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The CRC screening process in community settings: A conceptual model for the Population-based Research Optimizing Screening through Personalized Regimens Consortium

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Abstract

Reducing colorectal cancer (CRC) mortality by promoting screening has been a national goal for two decades. The National Cancer Institute's *Population-based Research Optimizing Screening through Personalized Regimens* (PROSPR) consortium is the first federal initiative to foster coordinated, transdisciplinary research evaluating the entire cancer screening process in community settings. PROSPR is creating a central data repository to facilitate research evaluating the breast, cervical, and CRC screening process across different patient populations, provider types, and delivery systems. Data are being collected and organized at the multiple levels in which individuals are nested (e.g., healthcare systems, facilities, providers, patients). Here, we describe a conceptual model of the CRC screening process guiding data collection and highlight critical research questions that will be addressed through pooled data. We also describe the three Research Centers focused on CRC screening with respect to study populations, practice settings, and screening policies. PROSPR comprehensively elucidates the complex screening process through

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observational study, and has potential to improve care delivery beyond the healthcare systems studied. Findings will inform intervention designs and policies to optimize CRC screening delivery and advance the Institute of Medicine's goals of effective, efficient, coordinated, timely, and safe health care with respect to evidence-based cancer screening.

Keywords

colorectal neoplasms; mass screening; delivery of health care; model/framework

In the U.S., colorectal cancer (CRC) is the second leading cause of cancer deaths despite availability of screening tests that could greatly reduce both CRC incidence and mortality (1-3). Guidelines recommend three screening strategies: guaiac-based fecal occult blood testing (gFOBT) or fecal immunochemical testing (FIT) every year, flexible sigmoidoscopy every 5 years with gFOBT/FIT every 3 years, or colonoscopy every 10 years (4-6). Most intervention research has focused on one-time participation in guideline-recommended CRC screening (7, 8). However, the CRC screening process is complex and involves delivery of several steps of care beyond one-time screening, including diagnostic evaluation following an abnormal test result, treatment of detected lesions, surveillance after abnormal results or—for those with normal results—repeat screening at guideline-appropriate intervals. Completion of the CRC screening process requires coordination of care and transfer of responsibilities among healthcare teams (physicians, nurses, and staff) in primary care, gastroenterology, and oncology (9). For screening to achieve greater impact on CRC incidence and mortality, teams and delivery systems must implement efficient, effective interventions that address the full CRC screening process (10, 11).

There are gaps in our knowledge about effective delivery of CRC screening including the best ways to measure breakdowns in the screening process and the impact of implementing evidence-based interventions on screening outcomes in community settings (7, 12). Given the complexity of the CRC screening process, more research is needed on the multiple factors acting at the patient-, provider-, and system-levels that dynamically influence optimal screening test use. This knowledge will inform future interventions and policies to improve CRC screening in real-world settings.

To address these gaps, the National Cancer Institute established in 2011 the *Population-based Research Optimizing Screening through Personalized Regimens* (PROSPR) consortium. PROSPR's overall aim is to promote multi-site, coordinated, transdisciplinary research that evaluates and improves breast, cervical, and colorectal cancer screening in community settings (13). A key PROSPR goal is to create a central data repository on the entire cancer screening process. Recognizing the numerous factors influencing delivery, PROSPR is collecting and organizing data at the multiple levels in which individuals are nested (e.g., healthcare systems, facilities, providers, patients) for a large, geographically and demographically diverse patient cohort. Common data elements, measured at the patient-, provider-, facility-, and system-level, include information on tests and procedures ordered and performed, cancer outcomes, and characteristics empirically associated with the screening process (e.g., patient sociodemographics and healthcare coverage, provider

specialty and patient volume, facility and systems policies and incentives to promote screening). Prior to annual data submission, investigators refine operational definitions and expand the list of required elements to broaden comprehensiveness and robustness of the dataset. Data pooled across participating sites (described below) will facilitate research comparing screening performance across different patient populations, provider types, and delivery systems.

The PROSPR consortium has established seven Research Centers and one Statistical Coordinating Center. Three Research Centers are focused on studying and improving the CRC screening process—Group Health Research Institute (Group Health), Kaiser Foundation Research Institute [Kaiser Permanente Northern California (KPNC) and Kaiser Permanente Southern California (KPSC)], and the Parkland Health & Hospital System/University of Texas-Southwestern Medical Center (Parkland-UTSW).

Here, we: 1) describe the conceptual model depicting the CRC screening process that is guiding data collection; 2) highlight CRC-specific research questions that will be addressed using pooled data and some of the methodologic challenges to these analyses; and 3) provide an overview of the Research Centers with respect to study populations, settings, and policies, procedures, and programs to facilitate completion of the CRC screening process.

PROSPR Research Centers Focused on CRC screening

Each CRC Research Center has two principal aims. The **first aim** is to execute three research projects around a central theme that addresses key factors affecting the CRC screening process. Group Health, an integrated healthcare system located in Seattle, is assessing the effectiveness of different CRC screening strategies and identifying low-risk groups for whom a less intensive screening approach might be appropriate. KPNC/KPSC is examining screening delivery among its enrollees, with the aim of optimizing FIT and colonoscopy screening strategies. Parkland-UTSW is evaluating screening delivery within an integrated safety-net system, including use of personalized approaches and whether these approaches improve outcomes in a low-income, uninsured population.

The **second aim** is to contribute data to the central repository and collaborate on analyses both specific to CRC and across cancer types: breast, cervical, and colorectal. Research using pooled data requires establishing a common conceptual and methodological model (e.g., similar operational definitions), so that data can be validly integrated for comparative studies of the screening process.

The CRC Screening Process Model

Our CRC Screening Process Model (Figure 1) expands on the general continuum of cancer care developed by Taplin and Zapka (10, 11, 14-17). The model illustrates challenges specific to delivering CRC screening, including the multiple test modalities involved, the many activities that require coordination between primary and specialty care teams, and the need to identify patients with symptoms who enter the process at the diagnostic step. This model is intended to represent the screening process for patients at average CRC risk because it allows for completion of the process with any of the three guideline-

recommended screening modalities. Patients at elevated CRC risk due to personal history (e.g., adenoma) and/or family history (e.g., first-degree relative diagnosed with CRC) should follow surveillance guidelines recommending colonoscopy at more frequent intervals and/or an earlier starting age (18, 19).

We used Taplin and Zapka's typology for classifying aspects of the CRC screening process (9). Figure 1 highlights in grey the four *types* of care that are critical to accomplishing key goals of the CRC screening process – risk assessment, detection, diagnostic evaluation, and treatment. *Steps*, represented by boxes, are medical encounters or actions required of patients, providers or clinical staff. Steps with dashed borders depict *interfaces* where information and/or responsibility must be transferred among different healthcare teams (e.g., primary care and specialist) to progress to the next step. *Transitions* are sets of multiple steps and interfaces necessary to move from one type to the next (e.g., detection to diagnosis).

Our model depicts all steps that may occur during one screening episode. The process can begin in three ways: 1) a provider recommends screening to a patient during a clinical encounter; 2) the healthcare organization systematically invites eligible patients to screen; or 3) a patient requests screening (Figure 1, Transition #1). Which screening test modality is used depends on patient and provider preferences, resources of the patient, and policies of the organization. If results are normal, the process for this episode ends and guideline-based recommendations for repeat screening are communicated to the patient and relevant providers. Patients are referred for diagnostic colonoscopy if the screening process began with other tests (e.g., gFOBT, FIT, sigmoidoscopy, or CT colonography) with abnormal findings. Symptomatic patients (e.g., iron deficiency anemia, gastrointestinal bleeding) enter the process at referral for diagnostic colonoscopy (Figure 1, Transition #2). Because colonoscopy can be performed for screening or diagnostic purposes, defining and documenting the exam's indication is particularly important, yet challenging (20-24). Also, critically important is reporting of colonoscopy results, to help providers and organizations identify patients at elevated risk who may require a more frequent screening or surveillance regimen. There are several interfaces within each type of care and during care transitions that require coordination between primary care and specialty providers; these interfaces may be particularly vulnerable to breakdown (10, 15). Unless cancer is detected or surveillance is recommended at the end of the screening episode, the process begins again and the patient re-enters the model based on guidelines and patient and provider preferences. PROSPR uniquely positioned to address questions raised by our conceptual model.

PROSPR CRC-specific pooled questions and analyses

Pooled PROSPR data offer unique opportunities to assess the CRC screening process in diverse, community settings. PROSPR CRC investigators intend to examine a wide range of clinical and policy-relevant research questions addressing:

- What are the best strategies to promote appropriate use of CRC screening and follow-up, in terms of patient preference, patient adherence, local healthcare systems, and specific populations (25)? For example, Holden et al.(7) found strong evidence that elimination of structural barriers, one-on-one interactions, patient

reminders, and system-level interventions improved screening rates; however, what is the impact of deploying these evidence-based strategies in real-world settings? What contextual factors hamper their effectiveness (e.g., characteristics of the patient population, providers, and/or facilities)?

- What steps in the screening process (Figure 1) are vulnerable to failure (26, 27)? What types of patients are at particular risk for failures (8, 28) and what are the factors at the provider-, facility-, and system levels that contribute to failures (11, 15, 29-33)?
- What are the performance characteristics (sensitivity, specificity, positive predictive value) of CRC screening tests conducted in the diverse health systems represented in PROSPR (34, 35)?
- To what extent do underuse, misuse, and overuse of CRC screening occur (7)? For example, how often are FITs given to patients who had a recent colonoscopy (less than 10 years) with normal results? How often do physicians recommend a FIT to patients who are in colonoscopy surveillance program due to prior adenomas? What strategies ameliorate misuse and overuse patterns (7)?
- How does CRC risk change following screening (36, 37)? Can a risk-based management strategy be used for screening and surveillance (38, 39)?
- What is the comparative effectiveness (i.e., balance of benefits and harms) of FIT versus colonoscopy screening regimens in the diverse health systems and patient populations represented in PROSPR, and the generalizability of these organized screening approaches to resource-limited settings (40-42)?

Findings will inform policy and clinical recommendations issued by experts, as well as design and implementation of population-based screening programs such as those supported by the Centers for Disease Control and Prevention (43).

To generate pooled data, CRC PROSPR investigators are establishing operational definitions for a wide array of common data elements characterizing the CRC screening process (e.g., benefits and harms of screening, colonoscopy indication) and are harnessing relevant clinical information systems including the EMR and local clinical and administrative databases. Research Centers submit data on an annual basis and each year the required list of common data elements is reviewed, refined, and expanded to ensure the comprehensiveness and robustness of the pooled dataset. Research Centers are linking screening process data with cancer outcomes available from regional and local cancer registries and considering linkages with pertinent contextual data to derive measures of community-level health status, resources, and utilization (e.g., US Census, Health Resources and Services Administration's Area Resource File) (44-46).

While pooled PROSPR data provide a unique opportunity to address important questions about CRC screening, they also pose several challenges for analysis. Accounting for potential confounders and heterogeneity across systems are two key challenges. Screening rates and performance characteristics are likely to vary across Research Centers due to differences in preferred test modality, approaches to facilitate screening, and characteristics

of the screen-eligible patient populations. To minimize bias, investigators are utilizing methods to account for confounding when combining information across the Research Centers. For example, instrumental variable analysis (47, 48) or propensity score adjustment (49, 50) are approaches used to minimize selection bias (51, 52). Also, system-level variability can be addressed using multilevel modeling (53). Another challenge is accurate measurement of patient-level risk factors for prediction of short- and long-term outcomes, because risk factor information may change at any step in the screening process. Accuracy of information affect whether risk prediction algorithms can be used to develop personalized screening regimens and improve population-level screening outcomes. We are also assessing patient comorbidity to examine competing risks. Although conducting comparative effectiveness analyses of different CRC screening strategies with PROSPR's observational data is complex, validity can be greatly improved by carefully formulating research questions, implementing appropriate study designs, and applying sophisticated statistical methods.

Overview of the PROSPR CRC Research Centers

The three CRC Research Centers are uniquely positioned to answer the key research questions described above. The Research Centers are comprised of four U.S. integrated health care systems covering four geographic regions. Integrated systems have been recognized as ideal settings for assessing the entire screening process in contrast to loosely affiliated or unaffiliated primary care practices that refer to specialty providers. This is because integrated systems can systematically track data at multiple levels through a comprehensive electronic medical record (EMR) (54, 55) and care is delivered through a single, coordinated organization of primary and specialty practices (56-59).

Group Health is a mixed-model, non-profit, health plan serving nearly 625,000 members in Washington State. The Kaiser Permanente Research Center is comprised of two healthcare systems delivering care to about 7 million members in Northern (KPNC) and Southern (KPSC) California. Parkland-UTSW is the sole safety-net provider for under-insured and uninsured Dallas County residents living at 200% of federal poverty level; approximately 64,000 adults each year use Parkland's eleven primary care clinics. These four systems have a combined population of over 7.7 million people from which a pooled, dynamic CRC cohort has been derived.

Identification of the PROSPR CRC Cohort

We have developed cohort definitions and eligibility criteria to facilitate pooling of the screening process data (Table 1). The Group Health and Kaiser Permanente cohorts consist of health plan members ages 50 to 89 years on or after January 1, 2010 with new cohort members added as they become eligible for CRC screening (i.e., enters cohort on 50th birthday). For the Kaiser Permanente cohort, one year of prior membership is also required for cohort inclusion. Membership eligibility criteria were used to provide new enrolled Kaiser Permanente patients with a sufficient period of time for providers to document CRC screening history, determine screening eligibility, and offer screening services. For Parkland-UTSW, Dallas County residents ages 50-64 with a visit at one of Parkland's eleven primary care clinics on or after January 1, 2010 are entered into the cohort on the date of

their visit. These latter eligibility criteria were applied for two reasons: 1) access to CRC screening services at Parkland is limited to patients seen in primary care (as opposed to those seen only in the emergency department or at a specialty clinic); and 2) Parkland is obligated to care for all uninsured Dallas county residents but residents who become Medicare-eligible at age 65 may opt to receive care outside the Parkland system. All Research Centers excluded patients diagnosed with CRC or with a partial or total colectomy prior to cohort entry date.

PROSPR CRC Cohort Characteristics by Health Care System

Table 2 describes sociodemographic characteristics and screening process outcomes of cohort members who entered in 2010 for each of the four systems. Age distributions of screen-eligible patients at Group Health, KPNC, and KPSC are very similar, with approximately 75% of patients in the fifth and sixth decade of life and 25% in the seventh and eighth decades. Because of the restricted age range of the Parkland-UTSW cohort, almost 72% of the patients are in their fifties. More than half of the patients are female, with the highest proportion of females at Parkland-UTSW (64%). There is substantial racial and ethnic variation across the systems. Group Health members are predominantly white (72.1%) and, although the proportions are lower at KPNC (58.4%) and KPSC (45.7%), non-Hispanic whites still comprise the majority. Nearly a quarter of the KPSC cohort is Hispanic, compared with 11.6% at KPNC and 3.3% at GH. Only 18.4% of Parkland-UTSW patients are white; most are either non-Hispanic black (38.9%) or Hispanic (36.1%). Of the four systems, KPNC has the highest proportion of Asians and Pacific Islanders (14.0%).

Almost all patients across the four systems live in metropolitan areas (60, 61). Group Health, KPNC, and KPSC are very similar in insurance coverage distribution—most patients are privately insured (54.9-66.6%) or have Medicare (32.4-44.3%), and very small proportion have Medicaid or are dual-eligible for Medicare and Medicaid. In contrast, 68.4% of Parkland-UTSW patients are uninsured; their medical care costs are covered by Dallas County's medical assistance program financed by property taxes. About 9% of Parkland-UTSW patients have Medicare coverage; 7% are covered by Medicaid. Overall, significant heterogeneity of the pooled cohort with respect to race/ethnicity, age, and insurance coverage is evident.

FIT comprised the vast majority of stool-based tests performed in 2010 at KPNC, KPSC, and Parkland-UTSW. In contrast, Group Health used gFOBT during 2010 and transitioned to FIT in late 2011. More than 30,000 abnormal stool tests required diagnostic evaluation within the four systems during 2010. Across the four systems, colonoscopy was the most common endoscopy procedure. We are currently cross-validating methods to define indication as none of the systems' EMR has a discrete field for identifying reason for colonoscopy; this effort will enable definition of a screening episode and identification of misuse and overuse patterns. In 2010, more than 2,300 CRC cases were identified by the systems.

Provider, Facility, and Clinical Information System Characteristics by Health Care System

Table 3 describes the four systems' healthcare delivery resources. There is substantial range in number of primary care physicians who care for adult patients (total > 3,700) and number of endoscopy providers (total >250). Group Health and Parkland-UTSW use mid-level providers such as nurse practitioners and physician assistants in primary care. KPSC and Parkland-UTSW are teaching institutions that employ gastroenterology fellows; therefore, attending physicians and fellows perform endoscopy procedures. To meet increasing capacity needs over a wide geographic area, Group Health contracts with outside endoscopy providers to perform some colonoscopies; the contracted providers use various clinical information systems for storing data and are not all universally linked to Group Health members' EMR.

Endoscopy procedures are performed in three distinct facility types—ambulatory surgical centers, medical offices, and hospitals. These types are subject to different regulatory requirements (62, 63). These facilities may be owned and managed by the healthcare system or may have a formal contract with the system to provide services. The nature of the relationship may affect interfaces (i.e., transfer of clinical information and responsibility) between primary care and endoscopy providers and increase difficulty of extracting endoscopy results because scanned reports are stored as images and require more resources to extract than text information stored in the EMR. We are also cross-validating natural language processing and algorithm-based methods to systematically extract text data from endoscopy reports given the wide variation in how results are documented.

All four healthcare systems employ a common and comprehensive EPIC® platform-based EMR. The EPIC EMR can provide information on electronic orders, referrals, scheduling, test results, treatment, and billing for both inpatient and outpatient care. KPNC, KPSC and Parkland-UTSW have a Cerner-based clinical information system for reporting pathology results; Group Health uses Progeny. Group Health, KPNC, and KPSC carry out centralized processing of stool-based tests. In contrast, each of the eleven Parkland-UTSW primary-care clinics process FITs at local on-site laboratories. Pathology processing for endoscopy specimens is centralized for Parkland-UTSW and Group Health-performed procedures; for KPNC and KPSC and some contracted providers for Group Health, pathology processing is local to each endoscopy facility. The heterogeneous nature of the three CRC Research Centers not only contributes to the robust nature of the data collected in the PROSPR consortium but will also make findings from PROSPR studies more generalizable across populations and delivery settings.

Policies, Procedures, and Programs to Facilitate the CRC Screening Process

All CRC Research Centers have clinic- and system-level policies procedures, and programs targeted toward asymptomatic, average-risk individuals to facilitate completion of screening process steps, transitions between types of care, and interfaces among providers (Table 4) (9, 15, 16).

To initiate the screening process, Group Health, KPNC, and KPSC have organized programs that systematically invite all average-risk members aged 50-75 to participate in CRC

screening. Electronic clinical information systems identify and generate lists of eligible patients. Invitation letters are mailed and timing of delivery may be based on birth month or anniversary of prior screening. Stool blood testing is the preferred screening modality, but endoscopy is also available as an option based on patient/provider preference. At KPNC and KPSC, the FIT kit is mailed with the invitation letter; if endoscopy is chosen, a primary care provider must place an order or request a consult. At Group Health patients can self-refer for colonoscopy. Response to invitations is monitored and either a reminder is sent to non-adherent individuals or a patient's primary care team is notified. Timing and delivery mode of reminders varies across the systems. We are currently working to obtain data from these clinical information systems and expand our common data elements to identify moderators of program effectiveness.

At Parkland-UTSW, screening is available to all primary care patients 50 years of age or older opportunistically during in-person clinic visits. The screening modality offered is based on provider and patient preferences.

Across all four systems, screening results are reported to primary care providers via EMR in-basket. The systems have at least three methods for notifying patients about results (e.g., information is posted in a secure website, letter is mailed, or a provider calls) and delivery mode depends on the test modality and findings. Group Health, KPNC, and KPSC also have system- and practice-level strategies to encourage patients with abnormal test results to complete diagnostic evaluation. Finally, all four systems generate population-level reports based on data stored in their clinical information systems to monitor adherence to CRC screening guidelines.

Conclusion

Collaboration among the PROSPR CRC Research Centers will advance knowledge about the screening process by providing detailed, longitudinal, multi-level, population-based data about steps, transitions, and interfaces along the CRC screening process. Background information about the cohort, integrated healthcare systems, and CRC-specific policies and procedures illustrates that PROSPR is poised to comprehensively compare and systematically evaluate the CRC screening process in diverse metropolitan community settings.

There are a few limitations to acknowledge. Our main data source for the pooled dataset is the EMR. Because each system's EMR differs in its documentation of CRC screening process, we have simplified some of our common data elements. We refine operational definitions each year and expand the list of required elements to broaden the comprehensiveness and robustness of the pooled dataset. Also, the EMR does not systematically record patients' and providers' beliefs, intentions, or motivation for CRC screening; thus, we will not have information about those important variables. There are two limitations that impact generalizability of PROSPR CRC pooled dataset. We will have little data from patients living in rural areas. Data are from integrated systems and their ability to coordinate services along the screening process make differ substantially from other practice models. Therefore, we encourage researchers with access to rural populations and different

practice settings to use our conceptual model to collect similar data addressing research questions detailed above. PROSPR CRC investigators are interested in collaborating to broaden our collective understanding of CRC screening delivery. In accordance with the National Institutes of Health's data sharing policy, we are currently creating a web portal to receive proposals from researchers interested in collaborating with PROSPR investigators and use the pooled data.

Analysis of patient-, provider-, practice-, and system-level factors that influence screening process outcomes is critical to inform the design and evaluation of multi-level interventions and policies to optimize delivery of CRC screening in healthcare systems serving diverse populations. The ultimate goal of the PROSPR consortium is to optimize screening delivery so that it is consistent with the Institute of Medicine's goals of effective, efficient, coordinated, timely, and safe health care (64).

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Abbreviations

ASC ambulatory surgery centers

COL	colonoscopy
CRC	colorectal cancer
EMR	electronic medical record
FIT	fecal immunochemical test
gFOBT	guaiac-based fecal occult blood test
KPNC	Kaiser Permanente Northern California
KPSC	Kaiser Permanente Southern California
MOB	medical office buildings
Parkland-UTSW	Parkland Health & Hospital System – University of Texas Southwestern Medical Center
PCP	primary care provider
PROSPR	Population-based Research Optimizing Screening through Personalized Regimens
SIG	flexible sigmoidoscopy

Figure 1. PROSPR Colorectal Cancer (CRC) Screening Process Model

Table 1
Cohort definitions and eligibility criteria for PROSPR CRC Research Centers, by health care system

	Group Health	KPNC	KPSC	Parkland-UTSW
Cohort membership & entry date	Individuals enrolled in the health plan <i>on or after</i> January 1, 2010			Dallas County residents with a Parkland primary care provider visit <i>on or after</i> January 1, 2010
Inclusion Criteria:				
Age at cohort entry	50-89 years			50-64 years
Length of Association with System	None	Continuous enrollment in the health plan for1 year prior to cohort entry date with no more than 90-day gap in coverage		None
Exclusion Criteria:				
	Diagnosed with CRC or underwent a partial/total colectomy prior to cohort entry date			
Newly-eligible Membership Criteria:				
Age	Newly eligible for CRC screening based on birthdate (i.e., enters cohort on 50 th birthday)			

Table 2
Cohort demographics and CRC screening process outcomes of the PROSPR CRC
Research Centers during the first year of cohort enrollment, by health care system, 2010

Variables	Group Health	KPNC	KPSC	Parkland-UTSW
	N (%)	N (%)	N (%)	N (%)
Total age-eligible population	N=156,540	N=1,028,609	N=1,050,208	N = 29,307
Age (10 year age groups)				
50-59	67,433 (43.1%)	464,782 (45.2%)	481,182 (45.8%)	20,980 (71.6%)
60-69 ^a	52,418 (33.5%)	322,043 (31.3%)	325,193 (31.0%)	8,327 (28.4%)
70-79	22,437 (14.3%)	166,138 (16.2%)	170,418 (16.2%)	-
80-89	14,252 (9.1%)	75,656 (7.4%)	73,415 (7.00%)	-
Sex - % Male	70,123 (44.8%)	472,461 (45.9%)	491,993 (46.8%)	10,542 (36.0%)
Race/ethnicity				
Non-Hispanic White	112,844 (72.1%)	601,195 (58.4%)	480,137 (45.7%)	5,386 (18.4%)
Non-Hispanic Black	5,109 (3.3%)	67,393 (6.6%)	102,905 (9.8%)	11,390 (38.9%)
Hispanic	5,226 (3.3%)	119,584 (11.6%)	249,043 (23.7%)	10,594 (36.1%)
Asian/Pacific Islander	10,451 (6.7%)	143,943 (14.0%)	97,969 (9.3%)	1,733 (5.9%)
Native American/ Alaskan Native	1,022 (0.6%)	4,776 (0.5%)	1,972 (0.2%)	81 (0.3%)
Other/Multi-racial	1,873 (1.2%)	40,268 (3.9%)	21,340 (2.0%)	0
Unknown	20,035 (12.8%)	51,460 (5.0%)	96,842 (9.2%)	123 (0.4%)
Rural-Urban Continuum measure				
Metropolitan (1-3)	148,959 (95.1%)	972,670 (94.6%)	1,034,089 (98.5%)	29,307(100.0%)
Micropolitan	3,722 (2.4%)	26,083 (2.5%)	8,643 (0.8%)	-
Low density	1,805 (1.2%)	8,851 (0.9%)	1,723 (0.2%)	-
Unknown	2054 (1.3%)	21,015 (2.0%)	5,753 (0.5%)	-
Health Insurance				
Medicare ^b	57,882 (37.0%)	456,005 (44.3%)	340,582 (32.4%)	2,717 (9.2%)
Medicaid	3,941 (2.5%)	3,716 (0.4%)	9,725 (0.9%)	2,145 (7.3%)
Commercial/private	94,717 (60.5%)	564,931 (54.9%)	699,085 (66.6%)	1,814 (6.2%)
Other	-	3,783 (0.4%)	743 (<0.1%)	82 (0.3%)
Uninsured	-	184 (<0.1%)	73 (<0.1%)	20,038 (68.4%)
Unknown	-	-	-	2,511 (8.6%)
Tests and Results in 2010				
Number of FIT performed	510	311,535	282,448	7,580
Number of gFOBT performed	23,436	2,034	5,097	912
Number of sigmoidoscopies performed	1,372	24,561	16,116	41
Number of colonoscopies performed ^c	13,197	46,554	81,452	2,433
Number of abnormal FIT/gFOBT	1180	13,968	15,893	404
Number CRC cancers diagnosed	225	948	1,111	84

^a Age group for Parkland-UTSW cohort consists of 60-64 year olds because of cohort eligibility criteria. At Group Health, KPNC, and KPSC, the percentage of the cohort ages 60-64 years is: 20.9%, 18.5%, and 18.3%, respectively.

^b Individuals dual eligible for Medicare and Medicaid were grouped into the Medicaid category.

^c Total includes both screening and diagnostic colonoscopies.

Table 3
Provider, facility, and clinical information system characteristics of the CRC PROSPR
Research Centers, by health care system, December 2012

Variables	Group Health	KPNC	KPSC	Parkland-UTSW
Number of primary care providers ^a	Physicians: 349 Mid-level: 138	Physicians: 1,700	Physicians: 1,646 ^b	Physicians: 83 Mid-level: 12
Number of Endoscopy providers ^a	Physicians: 14	Physicians: 122	Physicians: 115 ^a	Physicians: 18 Fellows: 22
Number of Endoscopy facilities ^c	Group Health: 2 Contracted: 300	ASC: 1 MOB: 15 Hospital: 3	ASC: 2 MOB: 1 Hospital: 14	ASC: 1 Hospital: 1
Number of hospitals	Contracted: 40	19	13	1
Type of FOBT/FIT kit	Polymedco OC FIT-CHEK ^d 1 sample test			Beckman Coulter Hemocult ICT FIT 3 sample test
EMR system	EPIC	EPIC	EPIC	EPIC
Pathology system	Progeny	Cerner CoPath Plus		Cerner Millennium
Pathology processing (centralized vs. local)	FOBT/FIT: Centralized Group Health SIG/COL: Centralized Contracted SIG/COL: Local to each facility	FIT: Centralized SIG/COL: Local to each medical center		FIT: Local to each primary care clinic SIG/COL: Centralized

^aPhysician numbers include family practitioners and internists who care for adults; obstetrician-gynecologists were not included. Contracted providers (e.g., not employed by the health care system) are not included in these numbers.

^bKPSC physician numbers do not include per diem physicians and residents.

^cThree types of facilities perform endoscopy procedures: ambulatory surgery centers (ASC), medical office buildings (MOB), hospital; facilities may be owned by health care system or be a contracted provider.

^dDifferent automated systems are used to process OC FIT-CHEK test (OC-Auto Micro 80 or OC-Sensor Diana)

Table 4
Policies and procedures for CRC screening recruitment and follow-up in PROSPR
Research Centers, by health care system, Dec 2012

Variables	Group Health	KPNC	KPSC	Parkland-UTSW
Target population with respect to screening eligibility	Average-risk members aged 50-75			Primary care patients aged 50+
Screening Strategy (test modality & interval)	Organized program with FIT as preferred modality and follow-up with diagnostic COL if FIT is abnormal. COL every 10 years or SIG every 5 years ^a is available based on patient/ provider preference	Organized program with FIT as primary outreach modality and follow-up with diagnostic COL if FIT is abnormal. COL every 10 years or SIG every 5 years ^a is also available based on patient/ provider preference		Offered as part of usual care during clinic visits; test modality based on patient/ provider preference
Method to identify eligible patients	Electronic tool/clinical information system and EMR ^b			Provider recognize with assistance of EMR health maintenance module
Invitation method	Mailed letter. Timing depends on site and is based on birthdate or anniversary of prior screening.			Verbal invite by provider
FOBT/FIT Distribution Method	Patient pick up at clinic, pharmacy, or lab. Patients may ask PCP team to mail a kit.	Kits mailed with invitation letter. Kits also available at clinic and lab.		During clinic visit
SIG/COL Referral System	Patient self-refer or provider order via EMR ^c	Provider order or consult request via EMR		
Reminder system and timing	System notifies PCP team to call patient after 1 month	System delivers automated call after 3 weeks and mails a letter after 6 weeks. If still non-adherent, system notifies PCP team to call patient and send secure e-mail.	System or PCP team calls after 30 days	None
Method of Notifying Patients about FIT Result	Normal FIT: letter sent (unless opted-out) and posted on patient-facing secure website Abnormal FIT: nurse calls	Normal FIT: postcard sent and posted on patient-facing secure website Abnormal FIT: physician calls and posted on patient-facing secure website	Normal FIT: posted on patient-facing secure website Abnormal FIT: nurse calls	Normal FIT: letter sent. Abnormal FIT: nurse calls.
Method of Notifying Patients about Colonoscopy Result	Normal COL (e.g., no pathology specimen): same-day posting on patient-facing secure website Abnormal COL: letter sent if benign pathology; provider calls if follow-up is needed.	Normal COL (e.g., no pathology specimen): verbal communication post-procedure. Abnormal COL: secure email or call if benign pathology; provider calls if malignant.	Normal COL (e.g., no pathology specimen): verbal communication post-procedure. Abnormal COL: provider calls if benign or malignant pathology	Normal COL (e.g., no pathology specimen): verbal communication post-procedure. Abnormal COL: letter sent if benign pathology; provider calls if malignant.
Provider Test Result Notification	EMR in-basket			
Tracking Adherence to Follow-up of Abnormal Test Results ^c	Safety net program where system notifies PCP team until a COL is completed for	System- and practice-level tracking and follow-up. Weekly report notifies PCP	System- and practice-level tracking and follow-up. Endoscopy facility contacts	No system-level program to monitor adherence to follow-up. PCP teams at each

Variables	Group Health	KPNC	KPSC	Parkland-UTSW
	patients with no follow-up within 4 months of an abnormal result.	team about patients who have not been referred or have not completed their COL.	patient to book COL with a scheduling goal of <30 days.	clinic may choose to implement a program.
Role of primary care in the screening process	PCP team serves as “back-up” to system-level organized program. EMR tool enables PCP to identify non-adherent patients and offer FIT. PCP team supports delivery of screening reminders and referrals for diagnostic evaluation. PCP team receives reports on screening process outcomes to improve care delivery.			PCP team has primary responsibility for facilitating the screening process. PCP receives reports on screening rates to improve care delivery.

^a Sigmoidoscopy strategy varies across systems— Group Health recommends FIT every 3 years with SIG; at KPNC and KPSC, SIG can be offered with or without FIT.

^b Electronic tool to generate patient lists for outreach varies across systems—Group Health has a data warehouse that uses patient birth dates and past screening history; KPNC also utilizes administrative data; KPSC has a stand-alone population care management electronic tool

^c Whether a provider employed by Group Health or a contractor performs COL depends on patients' location