Pre-Expansion	**1.42** (1.16-1.74)**	**1.87** (1.33-2.62)**	0.65 (0.29-1.46)	1.76 (0.06-52.08)
1 Year Pre-Expansion	1.46 (0.68-3.16)	**3.91** (1.44-10.62)**	1.69 (0.46-6.16)	1.00 (0.15-6.76)
Expansion Year	1.18 (0.92-1.51)	**2.36** (1.51-3.70)**	0.77 (0.51-1.14)	1.23 (0.04-42.09)
1 Year Post-Expansion	**2.35* (1.18-4.67)**	**4.14** (1.46-11.74)**	0.38 (0.03-4.82)	**79.44** (29.74-212.27)**
2 Years Post-Expansion	1.25 (0.91-1.72)	**2.80** (1.39-5.63)**	**0.16** (0.04-0.63)**	5.84 (0.21-162.80)
3 Years Post-Expansion	0.89 (0.46-1.71)	3.30 (0.48-22.55)	1.30 (0.30-5.63)	12.72 (0.32-498.72)
4 Years Post-Expansion	1.01 (0.64-1.60)	1.42 (0.62-3.28)	0.36 (0.13-1.02)	1.16 (0.03-41.20)
5 Years Post-Expansion	0.78 (0.33-1.88)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age (40-44, 45-49, 50-54, 55-59, 60-64), race/ethnicity (White non-Hispanic, Black non-Hispanic, other race non-Hispanic, Hispanic), educational attainment level (some high school, high school graduate, some college, college graduate), income level (<$10,000, $10,000-<$15,000, $15,000-<$20,000, $20,000-<$25,000, $25,000+), employment status (employed, not employed), having a regular healthcare provider (yes/no), rurality (urban, suburban, rural), as well as state and year fixed effects.

Table 3B. Associations of year of state Medicaid expansion with up-to-date cervical cancer screening rates, stratified by race/ethnicity

	Up-to-date Cervical Cancer Screening, aOR (95% CI)			
	Race/Ethnicity			
Medicaid Expansion	**White, Non-Hispanic**	**Black, Non-Hispanic**	**Other race, Non-Hispanic**	**Hispanic**
7 Years Pre-Expansion	2.10 (0.95-4.62)	1.03 (0.11-9.75)	3.00 (0.13-71.90)	1.40 (0.84-2.35)
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.15 (0.57-2.29)	1.09 (0.12-9.80)	31.59 (0.32-3164.61)	1.00 (*omitted*)
4 Years Pre-Expansion	**1.47** (1.21-1.77)**	1.16 (0.64-2.09)	0.44 (0.10-1.84)	**27.93** (4.45-175.25)**
3 Years Pre-Expansion	0.99 (0.51-1.92)	1.08 (0.13-8.96)	3.23 (0.25-42.24)	1.38 (0.58-3.26)
2 Years Pre-Expansion	**1.43** (1.23-1.66)**	**0.52* (0.29-0.93)**	1.00 (0.50-2.00)	**7.59* (1.13-50.95)**
1 Year Pre-Expansion	1.39 (0.63-3.06)	0.83 (0.07-10.29)	4.33 (0.86-21.92)	1.94 (0.61-6.12)
Expansion Year	**1.62** (1.27-2.07)**	1.13 (0.70-1.83)	0.98 (0.47-2.03)	5.04 (0.82-31.13)
1 Year Post-Expansion	1.05 (0.52-2.12)	0.51 (0.04-5.91)	0.73 (0.09-5.76)	**3.86** (1.48-10.09)**
2 Years Post-Expansion	**1.68** (1.23-2.29)**	**0.26** (0.11-0.59)**	**0.25** (0.10-0.61)**	5.73 (0.70-47.21)
3 Years Post-Expansion	1.65 (0.71-3.86)	3.02 (0.42-21.77)	2.26 (0.30-16.75)	**13.88* (1.07-180.60)**
4 Years Post-Expansion	**1.80** (1.22-2.65)**	0.74 (0.37-1.50)	0.39 (0.12-1.31)	4.46 (0.75-26.61)
5 Years Post-Expansion	0.96 (0.14-6.71)	**167.86** (22.28-1264.67)**	1.00 (*omitted*)	1.00 (*omitted*)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age (18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64), race/ethnicity (White non-Hispanic, Black non-Hispanic, other race non-Hispanic, Hispanic), educational attainment level (some high school, high school graduate, some college, college graduate), income level (<$10,000, $10,000-<$15,000, $15,000-<$20,000, $20,000-<$25,000, $25,000+), employment status (employed, not employed), having a regular healthcare provider (yes/no), rurality (urban, suburban, rural), as well as state and year fixed effects.

Table 4A. Associations of year of state Medicaid expansion with up-to-date breast cancer screening rates, stratified by rurality

	Up-to-date Breast Cancer Screening, aOR (95% CI)		
	Rurality		
Medicaid Expansion	**Urban**	**Suburban**	**Rural**
7 Years Pre-Expansion	1.96 (0.44-8.80)	2.20 (0.65-7.42)	2.17 (0.75-6.28)
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.76 (0.44-7.09)	0.75 (0.17-3.42)	0.38 (0.13-1.12)
4 Years Pre-Expansion	**3.05** (2.04-4.58)**	**2.42** (1.70-3.46)**	1.08 (0.83-1.41)
3 Years Pre-Expansion	3.60 (0.81-15.96)	0.69 (0.25-1.94)	0.87 (0.33-2.27)
2 Years Pre-Expansion	0.92 (0.66-1.26)	1.07 (0.79-1.46)	**0.73** (0.58-0.93)**
1 Year Pre-Expansion	1.83 (0.59-5.64)	0.67 (0.21-2.17)	0.65 (0.30-1.41)
Expansion Year	0.82 (0.56-1.21)	0.86 (0.54-1.37)	0.87 (0.63-1.20)
1 Year Post-Expansion	**4.18* (1.35-12.92)**	1.19 (0.32-4.44)	1.10 (0.58-2.12)
2 Years Post-Expansion	1.10 (0.73-1.66)	1.10 (0.47-2.54)	0.92 (0.65-1.32)
3 Years Post-Expansion	1.40 (0.56-3.52)	1.36 (0.36-5.18)	0.40 (0.11-1.47)
4 Years Post-Expansion	0.56 (0.30-1.08)	0.83 (0.47-1.48)	1.01 (0.59-1.72)
5 Years Post-Expansion	2.55 (0.17-38.02)	0.81 (0.17-3.76)	**0.34** (0.16-0.75)**

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age (40-44, 45-49, 50-54, 55-59, 60-64), race/ethnicity (White non-Hispanic, Black non-Hispanic, other race non-Hispanic, Hispanic), educational attainment level (some high school, high school graduate, some college, college graduate), income level (<$10,000, $10,000-<$15,000, $15,000-<$20,000, $20,000-<$25,000, $25,000+), employment status (employed, not employed), having a regular healthcare provider (yes/no), rurality (urban, suburban, rural), as well as state and year fixed effects.

Table 4B. Associations of year of state Medicaid expansion with up-to-date cervical cancer screening rates, stratified by rurality

	Up-to-date Cervical Cancer Screening, aOR (95% CI)		
	Rurality		
Medicaid Expansion	**Urban**	**Suburban**	**Rural**
7 Years Pre-Expansion	0.92 (0.44-1.89)	**0.30* (0.11-0.80)**	**4.46* (1.02-19.47)**
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.02 (0.52-2.02)	**0.24** (0.09-0.63)**	1.43 (0.39-5.19)
4 Years Pre-Expansion	0.90 (0.69-1.19)	**1.71** (1.18-2.47)**	**1.99* (1.03-3.85)**
3 Years Pre-Expansion	0.94 (0.53-1.65)	0.39 (0.15-1.05)	1.22 (0.38-3.93)
2 Years Pre-Expansion	**0.53** (0.43-0.64)**	1.07 (0.85-1.34)	0.98 (0.76-1.25)
1 Year Pre-Expansion	0.95 (0.39-2.33)	0.85 (0.28-2.53)	1.29 (0.40-4.13)
Expansion Year	**0.63** (0.49-0.81)**	1.24 (0.96-1.61)	0.98 (0.76-1.25)
1 Year Post-Expansion	0.48 (0.21-1.09)	0.88 (0.27-2.90)	1.29 (0.40-4.19)
2 Years Post-Expansion	**0.57** (0.43-0.74)**	0.89 (0.49-1.63)	0.92 (0.48-1.75)
3 Years Post-Expansion	1.56 (0.37-6.53)	1.87 (0.59-5.99)	1.18 (0.24-5.85)
4 Years Post-Expansion	**0.36** (0.21-0.62)**	**2.41** (1.38-4.19)**	1.24 (0.77-2.01)
5 Years Post-Expansion	1.08 (0.17-6.86)	2.16 (0.77-6.03)	0.46 (0.07-3.10)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age (18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64), race/ethnicity (White non-Hispanic, Black non-Hispanic, other race non-Hispanic, Hispanic), educational attainment level (some high school, high school graduate, some college, college graduate), income level (<$10,000, $10,000-<$15,000, $15,000-<$20,000, $20,000-<$25,000, $25,000+), employment status (employed, not employed), having a regular healthcare provider (yes/no), rurality (urban, suburban, rural), as well as state and year fixed effects.

Table 5. Associations of year of state Medicaid expansion with up-to-date breast and cervical cancer screening rates, sensitivity analysis using common support region

	Up-to-date Breast Cancer Screening		Up-to-date Cervical Cancer Screening	
Medicaid Expansion	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
7 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
4 Years Pre-Expansion	**1.79** (1.48-2.16)**	**2.60** (2.10-3.22)**	1.23 (0.89-1.70)	**2.09** (1.46-2.99)**
3 Years Pre-Expansion	1.16 (0.66-2.05)	1.51 (0.92-2.49)	0.73 (0.39-1.38)	1.42 (0.70-2.91)
2 Years Pre-Expansion	**1.15** (1.04-1.28)**	**1.60** (1.39-1.83)**	**0.81* (0.68-0.97)**	**1.30** (1.07-1.59)**
1 Year Pre-Expansion	0.77 (0.41-1.41)	0.97 (0.53-1.79)	0.80 (0.43-1.50)	1.40 (0.67-2.92)
Expansion Year	**0.77* (0.62-0.97)**	1.11 (0.87-1.41)	0.82 (0.67-1.00)	**1.27* (1.05-1.54)**
1 Year Post-Expansion	**1.94* (1.13-3.31)**	**2.48** (1.42-4.32)**	1.00 (0.60-1.69)	1.66 (0.87-3.18)
2 Years Post-Expansion	1.05 (0.80-1.38)	1.47 (0.93-2.31)	0.97 (0.70-1.33)	1.39 (0.89-2.17)
3 Years Post-Expansion	1.52 (0.86-2.69)	**1.98** (1.28-3.08)**	2.02 (0.67-6.07)	**3.92* (1.07-14.42)**
4 Years Post-Expansion	**0.63** (0.49-0.81)**	0.85 (0.59-1.22)	0.77 (0.48-1.24)	1.19 (0.76-1.85)
5 Years Post-Expansion	0.62 (0.24-1.61)	0.71 (0.28-1.82)	**0.51 (0.29-0.90)**	0.78 (0.46-1.32)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age, race/ethnicity, educational attainment level, income level, employment status, having a regular healthcare provider, rurality, as well as state and year fixed effects.

Table 6. Associations of year of state Medicaid expansion with up-to-date breast and cervical cancer screening rates, sensitivity analysis using age

	Up-to-date Breast Cancer Screening		Up-to-date Cervical Cancer Screening	
Medicaid Expansion	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
7 Years Pre-Expansion	**3.09** (1.36-7.05)**	**4.61** (2.25-9.45)**	0.81 (0.38-1.71)	1.70 (0.70-4.10)
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	1.45 (0.69-3.02)	**2.12* (1.02-4.41)**	0.61 (0.30-1.24)	0.95 (0.41-2.18)
4 Years Pre-Expansion	1.25 (0.91-1.71)	**1.83** (1.38-2.44)**	1.00 (0.74-1.36)	**1.68** (1.24-2.29)**
3 Years Pre-Expansion	1.52 (0.65-3.56)	2.11 (0.98-4.55)	0.63 (0.32-1.24)	0.98 (0.43-2.20)
2 Years Pre-Expansion	**0.74** (0.59-0.92)**	1.07 (0.80-1.43)	**0.76** (0.65-0.89)**	1.18 (0.98-1.43)
1 Year Pre-Expansion	0.96 (0.53-1.76)	1.41 (0.80-2.48)	0.89 (0.40-1.99)	1.30 (0.50-3.39)
Expansion Year	**0.65** (0.47-0.90)**	0.93 (0.69-1.25)	0.88 (0.75-1.04)	**1.30** (1.09-1.55)**
1 Year Post-Expansion	1.37 (0.65-2.90)	1.90 (0.90-4.02)	0.71 (0.40-1.26)	0.92 (0.42-2.01)
2 Years Post-Expansion	0.93 (0.71-1.22)	1.29 (0.88-1.89)	**0.72** (0.57-0.90)**	0.97 (0.72-1.30)
3 Years Post-Expansion	0.71 (0.35-1.47)	0.87 (0.42-1.81)	1.31 (0.56-3.05)	1.89 (0.65-5.49)
4 Years Post-Expansion	**0.47** (0.31-0.70)**	**0.58* (0.37-0.90)**	0.91 (0.64-1.29)	1.38 (0.99-1.93)
5 Years Post-Expansion	0.55 (0.19-1.57)	0.56 (0.19-1.64)	1.05 (0.35-3.20)	1.45 (0.36-5.88)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age, race/ethnicity, educational attainment level, income level, employment status, having a regular healthcare provider, rurality, as well as state and year fixed effects.

Table 7. Associations of year of state Medicaid expansion with up-to-date breast and cervical cancer screening rates, sensitivity analysis using education

	Up-to-date Breast Cancer Screening		Up-to-date Cervical Cancer Screening	
Medicaid Expansion	**OR (95% CI)**	**aOR (95% CI)**	**OR (95% CI)**	**aOR (95% CI)**
7 Years Pre-Expansion	1.02 (0.71-1.49)	**1.60*** **(1.01-2.54)**	0.92 (0.74-1.15)	1.31 (0.91-1.88)
6 Years Pre-Expansion	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)	1.00 (*omitted*)
5 Years Pre-Expansion	0.85 (0.60-1.20)	1.11 (0.73-1.68)	0.90 (0.70-1.14)	1.25 (0.87-1.81)
4 Years Pre-Expansion	1.14 (0.97-1.34)	**1.53**** **(1.23-1.91)**	**0.80**** **(0.69-0.94)**	1.26 (0.99-1.61)
3 Years Pre-Expansion	0.94 (0.71-1.24)	1.02 (0.64-1.64)	**0.78**** **(0.66-0.93)**	1.10 (0.81-1.48)
2 Years Pre-Expansion	1.07 (0.95-1.20)	1.10 (0.96-1.26)	**0.80**** **(0.74-0.85)**	1.09 (0.97-1.21)
1 Year Pre-Expansion	0.80 (0.60-1.06)	0.79 (0.53-1.18)	**0.79**** **(0.68-0.92)**	1.06 (0.69-1.64)
Expansion Year	1.00 (0.91-1.11)	0.95 (0.79-1.13)	**0.77**** **(0.71-0.83)**	**1.10*** **(1.01-1.19)**
1 Year Post-Expansion	0.82 (0.64-1.05)	0.89 (0.56-1.44)	**0.69**** **(0.53-0.89)**	0.80 (0.57-1.13)
2 Years Post-Expansion	1.09 (0.97-1.23)	1.13 (0.93-1.37)	**0.83**** **(0.75-0.92)**	1.07 (0.94-1.22)
3 Years Post-Expansion	0.93 (0.72-1.18)	1.04 (0.69-1.57)	0.72 (0.50-1.04)	1.09 (0.72-1.64)
4 Years Post-Expansion	**1.14**** **(1.03-1.25)**	1.02 (0.87-1.20)	**0.75**** **(0.68-0.83)**	0.92 (0.77-1.08)
5 Years Post-Expansion	0.97 (0.69-1.35)	0.81 (0.33-1.95)	0.79 (0.55-1.14)	1.28 (0.73-2.26)

* Denotes a coefficient significant at the 5% level.
** Denotes a coefficient significant at the 1% level.

Note: Models use robust standard errors, clustered by state. All models weighted using final sample weights combining landline and cellphone data in BRFSS. Adjusted odds ratio includes the following control variables: age, race/ethnicity, educational attainment level, income level, employment status, having a regular healthcare provider, rurality, as well as state and year fixed effects.

6. APPENDIX

Appendix A. Medicaid expansion status, by state

State	Date of Implementation
Alabama	---
Alaska	09/01/2015
Arizona	01/01/2014
Arkansas	01/01/2014
California	01/01/2014
Colorado	01/01/2014
Connecticut	01/01/2014
Delaware	01/01/2014
District of Columbia	01/01/2014
Florida	---
Georgia	---
Hawaii	01/01/2014
Idaho	01/01/2020
Illinois	01/01/2014
Indiana	02/01/2015
Iowa	01/01/2014
Kansas	---
Kentucky	01/01/2014
Louisiana	07/01/2016
Maine	01/10/2019
Maryland	01/01/2014
Massachusetts	01/01/2014
Michigan	04/01/2014
Minnesota	01/01/2014
Mississippi	---
Missouri[1]	---
Montana	01/01/2016
Nebraska	10/01/2020
Nevada	01/01/2014
New Hampshire	08/15/2014
New Jersey	01/01/2014
New Mexico	01/01/2014
New York	01/01/2014
North Carolina	---
North Dakota	01/01/2014

Ohio	01/01/2014
Oklahoma[2]	---
Oregon	01/01/2014
Pennsylvania	01/01/2015
Rhode Island	01/01/2014
South Carolina	---
South Dakota	---
Tennessee	---
Texas	---
Utah	01/01/2020
Vermont	01/01/2014
Virginia	01/01/2019
Washington	01/01/2014
West Virginia	01/01/2014
Wisconsin	---
Wyoming	---

1. A ballot measure was approved by Missouri voters on August 4, 2020, adding Medicaid expansion as an amendment to the state's constitution. This would require the state to submit state plan amendments (SPAs) to the Centers of Medicare & Medicaid (CMS) by March 1, 2021, allowing for implementation of expansion on the first of July in this same year.
2. A ballot measure was approved by Oklahoma voters on June 30, 2020, adding Medicaid expansion as an amendment to the state's constitution. This required the state to submit SPAs to the CMS within 90 days after the measure was approved, allowing for implementation of expansion on July 1, 2021. This amendment also prohibits any additional restrictions to accessing Medicaid for eligible populations. Oklahoma submitted a SPA to expand Medicaid on May 28, 2020, but this was withdrawn.

Appendix B. Predicting whether a state adopts Medicaid expansion

State-level variable	Coefficient
Percent of population below the FPL	-4.2746 (3.7519)
Percent of population that identifies as Black	0.0005 (0.9624)
Percent of population that identifies as Hispanic	0.0615 (1.0080)
Percent of population that identifies as other race	0.4522 (0.8234)
Percent of population with a college degree	0.6813 (1.8043)
Percent of population with public assistance income	16.2359* (7.4759)
Percent of population living in rural areas	0.0277 (0.8011)
Percent of population that is unemployed	2.1518 (4.1906)
N	51
R^2	0.2646

* Denotes a coefficient significant at the 5% level.

Note: Standard errors in parentheses.