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Computer-tailored Intervention Increases Colorectal Cancer Screening Among Low-Income African Americans in Primary Care: Results of a Randomized Trial

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Abstract

Introduction: Although African Americans have the highest colorectal cancer (CRC) incidence and mortality rates of any racial group, their screening rates remain low.

Study Design/Purpose: This randomized controlled trial compared efficacy of two clinic-based interventions for increasing CRC screening among African American primary care patients.

Methods: African American patients from 11 clinics who were not current with CRC screening were randomized to receive a computer-tailored intervention (n=335) or a non-tailored brochure (n=358) designed to promote adherence to CRC screening. Interventions were delivered in clinic immediately prior to a provider visit. Univariate and multivariable logistic regression models analyzed predictors of screening test completion. Moderators and mediators were determined using multivariable linear and logistic regression analyses.

Results: Significant effects of the computer-tailored intervention were observed for completion of a stool blood test (SBT) and completion of any CRC screening test (SBT or colonoscopy). The colonoscopy screening rate was higher among those receiving the computer-tailored intervention group compared to the nontailored brochure but the difference was not significant. Predictors of SBT completion were: receipt of the computer-tailored intervention; being seen at a Veterans Affairs Medical Center clinic; baseline stage of adoption; and reason for visit. Mediators of intervention effects were changes in perceived SBT barriers, changes in perceived colonoscopy benefits, changes in CRC knowledge, and patient-provider discussion. Moderators of intervention effects were age, employment, and family/friend recommendation of screening. Conclusion: This one-time computer-tailored intervention significantly improved CRC screening rates among low-income African American patients. This finding was largely driven by increasing SBT but the impact of the intervention on colonoscopy screening was strong. Implementation of a CRC screening quality improvement program in the VA site that included provision of stool blood test kits and follow-up likely contributed to the strong intervention effect observed at that site.

The trial is registered at ClinicalTrials.gov as NCT00672828.

Keywords

colorectal cancer; screening; computer-tailored intervention; tailored intervention; randomized trial

Introduction

African Americans (AAs), disproportionately affected by colorectal cancer (CRC), have the highest incidence (40.4/100,000) and mortality rates (17.7/100,000) of any racial/ethnic group in the US [1] due, in part, to their lower screening rates compared to whites (65% vs. 68%, respectively) [2]. Routine CRC screening for AAs is an essential step in lowering overall mortality. Research has shown that lower screening rates in AAs are driven by

inadequate health insurance coverage, lack of provider recommendation, as well as limited knowledge about test options, the importance of screening in absence of symptoms, and curability of CRC if detected early. Additional barriers to CRC screening in this population include lack of time, cost, lack of interest, fear of positive findings, embarrassment, fear of invasiveness, and cancer fatalism beliefs [3, 4]. Thus, it is imperative that interventions be developed to increase overall CRC screening in the AA population using messaging that is directed toward the barriers that are highly prevalent in this population.

CRC interventions such as mailings, brochures, and videos have been tested and found to be moderately effective promoting health behaviors, but few have been implemented in routine primary care [5, 6]. Additionally, although interventions may be culturally appropriate, few have used tailored messaging that addresses individual specific barriers in AAs. The broader health promotion literature has found efficacy for tailored over non-tailored interventions [7–17]. Although studies have shown that tailored interventions are more effective than non-tailored at promoting breast cancer screening [16, 18–20], evidence regarding the effectiveness of tailored CRC screening interventions is limited especially among diverse racial, ethnic, and socioeconomic groups in the United States [21–24]. To our knowledge, few studies have tested effects of tailored interactive programs in which CRC screening messages were delivered in real-time based on participants' responses to questions posed by an interactive computer program [22, 25–27]. According to the Elaboration Likelihood Model, tailored interventions stimulate greater cognitive activity and central information processing, leading to more thoughtful message consideration, and greater persuasion [28, 29].

The purpose of this randomized trial was to compare the efficacy of two interventions (i.e., a computer-tailored interactive program vs. a non-tailored brochure) to promote CRC screening among AA primary care patients. Our theory-based, computer-tailored intervention was specifically designed to deliver messages to increase knowledge, perceived risk, perceived benefits, and self-efficacy for CRC screening while lowering perceived barriers. Three hypotheses were tested: 1) significant differences will be observed between the intervention groups in completion of stool blood test [SBT], colonoscopy, and any test (SBT or colonoscopy) at 6 months post-intervention; 2) patient characteristics (age, gender, education, income, number of comorbid conditions, baseline stage of adoption) and clinic variables (site, reason for visit) will moderate intervention effects; and 3) changes in health beliefs (perceived risk, perceived benefits, self-efficacy, perceived barriers, and cancer fatalism) will mediate intervention effects.

Methods

Interventions

Intervention details have been published elsewhere [30]. Briefly, the computer-tailored intervention assessed a participant's perceived risk, benefits and barriers to CRC screening, age, gender and family history in real time followed by tailored messages to support development of beliefs that would be most aligned with a decision to screen for CRC. For instance, if a person had a close family member with a history of CRC, a message was delivered that informed the participant of their increased risk for CRC. The story theme and

content delivery of the interactive computer program focused on a 50th birthday celebration for an AA man (the main character of the storyline) after he had visited his primary care provider. To accommodate patients with low literacy, the program was fully narrated.

The tailored intervention was developed with input from a community advisory board consisting of eight AAs and grounded in the Health Belief and Transtheoretical Models. Content included information about CRC, screening, colon anatomy, and development of CRC from polyps. Information about racial disparities in CRC incidence and mortality were tailored by gender. Based on national guidelines, patients with a first-degree relative (FDR) diagnosed before age 60 or more than one FDRs diagnosed at any age viewed a colonoscopy procedure [31]; those with average risk watched demonstrations of both SBT and colonoscopy and were asked which test they were most likely to consider. Barriers to the preferred test (for those at average risk) or to colonoscopy (for those at increased risk) were assessed followed by delivery of tailored messages design to decrease barriers. Finally, after participants completed the program, a tailored, single-page colored printout was generated for participants that summarized personal CRC risk factors, risk-appropriate test recommendations and, for average risk users, preferred test. The printout was designed to provide a summary of information for patients to keep and as a reminder to discuss CRC screening with their provider during their visit. The comparison group received a non-tailored CRC screening brochure developed by the American Cancer Society (ACS) which supported discussion of screening options with their provider [32].

Study Sample

Participants were recruited between January 2008 to December 2010 from 11 urban primary care clinics in Indianapolis, Indiana and Louisville, Kentucky: 5 community-based safety-net clinics; 4 Veterans Affairs Medical Center (VA) clinics; and 2 university-affiliated clinics. Patients were eligible if they self-identified as Black or AA, were aged 51 to 80 years, not up-to-date with CRC screening and scheduled for an upcoming visit with their primary care provider. Patients were excluded if they did not speak English or had a personal history of CRC, a medical condition that prohibited screening, or a cognitive, speech, or hearing impairment. All study procedures were HIPAA compliant and approved by the Indiana University Purdue University Indianapolis Institutional Review Board. This study is registered at ClinicalTrials.gov (#NCT00672828) and the full protocol is available from the lead author upon request.

Procedure

After obtaining provider approvals, recruiters contacted, 2554 potentially eligible and provider-approved participants identified from clinic databases. Patients with upcoming appointments were mailed introductory letters, a brochure explaining the study, and the consent form. Patients who did not call to opt-out were contacted by a recruiter who explained the study, assessed eligibility, answered questions, and obtained verbal consent. Eligible consented patients (n=927) were scheduled for a 30-minute baseline telephone interview conducted by interviewers at the Indiana University Center for Survey Research using a computer-assisted telephone interview (CATI) system. Randomization occurred by computer immediately upon completion of the baseline interview at a 1:1 ratio. Follow-up

data were collected from January 2008 to July 2011. Telephone interviews were conducted at one week (T2) to assess changes in knowledge and health beliefs [26] as well as patient-provider discussions [33]. Interviews and medical record reviews were conducted at six months post-intervention (T3) to assess CRC screening outcomes (Figure 1). A total of 927 (63%) of eligible patients consented to participate and 817 (88%) of these were reached to complete the baseline interview. Study staff met participants 30–45 minutes prior to appointments to complete enrollment and deliver interventions. Recruitment concluded when the study enrollment period ended.

Measures

CRC screening outcomes were extracted from medical records, as was reason for the visit at 6 months post-intervention. *CRC knowledge, perceived CRC risk, perceived benefits and barriers to screening, and screening self-efficacy* were assessed via telephone interviews at baseline, one week and 6 months post-intervention. *CRC knowledge* about risk factors, screening test options, and test frequency was measured using 11 items developed for this study (Cronbach alpha=0.63). *Perceived CRC risk* was assessed using a 3 item scale originally developed by Champion to measure perceived breast cancer risk (4-point response) in the next 5 and 10 years, and during entire lifetime (alpha= 0.82) [28, 30]. *Perceived benefits and barriers* were measured separately for SBT and colonoscopy using valid and reliable scales with 4-point responses. The SBT benefits scale included 3 items (alpha = 0.67) and the colonoscopy benefits scale had 4 items (alpha=0.76) [32]. The SBT barriers scale included nine items (alpha=0.82); whereas the colonoscopy scale had 15 items (alpha=0.89). *Self-efficacy* for screening was measured via an 8-item scale for SBT and 11 items for colonoscopy (alpha=0.87 for both scales).

Statistical Analyses

Our sample size was based on achieving 80% power for the two-sided chi-square test of two proportions, with alpha=.05. Randomization was stratified by sex, age (≥65 and <65 years) and clinic site (VA vs. non-VA). Patients who were randomized but never received interventions because they failed to attend their clinic visit (n=124) were excluded from analyses. Analyses for main and moderation effects were completed using data from all 693 consented subjects who completed the intervention. Mediational analyses used data from the 595 subjects who completed 6-month interviews. Statistical modeling with logistic regression included generalized estimating equations controlling for correlation of outcomes due to differences in providers. Participant age and gender, as well as VA site, were included in all models. We considered main effects of pre-specified covariates including age, gender, VA site, years of education, reason for visit (acute care, preventative, did not see doctor), Charlson co-morbidity score, income (<$15K, $15K-$30K, >$30K), and baseline stage of screening adoption (precontemplation, contemplation, preparation). Variables other than age, gender and VA site were examined separately in bivariate analyses and included in the final main effects model only if significant at the p=0.20 level.

After developing the final main effects models, we used these models to test for moderation effects for both the pre-specified and a group of 10 post-hoc variables: married (yes/no), have insurance or are a VA patient (yes/no), employed (yes/no), body mass index (BMI),

number of doctor visits in the year prior to Time 1, literacy score, objective risk (high, not high), past history of cancer (yes/no), having a relative with CRC (yes/no), and having a family or friend recommend the test (yes/no). Each variable was tested separately. We tested for a significant interaction effect by including the main effect for the covariate (if not already in the final main effects model) and the appropriate intervention by covariate interaction.

The Baron and Kenny approach was used for mediation [34] For Step 1, we identified models in which a significant intervention effect was observed after adjusting for pre-specified covariates (see description of main effects model above). In Step 2, we examined whether each potential mediator was related to the intervention by fitting a model with intervention as a predictor and potential mediator as an outcome, adjusting for covariates in the main effects model. Potential mediators included changes in CRC knowledge and health belief scales from baseline (Time 1) to 6 months (Time 3), doctor recommendation of CRC test, and patient-provider discussion of CRC tests. In Step 3, for those mediators related to intervention group, we included the potential mediator in the final main effects model for outcomes of interest and examined what effect inclusion of the potential mediator had on relationship between intervention and outcomes. A separate model was fit to test each potential mediator. If the intervention effect was significantly related to the outcome before inclusion of the potential mediator but not after inclusion, we concluded that mediation was taking place. Because participants who did not complete the 6-month (T3) interview were excluded from mediation analyses, we compared those who completed the 6 month interview to those who did not using chi-square and two sample t-tests to examine potential differences in their demographics.

Results

Participant Characteristics

Participants were a mean age of 57.3 years (*SD*=6.2) and approximately 51% female. Most had completed high school, had health insurance, were not married, and not currently employed. Annual household incomes were low; 88% were below $30,000 and the majority had incomes less than $15,000. Most (79%) patients were being seen in non-VA clinics. There were no differences in characteristics between intervention groups (See Table 1).

Screening Uptake

The computer-tailored intervention resulted in higher rates of CRC screening than the nontailored brochure. Completion of screening with SBT was significantly higher in the group receiving the computer intervention compared to the brochure group (Table 2; 12.5% vs. 7.3% respectively, p=.02). While the difference between groups who were screened with colonoscopy did not reach significance, a higher proportion who received the computer-tailored intervention completed colonoscopy compared to the brochure group (18.5% vs. 14.0%; p=.14). Additionally, number of participants in both groups who completed colonoscopy was higher than those completing SBT. Since completion of either SBT or colonoscopy defines adherence to CRC screening guidelines, we created a variable that

reflected adherence to screening with any of these tests and found higher completion of any test (SBT or colonoscopy) (26.3% vs. 18.4%, p=.03) in the intervention group.

Covariates in the model for SBT at 6 months were intervention group, age, male gender, education, VA site, and baseline stage of adoption for SBT. A significant intervention effect favoring the computer-tailored intervention was found for SBT completion rates after adjusting for all covariates (p= 0.02). VA site and baseline stage also were significant predictors for SBT at 6 months. Covariates in the final main effects model for colonoscopy at 6 months were age, male gender, intervention group, VA site, reason for visit, income, and baseline stage of adoption for colonoscopy. No significant intervention effect was found for colonoscopy after adjusting for covariates (p= 0.12). Baseline stage and reason for clinic visit were significant predictors of colonoscopy at 6 months. Covariates in the final model for any colon test at 6 months were intervention, age, male gender, VA site, education, income, and baseline stage of adoption. A significant effect of the tailored intervention was found for any colon test after adjusting for all covariates (p=.046). Baseline stage significantly predicted any colon test at 6 months.

Evidence of Moderation Effect

For SBT completion at 6 months, significant moderators were age, employment, and family/friend recommendation of SBT. Table 4 shows intervention effects for various representative values of the continuous variable age to characterize the nature of the moderation effect. For subjects near 50, there was no intervention effect, but as age increased the tailored intervention effect became significant. While there was no intervention effect for employed participants, there was a significant effect for those not employed; participants who were not currently employed were 2.7 times more likely to be screened than those who were employed. Finally, there was a significant effect of the computer-tailored intervention for those who did not have a family/friend recommend screening; participants who reported they did not have a family member or friend recommend getting screened were 2.8 times more likely to get screened than those who received such a recommendation. For colonoscopy at 6 months, the only significant moderator was number of doctor visits in the year prior to baseline. There were no significant intervention group effect when number of visits was 3 or 4 visits; however, the effect did increase in favor of the computer-tailored intervention as number of visits increased, and was statistically significant for 12 or more numbers of visits. There were no moderation effects for any colon test at 6 months.

Evidence of Mediation Effect

Because significant effects of the tailored intervention were found for completion of SBT and any colon test at 6 months, we tested mediation effects. Four mediators were significant - three for SBT and four for any test. Table 5 shows intervention effects both before and after inclusion of the mediator to show attenuating effects of the mediators. For SBT completion at 6 months, change in mean SBT barriers score from baseline (T1) to 6 months (T3), change in CRC knowledge score from T1 to T3, and patient-provider discussion of SBT mediated the effect of the tailored intervention. For completion of any test, change in mean SBT barriers score from T1 to T3, change in mean colonoscopy benefits score from T1 to T3, change in CRC knowledge score from T1 to T3, and patient-provider discussion of SBT

mediated the effect of the tailored intervention. Participants who did not complete the 6 month interview were more likely to be male (18% vs. 11%, p=.01) and have a lower mean BMI (29.1 vs. 31.5, p=.005).

Discussion

This randomized trial found that a tailored computer intervention delivered in a primary care clinic significantly increased screening with SBT and any test (SBT or colonoscopy) in an AA population. A clinically important, but not statistically significant, effect was observed for colonoscopy alone. Other studies have shown that culturally-appropriate tailored media, lay health educators, and navigators successfully increased CRC screening rates [35–44]. In a randomized trial among primary care AAs, Myers found that combining a tailored approach with telephone navigation increase SBT by over two times that of a standard intervention, even when stool kits were mailed to both groups [44]. It may be harder to facilitate participation in the more invasive test. It is even possible that interventions stressing colonoscopy as the preferred screening for those at average risk may be counterproductive. Indeed, Inadomi and colleagues found that limiting provider recommendation to colonoscopy resulted in lower screening rates compared to providing a choice between SBT and colonoscopy, especially among ethnic/racial minorities [45]. In our study of non-adherent patients, 52% reported a provider had previously recommended colonoscopy, and medical record audits confirmed many had received multiple colonoscopy recommendations over several visits.

We found two baseline characteristics that, irrespective of intervention group assignment, predicted participation in testing. Consistent with previous studies, advanced baseline stage of adoption was a significant predictor of participation in screening through SBT, colonoscopy, and having any screening test [46]. Being seen in the VA system was also predictive of CRC screening post-intervention. During this intervention study, the VA clinics implemented a CRC screening quality improvement initiative combining clinic staff-led checklists, systematic provision of SBT, follow-up letters if cards were not returned, as well as monthly provider performance feedback and incentives. Studies conducted by our team [46] and those of others, have consistently shown that distributing stool tests kits is a highly effective strategy in and of itself. Our finding highlights the importance of multi-level interventions, such as the computer-tailored intervention delivered in this study, timely provision of stool blood test kits and other health system-level interventions; VA participants were more than 6 times more likely to complete SBT than those from non-VA clinics. Because a comprehensive system approach to increase SBT was implemented in the VA, we conducted posthoc analysis to examine intervention effects when VA patients were excluded (n=548). Results of that analysis showed that a significant effect of the computer intervention on stool blood testing remained in non-VA clinic sites from which the majority of patients were recruited (p=0.0293).

Mediators of the computer-based intervention effect on SBT and completion of any screening test were: 1) increased CRC knowledge; 2) reduction in perceived SBT barriers; 3) increased perceived benefits of colonoscopy; and 4) having had a patient-provider discussion about CRC screening during the visit. These results were similar to those of Maxwell and

colleagues, who found that CRC knowledge and having a CRC screening discussion with a provider were important mediators of an intervention to increase CRC screening among Filipino-Americans [47]. However, when reviewing three intervention studies to promote CRC screening, Williams found a moderation effect for barriers reported with two studies and an inverse relationship of benefits to colonoscopy screening in one, while mediation was not found in any of the reported studies [48].

Knowledge of CRC screening has been consistently shown to be low, especially among minority and underserved populations. In our study, baseline knowledge scores were low and there was a significantly greater increase in knowledge scores among the computer-tailored intervention group at one week post-intervention [30]; furthermore, increased knowledge was an important mediator of the tailored intervention's effect on SBT completion and completion of any test. Jerant and colleagues [49] conducted a RCT of a tailored intervention to promote CRC screening that, compared to a nontailored control intervention, significantly increased knowledge in a diverse sample of 1164 primary care patients from 26 sites. Knowledge scores were independently associated with CRC screening self-efficacy, an important predictor of screening. Until awareness of CRC screening becomes widespread among the general public, improving knowledge will likely be an essential first step to moving people toward action.

Provider recommendation has consistently been shown to be one of the most important predictors of CRC screening and most patients receive that recommendation by having a discussion with their provider. In a review of interventions to increase SBT in AAs, Roy found that interventions to increase trust in the patient-provider relationship were successful at increasing CRC screening [50]. Our computer-tailored intervention effectively stimulated CRC screening discussions [30] and CRC screening. These results illustrate the essential role of health care providers in promoting screening and the appropriateness of delivering interventions designed to activate primary care patients to participate in such discussions and subsequent decision-making. A prior study suggests that the amount of time (30 minutes or more) spent viewing a multimedia CRC screening intervention predicted whether a patient-provider discussion occurred [51]. Our intervention was relatively brief and was effective, making it feasible to incorporate into clinical practice [33].

Several moderators of intervention effects were observed. Specifically, the computer-tailored intervention was more effective for older patients, those not currently employed, and those who did not have a family/friend recommend CRC screening. It may be that those who were not currently employed had more time available to prioritize getting screened. The importance of family/friend recommendation for screening has been identified in prior studies, however, the strength and direction of the influence of this variable in this study was an important finding in an unexpected direction [52]. It may be that the intervention was able to compensate for the lack of a family/friend recommendation for screening. The computer-tailored intervention also was more effective at increasing colonoscopy screening for patients who had more doctor visits in the past year. This was likely due to the multiple opportunities for discussions and recommendations made possible by frequent and repeated encounters.

Strengths and Limitations

Study strengths include a randomized design and a large sample of low-income AAs who had never been screened or were overdue for screening at baseline. Additionally, we examined CRC screening with both SBT and colonoscopy separately as well as the combined outcome of any CRC screening test, believing that these screening tests involve very distinct behaviors that are likely to have different predictors, moderators, and mediators. Finally, the computer intervention was individually tailored but culturally targeted to AAs, providing patients with specific test recommendations based on objective CRC risk due to family history. This point-of-care intervention was delivered immediately prior to a clinic visit to inform and activate patients to discuss CRC screening with their providers.

Several limitations must be considered when interpreting results. Eligible patients who chose not to enroll may be systematically different from participants in ways that we could not observe. Since more than half of participants had previously received a CRC screening recommendation from their provider but were nonetheless non-adherent, they may be different, perhaps more resistant to screening. It is likely that motivating these individuals to get screened may require more intensive or multiple interventions, which involve simple outreach strategies using a stepped approach [53, 54]. Additionally, the mediation results may not be as generalizable to men or those with lower BMI. Finally, although this intervention significantly increased both SBT and completion of any test, the overall rates of screening were low. It will be important to use multilevel approaches to increase CRC screening levels is this disadvantaged population.

Conclusion

Computer-tailored interventions may have great potential to supplement primary care encounters by preparing patients and activating them to have discussions and engage in shared decision-making about CRC screening. Given the overall low rates of CRC screening, future research is needed, particularly among low-income and minority groups, to determine ways to increase the effectiveness of computer-tailored interventions, examine cost-effectiveness of such interventions, and translate them into primary care practices. Finally, future research needs to consider intervention strategies which can track when repeat screening for SBT and deliver appropriate interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

This computer-tailored intervention improved CRC screening rates among low-income African American patients in primary care.

Significant effects of the computer intervention were observed for completion of stool blood test and any screening test.

Colonoscopy screening rate was higher in the computer-tailored intervention group, though not statistically significant.

Moderators of intervention effects were age, employment, and family/friend recommendation of screening.

Mediators were changes in CRC knowledge, SBT barriers, colonoscopy benefits, and having a patient-provider discussion.

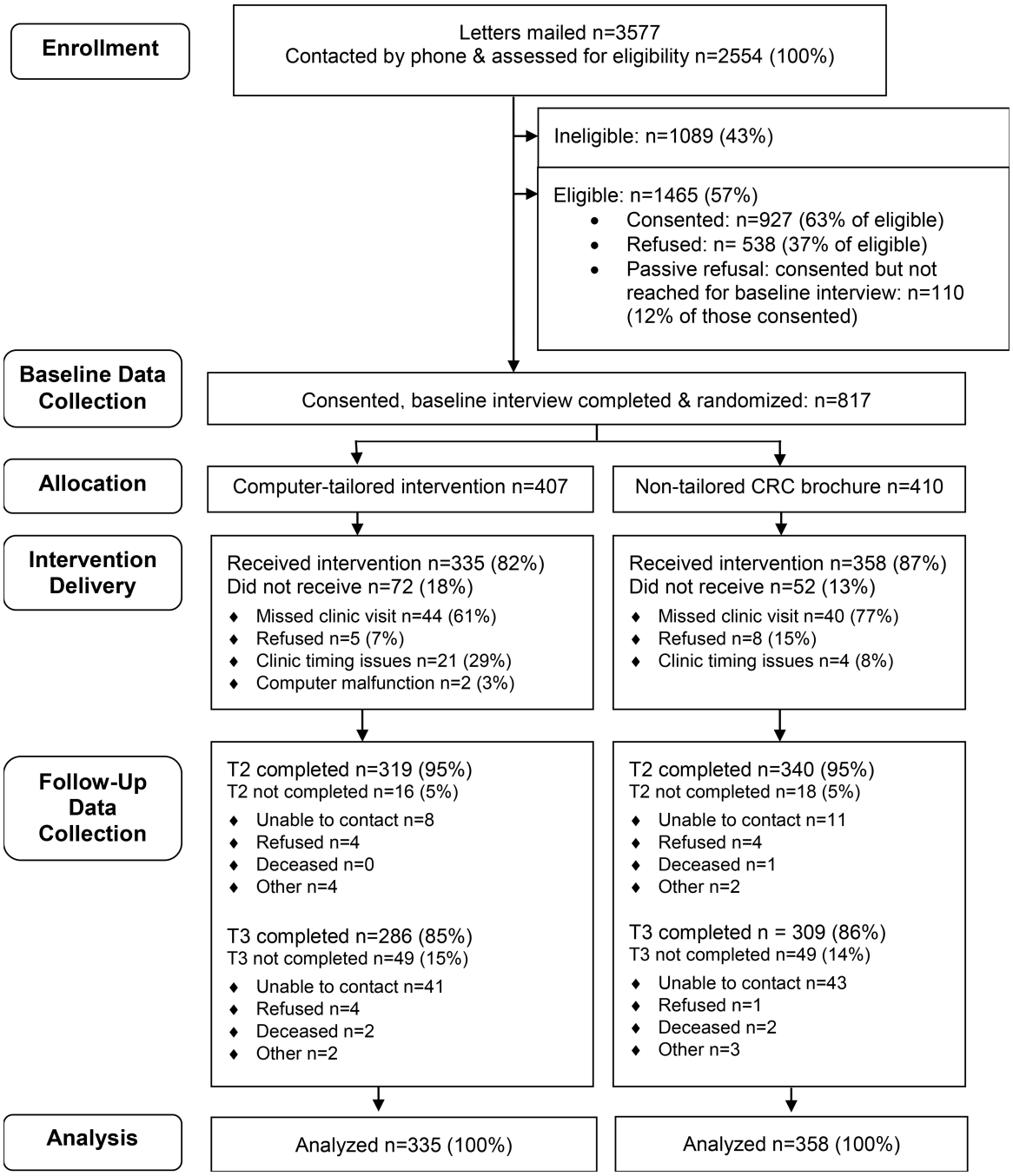

Figure 1.
Participant Flow Diagram

Table 1.

Characteristics by intervention group

Variable		Computer group (n=335)		Brochure group (n=358)		*p*-value
		M	(SD)	M	(SD)	
Age		56.8	(6.0)	57.8	(6.4)	0.046
Years of Education		12.2	(1.8)	12.3	(1.9)	0.683
		N	(%)	N	(%)	*p*-value
Gender:	Male	165	(49)	172	(48)	0.75
	Female	170	(51)	186	(52)	
Married/partnered:	Yes	102	(30)	117	(33)	0.51
	No	233	(70)	240	(67)	
Currently Employed:	Yes	74	(22)	76	(21)	0.78
	No	261	(78)	282	(79)	
Health Insurance:	Yes	305	(91)	314	(88)	0.19
	No	30	(9)	43	(12)	
Household Income:	< $15,000	196	(61)	190	(55)	0.32
	$15–30,000	88	(27)	111	(32)	
	> $30,000	39	(12)	42	(12)	
Clinic Site:	VAMC	74	(22)	71	(20)	0.46
	Non-VA	261	(78)	287	(80)	

Note. Some columns may not add to 100% due to missing data.

Table 2.

CRC screening test completion by group unadjusted for covariates

Test completed	Computer group (n=335)		Brochure group (n=358)		OR	95% CI	*p*-value
	n	(%)	n	(%)			
SBT	**42**	**(12.5)**	**26**	**(7.3)**	**1.83**	**1.11–3.03**	**.0186**
Colonoscopy	62	(18.5)	50	(14.0)	1.40	0.89–2.19	.1413
Any Test	**88**	**(26.3)**	**66**	**(18.4)**	**1.58**	**1.05–2.37**	**.0283**

Note. SBT = stool blood test

Final main effects models appear in Table 3.

Table 3.

Main effect models with pre-specified covariates (N=693)

Predictors	SBT (n=693)		Colonoscopy (n=693)		Any test (n=693)	
	OR (95% CI)	***p*-value**	**OR (95% CI)**	***p*-value**	**OR (95% CI)**	***p*-value**
Intervention: computer vs. brochure	**1.81 (1.08, 3.04)**	**0.0237**	**1.43 (0.91, 2.26)**	**0.1217**	**1.54 (1.01, 2.35)**	**0.0460**
Age	0.99 (0.97, 1.02)	0.7104	0.99 (0.95, 1.02)	0.4951	0.99 (0.96, 1.02)	0.4196
Male	0.64 (0.33, 1.24)	0.1840	1.30 (0.74, 2.28)	0.3565	1.00 (0.62, 1.60)	0.9841
Site: VA vs. Non-VA	**6.61 (2.65, 16.53)**	**<.0001**	0.84 (0.46, 1.51)	0.5531	1.39 (0.75, 2.58)	0.2962
Years of education	1.14 (0.99, 1.31)	0.0741			1.09 (0.99, 1.20)	0.0956
Household Income: 15–30K vs. < 15K ≥ 30K vs. < 15K			1.42 (0.91, 2.23) 0.37 (0.13, 1.03)	0.1240 0.0566	1.32 (0.89, 1.98) 0.61 (0.32, 1.17)	0.1714 0.1351
Baseline stage: Contemplation vs.Precontemplation Preparation vs. Precontemplation	**2.05 (1.19, 3.53)** **2.41 (1.04, 5.61)**	**0.0096** **0.0410**	**2.27 (1.51, 3.44)** **3.05 (1.61, 5.76)**	**<.0001** **0.0006**	**1.90 (1.31, 2.75)** **2.60 (1.61, 4.20)**	**0.0007** **<.0001**
Reason for clinic visit: Preventive care vs.acute visit Did not see MD vs. acute visit			0.85 (0.49, 1.49) **0.12 (0.02, 0.93)**	0.576 **0.042**		

Note. SBT = stool blood test; VA = Veterans Affairs Medical Center site; MD = medical doctor. Comorbidity was a pre-specified covariate but not entered in any of the models as it was NS at $p \geq .20$.

Table 4.

Moderating effects for SBT and colonoscopy with pre-specified and post-hoc variables (n=693)

Moderator	**OR (95% CI) of interventioneffect on outcome variable**	***p*-value**
SBT (n=693)		
Age: 51 years (mode)	1.00 (0.45 – 2.22)	0.998
60 years (75th percentile)	**2.33 (1.37 – 3.97)**	**0.002**
70 years (95th percentile)	**5.44 (1.95 – 15.23)**	**0.001**
Currently Employed: Yes	0.50 (0.17 – 1.48)	0.211
No	**2.70 (1.49 – 4.88)**	**0.001**
Family or Friend Recommendation: Yes	0.67 (0.25 – 1.80)	0.429
No	**2.80 (1.55 – 5.06)**	**0.001**
Colonoscopy (n=693)		
Number of doctor visits in year prior to enrollment: 3 visits (mode)	1.12 (0.69 – 1.84)	0.642
4 visits (median)	1.18 (0.73 – 1.91)	0.504
12 visits (90th percentile)	**1.73 (1.04 – 2.87)**	**0.034**

Note. SBT = stool blood test. Each variable was tested as a moderator in separate models.

Table 5.

Mediation effects for SBT and any colon screening test at 6 months (n=693)

Mediator	**OR (95% CI) ofintervention effect on outcome variable**	***p*-value interventionto outcome**
SBT (n=693)		
Model before inclusion of any mediators	1.81 (1.08 – 3.04)	**0.0237**
Model after inclusion of each mediator*		
Change in SBT barrier mean from T1 to T3	1.66 (0.99 – 2.77)	0.0530
Change in CRC knowledge score from T1 to T3	1.47 (0.86 – 2.51)	0.1540
Patient-provider discussion of SBT test	1.50 (0.82 – 2.74)	0.1905
Any colon test (n=693)		
Model before inclusion of any mediators	1.55 (1.02 – 2.36)	**0.041**
Model after inclusion of each mediator*		
Change in SBT barrier mean from T1 to T3	1.56 (0.98 – 2.47)	0.0591
Change in colonoscopy benefit mean from T1 to T3	1.52 (0.95 – 2.44)	0.0819
Change in CRC knowledge score from T1 to T3	1.39 (0.86 – 2.23)	0.1773
Patient-provider discussion of colon test	1.24 (0.77 – 1.99)	0.3724

Note. SBT = stool blood test.

*Each variable was tested as a mediator in separate models