Published in final edited form as:
Prev Med. 2019 September ; 126: 105774. doi:10.1016/j.ypmed.2019.105774.

Correlates of colorectal cancer screening rates in primary care clinics serving low income, medically underserved populations

Krishna P. Sharma[a,*], **Amy DeGroff**[a], **Lia Scott**[a], **Sundar Shrestha**[b], **Stephanie Melillo**[a], **Susan A. Sabatino**[a]

[a]Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, CDC, Atlanta, GA, United States of America

[b]Office of Smoking Health, National Center for Chronic Disease Prevention and Health Promotion, CDC, Atlanta, GA, United States of America

Abstract

Introduction: Screening for colorectal cancer (CRC) is effective in reducing CRC burden. Primary care clinics have an important role in increasing screening. We investigated associations between clinic-level CRC screening rates of the clinics serving low income, medically underserved population, and clinic-level screening interventions, clinic characteristics and community contexts.

Methods: Using data (2015–16) from the Centers for Disease Control and Prevention's (CDC) Colorectal Cancer Control Program, we linked clinic-level data with county-level contextual data from external sources. Analysis variables included clinic-level CRC screening rates, four different evidence-based interventions (EBIs) intended to increase screening, clinic characteristics, and clinic contexts. In the analysis (2018), we used weighted ordinary least square multiple regression analyses to associate EBIs and other covariates with clinic-level screening rates.

Results: Clinics (N = 581) had an average screening rate of 36.3% (weighted. Client reminders had the highest association (5.6 percentage points) with screening rates followed by reducing structural barriers (4.9 percentage points), provider assessment and feedback (3.2 percentage points), and provider reminders (< 1 percentage point). Increases in the number of EBIs was associated with steady increases in the screening rate (5.4 percentage points greater for one EBI). Screening rates were 16.4 percentage points higher in clinics with 4 EBIs vs. no EBI. Clinic characteristics, contexts (e.g. physician density), and context-EBI interactions were also associated with clinic screening rates.

Conclusions: These results may help clinics, especially those serving low income, medically underserved populations, select individual or combinations of EBIs suitable to their contexts while considering costs.

*Corresponding author at: 4770 Buford Highway, MS-MF76, Atlanta, GA 30341, United States of America. KSharma@cdc.gov (K.P. Sharma).

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

Declaration of Competing Interest
None of the authors has any conflicts of interest to report.

MeSH:

Colorectal neoplasms; Community health centers; Evidence based practices; Early detection of cancer

Keywords

Colorectal cancer screening; Primary care clinics; Screening interventions; Evidence-based interventions (EBI); Clinic contexts

1. Introduction

Colorectal cancer (CRC) is the third most prevalent cancer among men and women and the second leading cause of cancer related deaths (Centers for Disease Control and Prevention (CDC), 2018). In 2015, 140,788 men and women were diagnosed with CRC and 52,396 deaths were attributed to the disease (U.S. Cancer Statistics Data Visualizations Tool, Based on November 2017 Submission Data (1999–2015), 2018). Recent estimates in the United States (U.S.) indicate that 39% of CRC cases are found at localized stage compared with 21% at distant stage with 5-year survival rate of 89.9% and 13.9% (Howlader et al., n.d.), respectively.

These data highlight the importance of CRC prevention or early detection. Screening is the most effective prevention and early detection strategy to reduce CRC burden (Zauber et al., 2012). Increased use of screening would reduce overall mortality (Lin et al., 2016) and economic burden related to the disease (Etzioni et al., 2003). However, 2015 National Health Interview Survey data indicated only 62.4% of persons ages 50–75 received screening tests consistent with United States Preventive Services Task Force (USPSTF) recommendations (White et al., 2017). Screening rates are often associated with factors including patients' age, gender, ethnicity, insurance coverage, and routine clinic visits (Ioannou et al., 2003; Beydoun and Beydoun, 2008; Holden et al., 2010). For example, CRC screening use among average risk men and women aged 65 and older are 14 to 17 percentage points higher, respectively, than among those aged 50–64 years (Tessaro et al., 2006; Meissner et al., 2006). There are important disparities in CRC screening and outcomes attributed to socio-demographic factors, insurance coverage and geographic locations (Emmons et al., 2009; Wong, 2015; Siegel et al., 2015; Burnett-Hartman et al., 2016). Federally Qualified Health Centers (FQHCs), which traditionally serve low-income, medically underserved populations, have much lower screening rates than the national average. In 2015, FQHCs' average rate was 38.4% compared to the national average of 62.5% (White et al., 2017; 2016 National Health Center Data, 2016).

Historically, cancer screening in the U.S. has been predominantly opportunistic, i.e. based on individual's decision or health care provider recommendation during health encounters (Miles et al., 2004). Recently, public health researchers have promoted more organized approaches to screening (Plescia et al., 2012), including maximizing the role of primary care in prevention and early detection efforts (Rubin et al., 2015). Primary care clinics are uniquely positioned to implement interventions shown to be effective in increasing CRC screening rates (Sarfaty et al., 2013). In 2015, the Centers for Disease Control and Prevention (CDC) funded the Colorectal Cancer Control Program (CRCCP), which includes 30 state, tribal, and university grantees, for five years with the aim to increase CRC screening rates and reduce disparities among high need populations. The program prioritized populations who were low income, medically underserved and who also had low screening rates. CRCCP grantees partner with health systems such as FQHCs and clinics serving the priority populations to implement up to four priority evidence-based interventions (EBIs) recommended in *The Community Guide* (Force CPST, 2017) and up to four supporting activities (SAs) (Table 1).

To evaluate the CRCCP, the CDC collects a baseline record, including clinic-level screening rates, at the time of clinic recruitment followed by an annual record thereafter (Satsangi and DeGroff, 2016). Analysis of these clinic data completed after one year of program implementation found that grantees were working with the intended population - over 70% of clinics were FQHCs and 30% of clinics had populations with 20% or greater uninsured patients. Additionally, the average baseline CRC screening rate for clinics was 43%, far lower than national rates. Previous research suggests individual-level screening decisions are related to clinic factors including size, distance to endoscopy centers, clinical support arrangements (Weiss et al., 2013; Yano et al., 2007; Pruitt et al., 2014; Wheeler et al., 2014), and contextual factors such as physician density, rural/urban status, and other aspects contributing to socio-economic deprivation (Anderson et al., 2013; Calo et al., 2015; Davis et al., 2017; Doubeni et al., 2012; Shariff-Marco et al., 2013). CRCCP data allows us to explore similar relationships at the clinic level, where little research exists. In this paper, we investigated associations between clinic-level screening rates among clinics serving low income, medically underserved populations and clinic-level EBI use at baseline, controlling for the effects of clinic and contextual factors.

2. Methods

2.1. Population and data

All clinics recruited through the CRCCP's second program year with a baseline CRC screening rate reported were included in the analysis. Clinic data included clinic characteristics (e.g., size, type, preferred CRC test, proportion of uninsured patients), implementation status of EBIs/SAs, and CRC screening rate. Information about the clinic data, including related collection and reporting processes, have been previously published (Satsangi and DeGroff, 2016; DeGroff et al., 2018). Clinic data are self-reported. The baseline screening rates represent the 12-month period prior to program participation spanning from 2015 to 2016. We used county-level contextual data from external sources: Spatial Impact Factor database (2015), United States Department of Agriculture (USDA) – Rural Atlas (2013), and United States Cancer Statistics (USCS) (2015). External data were linked with CRCCP clinic data using county identifiers. Contextual data provided county level socio-demographic and other health-related information for counties where CRCCP clinics were located. The clinic data were collected in 2015–2016 and analysis was conducted in 2018.

2.2. Variables

The outcome/dependent variable was the clinic CRC screening rate, defined as the percentage of 50–75 year old clinic patients up-to-date with CRC screening according to USPSTF guidelines. Explanatory/independent variables included four dichotomous (0, 1) variables for the clinic level EBIs, representing whether the respective EBIs were in place or not in place. Other explanatory variables included ones for clinic characteristics and clinic contexts. Variables for clinic characteristics included number of SAs, clinic size and type, percentage of patients uninsured, preferred screening test type by the clinic, and availability of free fecal tests such as fecal immunochemical tests (FIT). All clinic characteristics were categorical except the number of SAs which was a count variable. Clinic contextual variables (county-level) were all continuous. They included average distance to an endoscopy suite in miles from Special Impact Factor database; number of primary care providers (PCPs) per 100,000 population, poverty rate (percent in 2014), percent of people with college education or higher, percent of Hispanic, Black and Asian residents from Rural Atlas – USDA database; and CRC incidence rate (per 100,000 population in 2010–2014) from uses.

2.3. Statistical analysis

We used bivariate and multiple regression analyses to associate the clinic-level interventions with the dependent variable. We used an ordinary least square (OLS) regression model where observations (i.e., clinics) were weighted by the clinic's number of screening eligible patients. A *P*-value $p < .05$ was used to determine the statistical significance of estimated regression coefficients. Bonferroni correction was applied a posteriori to avoid the risk of making a type-I error because the study involved simultaneous testing of several hypotheses. For Bonferroni correction, we used a *p*-value of 0.05/34 = 0.0015 where 34 was the total number of independent variables including constant tested in these regression models.

We used different OLS models to determine associations between clinic level EBIs and clinic screening rates. First, we used bivariate models to examine the association between each independent variable and the outcome variable. Next, we used the EBIs + SAs Model with covariates limited to EBIs and SAs. The Partial Model extended the EBIs + SAs Model by adding clinic characteristic variables as covariates. The Full Model extended the Partial Model to include all covariates (Partial Model covariates plus contextual variables).

Additionally, we estimated several regression models using screening rate as the dependent variable and different sets of independent variables. We used EBI count (0–4, with 0 EBIs as the referent) as the independent variable with no covariates (Bivariate EBI Count Model) and with all covariates (Full EBI Count Model). Next, we used every combination of the 4 EBIs without (Partial Multi-Component Model) and with covariates (Full Multi-Component Model). The Multi-Component Models used 15 EBI interaction terms – indicators for each combination of EBI categories (0 and 1). Given a large number of covariates used in the analysis, we conducted a post-hoc power analysis to detect an effect size of 3% with α = 0.01 on a sample of 581 clinics. The Full Multi-Component Model had the largest number of covariates – a total of 34 predictors. Power analysis showed that with the sample size of 581 clinics (unweighted), we had at least 94.4% chance of detecting a moderation effect size of

3%, if the effect truly is present. All statistical analyses were conducted using STATA (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). Power analysis was conducted using G*Power software by Heinrich Heine University. CDC determined this study to be public health practice and exempt from human subjects review.

3. Results

Analysis included 581 clinics in total. All results presented were weighted unless specified as unweighted. A large proportion (69%, unweighted) of clinics were FQHCs, while other types comprised 31% (unweighted) or less (Table 2). After weighting, the share of FQHCs was only 54%. More than one fifth of the clinics (22%) reported serving a patient population with over 20% uninsured. At least one EBI was used in 87% of clinics with provider reminders most often in place (66%). Among clinics, 67% had at least one SA in place. The average distance to an endoscopy suite in clinic counties was about 14 miles and there were an average of 81 primary care providers (PCPs) per 100,000 population. The average population with a college degree or higher was 30%. The average CRC incidence rate was 46 per 100,000 population (2010–2014).

Regression results are presented in Tables 3-4. All four priority EBIs were positively associated with clinic screening rates with statistical significance (Table 3). Results were generally consistent across all four models. In the Full Model, client reminders had the most substantial association with screening rates (5.6 percentage points) followed by reducing structural barriers (4.9 percentage points) and provider assessment and feedback (3.2 percentage points). Provider reminders were also positively associated with clinic screening rates, but the association (< 1 percentage point) was the weakest of all EBIs. The strength of the association between EBIs and the outcome was sensitive to model specification. The magnitude of the regression coefficients on EBIs were larger in bivariate models compared to all other models suggesting their correlations with the added covariates. SAs, although statistically significant, were weakly associated with the outcome.

The associations between clinic characteristics and the outcome were mixed. Compared to the clinics with less than a 5% uninsured patient population, clinics with 5–20% and above 20% uninsured patients had lower screening rates (−3.8 and −5.5 percentage points, respectively). Both medium and large size clinics were associated with higher clinic screening rates compared with small size clinics. Likewise, when compared to FQHCs, all other clinic types were associated with higher screening rates. The association ranged from 9.4 percentage points for health department clinics to 16.2 percentage points for health system/hospital owned clinics. Clinics using FIT as the primary CRC screening test and providing free fecal test kits were both associated with lower screening rates than clinics primarily referring for colonoscopy (−2.5 and −6.3 percentage points respectively).

The average distance to endoscopy suites and the number of PCPs per 100,000 population were negatively associated with clinic screening rates. The percent of county population with a college degree and higher had the largest positive association with clinic screening rates (0.7 percentage points) followed by percent of the non-Hispanic Asian population (0.4) and CRC incidence rate (0.3). Poverty rates (0.2) and percent of the Hispanic population percentage (0.1) in counties were also associated positively while the percentage of non-Hispanic Black populations was associated negatively with clinic screening rates.

3.1. Combinations of EBIs

Overall, when controlling for clinic and contextual factors, higher numbers of EBIs were associated with a steady increase in clinic screening rates from 5.4 percentage points for any one EBI to 15.1 percentage points for all 4 EBIs (Table 4, Full EBI Count Model). However, compared to no EBIs, different combinations of two or more EBIs did not have similarly steady associations with the outcome. Some inconsistencies were likely due to the small number of clinics in the group. However, a consistent pattern emerged when clinics had any of three or all four EBIs in place. Clinics with three or four EBIs in place had 9.1 to 16.4 percentage points higher screening rates compared to those with none in place (Table 4, Full Multi-Component Model). Almost all estimated statistically significant coefficients in Table 3 and Table 4 remained significant at 5% level after Bonferroni correction. Boldface indicates statistical significance at 5% level even after Bonferroni correction.

4. Discussion

In this exploratory work, we used a unique dataset from CDC's CRCCP to measure associations between EBIs recommended in *The Community Guide* and baseline clinic-level CRC screening rates. The study was not designed to measure causal impact, therefore, the estimated associations do not necessarily indicate causal links between covariates and CRC screening rates.

These results contribute to the literature by showing that the four priority EBIs used in the CRCCP are positively associated with screening use in low-resourced, community-based settings including FQHCs and local health department clinics serving low income, medically underserved populations. Given that all EBIs and almost all EBI combinations were associated with higher mean clinic screening rates, clinics may be able to choose to implement EBIs most suitable and least costly to them. Findings indicate that all individual EBIs, all numbers of EBIs, and all combinations of EBIs, except one, were associated with increased screening use. Thus, clinics may be able to select EBIs or combinations of EBIs that they believe best address their local needs. However, findings also indicate that some EBIs and combinations of EBIs may be associated with greater screening use than others. For example, larger numbers of EBIs were associated with higher screening use than a single EBI.

Our results are consistent with past studies, and, therefore, further strengthen the body of evidence tying these interventions to increased screening use. A systematic review (Holden et al., 2010) of past studies found that the influence of client reminders on CRC screening rates ranged from 5 to 15 percentage points and no influence of provider reminder, consistent with our estimates. However, the same study found that eliminating structural barriers increased CRC screening rates by 15.0 to 42.0 percentage points, much higher than our finding of association between reducing structural barriers and clinic level screening rates. A meta-analysis of evidence on CRC screening interventions examined the effect of provider assessment and feedback, client reminders, and provider reminders (Stone et al., 2002). Among the three EBIs, client reminders had the greatest effect, followed by provider reminders and provider assessment and feedback. Our results found client reminders and reducing structural barriers to have greater associations with screening rates, followed by provider assessment and feedback and provider reminders. Our finding that supporting activities were weakly, although positively, associated with screening rates are also compatible with results from a past study (Holden et al., 2010). However, we should note that, unlike the past systematic reviews/meta analyses cited above, our unit of analysis was the clinic, not patients. This implies that using clinics as the unit of analysis also allows us to reach similar conclusions about the relationships between interventions and outcomes.

Our finding of the significant and negative association between the percent uninsured in a clinic and screening rate was expected, corroborating findings from previous studies (Beydoun and Beydoun, 2008; Holden et al., 2010). That non-FQHC clinics had higher screening rates than FQHCs may highlight the fact that the latter serve patients who are more disadvantaged with lower screening rates than other populations included in this study. Similarly, our finding that clinics with larger patient populations had higher screening rates suggests availability of resources and clinic capacity may underlie their performance. Programmatically, because EBIs can be resource-intensive to implement irrespective of the clinic size, our results support targeting larger clinics, when feasible and appropriate, where greater impact can be achieved. Our finding that clinics primarily using FIT tests or providing free fecal kits were associated with lower screening rates might represent a relationship between clinics preferring FIT tests and clinics with lower screening rates (such as FQHCs). Additionally, assuring annual FIT testing may be more difficult in contrast to colonoscopy which is required only once each 10 years.

Importantly, findings indicate stronger associations with higher screening rates when multiple EBIs were implemented. Additionally, the association between the number of EBIs and clinic screening rates increased steadily as the number of EBIs increased. Unlike the combinations of two EBIs, any combination of three or all four EBIs had greater and more consistent associations with higher screening rates. We also observed that having provider reminders in the EBI combination was associated with a smaller increase in screening rates than not having it. This reconfirms the weaker association of provider reminders we observed as an independent EBI in the base model. Together, these results for two or more EBI combinations are consistent with evidence supporting multi-component interventions reported in the past by the Community Preventive Services Task Force (Weiss et al., 2013) and other studies (Power et al, 2009; Community-Preventive-Services-Task-Force, 2016). Further, the effectiveness of these EBIs can substantially vary by context. Future work in this area can evaluate the association between EBIs and screening rate in different contexts.

4.1. Limitations

Several limitations are noted. First, the clinic data are self-reported by CRCCP awardees and we lacked information on the quality or intensity of EBI implementation. Consequently, the effectiveness of EBIs likely varied across clinics. Moreover, grantees follow recommendations detailed in *The Community Guide* about these strategies which could be different than the way they have been implemented in studies that established their effectiveness. Second, the data do not capture all variables likely to influence and explain variation in clinic-level screening rates. This implies our results may suffer from omitted variable bias, similar to most regression models. Some important omitted variables in this study include those that capture characteristics of individual patients (e.g. age, education, insurance coverage and other barriers) and the ability of clinics to implement EBIs including EBI quality and intensity. Also, the use of county-level information cannot sufficiently capture the variations in contexts with potential ecological biases in results. With county-level variables, we can only interpret those effects as change in outcomes associated with change in clinic contexts (such as socio-demographic characteristics of the population served) represented by those variables. Making inferences on clinic-level relationships using aggregated county-level data could potentially suffer from ecological fallacy (i.e. individual level relationships can be eclipsed due to data aggregation). Further, as associations are not causal, other factors may have confounded relationships with EBIs and clinic screening rates. For instance, a clinic's ability to implement multiple EBIs might also be influenced by its culture, priorities, and supporting infrastructure. Existence of these factors might affect screening use through avenues other than the implementation of EBIs. Finally, this study was conducted primarily among clinics serving low income, medically underserved populations in community clinics such as FQHCs. The generalizability of these results, therefore, is limited.

5. Conclusions

Results from our analysis provide new insights on how clinic-level interventions including EBIs and SAs, clinic characteristics, and contextual factors are associated with clinic-level CRC screening rates. Such insights, combined with other practical considerations, can inform the design and implementation of clinic-focused, organized approaches to increase CRC screening rates.

References

2016 National Health Center Data. Health Resources and Service Administration (HRSA); 2016 https://bphc.hrsa.gov/uds/datacenter.aspx. Accessed 07/15/2017.

Anderson AE, Henry KA, Samadder NJ, Merrill RM, Kinney AY, 2013 Rural vs urban residence affects risk-appropriate colorectal cancer screening. Clin. Gastroenterol. Hepatol. 11 (5), 526–533. [PubMed: 23220166]

Beydoun HA, Beydoun MA, 2008 Predictors of colorectal cancer screening behaviors among average-risk older adults in the United States. Cancer Causes Control 19 (4), 339–359. [PubMed: 18085415]

Burnett-Hartman AN, Mehta SJ, Zheng Y, et al., 2016 Racial/ethnic disparities in colorectal cancer screening across healthcare systems. Am. J. Prev. Med. 51 (4), e107–e115. [PubMed: 27050413]

Calo WA, Vernon SW, Lairson DR, Linder SH, 2015 Associations between con-textual factors and colorectal cancer screening in a racially and ethnically diverse population in Texas. Cancer Epidemiol. 39 (6), 798–804. [PubMed: 26651438]

Centers for Disease Control and Prevention (CDC), 2018 Colorectal cancer statistics. https://www.cdc.gov/cancer/colorectal/statistics/index.htm, Accessed date: 5 February 2019.

Community-Preventive-Services-Task-Force, 2016 Increasing cancer screening: multi-component interventions, https://www.thecommunityguide.org/content/multicomponent-interventions-recommended-increase-cancer-screening, Accessed date: 18 May 2015.

Davis MM, Renfro S, Pham R, et al., 2017 Geographic and population-level dis-parities in colorectal cancer testing: a multilevel analysis of Medicaid and commercial claims data. Prev. Med. 101, 44–52. [PubMed: 28506715]

DeGroff A, Sharma K, Satsangi A, et al., 2018 Increasing colorectal Cancer screening in health care systems using evidence-based interventions. 15.

Doubeni CA, Jambaulikar GD, Fouayzi H, et al., 2012 Neighborhood socioeconomic status and use of colonoscopy in an insured population–a retrospective cohort study. PLoS One 7 (5), e36392. [PubMed: 22567154]

Emmons KM, Lobb R, Puleo E, Bennett G, Stoffel E, Syngal S, 2009 Colorectal cancer screening: prevalence among low-income groups with health insurance. Health Aff. 28 (1), 169–177.

Etzioni R, Urban N, Ramsey S, et al., 2003 The case for early detection. Nat. Rev. Cancer 3 (4), 243–252. [PubMed: 12671663]

Force CPST, 2017 What Works: Cancer Screeing (Evidence Based Interventions for your Community). Online. .

Holden DJ, Jonas DE, Porterfield DS, Reuland D, Harris R, 2010 Systematic review: enhancing the use and quality of colorectal cancer screening. Ann. Intern. Med. 152 (10), 668–676. [PubMed: 20388703]

Howlader N, Noon A, Krapcho M, et al., eds. SEER Cancer Statistics Review, 1975–2012, Based on November 2014 SEER Data Submission, Posted to the SEER Web Site, April Bethesda, Md: National Cancer Institute Bethesda, MD, https://seer.cancer.gov/csr/1975_2012/.

Ioannou GN, Chapko MK, Dominitz JA, 2003 Predictors of colorectal cancer screening participation in the United States. Am. J. Gastroenterol. 98 (9), 2082–2091. [PubMed: 14499792]

Lin JS, Piper MA, Perdue LA, et al., 2016 Screening for colorectal cancer: updated evidence report and systematic review for the US Preventive Services Task Force. Jama 315 (23), 2576–2594. [PubMed: 27305422]

Meissner HI, Breen N, Klabunde CN, Vernon SW, 2006 Patterns of colorectal cancer screening uptake among men and women in the United States. Cancer Epidemiology and Prevention Biomarkers 15 (2), 389–394.

Miles A, Cockburn J, Smith RA, Wardle, 2004 A Perspective from Countries Using Organized Screening Programs Cancer, vol. 101 (S5). pp. 1201–1213. [PubMed: 15316915]

Plescia M, Richardson LC, Joseph D, 2012 New roles for public health in cancer screening. CA Cancer J. Clin. 62 (4), 217–219. [PubMed: 22573193]

Power E, Miles A, Von Wagner C, Robb K, Wardle J, 2009 Uptake of colorectal cancer screening: system, provider and individual factors and strategies to improve participation. Future Oncol. 5 (9), 1371–1388. [PubMed: 19903066]

Pruitt SL, Leonard T, Zhang S, Schootman M, Halm EA, Gupta S, 2014 Physicians, clinics, and neighborhoods: multiple levels of influence on colorectal cancer screening. Cancer Epidemiol. Biomark. Prev. 23 (7), 1346–1355.

Rubin G, Berendsen A, Crawford SM, et al., 2015 The expanding role of primary care in cancer control. Lancet Oncol. 16 (12), 1231–1272. [PubMed: 26431866]

Sarfaty M, Doroshenk M, Hotz J, et al., 2013 Strategies for expanding colorectal cancer screening at community health centers. CA Cancer J. Clin. 63 (4), 221–231. [PubMed: 23818334]

Satsangi A, DeGroff A, 2016 Planning a national-level data collection protocol to measure outcomes for the Colorectal Cancer Control Program. Journal of the Georgia Public Health Association 6 (2), 292 Suppl. [PubMed: 28042614]

Shariff-Marco S, Breen N, Stinchcomb DG, Klabunde CN, 2013 Multilevel predictors of colorectal cancer screening use in California. Am. J. Manag. Care 19 (3), 205–216. [PubMed: 23544762]

Siegel RL, Sahar L, Robbins A, Jemal A, 2015 Where can colorectal cancer screening interventions have the most impact? Cancer Epidemiology and Prevention Biomarkers 24 (8), 1151–1156.

Stone EG, Morton SC, Hulscher ME, et al., 2002 Interventions that increase use of adult immunization and cancer screening services: a meta-analysis. Ann. Intern. Med. 136 (9), 641–651. [PubMed: 11992299]

Tessaro I, Mangone C, Parkar I, Pawar V, 2006 Peer reviewed: knowledge, barriers, and predictors of colorectal cancer screening in an Appalachian church population. Prev. Chronic Dis. 3 (4).

U.S. Cancer Statistics Data Visualizations Tool, Based on November 2017 Submission Data (1999–2015), 2018 ed. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute.

Weiss JM, Smith MA, Pickhardt PJ, et al., 2013 Predictors of colorectal cancer screening variation among primary-care providers and clinics. Am. J. Gastroenterol. 108 (7), 1159. [PubMed: 23670114]

Wheeler SB, Kuo T-M, Goyal RK, et al., 2014 Regional variation in colorectal cancer testing and geographic availability of care in a publicly insured population. Health Place 29, 114–123. [PubMed: 25063908]

White A, Thompson T, White MC, et al., 2017 Cancer screening test use-United States, 2015. MMWR Morb. Mortal. Wkly Rep. 66 (8), 201–206. [PubMed: 28253225]

Wong SL, 2015 Medically underserved populations: disparities in quality and out-comes. J. Oncol. Pract. 11 (3), 193–194. [PubMed: 25901055]

Yano EM, Soban LM, Parkerton PH, Etzioni DA, 2007 Primary care practice organization influences colorectal cancer screening performance. Health Serv. Res. 42 (3pl), 1130–1149. [PubMed: 17489907]

Zauber AG, Winawer SJ, O'brien MJ, et al., 2012 Colonoscopic polypectomy and long-term prevention of colorectal-cancer deaths. N. Engl. J. Med. 366 (8), 687–696. [PubMed: 22356322]

Table 1

Clinic-level evidence-based interventions and supporting activities.

	Definition[a]
Evidence-Based Intervention (EBIs)	
Client reminders	Text-based (i.e., letter, postcard, e-mail) or telephone messages advising people that they are due (reminder) or overdue (recall) for screening.
Provider reminders	Use of prompts to inform health care providers that it is time for a patient's cancer screening test (reminder) or that the patient is overdue for screening (recall).
Provider assessment and feedback	Evaluation of provider performance in offering and/or delivering screening to patients (assessment) and sharing the results with providers (feedback).
Reducing structural barriers	Reducing or eliminating noneconomic burdens or obstacles that impede access to screening by addressing thing such as: distance to service delivery (e.g., modifying clinic hours, offering services in alternative or nonclinical settings) or administrative procedures.
Supporting Activities (SAs)	
Small media	Distribution of videos and printed materials such as letters, brochures, and newsletters.
Patient navigation	Individualized assistance offered to patients to help overcome health care system barriers and facilitate timely access to quality screening, follow-up, and initiation of treatment if diagnosed with cancer.
Professional development/ provider education	Interventions such as distribution of education materials, and/or continuing medical education directed at health care staff and providers to increase their knowledge and to change attitudes and practices around cancer screening.
Community health workers (CHWs)	Community based workers that have a deep understanding of, and are often from, the community they serve. CHWs educate people about and promote cancer screening, and provide peer support to people referred to cancer screening.

Abbreviations: CDC, Centers for Disease Control and Prevention; CRCCP, Colorectal Cancer Control Program.

[a]Based on definitions from *The Guide to Community Preventive Services.*

Table 2

Summary statistics of all study variables (categorical and continuous).

	Unweighted			Weighted[a]		
	Freq.	Percent	Average screening rate	Freq.	Percent	Average screening rate
Clinic level evidence based interventions (EBIs)						
Client reminder						
No	288	49.57	32.54	459,871	47.26	37.19
Yes	293	50.43	36.96	513,253	52.74	49.06
Provider reminder						
No	191	32.87	34.67	328,850	33.79	40.37
Yes	390	67.13	34.82	644,274	66.21	45.52
Reducing structural barriers						
No	315	54.22	33.84	586,342	60.25	42.26
Yes	266	45.78	35.87	386,782	39.75	46.07
Provider assessment and feedback						
No	271	46.64	30.63	374,762	38.51	36.19
Yes	310	53.36	38.39	598,362	61.49	48.53
Clinic characteristics						
Number of supporting activities[d]						
0	170	29.31	33.97	322,800	33.17	40.00
1	170	29.31	30.66	225,388	23.16	37.70
2	134	23.10	39.01	304,313	31.27	52.64
3	104	17.93	37.05	113,521	11.67	44.59
4	2	0.34	31.19	7050	0.72	15.31
Percent uninsured						
< 5% of clinic patients	258	44.41	38.78	560,361	57.58	48.91
5–20% of clinic patients	151	25.99	31.89	200,773	20.63	37.46
> 20% of clinic patients	172	29.6	31.30	211,990	21.78	36.19
Clinic size						
Small (< 500 patients)	159	27.37	27.81	70,369	7.23	24.33

	Unweighted			Weighted[a]		
	Freq.	Percent	Average screening rate	Freq.	Percent	Average screening rate
Medium (500–1500 patients)	207	35.63	32.92	194,059	19.94	34.23
Large (> 1500 patients)	215	37.01	41.69	708,696	72.83	48.32
Clinic type						
FQHC/CHC	399	68.67	32.63	526,045	54.06	36.75
Health system/hospital owned	78	13.43	43.67	263,457	27.07	58.92
Private/physician owned	45	7.75	41.04	88,146	9.06	45.94
Health department	59	10.15	32.65	95,476	9.81	38.71
FIT as primary						
No	267	45.96	38.12	578,181	59.41	38.12
Yes	314	54.04	31.92	394,943	40.59	31.92
Free fecal kit						
No	389	66.95	35.18	692,449	71.16	35.18
Yes	192	33.05	33.95	280,675	28.84	33.95
Number of evidence based interventions[c]						
0	77	13.25	30.19	122,317	12.57	34.29
1	117	20.14	33.21	199,746	20.53	39.11
2	124	21.34	32.31	182,983	18.8	39.31
3	158	27.19	37.89	295,353	30.35	48.87
4	104	18.07	38.07	172,725	17.75	51.90
Contextual variables[b]						
	Mean	**95% Conf. Interval**		**Mean**	**95% Conf. Interval**	
Average distance to endoscopy suite (miles)	14.63	13.59	15.68	13.75	13.73	13.77
Number or primary care physicians per 100,000 population	74.04	71.19	76.89	80.61	80.54	80.69
Poverty rate (percent of all ages in 2014)	16.32	15.78	16.85	15.05	15.04	15.06
Percent population with college degree or higher	26.97	26.02	27.93	29.94	29.91	29.96
Non-Hispanic black percentage in 2010	11.97	10.74	13.21	9.17	9.14	9.19
Non-Hispanic Asian percentage in 2010	3.03	2.69	3.37	3.23	3.22	3.24
Hispanic percentage in 2010	9.58	8.70	10.46	9.10	9.08	9.12
Colorectal cancer incidence rate per 100,000 population (2010–2014)	47.43	46.30	48.56	45.81	45.79	45.83

Abbreviations: FQHC/CHC (/Federally Qualified Fiealth Center/Community Health Center), FIT (Fecal Immunochemical Test).

[a]The clinic screening eligible patient population size was used as weights.

[b]All contextual variables were county level aggregates/averages for the counties where clinics were located.

[c]The count of number of evidence-based interventions (EBIs) used as a categorical variable and included the simple count of any of the four EBIs in place in those clinics.

[d]The count of supporting activities (SAs) used as count variable and included the simple count of any of the four SAs in place in those clinics.

Table 3

Results (estimated coefficients of associations) from different ordinary least square regression models[a].

	Bivariate models[b]	EBIs + SAs model[b]	Partial model[b]	Full model[b]
Clinic Level Evidence Based Interventions (EBIs)				
Client reminder	**11.17** *** (0.040)	**9.25** *** (0.048)	**1.81** *** (0.048)	**5.59** *** (0.047)
Provider reminder	**5.15** *** (0.044)	0.04 (0.053)	−0.13 ** (0.048)	**0.85** *** (0.045)
Reducing structural barriers	**3.81** *** (0.043)	**1.95** *** (0.049)	**6.78** *** (0.044)	**4.94** *** (0.042)
Provider assessment and feedback	**12.35** *** (0.042)	**10.37** *** (0.045)	**6.01** *** (0.041)	**3.15** *** (0.040)
Clinic characteristics				
Number of supporting activities (SAs)[e]	**5.66** *** (0.045)	**−1.13** *** (0.026)	**−0.69** *** (0.023)	**0.36** *** (0.021)
Percent uninsured				
< 5% of clinic patients	Reference			
5%–20% of clinic patients	**−11.45** *** (0.052)		**−2.83** *** (0.053)	**−3.78** *** (0.049)
> 20% of clinic patients	**−12.72** *** (0.051)		**−2.49** *** (0.051)	**−5.51** *** (0.052)
Clinic size				
Small (< 500 patients)	Reference			
Medium (500–1500 patients)	**9.90** *** (0.085)		**7.96** *** (0.075)	**4.61** *** (0.075)
Large (> 1500 patients)	**23.99** *** (0.077)		**18.00** *** (0.068)	**9.71** *** (0.070)
Clinic type				
FQHC/CHC	Reference			
Health system/hospital owned	**22.16** *** (0.044)		**13.48** *** (0.060)	**16.17** *** (0.057)
Private/physician owned	**9.19** *** (0.067)		**7.90** *** (0.066)	**12.76** *** (0.067)

	Bivariate models[b]	EBIs + SAs model[b]	Partial model[b]	Full model[b]
Health department	**1.96*** *** (0.065)		**6.18*** *** (0.067)	**9.39*** *** (0.067)
Tests used in clinics				
FIT as primary test used in clinic	**−15.27*** *** (0.042)		**−5.13*** *** (0.041)	**−2.50*** *** (0.041)
Free fecal test kit	**−8.30*** *** (0.045)		**−4.67*** *** (0.044)	**−6.27*** *** (0.042)
Contextual variables[c]				
Average distance to endoscopy suite (miles)	**−0.11*** *** (0.001)			**−0.05*** *** (0.002)
Number of primary care physicians per 100,000 population	**0.18*** *** (0.000)			**−0.02*** *** (0.001)
Poverty rate (percent of all ages in 2014)	**−0.95*** *** (0.003)			**0.15*** *** (0.004)
Percent population with college degree or higher	**0.56*** *** (0.001)			**0.74*** *** (0.003)
Non-Hispanic Black percentage in 2010	**−0.35*** *** (0.001)			**−0.16*** *** (0.002)
Non-Hispanic Asian percentage in 2010	**0.40*** *** (0.005)			**0.35*** *** (0.006)
Hispanic percentage in 2010	**0.04*** *** (0.001)			**0.11*** *** (0.002)
Colorectal cancer incidence rate per 100,000 population (2010–2014)	**−0.05*** *** (0.001)			**0.32*** *** (0.002)
Constant		**33.11*** *** (0.041)	**22.26*** *** (0.079)	**−11.35*** *** (0.161)
Observations		973,072	973,072	880,318
R^2		0.123	0.364	0.499

Standard errors in parentheses

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$ (before Bonferroni correction).

Boldface indicates statistical significance after Bonferroni correction.

Abbreviations: FQHC/CHC (Federally Qualified Health Center/Community Health Center), FIT (Fecal Immunochemical Test)

[a]Dependent variable: Clinic level CRC screening rate in percentage; model: Ordinary least square. Screening eligible patient population size was used as weights.

[b]Notes: Bivariate Model includes all (bivariate) models for each explanatory variable and outcome pair.

For bivariate models, the estimated Constant (R^2) were: Client reminder **37.89** *** (0.071), Provider reminder **40.37** *** (0.014), Reducing structural barriers **42.26** *** (0.008), Provider assessment and feedback **36.18** *** (0.083), Number of supporting activities **39.81** *** (0.026), % uninsured patients **48.91** *** (0.082), Clinic size **24.34** *** (0.139), Clinic type **36.75** *** (0.21), FIT as primary test **49.97** *** (0.129), Free FIT test kit **46.17** *** (0.032), Average distance to endoscopy suite (miles) **45.98** *** (0.004), Number or primary care physicians per 100,000 population **28.99** *** (0.098), Poverty rate (percent of all ages in 2014) **57.80** *** (0.069).

EBIs + SAs Model limits covariates to evidence based interventions (EBIs) and number of supporting activities in place. EBIs are dichotomous (1/0) variables and SAs are count (0–4) variable.

Partial Model extends EBIs + SAs Model by adding clinic characteristics as covariates

Full Model extends Partial Model by an addition of contextual variables

[c]All contextual variables were county level aggregates/averages for the counties where clinics were located.

[e]The number of supporting activities (SAs) included the simple count of any of the four SAs in place in those clinics.

Table 4

Regression results (estimated coefficients of associations) for evidence based interventions (EBIs) counts and EBI combinations[a].

	Bivariate EBI count model[b]	Full EBI count model[b]
Number of evidence based interventions (categories)		
0	Reference	
1	**4.79***** (0.072)	**5.44***** (0.059)
2	**6.38***** (0.076)	**9.23***** (0.062)
3	**17.73***** (0.081)	**10.09***** (0.064)
4	**21.20***** (0.090)	**15.06***** (0.074)
Constant	**34.84*****	**−12.67*****
Observations	973,072	973,072
R^2	0.094	0.498

EBI combinations: multi-component models

	Client reminder	Provider reminder	Reducing structural barriers	Provider assessment & feedback	Number of clinics in category (N = 581)	Partial multi-component model[b]	Full multi-component model[b]
0	0	0	0	0	77	Reference	
2	0	0	1	1	10	**8.69***** (0.159)	**15.38***** (0.124)
2	0	1	0	1	6	0.01 (0.101)	**8.47***** (0.135)
2	0	1	1	0	43	**10.53***** (0.171)	**2.54***** (0.087)
2	1	0	0	1	11	**−12.01***** (0.399)	**24.12***** (0.093)
2	1	0	1	0	3	**34.84***** (0.113)	−0.03 (0.352)
2	1	1	0	0	51	**−4.77***** (0.092)	**8.28***** (0.085)
3	0	1	1	1	49	**15.07***** (0.099)	**13.46***** (0.082)

						Bivariate EBI count model[b]	**Full EBI count model**[b]
3	1	0	1	1	7	**15.76** *** (0.179)	**18.73** *** (0.144)
3	1	1	0	1	68	**13.53** *** (0.109)	**9.12** *** (0.070)
3	1	1	1	0	34	**21.16** *** (0.082)	**14.66** *** (0.088)
4	1	1	1	1	105	**21.64** *** (0.086)	**16.44** *** (0.072)
	Constant					**34.91** ***	**−11.68** ***
	Observations					973,072	973,072
	R^2					0.205	0.544

Standard errors in parentheses

* $p < 0.05$,

** $p < 0.01$,

*** $p < 0.001$ (before Bonferroni correction).

Boldface indicates statistical significance ($p < 0.05$) after Bonferroni correction.

[a]Dependent variable: Clinic level screening rate in percentage; model: Ordinary least square.

[b]Notes: Bivariate EBI Count Model includes only the categories of EBI count as the independent variable. EBI count was a simple count of the number of EBIs in place. (0-4)

Full EBI Count Model extends the Bivariate EBI Count Model with the full set of covariates as in Full Model but results are not shown.

Partial Multi-Component Model only includes all possible combinations of the 4 EBIs and no covariates.

Full Multi-Component Model includes a full set of covariates as in Full Model, but their results are not shown.

In Partial Multi-Component Model and Full Multi-Component Model, results for the clinics with only one EBI are not shown.