The Effects of Medicare Eligibility on The Utilization of Cancer Screening Tools

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Abstract

This study examines the impact of Medicare eligibility on the utilization of cancer screening tools for colorectal, breast and prostate cancers in the USA. We have used the Behavioral Risk Factor Surveillance System data in our study. This project aims to shed light on the often-overlooked role of Medicare in cancer screening behavior, a topic that has received limited research attention. The Regression Discontinuity method has been used for finding any discontinuity for the probability of taking the tests within the last 12 months at age 65. The study's findings indicate significant shifts in the probability of individuals opting for various cancer screening tests. Notably, there was an absolute increase of 0.029 in the probability of individuals choosing colonoscopy and sigmoidoscopy examinations, an increase of 0.008 in the likelihood of stool blood tests, and a substantial absolute increase of 0.041 in the probability of individuals selecting prostate-specific antigen tests. These results underscore the considerable and positive impact of the factors or interventions under examination on encouraging participation in these crucial cancer screenings, potentially leading to early detection and improved health outcomes. However, while the results for mammograms (0.025) showed statistical significance, the relative changes were small. Additionally, the findings for Clinical Breast Exam demonstrated small and statistically insignificant changes at age 65.

Keywords: Medicare, Cancer, Cancer screening, Colonoscopy, Mammogram, PSA test

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I. Introduction

Cancer care is one of the costliest medical treatments in the United States, with patient out-of-pocket expenses totaling $5.6 billion in 2020. This amount was just 5% of the overall cancer treatment costs in the US (American Cancer Society, 2020). Private insurance firms and Medicare cover 49% and 33% of the total cost, respectively (ACS, 2020). The high cost of cancer treatment is further underscored by the fact that eleven out of twelve cancer drugs that received approval from the Food and Drug Administration in 2012 were priced above $100,000 per year (AARP, 2018).

Cancerous tumors can be most easily and effectively treated if they are detected at an early stage; so, cancer screening tools are not only important for survival and treatment but also cost of the procedure. Cancer screening tools can prevent thousands of additional cancer cases and deaths. Early detection of cancer through screening reduces mortality rates for cancers of the colon and rectum, breast, uterine cervix, prostate, and lung (Loud, 2017). Although many studies have proved the effect of early detection on cancer treatment, the screening rates are often below recommended levels due to the high cost. Because of this fact, health insurance has a significant impact on an individual's decision to undergo cancer screening. The Affordable Care Act (ACA) requires both Medicare and private insurers to cover fully the costs of certain cancer screening tests. However, if an individual's health plan was already in place before the ACA was passed, it may not offer the same coverage.

According to the National Cancer Institute, there are more than 100 types of cancer, but some of them are seen more frequently than others. In this study, we will focus on prostate, colorectal and breast cancers.

Colorectal cancer is a type of cancer that affects the colon or rectum, which are parts of the large intestine. It is one of the most common types of cancer in the United States, with an estimated 149,500 new cases and 52,980 deaths in 2021 alone. The American Cancer Society's estimates 1530,20 new colorectal cancer cases and 52,550 deaths in the United States for 2023. It is also the third leading cause of cancer-related deaths in the United States, after lung and prostate cancer in men and lung and breast cancer in women. However, it can be effectively treatable if it is caught by regular screening at an early stage.

Breast cancer occurs when cells in the breast tissue grow uncontrollably. It is the most diagnosed cancer in women in the United States (American Cancer Society). Although it is rare, it can be also seen in men. In fact, 1 out of 100 breast cancer cases is found in a man (CDC-Centers for Disease Control). The American Cancer Society's estimates about 297,790 new cases and 43,700 deaths among women in the United States for 2023. Although incidence and death rate are high, breast cancer mortality rates have been decreasing steadily since 1989, for an overall decline of 43% through 2020 (American Cancer Society, 2020). The survival rate is almost 100% if the cancer is detected at stage 1.

Prostate cancer is one of the most common cancer types, with three million cases per year in the United States and is also the second leading cause of cancer mortality among men (Yang XJ, 2019). According to the American Cancer Society, prostate cancer is the second most common cancer among men in the United States, after skin cancer. The incidence and mortality rates vary by age and race, but the risk increases as a person gets older. In fact, more than 60% of prostate cancer cases are among men over the age of 65 (American Cancer Society, 2022). Even though the incidence rate increases with age, doctors may not recommend screening or treatments for patients over age 80.

As I mentioned before, cancer screening plays a vital role in treatment efficacy, cost, and survival rates. This research aims to examine the relationship between Medicare and the utilization of cancer screening tools. Previous studies have mainly analyzed the impact of Medicare on cancer treatment and survival, but our study focuses on the effect of Medicare on cancer screening. We'll prioritize the general population rather than exclusively focusing on cancer patients. Furthermore, this study employs the Regression Discontinuity method, which is not commonly used in the previous studies. The Regression Discontinuity approach provides a clearer understanding of the changes related to Medicare at the threshold, given that the insurance eligibility will be determined by age. RD methods allow you to identify causal effects (unlike OLS) and are based on assumptions that may be more likely to be satisfied in practice than DiD. Finally, we will also analyze colorectal cancer screening behavior by gender. Previous research seldomly analyzed women and men separately, except for gender-specific cancers like breast or prostate cancer. Gender is also crucial in determining the effects of health insurance, and by examining how men and women utilize Medicare for cancer screening, we can gain a more comprehensive understanding of its impact.

II. Background

There are several screening tools available for colorectal cancer, but the most prevalent ones are colonoscopy, sigmoidoscopy, and fecal occult blood tests (stool blood test). The U.S. Preventive Services Task Force (Task Force) recommends that adults aged 45 to 75 be screened for colorectal cancer. The screening is not recommended for patients older than age 85. These tests can detect precancerous polyps or early-stage cancer, which can be treated before they become more dangerous; however, there are different recommendations for each test type. Colonoscopy is considered the best screening tool for colorectal cancers because it allows for a complete examination of the colon, and any precancerous polyps found can be removed during the procedure. The procedure is typically done under sedation, which means the patient is not fully conscious during the exam. CDC recommends colonoscopy every 10 years unless a person does not have an increased risk of colorectal cancer. However, there are some side effects and risks patients should know before colonoscopy procedure. Colonoscopy may lead to belly pain, bleeding, bad reaction to anesthesia and rarely infection as well. Sigmoidoscopy is another preferred test for colorectal cancer. It is quicker and less invasive than colonoscopy. It is also less expensive compared to colonoscopy. In contrast to colonoscopy, it is recommended in every 5 years unless the risk for colorectal cancer is high. However, this test also has some disadvantages as well. Sigmoidoscopy only examines the lower part of the colon and not all polyps can be removed during the procedure. Furthermore, a follow-up colonoscopy may be prescribed if biopsy is positive. There is also a small risk of perforation or bleeding. The last test is the stool blood test, also known as fecal occult blood test (FOBT). It is a non-invasive screening test used to detect blood in the stool, which can be a sign of colorectal cancer or other abnormalities in the colon and rectum. This test should be done every year according to CDC. The stool blood test is inexpensive, non-invasive, and convenient. However, this test has some disadvantages one needs to know. Stool blood tests can provide not only false-positive but also false-negative results. It has limited detection ability compared to colonoscopy or sigmoidoscopy since blood at stool is not a direct symptom of colorectal cancer. Finally, follow-up tests may be required depending on the results. Medicare covers Stool Blood Test once a year and patients do not pay any fee or copayment for this service. For Medicare, colonoscopy is covered once every 2 years. If the polyp is found and removed during the screening, patients pay 15% of the Medicare-Approved Amount for your doctors' services. They also pay the facility a 15% coinsurance in a hospital outpatient setting or ambulatory surgical center. Medicare covers a flexible sigmoidoscopy screening once every 48 months. Like colonoscopy screening, patients will pay 15% of fees for doctor services if any lesion is found or removed. Patients are also responsible to pay 15% coinsurance in a hospital outpatient setting or ambulatory surgical center.

For breast cancer, there are some tests available, but the preferred one is mammogram. A mammogram is an X-ray of the breast which can find cancerous tumors at an early stage before it causes pain or other symptoms. According to CDC, so far, a mammogram is the best screening tool for detecting breast cancer. The American Cancer Society (ACS) recommends that women at average risk of breast cancer begin yearly mammograms at age 45. In the US, mammography screening rates have increased over the years, with 65.4% of women aged 45-54 and 67.1% of women aged 55-74 reporting having a mammogram in the past two years, according to data from the Centers for Disease Control and Prevention (CDC). The USPSTF recommends that women who are 50 to 74 years old and are at average risk for breast cancer get a mammogram every two years. As usual, this test also has some disadvantages. Mammograms may give false positive results which lead to unnecessary biopsies or other tests. Since patients are exposed to radiation, it may increase cancer risk for some individuals. Furthermore, it may be less effective on women with dense breast tissue or women under age 50. Another test is the Clinical Breast Exam. It is an examination by a doctor or nurse, who uses his or her hands to feel for lumps or other changes. This test is non-invasive, convenient and can be performed during doctor visits. However, it has serious disadvantages compared to mammogram. First, it is hard to detect small and early-stage tumors. Second, effectiveness depends on performers (doctors, nurses) skills and experience. It may also lead to unnecessary additional testing. Medicare patients do not pay anything for annual Mammogram screening. For clinical breast exam, Medicare currently covers at no cost every 24 months for women with average risk and every 12 months for women with a high risk.

Finally, The Prostate Specific Antigen (PSA) test is the most popular screening tool for prostate cancer. It is a blood test that measures the level of protein produced by the prostate in a man's blood. The importance of the PSA test lies in its ability to detect prostate cancer early when it is most treatable. It can prevent 3 out of 1000 men from dying of prostate cancer. (IQWiG, 2006). According to American Cancer Society, the recommended starting age for PSA test is 50 for a man at average risk and 45 for men at higher risk, such as African American men or those with a family history of prostate cancer. If the result is above 2.5 ng/ml, a man should take this test every year, otherwise it is recommended every two years (American Cancer Society). However, this test is not recommended for men over age 80 or those expected to live less than 10 years. Despite the benefits of PSA test, there are some disadvantages that men should consider. Not all abnormal results are signs of prostate cancer, so PSA test may lead to unnecessary biopsies, overdiagnosis, and overtreatment, which can have significant side effects and impact a patient's quality of life. For example, the PSA test can sometimes detect cancers that are slow-growing and may not necessarily require treatment. Furthermore, it can give false-negative results as well. For example, around 15% of men with a normal PSA level may have prostate cancer, and 2% of men with a normal PSA level may have a fast-growing prostate cancer (Yorkshire Cancer Research). Overall, PSA test has contributed to early detection of prostate cancer and survival rate for men even though it has certain disadvantages. Medicare covers the PSA test once every 12 months, and patients will not pay any fee or copayment.

III. Literature review

Prior to Medicare eligibility, many Americans have lacked health coverage or had limited coverage requiring significant out-of-pocket expenses for preventive services. Uninsured individuals are less likely to access a healthcare provider, resulting in increased utilization of emergency departments and decreased office-based care, including preventive services (Decker et al, 2012). Cancer patients from disadvantaged communities benefit most from health insurance and there is a reduction in disparities in outcome. However, the gap produced by social determinants of health cannot be bridged by insurance alone (Abdelsattar, 2017). Lack of health insurance coverage is associated with poor access and receipt of cancer care and survival in the United States. Disruptions in coverage are common among low-income populations, but little is known about associations of disruptions with cancer care, including prevention, screening, and treatment, as well as outcomes of stage at diagnosis and survival (Yabroff, et al, 2020). The associations between health insurance type and quality of cancer care are not well defined, but some studies have reported lower quality of care for some specific cancers among individuals who were uninsured or on Medicaid insurance at the time of their cancer diagnosis (Patel, 2017). Persons having Medicaid or Medicare Medicaid dual coverage or having no insurance appear to consistently receive lower quality cancer care than privately insured patients, as indicated by adherence to multiple quality measures across several cancer types (Patel, 2017). Screening can increase early detection and reduce rates of advanced-stage cancer. Uninsured patients have been shown to have lower rates of screening. Previous studies have shown that uninsured patients and patients with Medicaid present with more advanced stages of cancer (Farkas, 2012). The findings suggest that access to continuous medical insurance is important for decreasing the likelihood of late-stage cancer diagnosis. Another study provides the first evidence that near-universal access to Medicare at age 65 is associated with improvements in population level cancer mortality (Myerson, 2020). Many such studies have focused on insurance expansion among the non-elderly, i.e., expansions of Medicaid or private insurance. While some studies found that access to insurance increased cancer screening, others found that the impact of insurance on cancer screening and detection varied by tumor site or the length of follow-up after a policy change (Han 2016;). The Oregon Health Insurance Experiment, a randomized expansion of Medicaid insurance, found that insurance increased cancer screening, but cancer detection and outcomes were not assessed (Baicker, 2013). Insured men with prostate cancer are less likely to present with metastatic disease, and more likely to be treated if they develop high-risk disease and are more likely to survive their cancer, (Mahal, 2014).

Eleven studies found significant increases, 5 found nonsignificant increases, 3 found nonsignificant decreases, and 1 study found a significant decrease in colorectal cancer screening. Free preventive colorectal cancer screening and Medicaid expansion because of the Affordable Care Act have been, in general, positively associated with modest improvements in screening rates across the country. In general, previous studies have mainly focused on cancer detection, treatment and survival rate, but not on the screening tools utilization (Xu et al, 2020).

Screening with mammography is generally recognized as effective in reducing morbidity and mortality from breast cancer (Elmore, 2005).

Relative to non-Hispanic whites, minorities were more likely to experience a diagnostic delay, present at a nonaccredited facility and at a disproportionate share hospital and involve multiple facilities in their diagnosis for breast cancer. Disparities in delay are partly due to a disproportionate presentation at lower resourced facilities by minorities (Molina, 2015).

Despite lower incidence rates, non-Hispanic black and Hispanic women are more likely to experience late-stage diagnosis and die of breast cancer (Shaver, 2003). Non-Hispanic black and Hispanic women experience longer delays to confirmed diagnosis of breast cancer, which has been associated with late-stage detection and poorer survival (Yabroff, 2004).

Non-Hispanic white women are more likely than non-Hispanic black or Hispanic women to obtain mammograms at facilities with academic affiliation, dedicated breast radiologists, and digital mammography (Rauscher, 2012). Black and Hispanic women, even though they report comparable levels of mammography usage, still receive their breast cancer diagnoses at a more advanced stage in comparison to white women. This advanced stage of diagnosis is, to some extent, accountable for the higher breast cancer mortality rates among black women as compared to white women in the US (Sassi, 2006).

Clinically advanced-stage prostate cancers were detected more frequently in African- Americans (12.3%) and Hispanics (10.5%) than in non-Hispanic whites (6.3%) (Hoffman et al, 2001). Racial and ethnic disparities exist in prostate cancer epidemiology, with African-Americans having the highest incidence and mortality rates compared to whites. On the other hand, Hispanics have lower incidence and mortality rates than non-Hispanic whites. The increased mortality rate among African-Americans is due to the higher risk of presenting with advanced-stage prostate cancer.

The screening rates increased for all three racial-ethnic groups, however, compared to whites, lower proportions of blacks and Hispanics underwent screening at all time points. The disparities between Hispanic and white screening rates remained, but the differences between black and white screening rates reduced in 2003 and increased again in 2005 (Doubeni et al, 2010). Lower screening rates among some minority populations are believed to be an important contributor to colorectal cancer disparities (Shneck, 2009). The cost of medical care, lack of adequate health insurance coverage, or lack of a usual source of health care impede colorectal cancer screening.

Cancer screening is crucial for effective treatment, cost management, and survival rates. Our research focuses on the relationship between Medicare and cancer screening utilization. Unlike previous studies, we prioritize the general population over cancer patients. Additionally, we employ the Regression Discontinuity method, which provides a clearer understanding of Medicare's impact at the eligibility threshold based on age. Analyzing colorectal cancer screening behavior by gender is another important aspect of our study, as it offers insights into the impact of health insurance on both men and women.

IV. Data

IV.1 Colorectal Cancer Screening Tools

In this study, we used data from the Behavioral Risk Factor Surveillance System (BFRSS) collected from 2014 to 2018. The BFRSS is a cross-sectional survey that is conducted by the Centers for Disease Control and Prevention (CDC) to monitor health-related behaviors and risk factors in the United States population. The BFRSS dataset includes numerous variables pertaining to the taking colonoscopy, sigmoidoscopy, and stool blood test among respondents. To begin our analysis, we first identified individuals who had undergone these procedures within the past 10 years. Subsequently, we further categorized these individuals based on whether they had received the tests within the past 12 months, assigning a value of 1 to those who had, and 0 to those who had not. This approach provided a more accurate representation of the rate of taking these tests, as we could definitively identify those who had not received the tests within the past year. In total, our sample for colorectal cancer screening comprised 540,000 observations in which 57.45% were female. The majority of the sample population were non-Hispanic whites (83%), followed by non-Hispanic blacks and Hispanics. The education level of the observations is diverse, but the sample was relatively well-educated, with 37.96% having a college degree and an additional 27.82% having some college education. In terms of income, roughly half of the population had an annual income above $50,000. Most of the observations had some form of healthcare coverage. Specifically, 23,220 respondents (4.3%) reported having no healthcare coverage. Unfortunately, the BFRSS dataset does not contain specific information on health insurance status for each variable. The mean age of respondents in our sample was 64.5 years. In terms of health-related behaviors and risk factors, the table shows that 16% of the sample had taken colonoscopy and sigmoidoscopy tests within the last year, while 71% had taken these tests within the past 10 years. The mean probability of having a Stool Blood test in the last 12 months is 10%. These findings are consistent with previously reported statistics on colorectal cancer screening rates in the United States population (Hubbard, 2013). However, the utilization rates may be underestimated due to factors such as underreporting or lack of awareness among respondents. Table 3 illustrates Summary statistics. The low prevalence of stool blood test in the sample suggests that there may be a need for increased efforts to promote screening among the population, especially given the high incidence and mortality rates associated with colorectal cancer.

Table 1. Summary statistics for the sample of colorectal cancer screening tools

Variable name	Number	Percentage
Sex		
Male	230,256	42.55
Female	310,879	57.45
Race & ethnicity		
White, non-Hispanic only	441,796	82.8
Black, non-Hispanic only	39,280	7.36
Other race, non-Hispanic only	17,748	3.33
Multiracial, non-Hispanic only	8,567	1.61
Hispanic	26,184	4.91
Education		
No high school	35,765	6.62
Highschool	149,148	27.6
Some college education	150,355	27.82
College graduate	205,172	37.96
Income		
< $15,000	46,385	9.96
$15,000 - $25,000	73,170	15.7
$25,000 - $35000	50,409	10.82
$35,000 - $50,000	70,493	15.13
> $50,000	225,481	48.39
Healthcare coverage		
No	23,220	4.3
Yes	517,162	95.7
Age	64.58	
	(5.79)	
Has Col & Sig last year	0.16	
	(0.37)	
Has Col & Sig last 10 years	0.71	
	(0.45)	
Having Stool Blood Test last year	0.10	
	(0.30)	
Number of observations	541,378	

Source: BFRSS. The numbers in brackets are the standard deviation.

Figures 1 and 2 show the mean rates of individuals who underwent colonoscopy and sigmoidoscopy in the past 12 months and past 10 years in 2014, 2016, and 2018. Generally, the rates of having the tests within the past 12 months increased in 2016 and then declined slightly in 2018 for those who had these tests within the past 12 months. However, the rate for the past 10 years gradually increased over time. For people who had these tests past 12 months, the non-Hispanic Blacks had the highest rate (20%) among the sample, while Hispanic individuals had the lowest rate (15%) during the same time period. The rate is around 1 percentage point higher for men comparing to women. Non-Hispanic Whites had a rate below the sample average for undergoing the tests within the past 12 months. However, they have the highest rate (73%) for having colonoscopy and sigmoidoscopy in last 10 years. Meanwhile, the rate of undergoing the tests over the past 10 years was much lower for Hispanic individuals (around 57%) compared to the other racial/ethnic groups and the sample average. Here, women also had a slightly higher rate than men. Finally, the test ratio increased roughly four times during the 10-year period compared to the past 12 months. Figure 3, on the other hand, displays the average rates of younger adults (aged 55-64) and older adults (aged 66-75) who underwent colonoscopy and sigmoidoscopy within the past 12 months. The rate for older adults was about 3 percentage points higher than for younger adults in the overall sample and subgroups. For both age groups, non-Hispanic Blacks has the highest rate in the sample (19% and 21.4%).

Figure 4 depicts the percentage of individuals who underwent a stool blood test in the preceding 12 months in the years 2014, 2016, and 2018. Except for Hispanic individuals, the rate has increased for all subgroups in the sample from 2014 to 2018. Notably, the rate for non-Hispanic Whites remains the lowest, hovering around 9.5% throughout the years. The rate for non-Hispanic Blacks, women, and men is similar across all years. The preference for this test among Hispanics might be due to its low cost. However, the overall rate of stool blood testing remains relatively low, ranging from 11% to 13%. Figure 5 reveals that the rate of undergoing stool blood testing has increased by 4 percentage points among older adults (age 66-75) compared to younger adults (55-64). Among older adults, Hispanic individuals have the highest rate (15%), while non-Hispanic Blacks have the highest rate (11.4%) among younger adults. In both age groups, non-Hispanic Whites have the lowest rate in the sample.

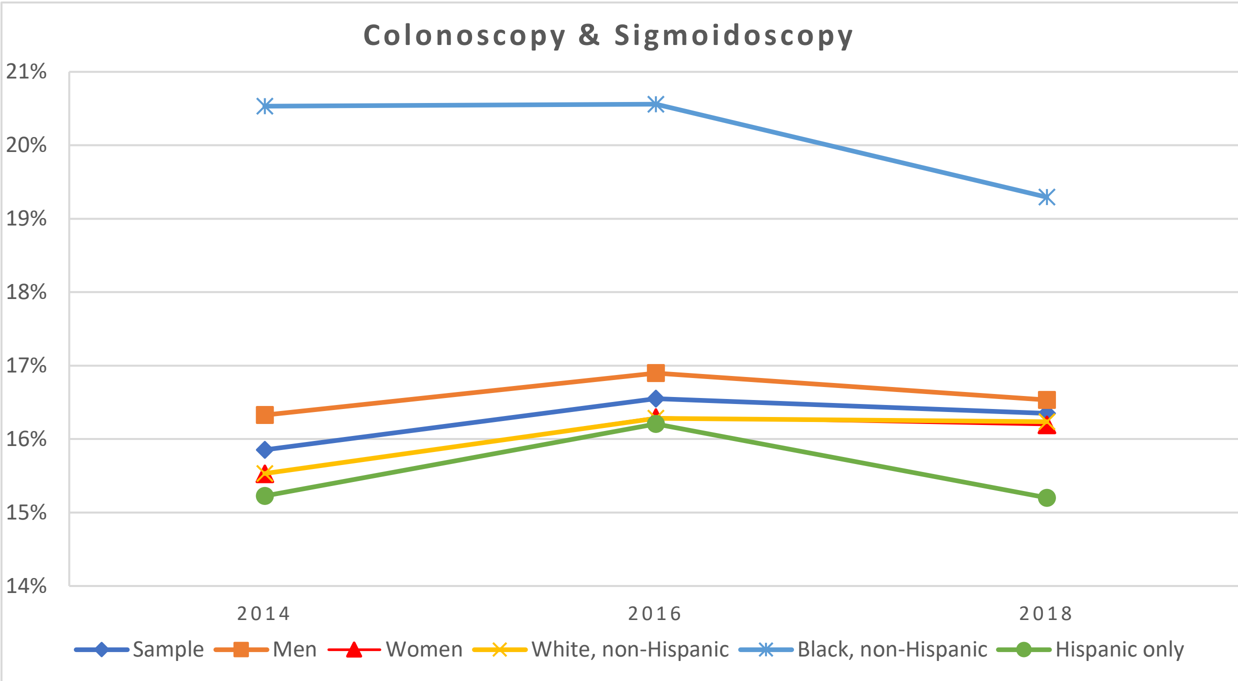

Figure 1: Rate of Having Colonoscopy or Sigmoidoscopy within last 12 months in 2014, 2016 and 2018. Source: BFRSS

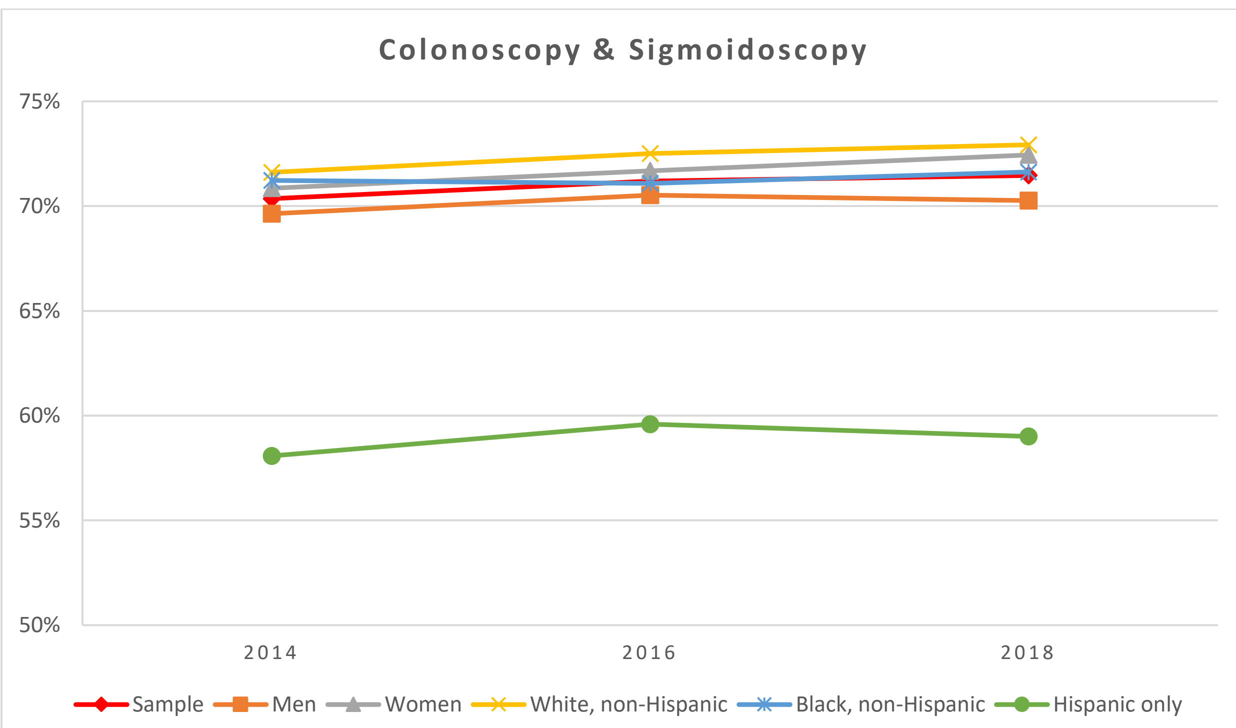

Figure 2. Rate of Having Colonoscopy or Sigmoidoscopy within last 10 years in 2014, 2016 and 2018. Source: BFRSS.

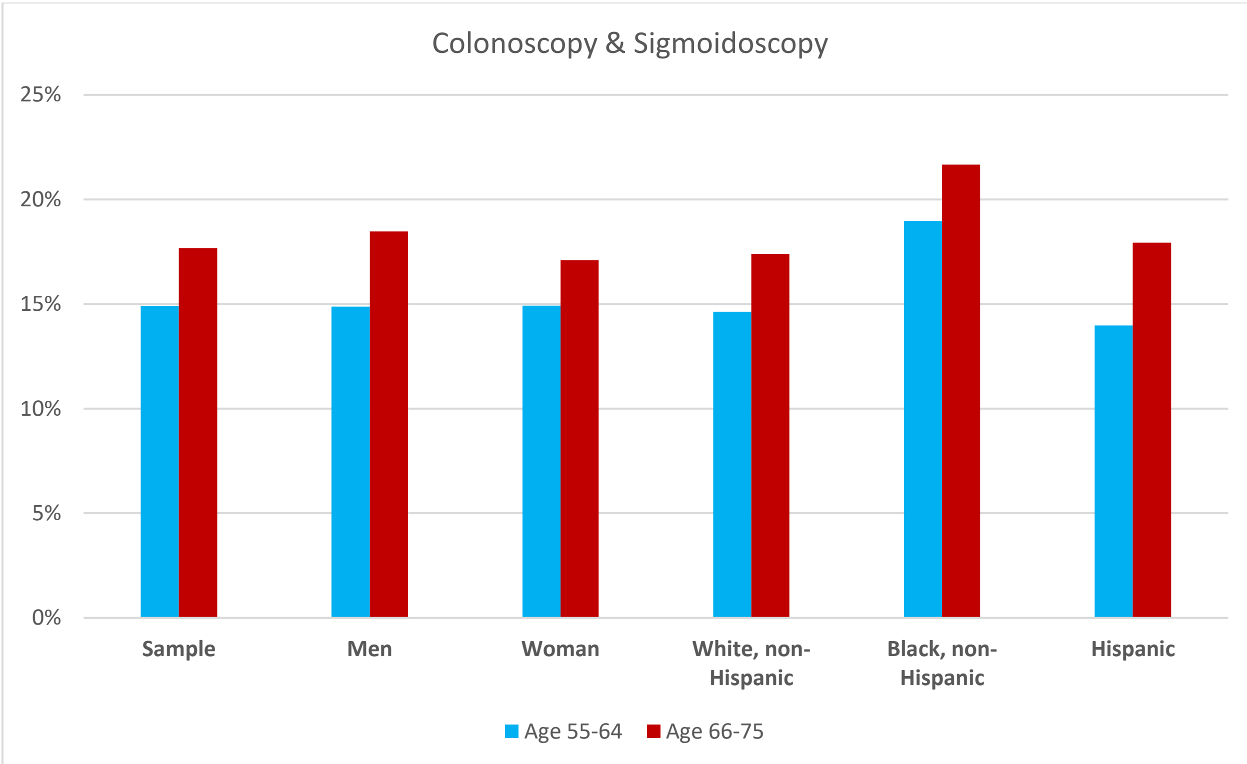

Figure 3. Rate of Having Colonoscopy or Sigmoidoscopy within last 12 months for the age groups. Source: BFRSS

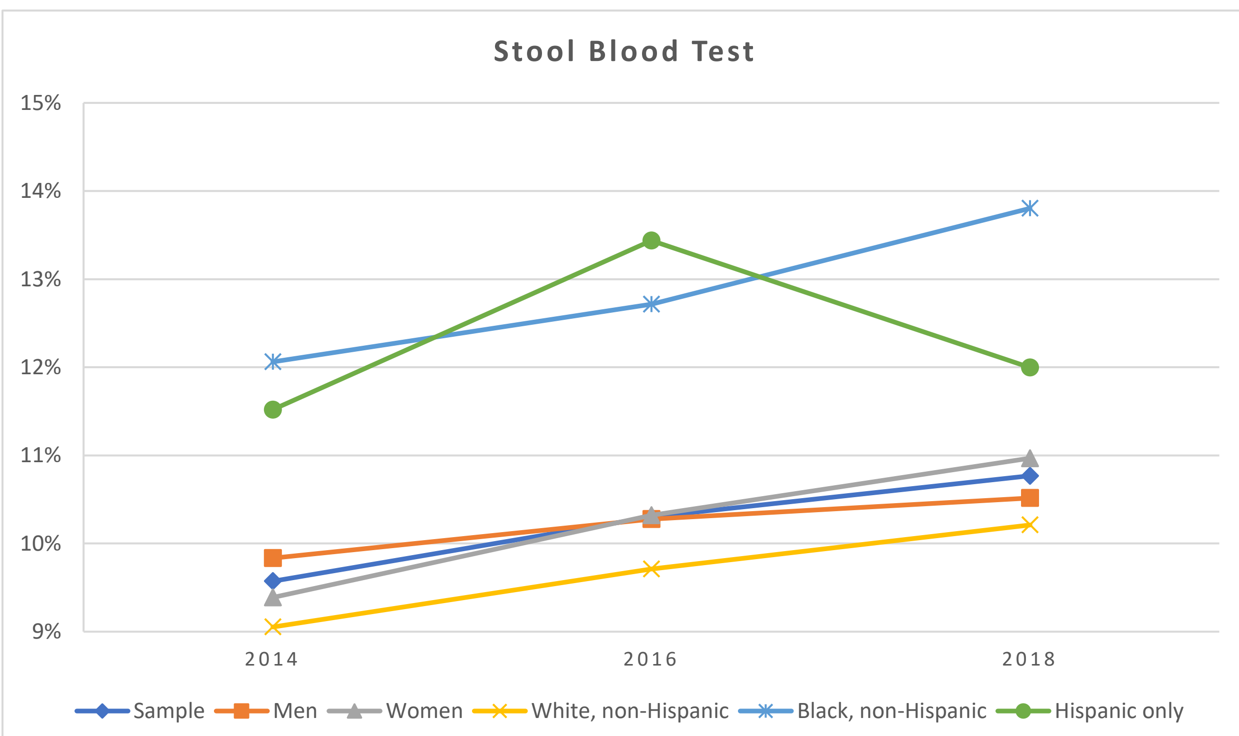

Figure 4. Rate of Having Stool Blood Test within last 12 months in 2014, 2016 and 2018. Source: BFRSS

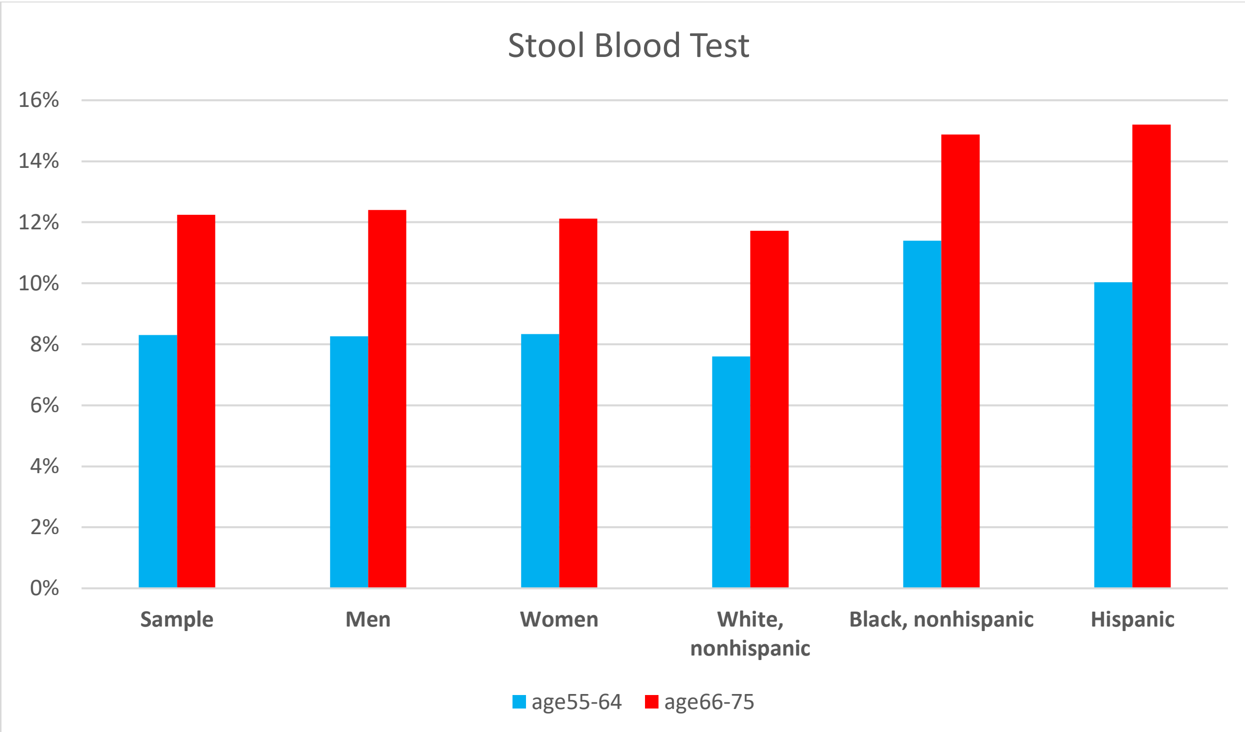

Figure 5. Rate of Having Stool Blood Test within last 12 months for the age groups. Source: BFRSS.

Figure 6 represents the proportion of individuals with any kind of health insurance coverage at each age. Analyzing the data, we observe a relatively stable health coverage rate for individuals aged 55 to 60, with values ranging from 91.4% to 93.6%. This suggests that the likelihood of having insurance remains relatively consistent within this age range. At age 65, there is a notable increase in the health coverage rate, jumping to 98.1%. This can be attributed to individuals becoming eligible for Medicare at age 65, which provides healthcare coverage for older adults. From age 66 to 72, the rate remains relatively high, ranging from 98.7% to 98.9%. As we move into the older age range, specifically 73 to 75, the insurance rate remains relatively stable ranging from 98.8% to 98.9%.

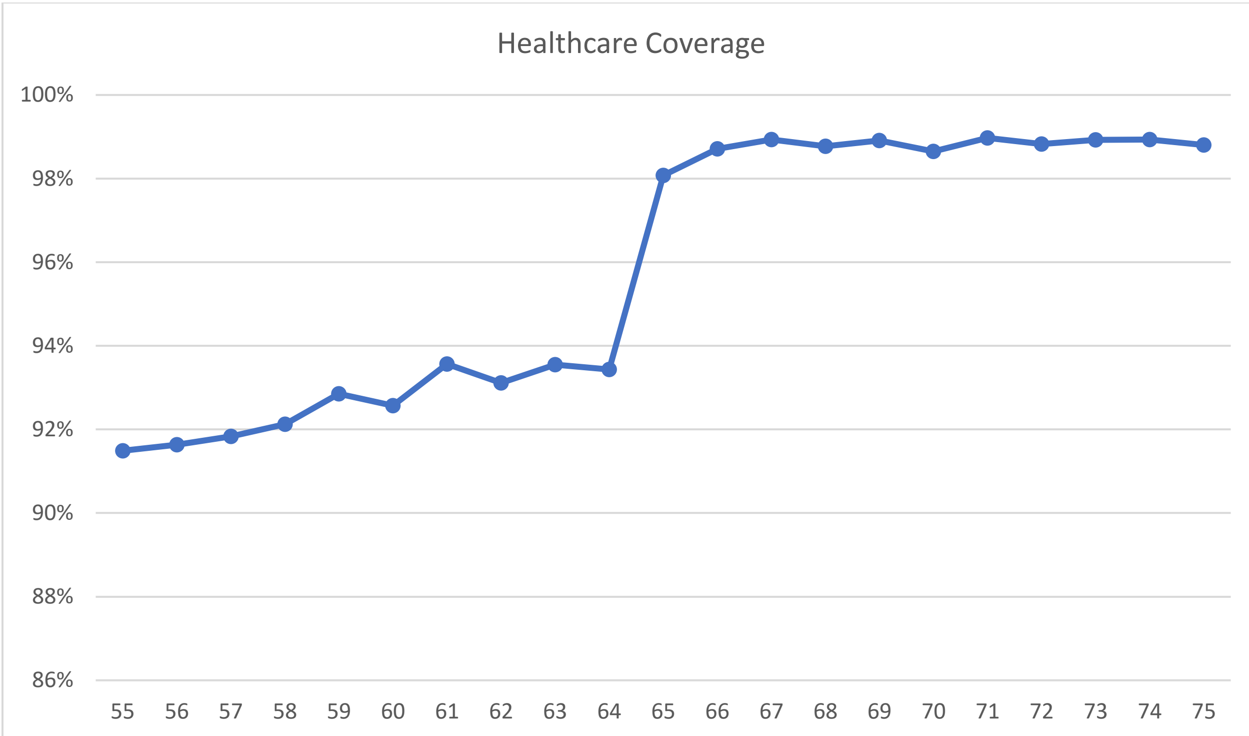

Figure 6 The rate of having any kind of Healthcare coverage (health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service) within the sample for Colorectal Cancer tests. Source:BFRSS

IV. 2 Breast Cancer Screening Tools

Since this sample is taken for mammogram, all the observations are females. We restricted the age between 50 and 80. The average age of the sample is 66.21 years, with a standard deviation of 9.25 years. The sample size is large, with 491,076 observations, which increases the generalizability of the findings. Most of the sample is non-Hispanic whites (82.39%), followed by non-Hispanic blacks.

In terms of education, 33.71% of individuals in the sample have a college degree, while 28.71% have some college education. The mean rate of having mammogram within the past 12 months is almost 60% which is high considering the recommendations.

Regarding the income, it shows that a substantial proportion of the sample population had a moderate to low income. The majority of the participants had an income below $50,000 (59% in total). The distribution of income levels in the sample is important because it may have an impact on the participants' access to healthcare and their ability to afford preventative measures, such as regular screenings for breast cancer. Previous research has suggested that low-income women are less likely to receive mammograms than their higher-income counterparts (Lantz et al., 2005). However, in our sample the mean rate for having mammogram within past 12 months is almost 60% which is high considering it is recommended in every two years. It should also be noted that the rate for taking mammogram within two years is 75%. Furthermore, most of the individuals in the sample have healthcare coverage (96.10%), while a small proportion (3.90%) do not. Table 2 shows the summary statistics.

Table 2. Summary statistics for the sample of breast cancer screening tools

Variable name	Frequency	Percentage
Race & ethnicity		
White, non-Hispanic only	399,571	82.39
Black, non-Hispanic only	38,188	7.87
Other race, non-Hispanic only	15,056	3.1
Multiracial, non-Hispanic only	7,232	1.49
Hispanic	24,902	5.13
Education		
No Highschool	37,801	7.71
Highschool	146,369	29.87
Some college education	140,688	28.71
College graduate	165,200	33.71
Income		
< $15,000	49,042	12.22
$15,000 - $25,000	78,242	19.5
$25,000 - $35000	49,474	12.33
$35,000 - $50,000	60,140	14.99
> $50,000	164,299	40.95
Healthcare coverage		
No	19,144	3.90
Yes	470,895	96.10
Age	66.21	
	(9.25)	
Mammogram last year	0.59	
	(0.49)	
Mammogram last 2 years	0.75	
	(0.43)	
Clinical Breast Exam last year	0.55	
	(0.50)	
Number of observations	491,076	

Source: BFRSS. The numbers in brackets are the standard deviation.

Figures 7 and 8 shows the proportion of women who underwent mammography in the past 12 months and 2 years, respectively, in 2014, 2016, and 2018. Non-Hispanic Black women exhibited the highest rate (67%), whereas non-Hispanic White women had the lowest rate (59%). The rates remained constant across all samples and subgroups over the years. Hispanic women had the second-highest rate, which was also above the sample average. Figure 9 displayed the average rates of mammography in the past 12 months for younger adults (age50-64) and older adults (66-80). Remarkably, the average rate was higher for younger adults than for older adults, and the most significant difference was observed in non-Hispanic White women, while the change for Hispanic women was subtle. Non-Hispanic Black women had the highest average rate for having mammography in the past 12 months for both age groups. Additionally, Figure 10 illustrates the rates for clinical breast examination for these age groups. Once again, non-Hispanic Black women had the highest rate for both age groups. In this test, clinical breast examination was less preferred by older women (ages 66-80) than by younger adults (ages 50-64) among all race and ethnicity.

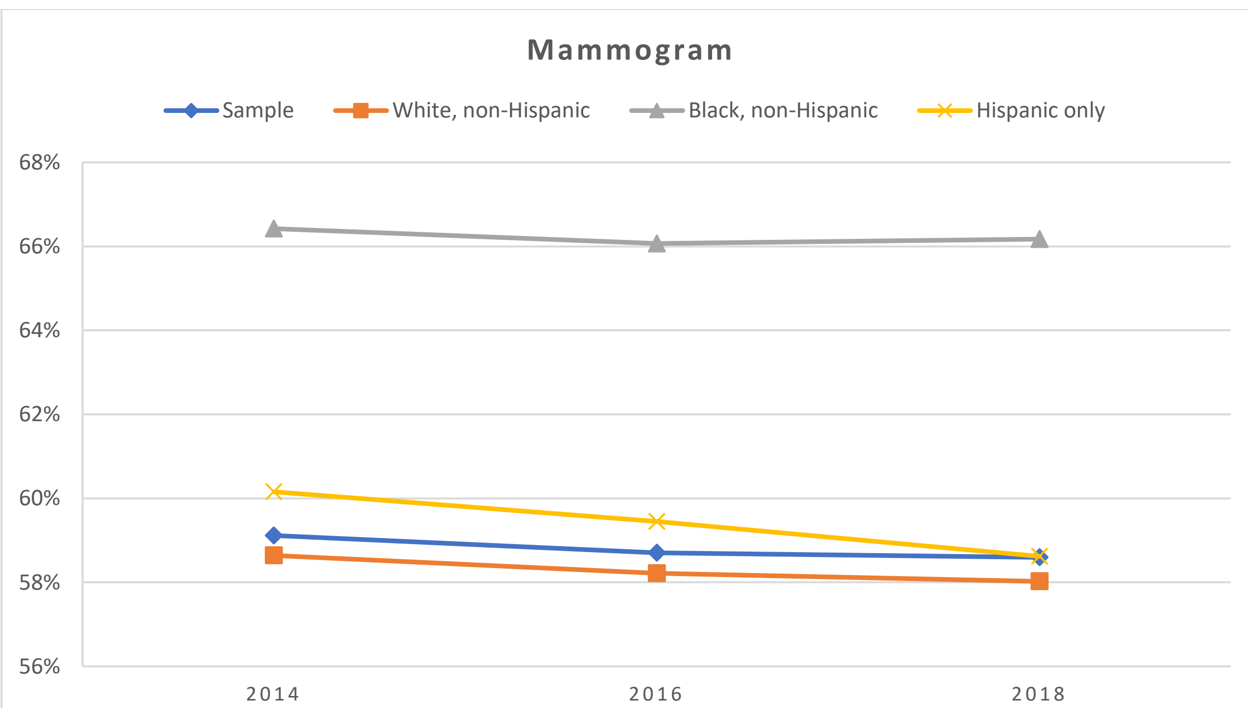

Figure 7. Rate of having Mammogram within last 12 months in 2014, 2016 and 2018 . Source: BFRSS

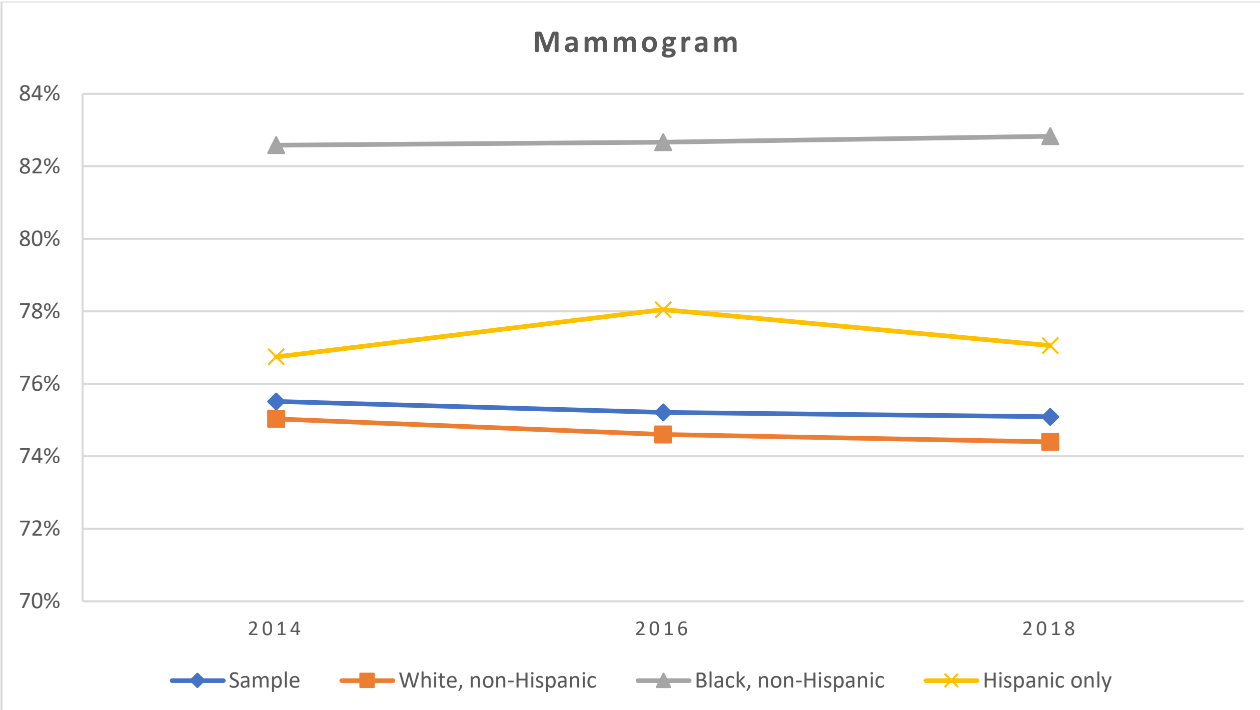

Figure 8. Rate of having Mammogram within last 2 years in 2014, 2016 and 2018. Source: BFRSS

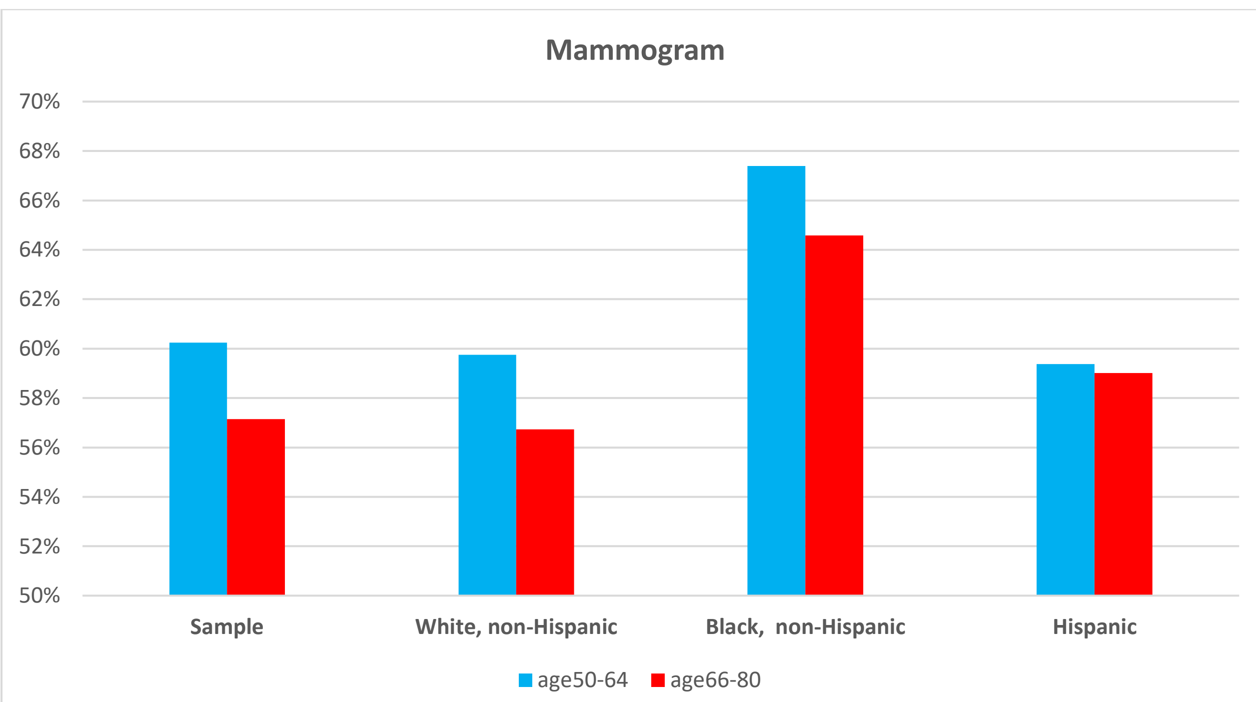

Figure 9. Rate of having Mammogram within last 12 months for the age groups. Source: BFRSS

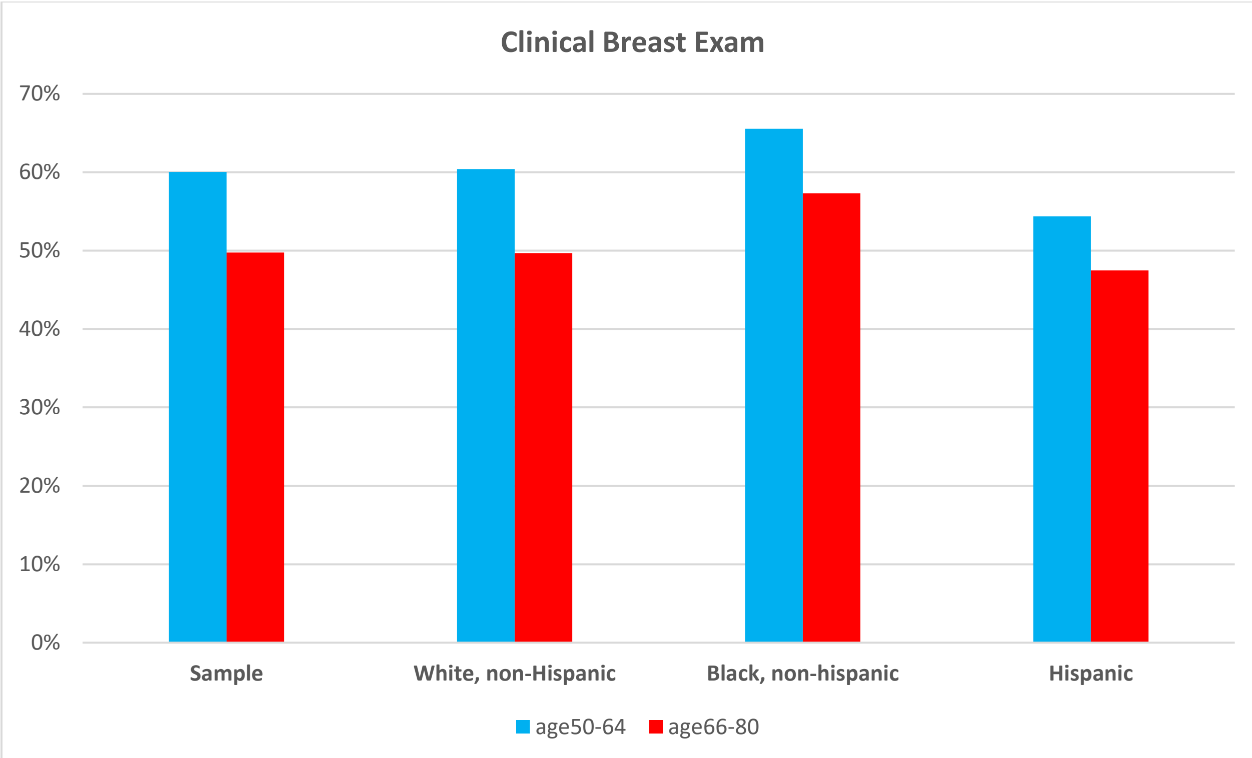

Figure 10. The rate of having Clinical Breast Exam within last 12 months for the age groups. Source: BFRSS

Figure 11 displays the percentage of individuals with healthcare coverage at each age. Examining the data, we can observe a gradual and consistent increase in the coverage rate from age 50 to 60. The rates range from 91.0% at age 50 to 93.5% at age 60. This indicates a steady rise in the proportion of individuals with insurance coverage within this age range. At age 65, there is a significant jump in the insurance rate, increasing to 98.3%. This sharp increase is likely due to individuals becoming eligible for Medicare, which provides healthcare coverage for older adults. From age 66 to 72, the insurance rate continues to rise, with rates ranging from 99.0% to 99.2%. This suggests a consistently high level of insurance coverage among individuals in this age group. As we move beyond age 72, the insurance rates remain relatively stable, ranging from 98.5% to 99.2%.

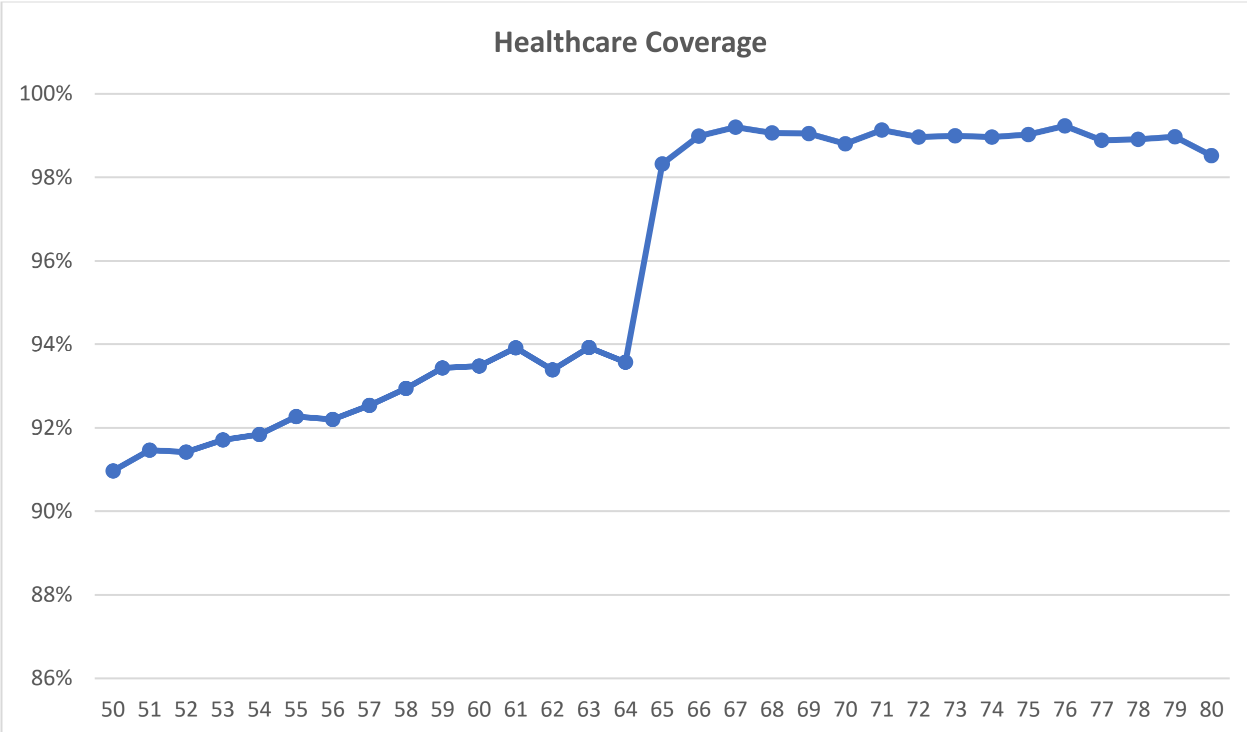

Figure 11. The rate of having any kind of Healthcare coverage (health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service) within the sample for Breast Cancer tests. Source:BFRSS

IV.3 Prostate Specific Antigen Test

The dataset used in this study only includes male respondents due to the fact that PSA tests are only applicable to men. The sample is restricted to individuals aged 50 to 80, with a mean age of 65 among men. We have restricted age between 50 and 80. The mean age for men is 65. In terms of race and ethnicity, 83.28% of the male respondents in the sample are non-Hispanic White, while 6.28% are non-Hispanic Black, and 5.06% are Hispanic. With regards to educational attainment, the largest group (40.26%) are college graduates, followed by those with some college education (24.85%), high school graduates (27.36%), and individuals without a high school education (7.53%). Regarding income, slightly more than half of male respondents earn above $50,000, with only 8% earning less than $15,000. A large majority of the respondents (94.80%) have some form of coverage, with only 5.20% lacking insurance. Finally, the mean rate for taking PSA test past 12 months is 40%, which seems low considering the recommendations. The table below illustrates summary statistics.

Table 3. Summary statistics for the sample of prostate cancer screening tools

Variable name	Frequency	Percentage
Race & ethnicity		
White, non-Hispanic only	269,070	83.28
Black, non-Hispanic only	20,301	6.28
Other race, non-Hispanic only	11,959	3.7
Multiracial, non-Hispanic only	5,394	1.67
Hispanic	16,354	5.06
Education		
No high school	24,712	7.53
Highschool	89,797	27.36
Some college education	81,577	24.85
College graduate	132,167	40.26
Income		
< $15,000	23,674	8.1
$15,000 - $25,000	41,252	14.12
$25,000 - $35000	29,995	10.26
$35,000 - $50,000	43,454	14.87
> $50,000	153,839	52.65
Healthcare coverage		
No	17,132	5.20
Yes	311,047	94.80
Age	65.15	
	(8.97)	
PSA last year	0.41	
	(0.49)	
PSA last 2 years	0.51	
	(0.49)	
Number of observations	328,916	

Source: BFRSS. The numbers in brackets are the standard deviations.

Figures 12 and 13 illustrate the rate of PSAs test in the years 2014, 2016, and 2018. Notably, there was an approximately 10 percentage point decrease in 2018 across all sample groups. The rates were similar for non-Hispanic White and non-Hispanic Black men but former had the highest rate in all years. Conversely, Hispanic men exhibited the lowest PSA test rate, with a difference of approximately 10 percentage points. In Figure 14, the mean PSA rates are presented for younger adults (50-64) and older adults (66-80). Notably, there was a 20-percentage point higher rate in older adults than in younger adults. Nevertheless, non-Hispanic White men had the highest test rate for both age groups, albeit with slight differences compared to other groups. Table 15 shows the healthcare coverage rate of individuals at each age. Analyzing the data, we observe a gradual increase in insurance rates from age 50 to 60, ranging from 88.1% to 92.0%. At age 65, there is a significant jump in the insurance rate, increasing to 97.6%, likely due to individuals becoming eligible for Medicare. From age 66 to 72, the insurance rates continue to rise, ranging from 98.3% to 98.9%. As we move beyond age 72, the insurance rates remain relatively stable, ranging from 98.2% to 98.8%.

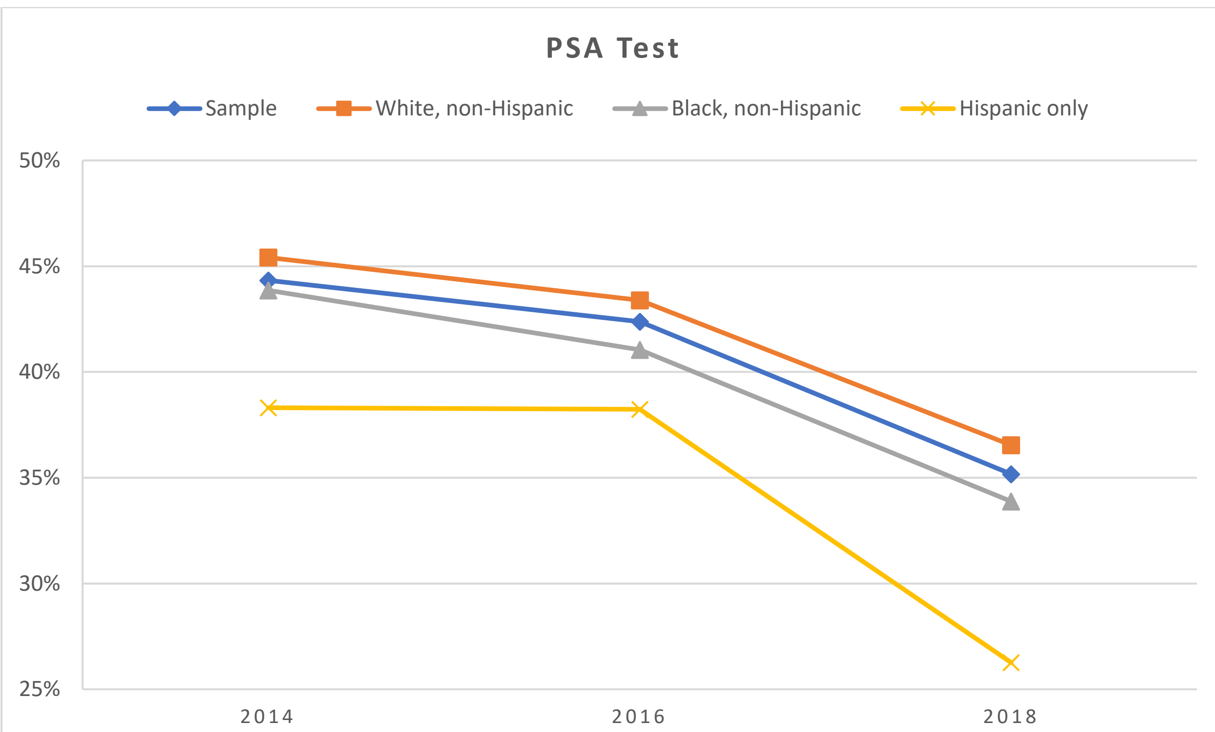

Figure 12. Rate of having PSA testwithin last 12 months in 2014, 2016 and 2018. Source: BFRSS

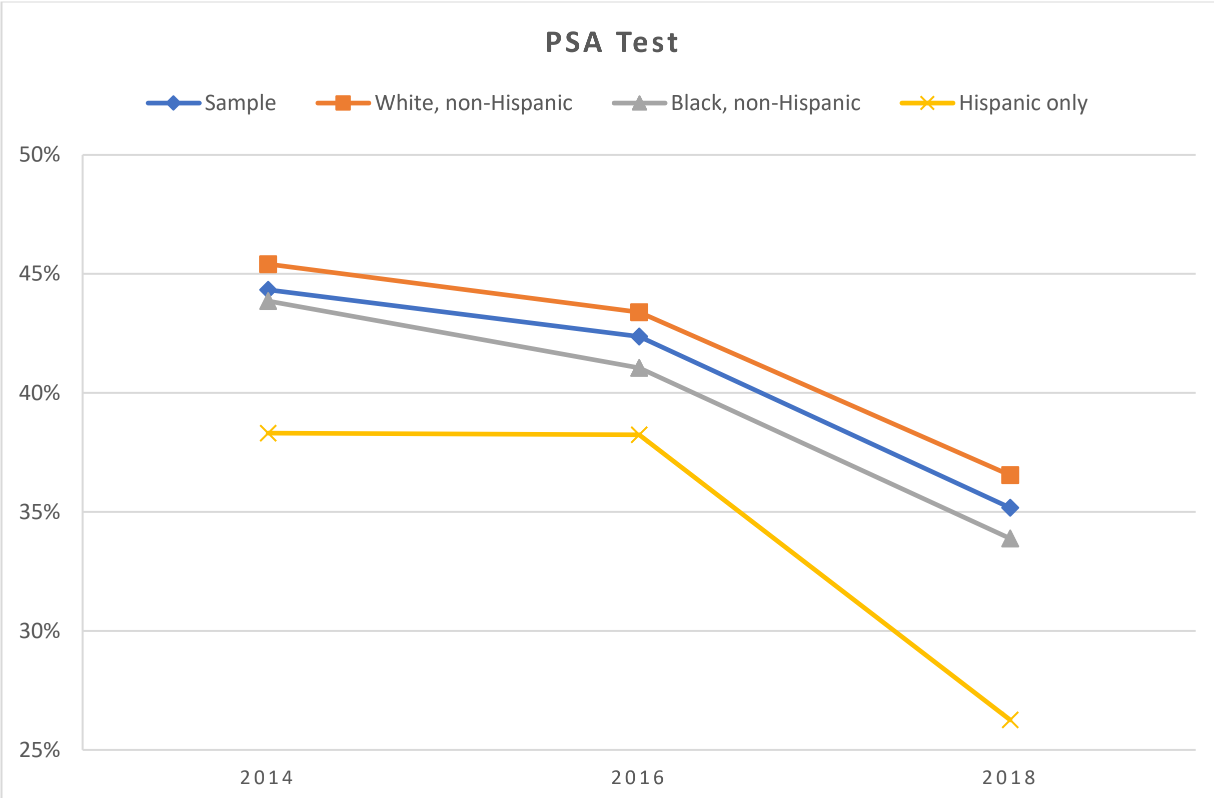

Figure 13. Rate of having PSA test within last 2 years in 2014, 2016 and 2019. Source: BFRSS

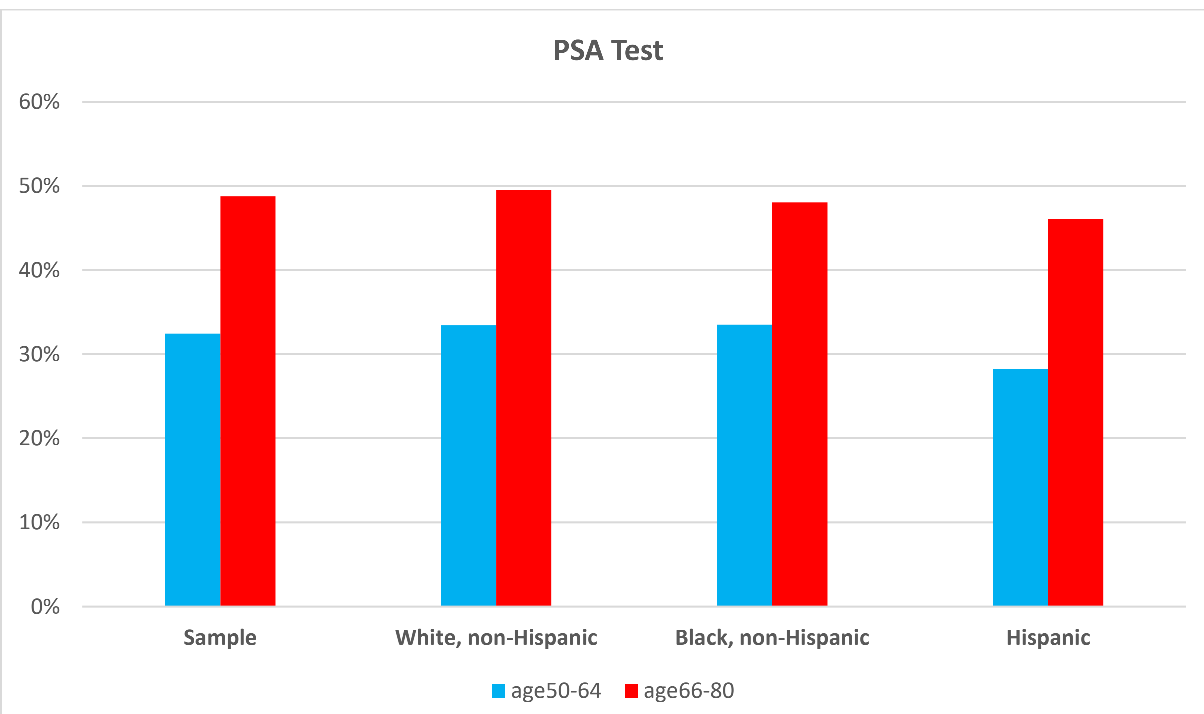

Figure 14. Rate of having PSA test last 12 months for the age groups. Source: BFRSS

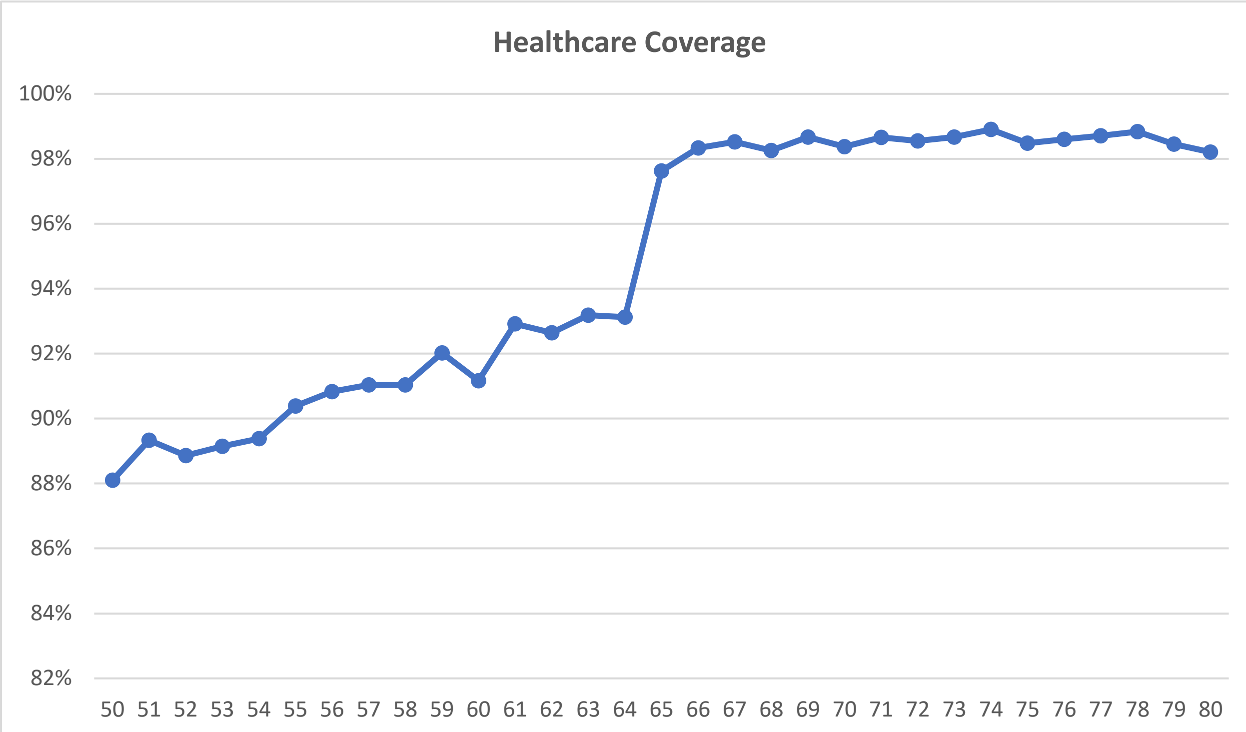

Figure 15. The rate of having any kind of Healthcare coverage (health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service) within the sample for Prostate Cancer test. Source:BFRSS

V. Method

We will use the Regression Discontinuity method to estimate the causal effect of Medicare eligibility on each cancer screening test. Most Americans are eligible for Medicare at age 65. The Medicare enrollment policy creates a distinct enrollment rate discontinuity at age 65 due to eligibility restrictions based on age. Only individuals with certain disabilities (e.g. End-Stage Renal Disease, ALS - Lou Gehrig's disease) can enroll in the program prior to turning 65. Furthermore, people close to cutoff on both sides should be similar except Medicare eligibility.

We will drop observations for age 65, since our outcome variable shows screening status past 12 months; so, a person may not be at age 65 once he/she has taken one of the screening tests.

In our model, age is running variable and cutoff score is 65. This cutoff score is exogenous and entirely based on an individual's age. We will use kernel triangular which puts more weight on the observations close to the cutoff. Furthermore, we will use 1st order polynomial in our estimations. According to Gelman and Imbens (2019), one should avoid using higher order polynomials because of the following reasons. First, polynomials impose weights" that can be noisy with polynomials of higher order. Second, estimates can be sensitive to the degree of the polynomial. Finally, confidence intervals don't have good coverage with higher order polynomials.

We will employ a non-parametric/local approach to estimate the effect of Medicare coverage on cancer screening. This approach uses observations within the bandwidth to model the outcome as a function of the running variable and the treatment. Treatment status is determined based on the running variable whether its value falls above or below a certain cut-off score. One can observe the unobserved difference between treatment and comparison group by properly controlling the value of the running variable.

As already noted, the non-parametric approach uses all observations within the bandwidths to estimate treatment effects based on a specific functional form for the outcome/rating relationship. The following equation provides a simple way to make this estimation procedure operational:

$$CScreening_i = a + B_0 T_i + f(r_i) + e_i$$

where:

• $CScreening_i$= Whether a person get a Cancer screening (=1) or not (=0)

• T_i= 1 if person i is at or over 65, otherwise it equals 0

• r_i= is running variable, which is the observation's age

• e_i=a random error term for observation i, which is assumed to be independently and identically distributed.

• The coefficient, B_0 represents the effect of Medicare on the screening rate.

Age is the running variable, and cutoff score is 65. A person is eligible for Medicare if he/she is 65 years or older. This cutoff score is exogenous and entirely based on an individual's age. A RD design is internally valid if a valid causal interference can be made for the sample that is being observed, as opposed to the population to which these findings will be generalized. (Campbell, 2002).

It is not possible to derive any causal interpretation if internal validity of the RD design is not established. One condition for internal validity is that Medicare eligibility (treatment variable) cannot influence or change the age (running variable). Since the people's ages do not depend on the Medicare eligibility, the condition holds. Another condition is that none of the other variables are discontinuous except the treatment. A third condition is that the functional form between age and cancer screenings $f(r_i)$ is continuous throughout the analysis interval absent the Medicare eligibility and is specified correctly. In this regression discontinuity model, I will use Triangular Kernel, which puts more weight on the observations who are closer to the threshold. The Mean Squared Error (MSE) method has been selected to determine the optimal bandwidth. The bandwidth represents the range around the cutoff score that determines the inclusion of observations in the analysis. "Plug-in" procedure has been used to choose the optimal bandwidth. In a straightforward manner, this procedure offers a closed-form analytical solution for the bandwidth that minimizes a specific trade-off between bias and precision. Fan and Gijbels (1996) originally introduced this method within the framework of local linear regressions, and subsequently, Imbens and Kalyanaraman (2009) and DesJardins and McCall (2008) have adapted and customized it for application in the RD setting (Jacob, 2012).

The key assumption is that, in the absence of Medicare, there will not be any discontinuous change in the screening probability within 12 months at the age of 65.

VI. Results

VI.1 Colorectal Cancer Screening Tools

The absolute increase in the probability of taking these tests is 2.95 percentage points, with a relative change of 19.8%. The coefficients are highly statistically significant, indicating that the probability of taking colonoscopy or sigmoidoscopy significantly increases at age 65. This finding is promising since these tests are recommended to be taken every 5 years for individuals at average risk for colon cancer. Furthermore, the analysis indicates that the change in the probability of taking these tests at age 65 is much higher for men compared to women, with a difference of 1.4 percentage points. It suggests that men are more likely to utilize these tools. The absolute change in the rates of men is higher than the sample's rate and the coefficient is highly statistically significant.

Regarding race/ethnicity, the findings suggest that Hispanic people experience the largest change in the probability of taking these tests, with an absolute increase of 3.16% and a relative change of 22.6%. Given that Hispanic people have the lowest mean rate of taking colonoscopy or sigmoidoscopy in the sample, this result is particularly promising, as it suggests that they are more likely to utilize these tools once they become eligible for Medicare. This finding could be attributed to the fact that Hispanic people are more likely to be uninsured or underinsured, making them less likely to receive preventive care. The onset of Medicare coverage at age 65 could, therefore, increase the likelihood of utilizing these benefits. In contrast, non-Hispanic Blacks show the smallest increase in the rate of on undergoing Colonoscopy and Sigmoidoscopy, with an absolute change of only 0.05 and a relative change of 0.3%. Furthermore, the coefficient is only statistically significant at the 10% level. Notably, non-Hispanic Blacks have the highest mean probability of taking these tests in the sample (19%). The detailed results are presented in Table 4.

The mean rate of having Stool Blood Test within past 12 months is low in the sample and among different demographic subgroups. Specifically, at age 65, there is an absolute increase of 0.82 percentage points in the overall sample, with a corresponding relative increase of 9.9%. While men and women exhibit similar mean test rates, men demonstrate a much higher relative increase of 17.07% compared to 9.8% for women. In terms of race/ethnicity, non-Hispanic Whites have the lowest mean rate of SBT uptake. However, they experience a statistically significant absolute increase of 1 percentage point at age 65, with a corresponding relative change of 13.1%. Conversely, non-Hispanic Blacks have the highest mean rate of SBT uptake, with a rate of 11.4%. Nonetheless, they experience the lowest change, with an absolute increase of 0.87 percentage points and a relative increase of 6.79%, which is not statistically significant, either. Hispanic individuals experience the highest change upon becoming eligible for Medicare, with an absolute increase of 2.17 percentage points and a relative change of 21.6%, and the result is statistically significant. In general, low rates of taking Stool Blood Test may be because of low awareness or patients' preference to take other tests such as Colonoscopy which is more comprehensive.

Figures 16 and 17 present the regression discontinuity (RD) plots for colonoscopy & sigmoidoscopy and Stool Blood Test, respectively. In the case of Colonoscopy and Sigmoidoscopy, we observe an increasing trend in the rate of taking the tests until the age of 65, after that it becomes relatively stable. However, among the Hispanic population, there is a notable downward trend beyond age 65, indicating a potential difference in test utilization among this demographic group. For the Stool Blood Test, there is an upward trend in the rate of taking the test within 12 months as individuals get older, in addition to a discontinuity at age 65. This trend is consistent across both genders and all demographic groups in the sample.

Table 4. Regression discontinuity at age 65 for the probability of using Colorectal cancer screening tools

Variable names	Col-Sig				Stool Blood Test			
	Absolute change	Rel change	Bandwidth	N of obs	Absolute Change	Relative change	bandwidth	N of obs
Sample	0.029*** (-0.007)	19.77%	2.32	510,602	0.008*** (-0.002)	9.9%	3.56	522,295
Male	.04118*** (-0.0108)	27.55%	2.46	217,098	0.015*** (-0.003)	17.7%	4.26	223,496
Female	0.027** (-0.009)	18.08%	2.4	293,270	0.008*** (-0.002)	9.8%	3.9	298,560
nH-White	0.028*** (-0.007)	10.20%	2.21	416,916	0.010*** (-0.002)	13.1%	3.4	424,919
nH-Black	0.001* (-0.009)	0.28%	4.07	36,897	0.009 (-0.008)	7.7%	3.25	38,238
Hispanic	0.032*** (-0.011)	22.62%	4.15	24,673	0.022** (-0.009)	21.6%	4.04	25,703

Note: ***, ** and * mean p<0.001, p<0.05 and <0.1 respectively. *nH* stands for non-Hispanic. *Rel change* shows the relative change in probability compared to the mean of observations aged between 55 and 64. The numbers in brackets correspond to the standard errors.

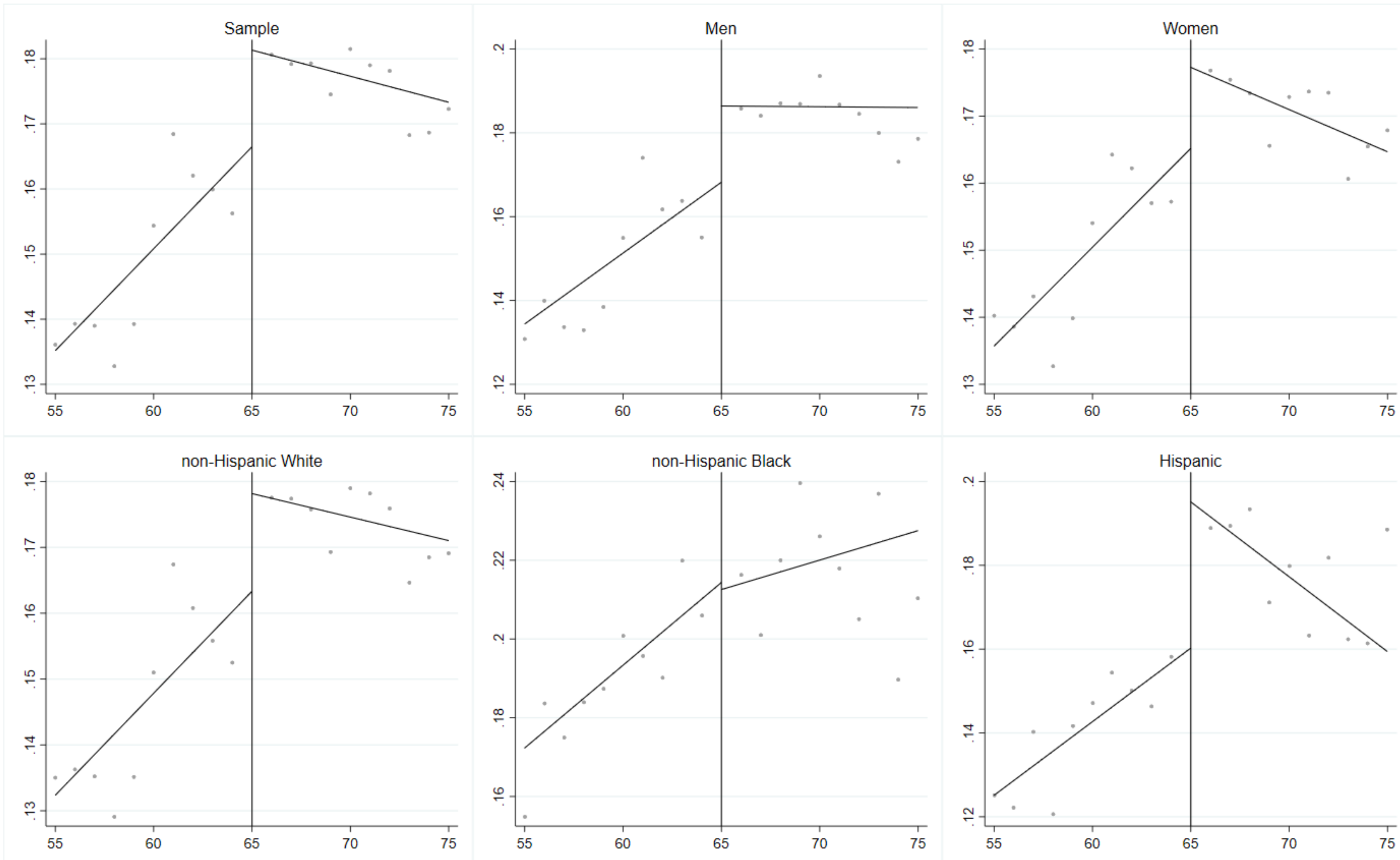

Figure 16. RD plot at age 65 for undergoing colonoscopy or sigmoidoscopy last 12 months. Source: BFRSS

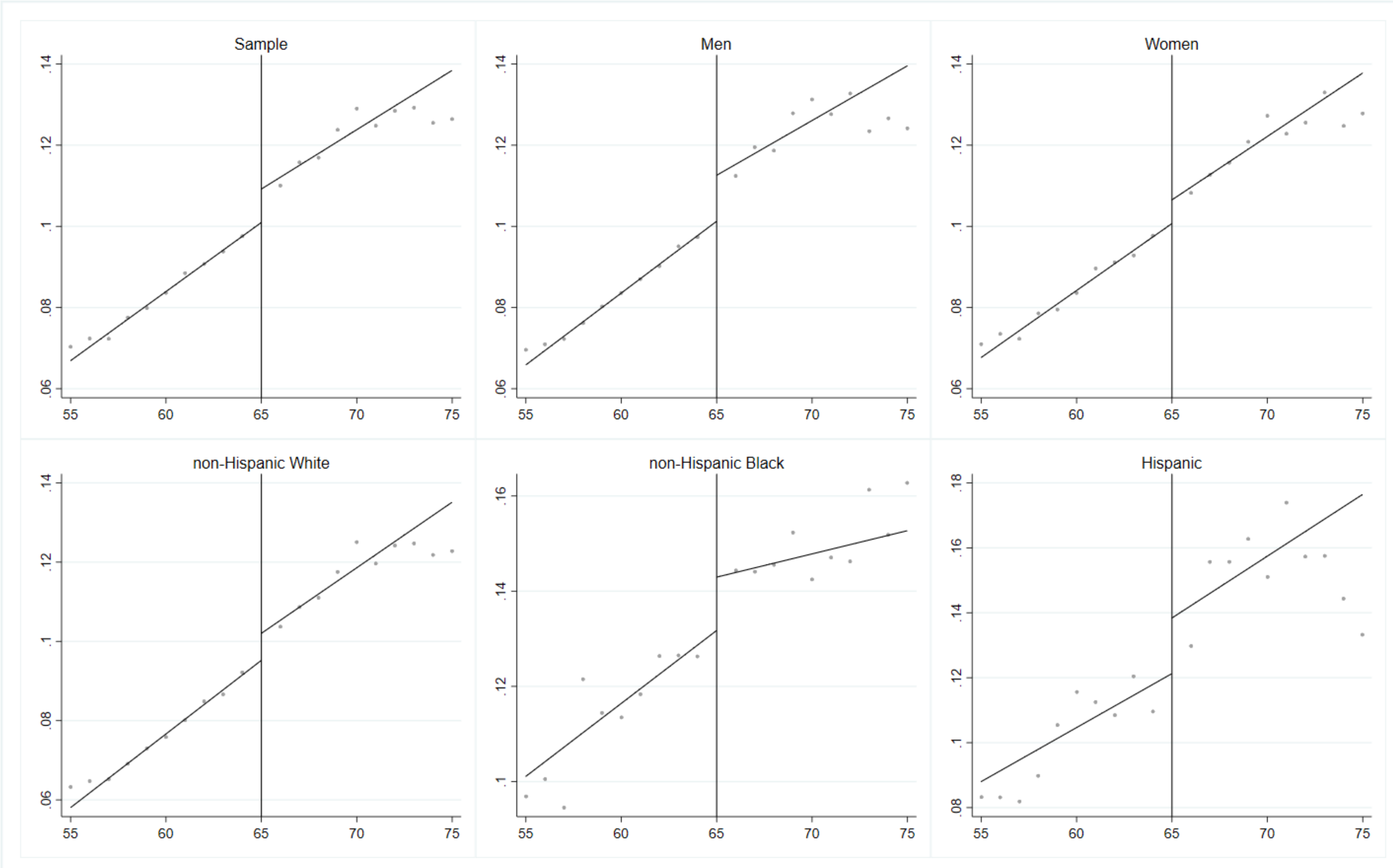

Figure 17. RD plot at age 65 for taking stool blood test last 12 months. Source: BFRSS

VI.2 Breast Cancer Screening Tools

Table 5 displays the regression discontinuity analysis on mammogram screening at age 65. The results indicate that there is 2.53 percentage points increase in the rate for the sample, which corresponds to a relative change of 4.2%, in mammogram screening. The changes appear to be marginal, given the mean screening rate of 60%. In terms of race/ethnicity, non-Hispanic Black women with 67.4% rate exhibit the highest average rate of mammogram screening in the United States. Nevertheless, the increase at age 65 is merely 0.59 percentage points, translating to a relative change of 0.90%, and the coefficient is not statistically significant, either. Conversely, Hispanic women experience a considerable change at age 65, with an absolute increase of 5.55 percentage points and a 9.34% relative increase in the probability. Among the different racial/ethnic groups, non-Hispanic White women exhibit the lowest mean rate of mammogram screening. The absolute increase is 2.6 percentage points, which is statistically significant, but still relatively small. Overall, despite the increase in the rate of mammogram at age 65, only Hispanic women experience a notable increase in the sample. The results reveal that the absolute and relative changes in clinical breast exams are generally negligible and statistically insignificant in the sample. Specifically, the absolute increase in the probability of receiving a clinical breast exam at age 65 is 0.45 percentage points, with a relative change of 0.82% for the sample. While non-Hispanic Black women exhibit the highest rate of clinical breast exam in the sample with 62.04% rate, it declines by 0.77 percentage points once they reach age 65. On the other hand, Hispanic women experience the lowest mean rate of clinical breast exams in the sample, yet they also face the highest absolute (2.95 percentage points) and relative increase (5.72%) at age 65. However, all the coefficients are statistically insignificant. One plausible explanation for the insignificant and low changes observed in the study is that women may prefer mammograms, which provide several advantages over clinical breast exams performed by medical professionals. The detailed outcomes are shown in Table 5. Figures 18 and 19 illustrate the regression discontinuity (RD) plots for Mammogram and Clinical Breast Exam, respectively. In the case of Mammogram, there is a slight increasing trend in the rate of utilization until the age of 65, after that the trend reverses and shows a gradual decline. This pattern is consistent across all racial and ethnic groups represented in the sample. For Clinical Breast Exam, the trend remains stable until the age of 65, after which there is a gradual decline in utilization. This suggests a potential decrease in the frequency of this exam among individuals beyond age 65.

Table 5. Regression discontinuity at age 65 for the probability of using Breast Cancer screening tools

Variable names	Mammogram				Clinical Breast Exam			
	Absolute Change	Rel change	Bandwidth	N of obs	Absolute change	Rel change	Bandwidth	number of obs
Sample	0.025***	4.20%	4.24	472,863	0.005	0.75%	2.52	183,024
	(-0.003)				(0.019)			
nH-White	0.026***	4.33%	4.36	385,072	0.002	0.28%	2.77	147,697
	(-0.004)				(0.006)			
nH-Black	0.006	0.88%	4.83	36,569	-0.008	-1.18%	3.2	13,549
	(-0.011)				(0.020)			
Hispanic	0.055***	9.34%	4.57	23,920	0.030	5.43%	4.79	9,085
	(-0.015)				(0.025)			

Note: ***, ** and * mean p<0.001, p<0.05 and <0.1 respectively. "*nH"* stands for non-Hispanic. *Rel change* shows the relative change in probability compared to the mean of observations aged between 50 and 64. The numbers in brackets correspond to the standard errors.

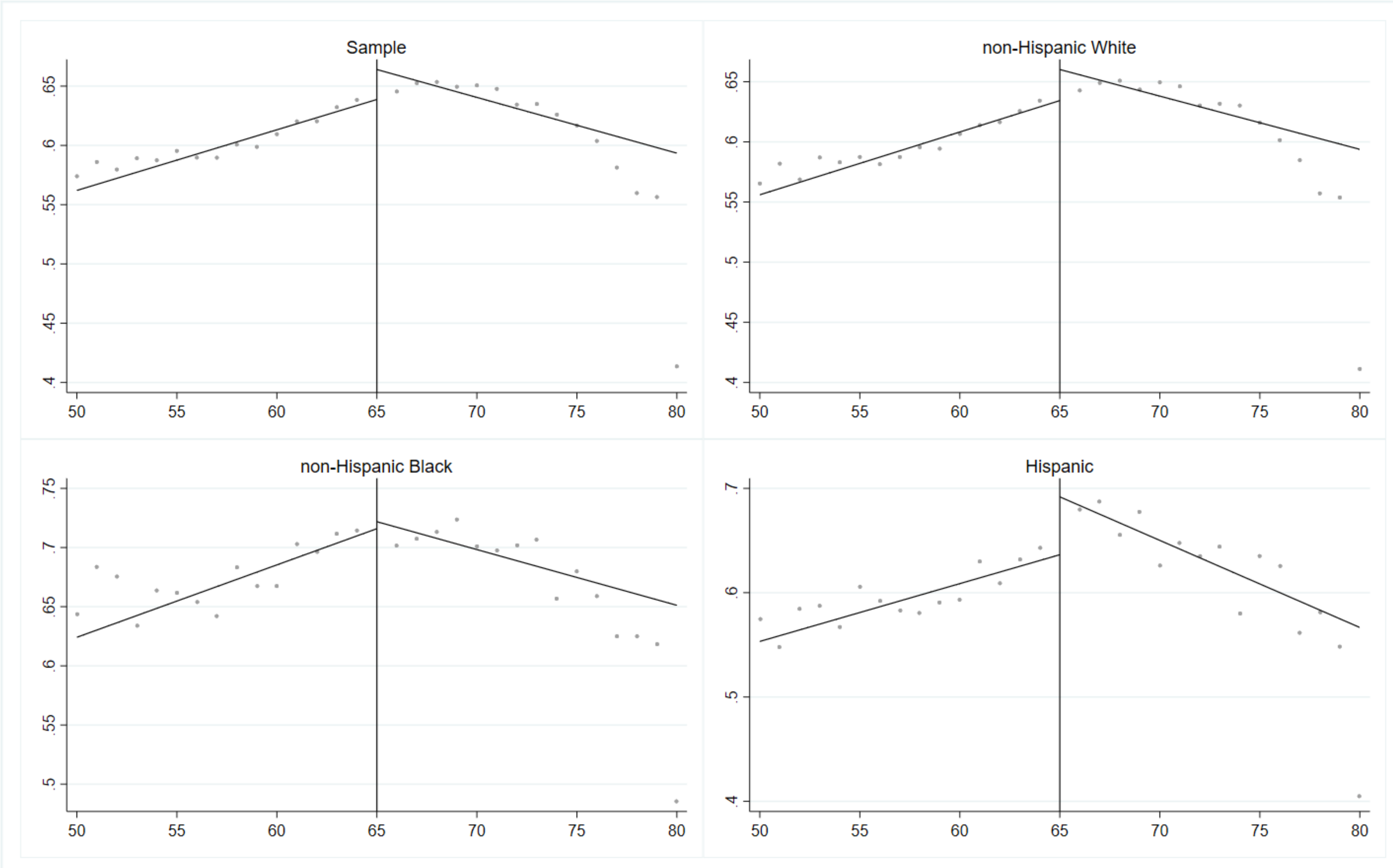

Figure 18. RD plot at age 65 for undergoing Mammogram last 12 months. Source: BFRSS

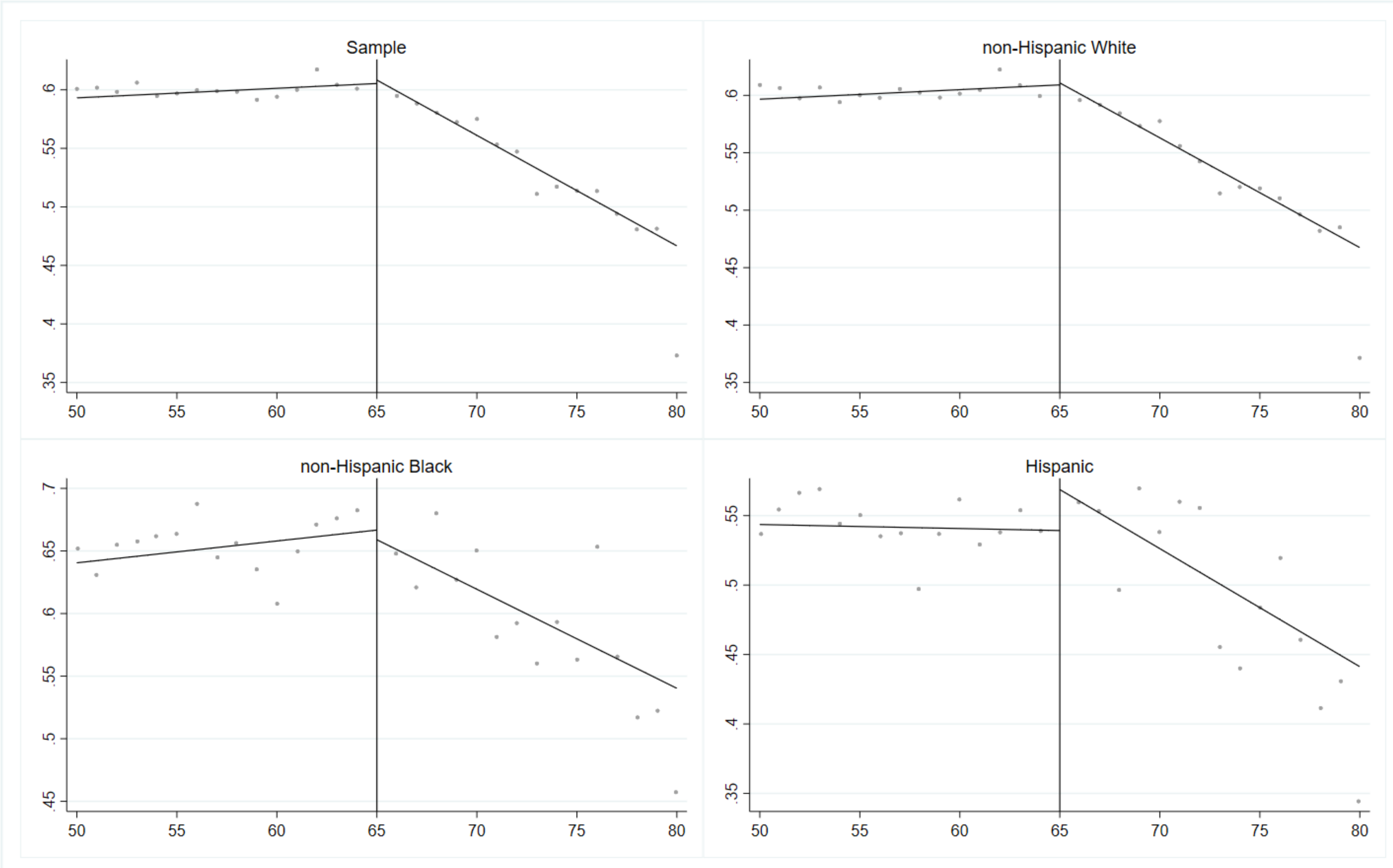

Figure 19. RD plot at age 65 for undergoing Clinical Breast Exam last 12 months. Source: BFRSS

VI.3 Prostate Cancer Screening Tools

The results reveal that the likelihood of taking the Prostate-Specific Antigen (PSA) test increases moderately upon becoming eligible for Medicare, as evidenced by the absolute change of 4.1 percentage points (10.06% relative change) for the sample. The coefficients are highly statistically significant, indicating a notable effect of Medicare eligibility on PSA screening rates. In terms of race and ethnicity, non-Hispanic Whites and Blacks have the same means. There is 4.06 percentage points increase (relative change of 12.12%) in the probability for non-Hispanic Whites. Non-Hispanic Blacks exhibit the greatest absolute and relative increase in PSA screening rates upon becoming eligible for Medicare, with an absolute change of 4.4 percentage points and a relative change of 13.01%. Conversely, Hispanic men have not only the lowest mean rate of taking PSA (34.82%) but also the lowest absolute (3.3 percentage points) and relative increase (11.67%) in the rate upon becoming eligible for Medicare. However, the coefficient for this group is weakly significant with a p-value of 0.089. Table 6 shows the findings of the regression discontinuity analysis for the PSA test.

Figure 20 presents the regression discontinuity plot at age 65. It reveals a notable upward trend in the utilization of the PSA test leading up to the age of 65, followed by a gradual increase thereafter. Importantly, this trend remains consistent across all demographic groups analyzed in the study.

Table 6. Regression discontinuity at age 65 for the probability of using Prostate cancer screening tools

Variable names	Prostate Specific Antigen Test			
	Absolute Change	Relative change	Bandwidth	N of obs
Sample	0.041*** (-0.004)	12.62%	4.590	316006
nH-White	0.041*** (-0.005)	12.12%	3.940	258500
nH-Black	0.044*** (-0.017)	13.01%	5.210	19468
Hispanic	0.033* (-0.019)	11.67%	4.060	15774

Note: ***, ** and * mean p<0.001, p<0.05 and <0.1 respectively. *"nH"* stands for non-Hispanic. *Relative change* shows the relative change in probability compared to the mean of observations aged between 50 and 64. The numbers in brackets correspond to the standard errors.

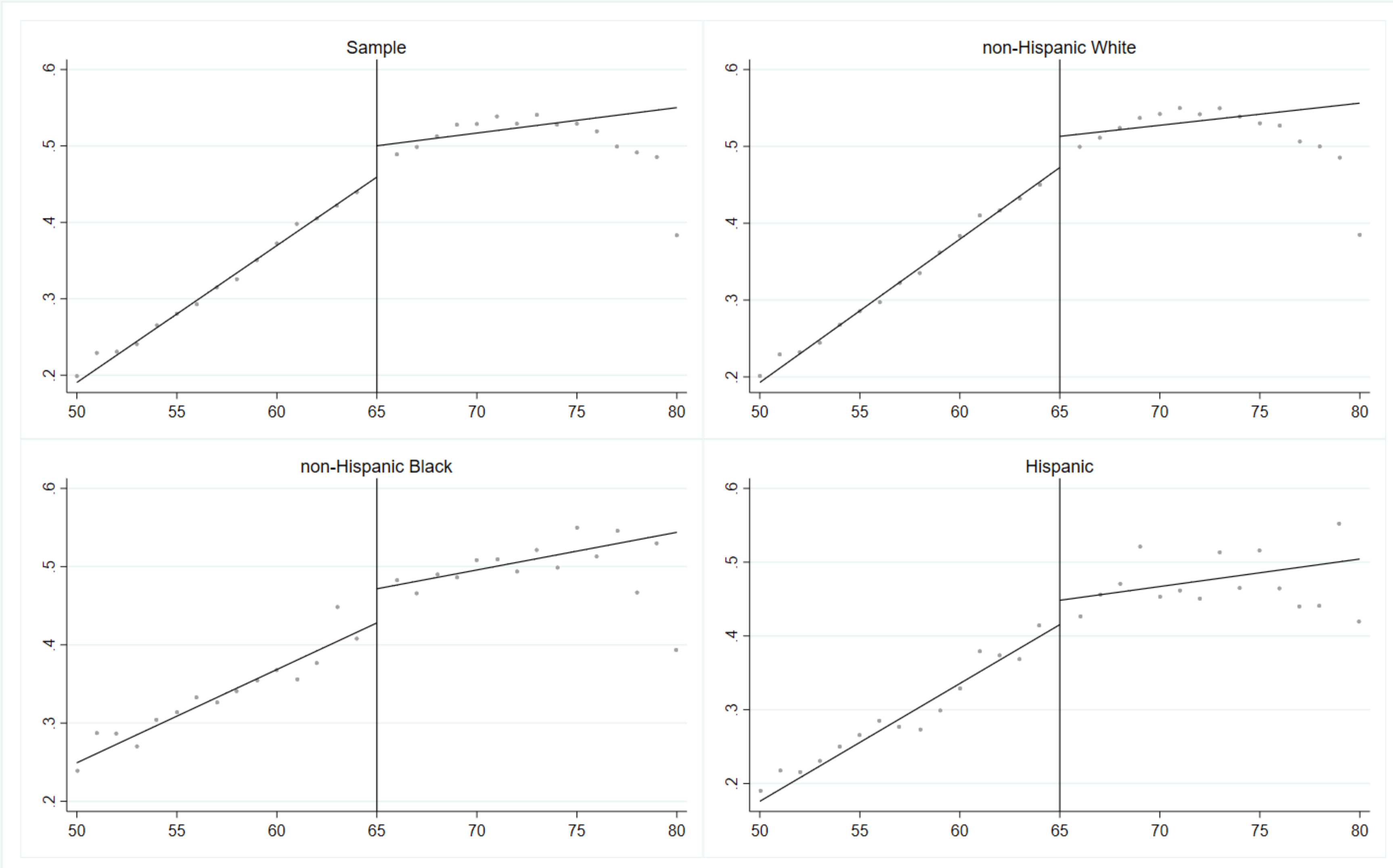

Figure 20. RD plot at age 65 for taking PSA test last 12 months. Source: BFRSS

VII. Conclusion

In this study, we have used regression discontinuity to estimate the effect of Medicare eligibility on patients' cancer screening behavior for Breast, Colorectal and Prostate cancer. Our findings indicate statistically significant changes in all tests except for the Clinical Breast Exam. However, changes in Mammogram screening are moderate to low even though the results are statistically significant. In contrast, there were significant changes in Colonoscopy and Sigmoidoscopy screening rates, as well as notable differences in Stool Blood Test rates. Additionally, our analysis reveals an important increase in the rates of taking PSA upon men become eligible for Medicare. Furthermore, the most significant changes were observed among Hispanic individuals for all tests except for PSA, while non-Hispanic Blacks exhibited the lowest changes in all tests excluding PSA.

The results reveal the importance of public health insurance programs like Medicare in promoting preventive healthcare measures. The results also suggest that the influence of Medicare eligibility on cancer screening is not uniform and may be influenced by the specific screening method. Furthermore, our analysis has revealed disparities in the impact of Medicare eligibility on different demographic groups. This research lays the groundwork for future studies in healthcare policy and the behavior of cancer screening. Researchers can build upon these findings to investigate the reasons behind the observed disparities and to develop targeted interventions aimed at improving cancer screening rates, especially in underserved populations. Understanding the impact of Medicare eligibility on cancer screening behavior can help in designing policies that promote early detection and prevention of cancer.

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Appendix

Table 7. Regression Discontinuity of cancer screening tools at age 62 and 63

Variable name	RD at age 62	P value	N of obs	RD at age 63	P value	N of obs
Mammogram	-0.00542	0.546	473,837	0.00941	0.319	475,035
	(0.00897)			(0.00945)		
Stool Blood Test	-0.00518	0.213	523,370	-0.00503	0.353	525,858
	(0.00416)			(0.00542)		
PSA Test	-0.01923	0.188	316,253	-0.00649	0.562	317,381
	(0.01461)			(0.0112)		
Colo & Sig	-0.0112	0.343	511,695	-0.0131	0.136	514,028
	(0.01181)			(0.00879)		

The numbers in brackets are the standard errors.

Table 8. Covariate balance test for Education

Variable name	coefficient	p value
Sample for Colorectal Cancer	-0.00968	0.269
Sample for Breast Cancer	-0.00135	0.855
Sample for Prostate Cancer	-0.0081	0.296

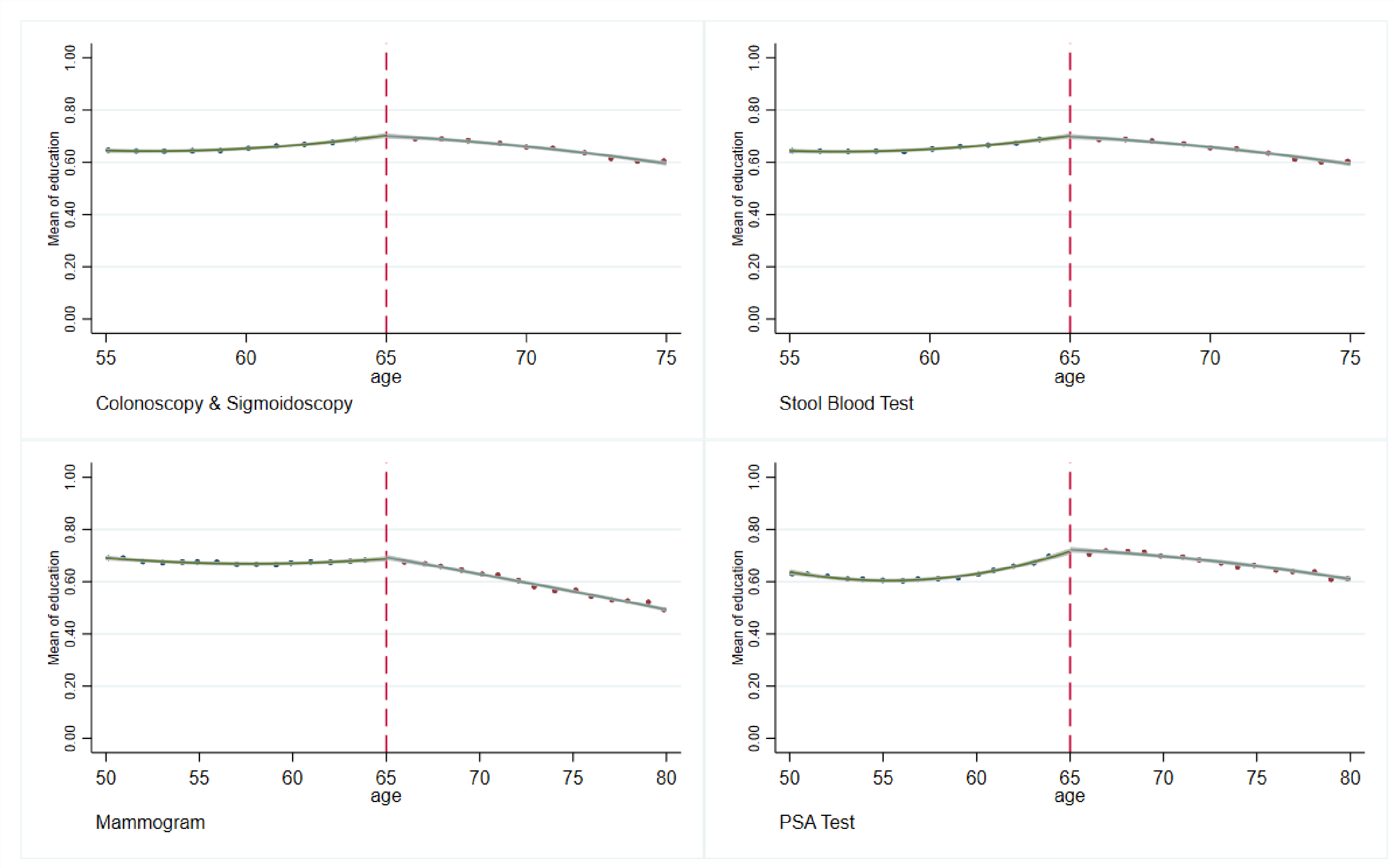

Figure 21. Covariate balance test for Education. 0 means havning no college education, and 1 means having some college education or a college degree. Source: BFRSS