Published in final edited form as:

Am J Prev Med. 2016 October ; 51(4): e107–e115. doi:10.1016/j.amepre.2016.02.025.

Racial/Ethnic Disparities in Colorectal Cancer Screening Across Healthcare Systems

Andrea N. Burnett-Hartman, PhD^{1,2}, Shivan J. Mehta, MD, MBA³, Yingye Zheng, PhD², Nirupa R. Ghai, PhD⁴, Dale McLerran, MS², Jessica Chubak, PhD⁵, Virginia P. Quinn, PhD⁴, Celette Sugg Skinner, PhD⁷, Douglas A. Corley, MD, PhD⁶, John Inadomi, MD⁸, and Chyke A. Doubeni, MD, MPH⁹ on behalf of the PROSPR Consortium

¹Institute for Health Research, Kaiser Permanente Colorado, Denver, Colorado

²Fred Hutchinson Cancer Research Center, Seattle, Washington

³Division of Gastroenterology, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania

⁴Department of Research and Evaluation, Kaiser Permanente Southern California, Pasadena, California

⁵Group Health Research Institute, Seattle, Washington

⁶Division of Research, Kaiser Permanente Northern California, Oakland, California

⁷University of Texas Southwestern Medical Center and the Harold C. Simmons Comprehensive Cancer Center, Dallas, Texas

⁸Division of Gastroenterology, University of Washington, School of Medicine, Seattle, Washington

⁹Department of Family Medicine and Community Health, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania

Abstract

Introduction—Racial/ethnic disparities in colorectal cancer (CRC) screening and diagnostic testing present challenges to CRC prevention programs. Thus, it is important to understand how differences in CRC screening approaches between healthcare systems are associated with racial/ethnic disparities.

Methods—This was a retrospective cohort study of patients aged 50–75 years who were members of the Population-based Research Optimizing Screening through Personalized Regimens cohort from 2010 to 2012. Data on race/ethnicity, CRC screening, and diagnostic testing came from medical records. Data collection occurred in 2014 and analysis in 2015. Logistic regression

Address correspondence to: Andrea N. Burnett-Hartman, PhD, 10056 E Harvard Ave., Ste. 300, Denver CO 80231. andrea.n.burnett-hartman@kp.org.

No financial disclosures were reported by the authors of this paper.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

models were used to calculate AORs and 95% CIs comparing completion of CRC screening between racial/ethnic groups. Analyses were stratified by healthcare system to assess differences between systems.

Results—There were 1,746,714 participants across four healthcare systems. Compared with non-Hispanic whites (whites), odds of completing CRC screening were lower for non-Hispanic blacks (blacks) in healthcare systems with high screening rates (AOR=0.86, 95% CI=0.84, 0.88) but similar between blacks and whites in systems with lower screening rates (AOR=1.01, 95% CI=0.93, 1.09). Compared with whites, American Indian/Alaskan Natives had lower odds of completing CRC screening across all healthcare systems (AOR=0.76, 95% CI=0.72, 0.81). Hispanics had similar odds of CRC screening (AOR=0.99, 95% CI=0.98, 1.00) and Asian/Pacific Islanders had higher odds of CRC screening (AOR=1.16, 95% CI=1.15, 1.18) versus whites.

Conclusions—Racial/ethnic differences in CRC screening vary across healthcare systems, particularly for blacks, and may be more pronounced in systems with intensive CRC screening approaches.

Introduction

Despite effective strategies for prevention, early detection, and treatment,^{1–9} there continue to be differences in colorectal cancer (CRC) incidence and survival by race/ethnicity.^{10–14} Specifically, African Americans have higher CRC incidence and lower 5-year survival rates than other racial/ethnic groups.^{10,11} This disparity may, in part, be due to differences in the utilization of CRC screening or access to health care.^{12,15,16}

Utilization of CRC screening and access to health care can be influenced by many factors. Based on the Health Beliefs Model, CRC screening behaviors vary by race/ethnicity because different racial/ethnic groups have distinct beliefs about the risks and benefits of CRC screening.¹⁷ These beliefs may interact with system-level factors, such as the healthcare delivery system's approach to CRC screening. Different approaches to CRC screening include: relying on providers to recommend screening during office visits, mailing reminder letters, and sending stool-based test kits to patients who are due for screening.^{18–20} Although some studies have evaluated health disparities in national or regional screening programs,^{21–23} few have examined racial/ethnic differences in the receipt of CRC screening and diagnostic testing between health systems in the U.S. that use different screening approaches.^{24,25}

Additionally, stool-based testing, including the fecal immunochemical test (FIT) and guaiac-based fecal occult blood test (gFOBT), is an important part of many CRC screening programs, and requires timely follow-up of positive stool-based test results with a colonoscopy to complete the screening episode. Prior studies that only measure initiation of CRC screening, but do not include follow-up of abnormal results, may overestimate CRC screening in the population and miss potential differences in CRC screening completion and diagnostic testing between groups.

The underlying hypothesis is that the association between race/ethnicity and colorectal cancer screening completion differs between healthcare systems that use different

approaches to CRC screening outreach. Thus, this study evaluates racial/ethnic differences in receipt of CRC screening and follow-up diagnostic testing across four diverse health systems and patient populations.

Methods

Study Setting and Population

This study was conducted as part of the National Cancer Institute–funded consortium Population-based Research Optimizing Screening through Personalized Regimens (PROSPR). The overall aim of PROSPR is to conduct multisite, coordinated, transdisciplinary research to evaluate and improve cancer screening processes. The ten PROSPR Research Centers reflect the diversity of U.S. delivery system organizations. The PROSPR CRC sites for this study were Group Health Research Institute (GH), the Kaiser Permanente consortium (Kaiser Permanente Northern California [KPNC] and Kaiser Permanente Southern California [KPSC]), and the Parkland Health & Hospital System/University of Texas Southwestern Medical Center (PHHS-UTSW).²⁶

During the study period, the healthcare delivery systems employed different approaches to CRC screening; all centers offered endoscopic and stool-based tests.²⁶ However, how these tests were offered varied by system. GH patients received take-home gFOBT/FIT test kits or recommendations for endoscopic screening during office visits. Patients also received annual reminder letters about screening and follow-up calls and could request that a stool-based test kit be mailed to them. KPNC and KPSC had intensive programs that relied on mailed FIT tests for all members not up to date with screening, regardless of whether or not members requested a test or had an office visit.¹⁸ PHHS-UTSW, the safety net provider for Dallas County residents, relied on providers to recommend and order tests based on patient preference.

The study population included screening-eligible cohort members from January 1, 2010 to December 31, 2012. For GH, KPNC, and KPSC, eligible patients included those who were aged 50–75 years. PHHS-UTSW patients included in the study had at least one visit with a Parkland primary care provider in 2010–2012, and were aged 50–64 years. This upper age limit of 64 years for PHHS-UTSW was due to incomplete data capture on Medicare-eligible patients.

Patients with a known history of colectomy; CRC prior to cohort entry; or incomplete data on race/ethnicity, cohort entry date, or sex were excluded. The authors also excluded those with a history of colonoscopy within 10 years or sigmoidoscopy within 5 years prior to cohort entry, because these cohort members were considered up to date with CRC screening.²⁷ Protocols and study procedures for PROSPR were approved by the IRBs at each research center and at the Fred Hutchinson Cancer Research Center, which manages the pooled PROSPR data.

Data Collection

Each healthcare system in the PROSPR CRC consortium uses comprehensive electronic medical record systems and administrative databases that were used to collect demographic

information (e.g., age, sex, and race and ethnicity) and track patient utilization, health insurance, orders, test results, and pathology results.²⁶

Cohort members were followed up for procedures and tests occurring from the time of cohort entry until the first of the following events: 18 months of follow-up; December 31, 2012; death; disenrollment; or in the case of PHHS-UTSW, known relocation outside of Dallas County. Prior history of sigmoidoscopy and colonoscopy, including time since the last procedure, were retrospectively collected from electronic databases, going back to 2006 for GH, 1999 for KPNC and KPSC, and 2010 for PHHS-UTSW. The study also collected data on continuous months of enrollment in the healthcare system (allowing for a 90-day gap in enrollment) prior to cohort entry and demographic information. Data collection occurred in 2014.

Measures

The key variable of interest, race/ethnicity, was generally obtained from patient self-report during health system enrollment or at office visits. Race/ethnicity was categorized as non-Hispanic white (white), non-Hispanic black (black), Hispanic, Asian/Pacific Islander (API), American Indian/Alaska Native (AI/AN), or multiple/other.²⁶

The primary outcome of interest was completion of an incident CRC screening episode. This was defined as having at least one of the following during the first 18 months after entry into the PROSPR cohort:

1. screening colonoscopy;
2. sigmoidoscopy;
3. gFOBT or FIT with a negative result; or
4. gFOBT or FIT with a positive result followed by a colonoscopy within 90 days.

Current Procedural Terminology, Healthcare Common Procedure Coding System, and lab codes were used to ascertain receipt of colonoscopy, sigmoidoscopy, and FIT or gFOBT. FIT and gFOBT results were derived from laboratory databases.

Statistical Analysis

Analyses were conducted in 2015 using the pooled data and also separately for each healthcare system. SAS, version 9.3 was used for all analyses.

Logistic regression models were used to calculate AORs and 95% CIs comparing completion of an incident CRC screening episode within 18 months of follow-up between each race/ethnic group and whites. All patients who completed incident screening within the first 18 months of follow-up were included in the models irrespective of follow-up duration, but those without incident screening and <18 months of follow-up were excluded ($n=315,554$). Models were adjusted for age, sex, healthcare system, length of prior health system enrollment, ZIP code–level median household income, insurance type, Rural Urban Commuting Area,^{28,29} and Charlson comorbidity score during the first 12 months of follow-

up as potential confounding factors related to access to care. Adjustment variables were parameterized according to the categories in Table 1, and those with missing values for any covariate were included in the models using a missing indicator for the covariate value. The interaction between race/ethnicity and health system was evaluated using the Wald p -value for the interaction term in the full model. This modeling approach was also used to compare the receipt of colonoscopy within 90 days for patients with a positive gFOBT/FIT result.

To limit the potential bias of excluding cohort members who had <18 months of follow-up and no incident CRC screening, the inverse probability weighting method was used^{30,31} for non-randomly missing data. The inclusion probability was calculated in the full cohort using a logistic regression model that included age, sex, length of follow-up in days, and race/ethnicity that may differentially affect follow-up. The contribution of individuals with <18 months of follow-up to the estimation was inversely weighted by the inclusion probability. Results were compared from both weighted and unweighted logistic regression models to evaluate potential bias.

Sensitivity analyses restricted to those who were aged 50–53 years, and separate analyses for those with at least 5 years of prior enrollment (KPNC, KPSC, and GH) were used to evaluate potential bias due to incomplete data on prior screening history. Results restricted to patients with at least 18 months of follow-up are also presented as a sensitivity analysis in this report. Interactions between race/ethnicity and markers of SES, including insurance status and income, were explored and chi-square tests were used to evaluate possible differences in the type of CRC screening test initiated by race/ethnicity. For receipt of colonoscopy following a positive FIT or gFOBT result, sensitivity analyses were conducted to assess whether the results differed using 180 or 365 days of follow-up.

Results

The study population included 1,746,714 individuals across the four sites (Appendix Figure 1). Overall, this was a predominantly metropolitan or micropolitan population (95.8%), with more women (54.1%) than men (Table 1).

Approximately 20% of participants were excluded from the analysis of CRC screening completion, because they did not have at least 18 months of follow-up and did not complete screening. Those that were excluded tended to be older and were more likely to be non-white than those who were included ($p<0.001$). Using the weighted model to account for this non-random subset of the population that was excluded, the probability of completing CRC screening within the first 18 months of entering the PROSPR cohort was 61.4% (data not shown). In the fully adjusted model for the overall cohort, compared with whites, the odds of completing a CRC screening episode within 18 months of entering the PROSPR cohort were lower for blacks (AOR=0.89, 95% CI=0.88, 0.91) and AI/ANs (AOR=0.76, 95% CI=0.72, 0.81), similar for Hispanics (AOR=0.99, 95% CI=0.98, 1.00), and higher for APIs (AOR=1.16, 95% CI=1.15, 1.18) and those of multiple/other race (AOR=1.30, 95% CI=1.28, 1.34) (Table 2).

The 18-month probability of completing a CRC screening episode was 65.3% at KPNC, 62.1% at KPSC, and 36.3% at GH. At PHHS-UTSW, there was a 44.5% probability of completing screening within 18 months among patients with at least one healthcare encounter (data not shown). Compared with whites, blacks had lower odds of completing CRC screening at KPNC (AOR=0.86, 95% CI=0.84, 0.88) and KPSC (AOR=0.91, 95% CI=0.89, 0.92), and similar odds at GH (AOR=1.01, 95% CI=0.93, 1.09) and PHHS-UTSW (AOR=1.12, 95% CI=0.93, 1.31). Hispanics had lower odds of completing CRC screening at KPNC (AOR=0.92, 95% CI=0.90, 0.93), but not at KPSC (AOR=1.02, 95% CI=1.01, 1.04), GH (AOR=1.09, 95% CI=1.00, 1.20), or PHHS-UTSW (AOR=1.15, 95% CI=0.97, 1.34) (Table 2). There were statistically significant interactions between race/ethnicity and health system, race/ethnicity and income, and race/ethnicity and insurance type (Wald $p<0.001$) (data not shown).

There were 1,014,156 patients who received FIT/gFOBT, of which 5.9% were positive (Table 3), with no substantive variation across healthcare systems (data not shown). In the fully adjusted model, the percentage positive was slightly lower in Hispanics, and higher in AI/ANs as compared with whites.

Among the 59,928 patients with positive FIT/gFOBT, 55.6% followed up with colonoscopy within 90 days (Table 4). The 90-day follow-up rate was higher at KPNC (54.6%) and KPSC (58.3%) than at GH (43.5%) and PHHS-UTSW (31.1%). In regression analyses, compared with whites, blacks (AOR=0.94, 95% CI=0.88, 1.05) and Hispanics (AOR=1.05, 95% CI=1.00, 1.10) had relatively similar odds of colonoscopy within 90 days after a positive result; odds were lower for APIs (AOR=0.87, 95% CI=0.82, 0.91) and AI/ANs (AOR=0.68, 95% CI=0.56, 0.83). There was no variation across healthcare systems in the association between race/ethnicity and receipt of timely diagnostic follow-up testing (data not shown).

Models restricted to cohort members with at least 18 months of follow-up produced similar results to the weighted logistic models in Table 2 (Appendix Table 1). Sensitivity analysis of patients aged 50–53 at cohort entry (Appendix Table 2) also showed similar results to the primary analyses. Analysis restricted to those with at least 5 years of data before cohort entry (Appendix Table 3) had lower odds of completing CRC screening for blacks and Hispanics, which may reflect the fact that KPNC and KPSC had more participants with at least 5 years of prior data. Among those initiating CRC screening, blacks were more likely to receive a screening colonoscopy as opposed to FIT/FOBT than other racial/ethnic groups ($p<0.001$) (data not shown). Sensitivity analyses using time cut points for follow-up colonoscopy within 180 and 365 days of a positive FIT/gFOBT, rather than the 90-day cut point that was used in the primary analyses, had similar results to the results presented in the primary analyses (Appendix Tables 4 and 5).

Discussion

Overall, compared with whites, blacks and AI/ANs had lower odds, APIs had higher odds, and Hispanics had similar odds of completing CRC screening. However, the association between race/ethnicity and receipt of CRC screening differed by healthcare system for blacks. Healthcare systems with intensive mailed FIT kit approaches had greater disparities

in the receipt of CRC screening for blacks than healthcare systems that relied on reminder letters and provider recommendation for screening during office visits. Also, in exploratory analyses among those who initiated screening, blacks were less likely to initiate screening via stool-based tests and more likely to receive endoscopic screening than other groups; APIs and AI/ANs were less likely to have a timely diagnostic colonoscopy after having a positive FIT/gFOBT. These results highlight steps along the CRC screening process where different race/ethnic groups may need more intensive or specialized outreach.

Overall, cohort members in systems using intensive mailed FIT approaches (KPNC and KPSC) had a higher probability of completing CRC screening than systems that relied on reminder letters and physician recommendation during office visits (GH and PHHS-UTSW). However, the odds of completing CRC screening episodes were more similar between whites and other racial and ethnic groups in the systems using reminder letters and provider recommendation. One possible explanation for these system-level differences is that the intensive FIT outreach initiatives increase screening uptake and result in fewer slippages along the screening continuum at the population level, but there is differential response to this type of outreach program by race/ethnicity.^{32,33} Therefore, systems seeking to reduce health disparities in CRC screening may not be able to achieve this goal through intensive outreach aimed at the general population. Instead, targeted approaches may be needed.

Results from prior studies of racial disparities in CRC screening have varied depending on the study population.^{34–36} National survey data in 2000 suggested lower odds of being up to date with CRC screening for Hispanics (AOR=0.71, 95% CI=0.59, 0.86) and African Americans (AOR=0.82, 95% CI=0.71, 0.95) compared with non-Hispanic whites.³⁵ Ananthakrishnan et al.³⁶ found that non-white Medicare patients were less likely to be screened in the initial years after Medicare coverage for screening colonoscopy (risk ratio [RR]=0.52, 95% CI=0.50, 0.53). Doubeni and colleagues¹³ found no significant differences between Hispanics or blacks and whites in a Medicare cohort when adjusting for socioeconomic factors. Differences in the results between studies may reflect differences in between-study populations, analysis methods, and variations in CRC screening delivery approaches.

Recent national survey data from 2010 showed lower rates for all minorities as compared with whites, and when fully adjusted for socioeconomic factors and access, Hispanic–Spanish (RR=0.76, 95% CI=0.69, 0.83), Hispanic–English (RR=0.94, 95% CI=0.91, 0.98), Asian (RR=0.78, 95% CI=0.73, 0.83), and AI/AN (RR=0.91, 95% CI=0.85, 0.97) patients still had decreased likelihood of screening.³⁷ However, this study did not allow for an evaluation of differences in associations according to healthcare system or by steps within the CRC screening process. The present study included four different healthcare systems, which allowed evaluation of differences in racial/ethnic disparities in CRC screening between healthcare systems that apply different approaches to CRC screening. The authors were also able to examine racial/ethnic differences in completion of CRC screening and receipt of follow-up diagnostic testing. The racial/ethnic groups that were less likely to receive timely follow-up colonoscopy were different than racial/ethnic groups that were less likely to complete CRC screening. Thus, it is important to evaluate multiple steps within the CRC screening process to get a full picture of race/ethnic disparities.

Limitations

Despite the large study population, these results should be interpreted in light of several limitations. First, the availability of prior screening history data varied across health systems, resulting in differences in the ability to restrict to only those who are due for CRC screening by site. However, the effect of this potential bias was estimated in sensitivity analyses restricted to those aged 50–53 years who were unlikely to have had prior CRC screening and in those with at least 5 years of prior screening data.³⁸ Results of these analyses suggested little bias due to missing data on prior screening history. Another limitation is that the study could not track complete follow-up colonoscopy after positive sigmoidoscopy, so this part of the CRC screening process was not assessed. Additionally, the results from these four systems may not be fully generalizable to all healthcare delivery environments. Nevertheless, the differences observed across settings and delivery approaches provide data to gauge the potential benefits and health disparities of implementing intensive organized screening approaches in new settings.

Conclusions

The percentage of patients with timely completion of CRC screening episodes was higher in health systems with intensive mailed FIT CRC screening approaches; yet, racial/ethnic disparities persisted in these systems. These disparities may be mitigated by targeted approaches, including targeted outreach that clearly presents multiple options for CRC screening.³⁹ Additional studies are needed to understand the effective components of organized CRC screening, the contribution of patient preferences to health disparities, and how these preferences should influence system-level decisions regarding the types of offered CRC screening tests and methods of outreach.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank the participating Population-based Research Optimizing Screening through Personalized Regimens (PROSPR) Research Centers for the data they have provided for this study. A list of the PROSPR investigators and contributing research staff are provided at: healthcaredelivery.cancer.gov/prospr/.

This work was supported by the National Cancer Institute at NIH (U54 CA163261, U54 CA163262, U54 CA163308, and U01 CA163304) and the National Center for Advancing Translational Sciences (KL2 TR000421). These study sponsors did not have a role in the analysis or interpretation of results.

References

1. Mandel JS, Bond JH, Church TR, et al. Reducing mortality from colorectal cancer by screening for fecal occult blood. Minnesota Colon Cancer Control Study. *N Engl J Med*. 1993; 328(19):1365–1371. <http://dx.doi.org/10.1056/NEJM199305133281901>. [PubMed: 8474513]
2. Schoen RE, Pinsky PF, Weissfeld JL, et al. Colorectal-cancer incidence and mortality with screening flexible sigmoidoscopy. *N Engl J Med*. 2012; 366(25):2345–2357. <http://dx.doi.org/10.1056/NEJMoal114635>. [PubMed: 22612596]

3. Nishihara R, Wu K, Lochhead P, et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. *N Engl J Med*. 2013; 369(12):1095–1105. <http://dx.doi.org/10.1056/NEJMoa1301969>. [PubMed: 24047059]
4. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med*. 2008; 149(9):627–637. <http://dx.doi.org/10.7326/0003-4819-149-9-200811040-00243>. [PubMed: 18838716]
5. Doubeni CA, Weinmann S, Adams K, et al. Screening colonoscopy and risk for incident late-stage colorectal cancer diagnosis in average-risk adults: a nested case-control study. *Ann Intern Med*. 2013; 158(5 Pt 1):312–320. <http://dx.doi.org/10.7326/0003-4819-158-5-201303050-00003>. [PubMed: 23460054]
6. Hardcastle JD, Chamberlain JO, Robinson MH, et al. Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. *Lancet*. 1996; 348(9040):1472–1477. [http://dx.doi.org/10.1016/S0140-6736\(96\)03386-7](http://dx.doi.org/10.1016/S0140-6736(96)03386-7). [PubMed: 8942775]
7. Atkin WS, Edwards R, Kralj-Hans I, et al. Once-only flexible sigmoidoscopy screening in prevention of colorectal cancer: a multicentre randomised controlled trial. *Lancet*. 2010; 375(9726):1624–1633. [http://dx.doi.org/10.1016/S0140-6736\(10\)60551-X](http://dx.doi.org/10.1016/S0140-6736(10)60551-X). [PubMed: 20430429]
8. Mandel JS, Church TR, Bond JH, et al. The effect of fecal occult-blood screening on the incidence of colorectal cancer. *N Engl J Med*. 2000; 343(22):1603–1607. <http://dx.doi.org/10.1056/NEJM200011303432203>. [PubMed: 11096167]
9. Kronborg O, Fenger C, Olsen J, Jorgensen OD, Sondergaard O. Randomised study of screening for colorectal cancer with faecal-occult-blood test. *Lancet*. 1996; 348(9040):1467–1471. [http://dx.doi.org/10.1016/S0140-6736\(96\)03430-7](http://dx.doi.org/10.1016/S0140-6736(96)03430-7). [PubMed: 8942774]
10. Robbins AS, Siegel RL, Jemal A. Racial disparities in stage-specific colorectal cancer mortality rates from 1985 to 2008. *J Clin Oncol*. 2012; 30(4):401–405. <http://dx.doi.org/10.1200/JCO.2011.37.5527>. [PubMed: 22184373]
11. Soneji S, Iyer SS, Armstrong K, Asch DA. Racial disparities in stage-specific colorectal cancer mortality: 1960–2005. *Am J Public Health*. 2010; 100(10):1912–1916. <http://dx.doi.org/10.2105/AJPH.2009.184192>. [PubMed: 20724684]
12. Cooper GS, Koroukian SM. Racial disparities in the use of and indications for colorectal procedures in Medicare beneficiaries. *Cancer*. 2004; 100(2):418–424. <http://dx.doi.org/10.1002/cncr.20014>. [PubMed: 14716780]
13. Doubeni CA, Laiyemo AO, Reed G, Field TS, Fletcher RH. Socioeconomic and racial patterns of colorectal cancer screening among Medicare enrollees in 2000 to 2005. *Cancer Epidemiol Biomarkers Prev*. 2009; 18(8):2170–2175. <http://dx.doi.org/10.1158/1055-9965.EPI-09-0104>. [PubMed: 19622721]
14. Doubeni CA, Field TS, Buist DS, et al. Racial differences in tumor stage and survival for colorectal cancer in an insured population. *Cancer*. 2007; 109(3):612–620. <http://dx.doi.org/10.1002/cncr.22437>. [PubMed: 17186529]
15. Laiyemo AO, Doubeni C, Pinsky PF, et al. Race and colorectal cancer disparities: health-care utilization vs different cancer susceptibilities. *J Natl Cancer Inst*. 2010; 102(8):538–546. <http://dx.doi.org/10.1093/jnci/djq068>. [PubMed: 20357245]
16. Siegel R, Desantis C, Jemal A. Colorectal cancer statistics, 2014. *CA Cancer J Clin*. 2014; 64(2):104–117. <http://dx.doi.org/10.3322/caac.21220>. [PubMed: 24639052]
17. Vernon SW. Participation in colorectal cancer screening: a review. *J Natl Cancer Inst*. 1997; 89(19):1406–1422. <http://dx.doi.org/10.1093/jnci/89.19.1406>. [PubMed: 9326910]
18. Levin TR, Jamieson L, Burley DA, Reyes J, Oehrli M, Caldwell C. Organized colorectal cancer screening in integrated health care systems. *Epidemiol Rev*. 2011; 33(1):101–110. <http://dx.doi.org/10.1093/epirev/mxr007>. [PubMed: 21709143]
19. Doubeni CA. The impact of colorectal cancer screening on the U.S. population: is it time to celebrate? *Cancer*. 2014; 120(18):2810–2813. <http://dx.doi.org/10.1002/cncr.28789>. [PubMed: 24895320]
20. Gupta S, Halm EA, Rockey DC, et al. Comparative effectiveness of fecal immunochemical test outreach, colonoscopy outreach, and usual care for boosting colorectal cancer screening among the

- underserved: a randomized clinical trial. *JAMA Intern Med.* 2013; 173(18):1725–1732. <http://dx.doi.org/10.1001/jamainternmed.2013.9294>. [PubMed: 23921906]
21. Benson VS, Patnick J, Davies AK, Nadel MR, Smith RA, Atkin WS. Colorectal cancer screening: a comparison of 35 initiatives in 17 countries. *Int J Cancer.* 2008; 122(6):1357–1367. <http://dx.doi.org/10.1002/ijc.23273>. [PubMed: 18033685]
 22. von Wagner C, Baio G, Raine R, et al. Inequalities in participation in an organized national colorectal cancer screening programme: results from the first 2.6 million invitations in England. *Int J Epidemiol.* 2011; 40(3):712–718. <http://dx.doi.org/10.1093/ije/dyr008>. [PubMed: 21330344]
 23. Blom J, Kilpelainen S, Hultcrantz R, Tornberg S. Five-year experience of organized colorectal cancer screening in a Swedish population - increased compliance with age, female gender, and subsequent screening round. *J Med Screen.* 2014; 21(3):144–150. <http://dx.doi.org/10.1177/0969141314545555>. [PubMed: 25070434]
 24. Rhoads KF, Patel MI, Ma Y, Schmidt LA. How do integrated health care systems address racial and ethnic disparities in colon cancer? *J Clin Oncol.* 2015; 33(8):854–860. <http://dx.doi.org/10.1200/JCO.2014.56.8642>. [PubMed: 25624437]
 25. Yano EM, Soban LM, Parkerton PH, Etzioni DA. Primary care practice organization influences colorectal cancer screening performance. *Health Serv Res.* 2007; 42:1130–1149. <http://dx.doi.org/10.1111/j.1475-6773.2006.00643.x>. [PubMed: 17489907]
 26. Tiro JA, Kamineni A, Levin TR, et al. The colorectal cancer screening process in community settings: a conceptual model for the population-based research optimizing screening through personalized regimens consortium. *Cancer Epidemiol Biomarkers Prev.* 2014; 23(7):1147–1158. <http://dx.doi.org/10.1158/1055-9965.EPI-13-1217>. [PubMed: 24917182]
 27. Lieberman DA, Rex DK, Winawer SJ, et al. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the U.S. Multi-Society Task Force on Colorectal Cancer. *Gastroenterology.* 2012; 143(3):844–857. <http://dx.doi.org/10.1053/j.gastro.2012.06.001>. [PubMed: 22763141]
 28. University of Washington Rural Health Research Center. [Accessed June 19, 2015] Rural-Urban Commuting Area Codes (RUCaA). <http://depts.washington.edu/uwruc>
 29. U.S. Department of Agriculture. [Accessed June 19, 2015] Rural-Urban Commuting Codes. www.ers.usda.gov/data-products/rural-urban-commuting-area-codes.aspx#.UgUbbm0kAVC
 30. Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. *Stat Methods Med Res.* 2013; 22(3):278–295. <http://dx.doi.org/10.1177/0962280210395740>. [PubMed: 21220355]
 31. Horvitz DG, Thompson DJ. A Generalization of Sampling Without Replacement From a Finite Universe. *J Am Stat Assoc.* 1952; 47(260):663–685. <http://dx.doi.org/10.1080/01621459.1952.10483446>.
 32. Stimpson JP, Pagan JA, Chen LW. Reducing racial and ethnic disparities in colorectal cancer screening is likely to require more than access to care. *Health Aff (Millwood).* 2012; 31(12):2747–2754. <http://dx.doi.org/10.1377/hlthaff.2011.1290>. [PubMed: 23213159]
 33. Benarroch-Gampel J, Sheffield KM, Lin YL, Kuo YF, Goodwin JS, Riall TS. Colonoscopist and primary care physician supply and disparities in colorectal cancer screening. *Health Serv Res.* 2012; 47(3 Pt 1):1137–1157. <http://dx.doi.org/10.1111/j.1475-6773.2011.01355.x>. [PubMed: 22150580]
 34. Jerant AF, Fenton JJ, Franks P. Determinants of racial/ethnic colorectal cancer screening disparities. *Arch Intern Med.* 2008; 168(12):1317–1324. <http://dx.doi.org/10.1001/archinte.168.12.1317>. [PubMed: 18574089]
 35. James TM, Greiner KA, Ellerbeck EF, Feng C, Ahluwalia JS. Disparities in colorectal cancer screening: a guideline-based analysis of adherence. *Ethn Dis.* 2006; 16(1):228–233. [PubMed: 16599375]
 36. Ananthakrishnan AN, Schellhase KG, Sparapani RA, Laud PW, Neuner JM. Disparities in colon cancer screening in the Medicare population. *Arch Intern Med.* 2007; 167(3):258–264. <http://dx.doi.org/10.1001/archinte.167.3.258>. [PubMed: 17296881]

37. Liss DT, Baker DW. Understanding current racial/ethnic disparities in colorectal cancer screening in the United States: the contribution of socioeconomic status and access to care. *Am J Prev Med.* 2014; 46(3):228–236. <http://dx.doi.org/10.1016/j.amepre.2013.10.023>. [PubMed: 24512861]
38. Rutter CM, Greenlee RT, Johnson E, et al. Prevalence of colonoscopy before age 50. *Prev Med.* 2015; 72:126–129. <http://dx.doi.org/10.1016/j.ypmed.2014.12.028>. [PubMed: 25565483]
39. Inadomi JM, Vijan S, Janz NK, et al. Adherence to colorectal cancer screening: a randomized clinical trial of competing strategies. *Arch Intern Med.* 2012; 172(7):575–582. <http://dx.doi.org/10.1001/archinternmed.2012.332>. [PubMed: 22493463]

Characteristics of the Study Population, Stratified by Race/Ethnicity: PROSPR Cohort 2010–2012

Table 1

Characteristics	Non-Hispanic white N=938,295 (%)	Non-Hispanic blacks N=157,999 (%)	Hispanic N=386,956 (%)	Asian/Pacific Islander N=236,776 (%)	American Indian/ Alaska Native N=7,824 (%)	Multiple/ other N=28,864 (%)
Age, years						
50–54	350,325 (37.3)	70,243 (44.5)	187,065 (48.3)	96,367 (42.5)	3,312 (42.3)	10,645 (36.9)
55–59	203,298 (21.7)	34,692 (22.0)	81,350 (21.0)	49,969 (22.0)	1,710 (21.9)	5,906 (20.5)
60–64	183,890 (19.6)	26,521 (16.8)	55,921 (14.5)	39,993 (17.6)	1,436 (18.4)	5,178 (17.9)
65–69	113,543 (12.1)	14,500 (9.2)	36,570 (9.5)	23,457 (10.3)	803 (10.3)	3,738 (13.0)
70–75	87,239 (9.3)	12,043 (7.6)	26,050 (6.7)	16,990 (7.5)	563 (7.2)	3,397 (11.8)
Gender						
Male	435,173 (46.4)	67,842 (42.9)	182,843 (47.3)	101,130 (44.6)	3,571 (45.6)	11,676 (40.5)
Female	503,122 (53.6)	90,157 (57.1)	204,113 (52.7)	125,646 (55.4)	4,253 (54.4)	17,188 (59.5)
ZIP code median income						
Q1 (0.53K)	148,665 (15.8)	72,933 (46.2)	152,484 (39.4)	35,273 (15.6)	1,788 (22.9)	4,457 (15.4)
Q2 (53K, 66K)	232,375 (24.8)	37,397 (23.7)	107,806 (27.9)	50,303 (22.2)	2,229 (28.5)	7,052 (24.4)
Q3 (66K, 82K)	261,225 (27.8)	27,413 (17.4)	72,951 (18.9)	63,327 (27.9)	2,010 (25.7)	8,185 (28.4)
Q4 (82K)	278,274 (29.7)	18,882 (12.0)	50,735 (13.1)	76,231 (33.6)	1,601 (20.5)	8,616 (29.9)
Unknown	17,756 (1.9)	1,374 (0.9)	2,980 (0.8)	1,642 (0.7)	196 (2.5)	554 (1.9)
Rural urban commuting area						
Metropolitan	883,129 (94.1)	155,480 (98.4)	377,190 (97.5)	223,633 (98.6)	7,235 (92.5)	27,333 (94.7)
Micro-politan	22,987 (2.4)	625 (0.4)	4,760 (1.2)	897 (0.4)	243 (3.1)	537 (1.9)
Rural	12,566 (1.3)	431 (0.3)	1,699 (0.4)	456 (0.2)	134 (1.7)	371 (1.3)
Unknown	19,613 (2.1)	1,463 (0.9)	3,307 (0.9)	1,790 (0.8)	212 (2.7)	623 (2.2)
Insurance type						
Medicaid	11,652 (1.2)	7,253 (4.6)	15,303 (4.0)	4,524 (2.0)	162 (2.1)	783 (2.7)
Medicare	8,211 (0.9)	3,061 (1.9)	3,366 (0.9)	978 (0.4)	32 (0.4)	20 (0.1)
Commercial/private	663,095 (70.7)	100,308 (63.5)	281,437 (72.7)	171,863 (75.8)	5,656 (72.3)	18,231 (63.2)
Medicare & commercial	244,036 (26.0)	34,184 (21.6)	69,430 (17.9)	45,204 (19.9)	1,866 (23.8)	9,527 (33.0)
Other	4,055 (0.4)	513 (0.3)	1,000 (0.3)	1,817 (0.8)	31 (0.4)	264 (0.9)

Characteristics	Non-Hispanic white N=938,295 (%)	Non-Hispanic blacks N=157,999 (%)	Hispanic N=386,956 (%)	Asian/Pacific Islander N=236,776 (%)	American Indian/ Alaska Native N=7,824 (%)	Multiple/ other N=28,864 (%)
Uninsured	5,418 (0.6)	9,784 (6.2)	13,303 (3.4)	1,835 (0.8)	67 (0.9)	20 (0.1)
Unknown	1,828 (0.2)	2,896 (1.8)	3,117 (0.8)	555 (0.2)	10 (0.1)	19 (0.1)
Study site						
Group Health	87,577 (9.3)	4,852 (3.1)	4,691 (1.2)	10,596 (4.7)	919 (11.7)	2,961 (10.3)
Kaiser Northern California	463,901 (49.4)	57,601 (36.5)	111,900 (28.9)	126,073 (55.6)	4,565 (58.3)	24,544 (85.0)
Kaiser Southern California	377,900 (40.3)	77,131 (48.8)	252,334 (65.2)	87,311 (38.5)	2,244 (28.7)	1,330 (4.6)
Parkland-UT Southwestern	8,917 (1.0)	18,415 (11.7)	18,031 (4.7)	2,796 (1.2)	96 (1.2)	29 (0.1)
Charlson comorbidity index						
0	539,168 (57.5)	73,962 (46.8)	183,368 (47.4)	122,396 (54.0)	3,979 (50.9)	15,299 (53.0)
1	119,863 (12.8)	22,133 (14.0)	54,531 (14.1)	31,275 (13.8)	1,166 (14.9)	4,953 (17.2)
2-3	73,696 (7.8)	16,090 (10.2)	31,269 (8.1)	17,655 (7.8)	715 (9.1)	3,231 (11.2)
4+	26,485 (2.8)	7,363 (4.7)	12,047 (3.1)	5,295 (2.3)	249 (3.2)	983 (3.4)
Unknown	179,083 (19.1)	38,451 (24.3)	105,741 (27.3)	50,155 (22.1)	1,715 (21.9)	4,398 (15.2)

PROSPR, Population-based Research Optimizing Screening through Personalized Regimens

Odds of Completing a CRC Screening Episode (During 18 Months) by Race/Ethnicity: PROSPR Cohort 2010–2012

Table 2

	Screened %	AOR ^a	95% CI	AOR ^b	95% CI
Overall		N=1,746,714			
Non-Hispanic white	54.4	1.00	(ref)	1.00	(ref)
Non-Hispanic black	50.9	0.93	0.92–0.95	0.89	0.88–0.91
Hispanic	53.9	1.07	1.06–1.08	0.99	0.98–1.00
Asian/Pacific Islander	59.2	1.20	1.18–1.21	1.16	1.15–1.18
American Indian/Alaska Native	47.7	0.84	0.79–0.89	0.76	0.72–0.81
Multiple/other	63.6	1.34	1.30–1.38	1.31	1.28–1.34
Group health		N=111,596			
Non-Hispanic white	32.1	1.00	(ref)	1.00	(ref)
Non-Hispanic black	30.8	1.02	0.95–1.09	1.01	0.93–1.09
Hispanic	32.5	1.07	0.99–1.15	1.09	1.00–1.20
Asian/Pacific Islander	35.9	1.31	1.25–1.39	1.23	1.16–1.29
American Indian/Alaska Native	24.7	0.77	0.64–0.92	0.72	0.59–0.88
Multiple/Other	29.0	1.06	0.95–1.22	0.94	0.85–1.04
Kaiser Northern		N=788,584			
Non-Hispanic white	58.2	1.00	(ref)	1.00	(ref)
Non-Hispanic black	53.2	0.90	0.88–0.92	0.86	0.84–0.88
Hispanic	53.7	0.97	0.96–0.99	0.92	0.90–0.93
Asian/Pacific Islander	61.6	1.22	1.20–1.24	1.18	1.16–1.20
American Indian/Alaska Native	50.0	0.83	0.76–0.91	0.75	0.69–0.80
Multiple/other	68.3	1.39	1.34–1.43	1.40	1.36–1.45
Kaiser Southern		N=798,250			
Non-Hispanic white	55.4	1.00	(ref)	1.00	(ref)
Non-Hispanic black	53.7	0.97	0.95–0.99	0.91	0.89–0.92
Hispanic	55.0	1.10	1.09–1.12	1.02	1.01–1.04
Asian/Pacific Islander	59.3	1.15	1.13–1.17	1.13	1.11–1.15

	Screened %	AOR ^a	95% CI	AOR ^b	95% CI
American Indian/Alaska Native	52.9	0.90	0.83–0.99	0.85	0.77–0.94
Multiple/Other	54.8	1.09	0.93–1.27	1.00	0.87–1.15
Parkland - UT Southwestern					
N=48,284					
Non-Hispanic white	33.7	1.00	(ref)	1.00	(ref)
Non-Hispanic black	37.0	1.06	0.98–1.14	1.12	0.93–1.31
Hispanic	45.7	1.47	1.36–1.58	1.15	0.97–1.34
Asian/Pacific Islander	38.3	1.11	0.95, 1.35	1.16	0.82–1.66
American Indian/Alaska Native	38.5	0.82	0.47–1.28	0.97	0.38–2.18
Multiple/other	27.6	0.60	0.22–1.39	0.47	0.09–1.94

^a Adjusted for age, sex, length of prior enrollment, and study site

^b Adjusted for age, sex, study site, length of prior enrollment, ZIP code median income, type of residence, insurance type, and Charlson co-morbidity score
CRC, colorectal cancer; PROSPR, Population-based Research Optimizing Screening through Personalized Regimens

Table 3

Among Those Completing FIT/gFOBT, Odds of a Positive FIT/gFOBT by Race/Ethnicity: PROSPR Cohort 2010–2012

	Positive FIT/gFOBT %	AOR ^a	95% CI	AOR ^b	95% CI
Overall		N=1,014,156			
Non-Hispanic white	6.0	1.00	(ref)	1.00	(ref)
Non-Hispanic black	6.3	1.10	1.07–1.14	1.00	0.96–1.03
Hispanic	5.6	0.95	0.93–0.97	0.90	0.88–0.92
Asian/Pacific Islander	5.6	0.97	0.94–0.99	0.97	0.95–1.00
American Indian/Alaska Native	7.4	1.29	1.15–1.45	1.21	1.08–1.36
Multiple/other	6.8	1.22	1.15–1.29	1.14	1.07–1.21

^a Adjusted for age, sex, length of prior enrollment, and study site

^b Adjusted for age, sex, study site, length of prior enrollment, ZIP code median income type of residence, insurance type, and Charlson co-morbidity score
FIT, fecal immunochemical test; FOBT, fecal occult blood test; PROSPR, Population-based Research Optimizing Screening through Personalized Regimens

Table 4

Odds of Completing Colonoscopy Within 90 Days of Positive FIT/gFOBT by Race/Ethnicity: PROSPR Cohort 2010–2012

	Follow-up Colonoscopy ^a %	AOR ^b	95% CI	AOR ^c	95% CI
Overall		N=59,928			
Non-Hispanic white	56.2	1.00	(ref)	1.00	(ref)
Non-Hispanic black	51.9	0.85	0.80–0.90	0.94	0.88–1.00
Hispanic	57.0	1.00	0.95–1.04	1.05	1.00–1.10
Asian/Pacific Islander	54.2	0.89	0.85–0.94	0.87	0.82–0.91
American Indian/Alaska Native	47.1	0.66	0.54–0.83	0.68	0.56–0.83
Multiple/other	50.0	0.81	0.72–0.91	0.83	0.74–0.93

^aColonoscopy within 90 days of a positive FIT/gFOBT^bAdjusted for age, sex, length of prior enrollment, and study site^cAdjusted for age, sex, study site, length of prior enrollment, ZIP code median income type of residence, insurance type, and Charlson co-morbidity score
FIT, fecal immunochemical test; FOBT, fecal occult blood test; PROSPR, Population-based Research Optimizing Screening through Personalized Regimens