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Computer-delivered tailored intervention improves colon cancer screening knowledge and health beliefs of African-Americans

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Abstract

We conducted a randomized controlled trial among African-American patients attending a primary-care provider visit to compare efficacy of a computer-delivered tailored intervention to increase colorectal cancer (CRC) screening ($n = 273$) with non-tailored print material—an American Cancer Society brochure on CRC screening ($n = 283$). Health Belief Model constructs were used to develop tailored messages and examined as outcomes. Analysis of covariance models were used to compare changes between CRC knowledge and health belief scores at baseline and 1 week post-intervention. At 1 week, patients who received the computer-delivered tailored intervention had greater changes in CRC knowledge scores ($P < 0.001$), perceived CRC risk scores ($P = 0.005$), FOBT barriers scores ($P = 0.034$) and colonoscopy benefit scores ($P < 0.001$). Findings show that computer-delivered tailored interventions are an effective adjunct to the clinical encounter that can improve knowledge and health beliefs about CRC screening, necessary precursors to behavior change.

Introduction

Colorectal cancer (CRC) is the second leading cause of cancer death in the United States among both men and women [1]. The 5-year survival when CRC is diagnosed at a localized stage is 91% but only 40% if diagnosed at an early stage [2]. More than half of CRC deaths could be prevented through screening, but participation rates remain low at 62% [3,4]. Current guidelines recommend that screening begin at age 50 years with one of six test options, each with a different testing schedule. Screening test options for people with no risk factors other than age include fecal occult blood or immunochemical testing (FOBT/FIT), stool DNA testing, flexible sigmoidoscopy, colonoscopy, air contrast barium enema or computed tomographic (CT) colonography, also called virtual colonoscopy [5]. Persons at increased risk due to family history should begin

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screening with colonoscopy at a younger age using individualized screening intervals [5].

CRC disparities in African-Americans

African-Americans are disproportionately affected by CRC, with the highest incidence and mortality rates of any racial/ethnic group [6] and higher rates of late-stage cancers [4]. These disparities have been attributed to lower screening rates, less use of diagnostic tests following an abnormal screen, limited access to health care and unique biological features in tumors of African-Americans [7]. Lack of knowledge about test options, importance of screening in the absence of symptoms and curability of CRC when detected early are among the many barriers to CRC screening [2]. Other barriers include lack of time, inconvenience, lack of interest, cost, fear of positive findings, embarrassment and fatalistic beliefs about cancer [2,8]. Having received a recommendation from a healthcare provider has been consistently shown to be the most important predictor of CRC screening [9–16].

Computer-delivered tailored interventions

Computer-delivered tailored interventions have become an increasingly common approach to promote health behaviors in both healthy and chronically ill populations, but few have been implemented into routine primary care. Several reviews examining the impact of tailored interventions on health behavior change have found efficacy of tailored interventions over non-tailored ones [17–27]. Specific conclusions were that: (i) information tailored on four to five theoretical concepts was more effective than those tailoring on fewer concepts, (ii) tailoring on beliefs/attitudes, self-efficacy, stage of change, processes of change and social support was associated with largest effect sizes and (iii) careful tailoring on demographic characteristics such as age, gender and race and giving feedback on the behavior itself may enhance the effectiveness of theoretically tailored interventions [20]. A meta-analysis of 88 computer-delivered tailored interventions revealed a clinically and statistically significant effect size of $g = 0.17$ averaged over four health behaviors including smoking cessation, physical activity, fruit and vegetable intake and mammography [17]. No significant differences were observed by communication channel (print, computer or automated phone interventions). Finally, according to the Elaboration Likelihood Model, tailored interventions are expected to stimulate greater cognitive activity and central processing of information, which leads to more thoughtful consideration and evaluation of health messages [28,29]. Because tailored messages are customized to the individual, they are viewed as personally relevant which increases engagement and makes them more persuasive.

While studies have shown that tailored interventions are more effective than non-tailored at promoting mammography [26,30–32], evidence regarding effectiveness of tailored CRC screening interventions is limited especially among racial, ethnic, socioeconomic and geographic groups [33]. And, to our knowledge, only one other study tested the effects of a computer-delivered tailored intervention, where CRC screening messages are delivered in real time based on participants' responses to questions posed by a computer program [34].

Purpose

Our ongoing randomized controlled trial is testing the efficacy of a computer-delivered tailored intervention to promote CRC screening among African-Americans. This theory-based intervention was designed to increase knowledge and change health beliefs in directions that would support behavior change, specifically CRC screening. The purpose of this study was to compare changes in CRC-related knowledge and health beliefs 1 week post-intervention delivery between patients who used the computer-delivered tailored intervention and those who received non-tailored print material (an American Cancer Society brochure on CRC screening). Two research questions were as follows: (i) Are there differential changes in total knowledge and health beliefs (perceived CRC risk, benefits, barriers and self-efficacy) scores between patients who received the computer-delivered tailored intervention versus those who received a non-tailored CRC

screening brochure at 1 week post-intervention? and (ii) Are there differential changes in individual items on the knowledge and health belief scales between patients who received the computer-delivered tailored intervention versus those who received a non-tailored CRC screening brochure at 1 week post-intervention? All procedures were HIPPA compliant and approved by the Indiana University-Purdue University at Indianapolis Institutional Review Board prior to study implementation.

Materials and methods

Intervention descriptions

The computer-delivered tailored intervention was an enhancement of a pilot program developed by this research team. The program, titled *Colon Testing: Celebrate Life for Years to Come*, was housed in a portable tablet computer and delivered messages, graphics and video tailored on real-time assessment of the user's age, gender, perceived risk for developing CRC, perceived barriers to testing and family history (e.g. those with a strong family history of CRC received recommendations only for colonoscopy whereas those without received information about the two most common test options recommended for average-risk individuals). Samples of tailored messages and visuals from the interactive program are included in the Appendix.

The computer program was created by the research team in collaboration with Eo Studios, a media design and production company in Athens, GA. This firm guided all aspects of intervention development through use of a web-based project site where documents, visuals and video and audio demonstrations were posted for viewing. Initial development focused on refining assessment questions, message libraries and computer algorithms to link messages to tailoring variables. Relevant graphics were developed including animations of polyps growing, charts illustrating changes in CRC risk and still photos. Permissions were procured to use segments from an American Cancer Society video titled *Get Tested for Colon Cancer. Here's how* (#2432.00; 2005) and a public service announcement featuring actor Morgan Freeman developed by the Centers for Disease Control and Prevention [35].

Additional segments filmed included a mock colonoscopy procedure, a doctor discussing colon testing with the main character in an examination room, and a pastor—who was also a CRC survivor—telling his story and giving testimonial to the benefits of testing. To control for variations in users' reading levels which could affect engagement, the program included voice over narration of all content. A database was designed and incorporated to electronically capture users' responses to assessment questions posed during the intervention. On average, the program required 17 min to complete. Prior to implementation, the program was pilot tested with 21 subjects in the target population at two primary-care clinics where it received satisfaction and usability scores of >90% on most items. Cultural relevance and appropriateness of program messages were evaluated by a community advisory group comprised of eight African-American men and women.

Revisions to message wording and delivery were made based upon their input. The context for message delivery focused on a family gathering for a 50th birthday celebration. After introducing the theme and characters, program content began by providing information about CRC and screening. Colon anatomy and physiology, as well as development of CRC from polyps, were explained through narration and animations. Racial disparities in CRC incidence and mortality were highlighted in messages and graphs, tailored on gender. Based upon the user's family history of CRC, segments explaining the two most commonly recommended test options were shown. Average-risk users watched demonstrations of both FOBT and colonoscopy and were asked to indicate which test they would be most likely to consider. Users at increased CRC risk viewed only the colonoscopy demo because this was the test recommended for them by national CRC screening guidelines [5].

Barriers to CRC screening in general and each test specifically were assessed and then tailored messages were delivered in the program to overcome each barrier endorsed by participants. Five barriers focused on CRC screening generically (no

problems with my bowels, don't want to know if something is wrong, too many others things to do, doctor didn't recommend, nothing you can do about getting colon cancer); six barriers were specific for either FOBT (collecting a stool sample is unpleasant, takes too much time, don't know how to do, too much trouble, etc.) or colonoscopy (test would be embarrassing, would be painful, have to clean out my bowels, need someone to drive me home, etc). At the program's end, a tailored, single-page colored printout was generated that imported visuals and data from the intervention and summarized the user's personal CRC risk factors, risk-appropriate testing recommendations and, if average risk, the user's preferred test (see sample tailored printouts in Appendix).

The comparison group received non-tailored print materials, specifically a commonly used CRC screening brochure developed by the American Cancer Society [36]. This informational brochure was written at the fourth-grade reading level and contained information about screening as a means to prevent CRC as well as encouragement to discuss testing options with their provider. This was considered an optimal 'usual care' condition and a consistent approach to convey a recommendation for CRC screening from the primary-care provider.

Recruitment procedures and eligibility criteria

Participants were eligible if they were 51–80 years of age, English-speaking, self-identified as African-American and currently non-adherent to CRC screening guidelines (were due for screening). Exclusion criteria were as follows: (i) personal history of CRC, (ii) FOBT in the past 12 months, sigmoidoscopy in the past 5 years or colonoscopy in the past 10 years; (iii) medical condition that prohibits CRC screening or (iv) cognitive, speech or hearing impairment.

Participants were recruited from: (i) five community-based clinics affiliated with our safety-net hospital serving African-American patients from the most medically underserved communities in Indianapolis; (ii) four primary-care clinics at the Indianapolis Veterans Affairs Medical Center (VAMC); (iii) one university-affiliated family medicine clinic in Indianapolis and (iv) one primary-care practice serving patients in medically underserved areas in central and west Louisville, Kentucky.

Participants from the five safety net hospital community clinics were recruited by experienced recruiters employed through our practice-based research implementation network. In other sites, recruiters were research staff specifically hired and trained for this study. All recruiters identified potentially eligible participants from primary-care clinic databases and obtained provider approval prior to contact. Of 178 providers, 164 (92%) granted approval to contact their potentially eligible patients. Approved patients who had an upcoming primary-care visit were mailed an introductory letter (signed by their provider), a recruitment brochure that explained the study, and a copy of the written informed consent. Within 1 week of this mailing, patients who did not call the toll-free number to opt-out received a phone call from a recruiter who assessed eligibility, explained the study and answered questions. Patients who verbally consented by phone were scheduled for baseline telephone interviews. As shown in Figure 1, our participation rate was 63%.

Enrollment and intervention delivery

Trained research assistants met participants who had completed the baseline telephone interview in private areas in the clinics 30–45 min prior to their scheduled appointments to complete enrollment and deliver interventions. Written informed consent and forms granting access to medical records were reviewed and signed by participants. Those assigned to the tailored interactive computer intervention were given the tablet computer and instructed on use of the stylus to answer questions posed during the program. Head phones were provided if desired to reduce noise and distractions. Research assistants remained nearby to answer questions or provide technical assistance. When participants finished the program, research assistants connected the tablet computer to a mobile color printer to

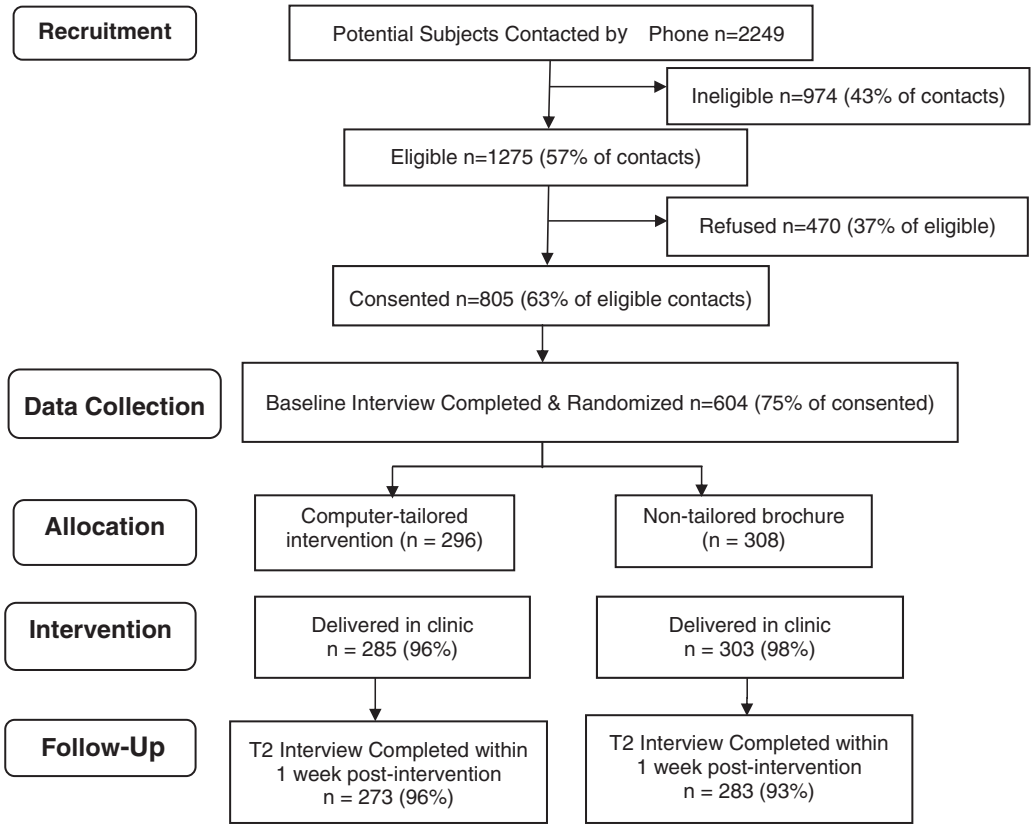

Fig. 1. Participant flow.

generate the tailored printout (See Appendix). The non-tailored brochure was provided to those assigned to this comparison group.

Data collection

Outcome data were collected using a computer-assisted telephone interview system at four time points by interviewers at the Indiana University Center for Survey Research. Baseline data were collected upon enrollment, before scheduled primary-care visits where the intervention was delivered. The second interview was conducted 1 week post-intervention delivery to assess changes in health beliefs and reactions to the interventions. Figure 1 shows the flow of participants through the study. We interviewed 96% of the computer-delivered tailored intervention group and 93% of the brochure group within 1 week of their clinic visit. To assess behavioral (screening) outcomes, a third interview was conducted at 6 months and a final interview at 15 months post-intervention. Data collected at baseline and 1 week post-intervention were used for this study. A companion manuscript will examine data collected at the third and fourth interviews in order to determine whether the intervention had an effect on CRC screening.

Measures

CRC knowledge was measured using 11 items developed specifically for this study. Several dimensions of CRC knowledge were assessed, including risk factors, screening test options and test frequency. Knowledge scores were computed by summing the number of correct responses, with a

possible range of 0–11. This multidimensional measure had a Cronbach α coefficient of 0.63.

Perceived CRC risk (susceptibility) was assessed using two measures: a five-item scale which contained three items originally developed by Champion to measure perceived breast cancer risk [37,38] and a single-item measure of perceived age- and gender-adjusted comparative risk [39]. The five item scale used a four-point response option, where 1 = very unlikely and 4 = very likely, to assess participants' beliefs about how likely they were to get CRC in the next 5 years, in the next 10 years and sometime during their lifetime. Two additional items assessed likelihood of getting CRC if they did or did not have regular colon testing. Comparative risk was assessed by 'Compared to other (men/women) your age, would you say your chance of getting colon cancer in the next ten years is. . .?'[39]. Response options were lower, about the same or higher than others my age. The Cronbach α for the five-item perceived risk scale was 0.79.

Perceived benefits, barriers and self-efficacy were measured for FOBT and colonoscopy separately using valid and reliable scales developed by our team [40,41]. All scales had Likert response options where 1 = strongly disagree to 4 = strongly agree. The FOBT benefits scale contained three items while the colonoscopy benefits scale had four items. In this sample, Cronbach α coefficients for FOBT benefits and colonoscopy benefits scales were 0.76 and 0.67, respectively. To assess FOBT barriers, participants were asked to indicate how much they agreed or disagreed with nine statements such as 'You might put off doing a stool blood test because. . . collecting a stool sample is unpleasant, you don't have the time or you don't know how to do one'. Colonoscopy barriers were assessed with 15 items where participants indicated agreement or disagreement with statements such as 'You might put off having a colonoscopy because. . .the cost would be a problem, it could be painful or finding someone to drive you home would be hard'. Cronbach α coefficients for the FOBT and colonoscopy barriers scales were 0.82 and 0.89, respectively. Self-efficacy for CRC screening was measured for FOBT (eight items) and colonoscopy (11 items) independently by asking participants to indicate how sure they were that they could take the steps necessary to complete the test. The Cronbach α coefficient for both self-efficacy scales was 0.87.

Data analysis

Baseline (T1) demographics were summarized and compared between computer and brochure groups. Age, years of education and number of healthcare provider visits in the last 12 months were compared using *t*-tests. Gender, marital status, employment status, health insurance status and income level were compared using χ^2 tests. Cronbach α coefficients were reported for the baseline (T1) health belief and knowledge scales. For knowledge, where the items are dichotomous, Cronbach's α is equivalent to that of the Kuder–Richardson 20 measure of reliability. We used analysis of covariance (ANCOVA) models to examine the effect of treatment (computer versus brochure) on the change in health beliefs and knowledge from T1 to T2 controlling for T1 health belief or knowledge and T1 demographic variables, i.e. gender, married status, health insurance status, employment status, household income, years of education and number of doctor visit in last 12 months. We examined treatment effects on individual health belief scale items similarly using ANCOVA. For the comparative risk question (dichotomized to 'higher or the same' perceived risk versus 'lower' risk) and knowledge items, we ran logistic regressions controlling for baseline values and demographics. Hochberg's [42] step-up Bonferroni method was used to adjust for multiple tests performed for each item within a scale. All analyses were performed using SAS (Version 9.2, Copyright ©2008 SAS Institute Inc., Cary, NC, USA).

Results

Baseline demographics of the sample are summarized in Table I. Mean age was 57.7 years, average education was 12.3 years and number of healthcare provider visits in the last 12 months was 6.7. Half

Table I. *Sample demographics at baseline*

Mean (SD)	Computer group ($n = 273$) Variable	Brochure group ($n = 283$) Mean (SD)	*P*
Age	57.3 (6.1)	58.1 (6.4)	0.147
Years of education	12.2 (1.8)	12.4 (2.0)	0.379
Number of healthcare provider visits in last 12 months	6.9 (8.7)	6.6 (8.7)	0.626
	n (%)	*n* (%)	*P*
Gender			
Male	141 (52)	139 (49)	0.551
Female	132 (48)	144 (51)	
Married/partnered			
Yes	86 (31)	91 (32)	0.846
No	187 (69)	191 (68)	
Employed			
Yes	61 (22)	60 (21)	0.744
No	212 (78)	223 (79)	
Insurance			
Yes	218 (80)	224 (79)	0.902
No	55 (20)	58 (21)	
Income			
<$15 000	159 (60)	147 (55)	0.331
$15 000–30 000	72 (28)	89 (33)	
>$30 000	32 (12)	33 (12)	

were males, 32% were currently married or living with a partner, 22% were employed full- or part-time, 80% had some kind of healthcare insurance and 58% had yearly household incomes below $15 000. There were no significant differences in demographics between the computer-delivered tailored group and the non-tailored brochure group.

Question 1: Are there differential changes in knowledge and health beliefs between patients who received the computer-delivered tailored intervention and those who received the non-tailored CRC screening brochure?

Treatment effects on changes from baseline to 1 week post-intervention on belief scales and the knowledge scale, controlling for baseline demographics, are summarized in Table II. Compared with the brochure group, the computer group had a greater increase in perceived risk scores ($P = 0.045$), a greater decrease in FOBT barrier scores ($P = 0.034$), a greater increase in colonoscopy benefit scores ($P < 0.001$) and a greater increase in knowledge scores ($P < 0.001$). Those reporting perceived CRC risk as 'higher' or 'about the same' as other people did not differ between groups at baseline (74% of computer group, 73% of brochure group) but at T2, a greater proportion of the computer group perceived their CRC risk to be at least the same as others (81% versus 70%, respectively; adjusted OR = 1.9, 95% CI = 1.2, 3.0; $P = 004$).

Research Question 2: Are there differential changes in individual items on the knowledge and health belief scales between patients who received the computer-delivered tailored intervention versus those who received a non-tailored CRC screening brochure at 1 week post-intervention?

Tables III–V display descriptive statistics and statistical tests for all scale items having unadjusted *P*-values ≤ 0.05. Of the five items on the perceived risk scale (Table III), significant differences in mean change scores were seen for two; patients in the computer group had higher perceived likelihood of

Table II. *Health belief and knowledge scale means and change scores from baseline to 1 week post-intervention by group (n = 273 in computer group and n = 283 in brochure group)*

Scale	Group	T1, mean (SD)	T2, mean (SD)	Estimated[a] mean change	T^a	P^a
Perceived risk	Computer	2.40 (0.66)	2.50 (0.63)	0.13	2.01	0.045
	Brochure	2.38 (0.73)	2.42 (0.72)	0.03		
FOBT benefits	Computer	3.49 (0.59)	3.55 (0.62)	0.07	1.06	0.290
	Brochure	3.47 (0.62)	3.47 (0.66)	0.02		
FOBT barriers	Computer	2.33 (0.73)	2.10 (0.80)	−0.21	−2.13	0.034
	Brochure	2.20 (0.73)	2.13 (0.79)	−0.10		
FOBT self-efficacy	Computer	3.63 (0.51)	3.76 (0.46)	0.14	1.83	0.067
	Brochure	3.63 (0.56)	3.72 (0.50)	0.08		
COL benefits	Computer	3.40 (0.63)	3.56 (0.58)	0.16	4.81	<0.001
	Brochure	3.42 (0.64)	3.36 (0.68)	−0.06		
COL barriers	Computer	2.26 (0.73)	2.08 (0.80)	−0.16	−0.89	0.373
	Brochure	2.22 (0.74)	2.12 (0.78)	−0.11		
COL self-efficacy	Computer	3.45 (0.53)	3.59 (0.49)	0.15	1.08	0.279
	Brochure	3.44 (0.61)	3.56 (0.53)	0.11		
Knowledge	Computer	3.86 (2.34)	6.38 (2.64)	2.59	12.20	<0.001
	Brochure	3.70 (2.29)	4.30 (2.42)	0.59		

[a]Estimated mean change, *T*-statistics and *P*-value from ANCOVA model controlling for T1 outcome and demographic variables. FOBT = fecal occult blood test, COL = colonoscopy.

Table III. *Changes in individual perceived risk scale item means from health belief scales from baseline to 1 week post-intervention by group (n = 273 in computer group and n = 283 in brochure group)*

Scale item	Group	T1, mean (SD)	T2, mean (SD)	Estimated[a] mean change	T^a	Adjusted P^a
How likely is it that you will get CRC sometime in your lifetime?	Computer	2.37 (0.94)	2.69 (0.82)	0.31	3.69	0.015
	Brochure	2.42 (0.96)	2.46 (0.88)	0.06		
How likely is it that you will get CRC in the next 10 years?	Computer	2.37 (0.88)	2.58 (0.87)	0.23	2.58	0.040
	Brochure	2.33 (0.94)	2.40 (0.91)	0.05		

[a]Estimated mean change, *T*-statistics and *P*-value (adjusted for multiple testing) from ANCOVA model controlling for T1 outcome and demographic variables.

getting colon cancer sometime in their lifetime (adjusted $P = 0.015$) and getting colon cancer in the next 10 years (adjusted $P = 0.040$).

After adjusting for multiple comparisons, none of the individual item means on the FOBT benefits (three items), FOBT barriers (nine items) or FOBT self-efficacy (eight items) scales differed between the two groups. For items on the colonoscopy benefits (four items), colonoscopy barriers (15 items) and colonoscopy self-efficacy (11 items) scales, mean scores for three benefit items were significantly different between groups (Table IV). Patients in the computer group were more likely to agree that having a colonoscopy will help them avoid getting colon cancer (adjusted $P < 0.001$), will lower their chance of dying from colon cancer (adjusted $P = <0.001$) and will help them not worry as much about colon cancer (adjusted $P = 0.030$). For the knowledge scale (Table V), patients from the computer group had significantly higher percentages

Table IV. *Changes in colonoscopy scale item means from health belief scales from baseline to 1 week post-intervention by group (n = 273 in computer group and n = 283 in brochure group)*

Scale item	Group	T1, mean (SD)	T2, mean (SD)	Estimated[a] mean change	T^a	Adjusted P^a
Benefit: Having a COL will help you avoid getting CRC.	Compute	3.03 (1.15)	3.31 (1.05)	0.27	4.49	<0.001
	Brochure	3.15 (1.13)	3.00 (1.17)	−0.13		
Benefit: Having COL will lower your chances of dying from CRC.	Computer	3.34 (0.96)	3.56 (0.78)	0.22	4.07	<0.001
	Brochure	3.37 (0.93)	3.29 (1.02)	−0.08		
Benefit: Having COL will help you not worry as much about CRC.	Computer	3.48 (0.80)	3.59 (0.75)	0.14	2.43	0.030
	Brochure	3.41 (0.88)	3.41 (0.91)	−0.02		

[a]Estimated mean change, *T*-statistics and *P*-value (adjusted for multiple testing) from ANCOVA model controlling for T1 outcome and demographic variables.

of correct responses on all 11 items compared with the brochure group (adjusted *P*-values ≤ 0.02).

Discussion

Our computer-delivered tailored intervention improved CRC knowledge and changed health beliefs about CRC screening in directions consistent with behavior change. African-American patients who were attending a scheduled primary-care visit and used the computer-delivered tailored intervention had significantly greater increases in scale scores for perceived CRC risk, perceived benefits of colonoscopy and CRC knowledge at 1 week post-intervention. In addition, the tailored intervention group showed a greater reduction in scale scores for FOBT barriers compared with those who received the non-tailored CRC brochure.

Most health behavior theories hypothesize that perceived risk/susceptibility/vulnerability to a disease or condition is a necessary motivational precursor to preventive health behavior change [43–45]. Several studies have demonstrated that perceived risk is associated with CRC screening [46–48]. 1 week after receipt, participants who used the computer-delivered tailored intervention had higher mean scores on several items assessing their perceptions of risk for, or susceptibility to, CRC.

To identify specific changes in knowledge and health beliefs, we also compared individual items on all scales between groups. Those in the tailored intervention group had greater increases in mean scores on two perceived risk items assessing their likelihood of getting CRC: (i) sometime in their lifetime and (ii) in the next 10 years. This is an important intervention effect since many African-Americans believe their CRC risk to be low [49–51].

Gerrard and colleagues suggested it may be essential to assess risk perceptions using a 'conditional' risk question, i.e. one that is contingent upon the performance of the behavior [52]. In this study, we added two conditional risk items to assess perceived chances of getting CRC if the participant: (i) got regular colon tests or (ii) did not get regular colon tests. We observed greater reductions in the tailored intervention group, trending toward significance, on one item—perceiving they would be less likely to get CRC if they had regular colon testing (adjusted $P = 0.051$). The tailored intervention raised participants' perceptions of their personal risk for CRC and enhanced beliefs that regular colon testing would reduce risk.

Significant increases in both overall colonoscopy benefit scores and several individual colonoscopy benefit items were observed in the computer group. Patients in this group had greater increases in post-intervention mean scores (indicating greater agreement) that colonoscopy would: (i) help them avoid CRC, (ii) lower their chance of dying from CRC and (iii) help them not worry as much about CRC. While we did not assess perceived benefits to deliver tailored messages, our tailored intervention

Table V. *Knowledge scale item from baseline to 1 week post-intervention by group (n = 273 in computer group and n = 283 in brochure group)*

Scale Item	Group	T1, % correct answer	T2, % correct answer	Odds ratio[a] (computer versus brochure)	χ^{2a}	Adjusted P^a
Can colon cancer ever be prevented?	Computer	50.18	63.00	1.74	8.38	0.002
	Brochure	47.00	50.00			
Who is more likely to get colon cancer? (Age group)	Computer	44.69	64.47	2.64	21.75	<0.001
	Brochure	40.99	46.10			
Who is more likely to get colon cancer? (Race/ethnicity group)	Computer	25.27	56.78	5.88	60.83	<0.001
	Brochure	31.10	27.66			
Who is more likely to get colon cancer? (relative)	Computer	24.54	36.63	1.64	5.45	0.020
	Brochure	21.20	26.60			
What is the chance for a woman to get colon cancer compared with men?	Computer	24.18	34.07	1.60	5.40	0.020
	Brochure	16.96	24.11			
What is a small growth inside the colon that might turn into cancer called (polyp)	Computer	32.23	61.54	2.01	10.31	0.004
	Brochure	29.68	48.06			
Which is the most effective way for people to lower their chances of dying from colon cancer?	Computer	38.10	73.63	4.16	40.62	<0.001
	Brochure	36.40	48.94			
What can be found by doing a take-home stool blood test?	Computer	53.48	80.95	2.80	20.07	<0.001
	Brochure	53.00	63.12			
If you choose to have a stool blood test and everything is normal, when will you need to have your next one?	Computer	41.39	47.62	1.60	6.34	0.020
	Brochure	40.99	37.59			
What is a doctor able to see during a colonoscopy?	Computer	46.52	72.53	3.57	32.63	<0.001
	Brochure	46.29	51.06			
If you choose to have a colonoscopy and everything is normal, when will you probably need to have your next one?	Computer	5.13	46.52	15.60	79.58	<0.001
	Brochure	6.01	7.09			

[a]Odds ratio, χ^2-statistics and *P*-value (adjusted for multiple testing) from logistic model controlling for T1 outcome and demographic variables.

delivered clear messages about the preventability of CRC and that a colon cancer diagnosis could be avoided through the removal of polyps. These findings support the efficacy of our messages about the benefits of colonoscopy.

The Health Belief Model constructs of perceived barriers and self-efficacy have been shown to predict CRC screening behavior [41,46,47,53,54] and our computer-delivered tailored intervention included messages to overcome or reduce barriers and increase self-efficacy. The tailored group had a greater decrease in FOBT barriers at post-intervention than the brochure group ($P = 0.034$). Although barriers to colonoscopy were reduced for both groups, the difference in change scores between groups on colonoscopy barriers was not significant ($P = 0.37$). It is possible that one-time delivery of tailored messages is not strong enough to reduce barriers to colonoscopy or that these barriers are more difficult to overcome. It is also possible that both interventions led to discussions about screening during the clinic visit where colonoscopy barriers could have been addressed by providers. Studies are needed to explore real-time discussions between participants and their providers about CRC screening. Although video segments in the computer-delivered tailored intervention demonstrated the steps involved in completing FOBT and colonoscopy to increase

self-efficacy, there were no significant between-group differences in self-efficacy change scores (they increased somewhat in both groups). These participants, who had relatively low levels of knowledge about CRC and screening, may need more than a single exposure to audio and video messages about these unfamiliar screening tests to see significant increases in self-efficacy.

Awareness of CRC and screening tests has increased over the past 20 years, yet lack of knowledge remains a major barrier to increasing participation, especially among African-Americans [49,55–57]. As a necessary first step to behavior change, the computer-delivered tailored intervention was developed to educate patients about the preventability of CRC, associated risk factors, development of CRC from polyps and screening test options. Our results indicated that the computer-delivered tailored intervention resulted in differential improvement in knowledge. This is important; Maxwell and colleagues reported that increasing knowledge of CRC screening mediated screening behavior and accounted for 13% of their intervention effect [58]. While knowledge is necessary but not sufficient for behavior change to occur, interventions that increase awareness of CRC, screening tests and preventability of CRC are an essential first step.

Few studies have examined changes in CRC-related health beliefs resulting from intervention. These findings contribute to the growing evidence on the effectiveness of computer-delivered tailored interventions to modify these important predictors of screening. Although the mechanisms by which the computer-delivered tailored intervention caused the observed changes are not yet clear, tailored interventions have two primary goals, to: (i) maximize the perceived salience or 'fit' of the information to the user and (ii) favorably influence mutable psychological characteristics that mediate health behavior, such as health beliefs [59]. Jerant *et al*. (2010) have suggested that interactive computer-delivered tailored interventions have great potential to reduce health disparities because they help to overcome several challenges minorities face, including limited health literacy, patient–provider communication barriers and the irrelevance of standard patient education materials to their unique perspectives and needs.

Computer-delivered tailored interventions that educate primary-care patients about CRC, assess individual risk factors and deliver tailored messages about risk-appropriate testing, and strategies to overcome barriers to testing have great potential to change health beliefs needed to move patients forward in their readiness to screen. Strengths of this randomized trial include its large sample size, high participation and low attrition rates and use of multiple primary-care recruitment sites. Participants were relatively young, with an average age of 58 years, representing the age group with the lowest CRC screening rates. Changing health beliefs about CRC screening among people in this age group has potential to make the greatest impact in increasing screening participation, thereby reducing CRC incidence and mortality.

Limitations include the potential for selection bias since patients who agreed to enroll may be more interested in CRC and screening. In addition, results may only be generalizable to similar populations of low-income African-American patients who have access to primary-care and CRC screening. Study settings were chosen specifically because the majority of patients were covered by some type of health insurance which provided access to CRC screening at low or no cost. Removing lack of insurance as a barrier to CRC screening may have influenced our results and limited their generalizability to the uninsured. However, there are similar safety net healthcare systems across the country in which we need to learn how to effectively facilitate participation in screening. While the computer-delivered tailored intervention produced significant changes in the desired directions, future analyses will determine if these changes in knowledge and health beliefs actually translate to CRC screening behavior.

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Conflict of interest statement

None declared.

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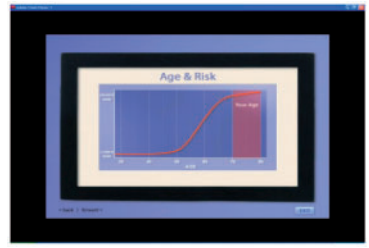
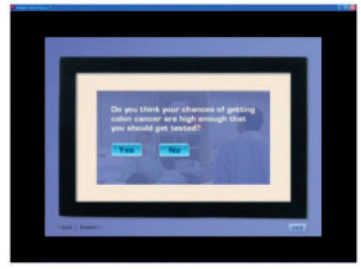
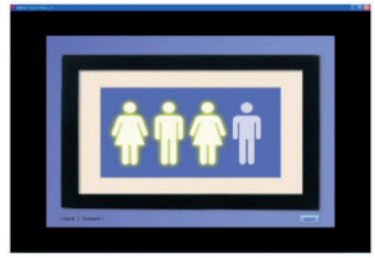
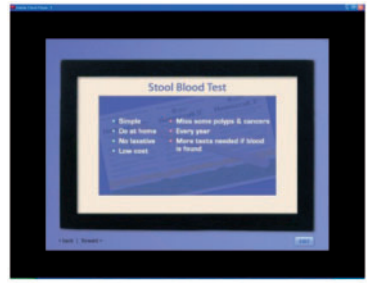
Appendix. Sample tailored messages and graphics in intervention

Tailoring variable	Sample message	Graphics/Video
Intro	Mr Robert Gibson celebrates his 50th birthday today with his family and friends. Robert's in good health—he watches what he eats, stays active and takes his blood pressure medicine. But there's something else he'll need to start doing to stay healthy in the years ahead. Colon testing is something everyone needs to think about when they get to be Robert's age.	
Age	(IF AGE = 70–79) And remember, your chances of getting colon cancer also depend on your age. Because you are now in your 70s, your chances are higher than when you were younger.	
Perceived risk	(IF LOW) You're like most people who think their chances of getting colon cancer are low. For almost everyone who gets it, it's a surprise. Most people with colon cancer will tell you they never expected to get it.	
Gender	(IF FEMALE) Unfortunately, African-American women are more likely than women of other races to get colon cancer and to die from it. One reason for this is because Black women are less likely to have regular colon testing.	

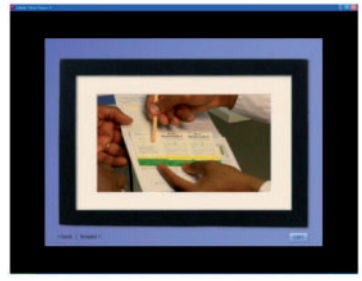
(continued)

Appendix *Continued*

Tailoring variable	Sample message	Graphics/Video
Family history of colon cancer	(IF NONE) It's good that you have no relatives with colon cancer. But, it's important to know that most people who get colon cancer are just like you. In fact, three of every four people who get this disease have no colon cancer in their family.	
	(IF ONE RELATIVE AFFECTED WITH CRC) Because you have a close relative who's had colon cancer, it's especially important for you to get tested. This picture shows how your chances of getting colon cancer go up when someone in your family has it.	
Screening test recom-mendation linked to user's objective CRC risk	(IF AVERAGE RISK) Stool blood test or colonoscopy? Which test should you do? That depends on what you and your doctor decide. Each has its advantages and disadvantages. The stool blood test is simple and can be done at home. You don't have to take a laxative to clean out your colon. And, it doesn't cost much. However, it can miss some polyps and cancers. It needs to be done faithfully every year. And, if blood is found, more tests must be run.	
	Colonoscopy is the most thorough colon test. Any polyps found can be removed on the spot. If no polyps are found, it only needs to be done every 10 years. On the downside, you do have to clean out your colon. You need to take the day off from work for the test and you need someone to drive you home. Depending on your insurance, it can be costly.	

(continued)

Appendix *Continued*

Tailoring variable	Sample message	Graphics/Video
	(IF INCREASED RISK) Because you have relatives who had colon cancer, it is especially important for you to have a colonoscopy. This test allows a doctor to see inside the entire length of your colon to find and remove polyps. During this test, the doctor uses a long, thin, flexible tube to view the inside of your colon or bowel. The tube has a tiny camera that sends pictures to a screen. The doctor watches the screen to look for polyps or anything unusual. If polyps are found, they can be removed right then and there.	
FOBT Barrier: *Don't know how to do the test*	(IF USER IS AVERAGE RISK AND SELECTED FOBT AS PREFERRED TEST) After a bowel movement, you use the stick that comes in the kit to dab a small amount of stool on one of the cards. You collect a small sample from three bowel movements in a row. Then you seal the card, place it in the return envelope and mail or drop it off to your doctor's office	
Colonos-copy Barrier: *Don't have time*	Robert: Would I have to take time off from work?... we're really short-handed right now. Doctor: Yes, you would need to take a day off, but it's just once in every 10 years. One day is a good tradeoff if it means adding years to the rest of your life. Could you take a personal or vacation day?	

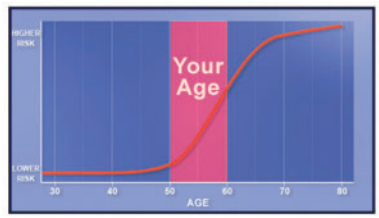
Sample tailored printout: woman at average risk for CRC

Dear Ms. Barker,

Thank you for using this program. This summary has been prepared especially for you based on the answers you gave the computer. Now you know how regular colon tests can keep you healthy. Be sure to talk with your doctor TODAY about the colon test that's right for you.

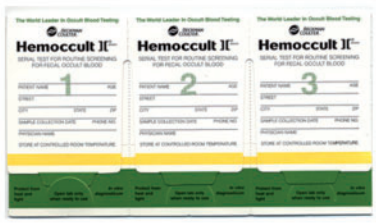
1. Your personal colon cancer risk profile:

You are now in your 50s and your chances of getting colon cancer will increase as you get older.



2. Your colon test options:

Stool Blood Test

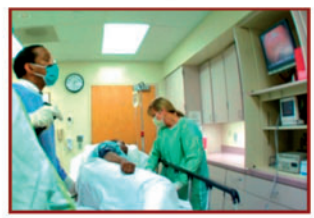


HOW IT WORKS
Finds hidden blood in your bowel movement

HOW OFTEN
Every Year

HOW TO GET ONE
Ask your doctor for a stool blood test kit

OR Colonoscopy



HOW IT WORKS
Allows a doctor to look inside the entire length of your colon to find and remove polyps

HOW OFTEN
Every 10 years or as suggested by your doctor

HOW TO GET ONE
Ask your doctor to help you get scheduled for a colonoscopy

3. It's great you are considering a stool blood test. If you have any concerns about being tested that weren't answered in the computer program, please discuss them with your doctor. Now is the time to get tested so you can CELEBRATE LIFE FOR YEARS TO COME.

TALK WITH YOUR DOCTOR TODAY!

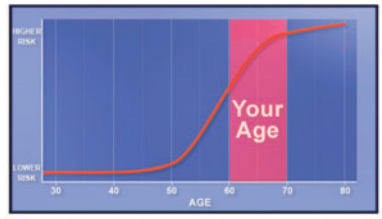
Sample tailored printout: man at increased risk for CRC due to family history

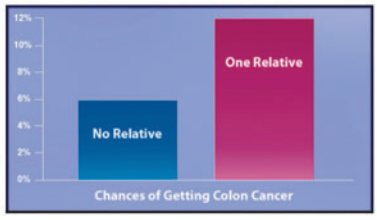
Dear Mr. Franklin,

Thank you for using this program. This summary has been prepared especially for you based on the answers you gave the computer. Now you know how regular colon tests can keep you healthy. Be sure to talk with your doctor TODAY about the colon test that's right for you.

1. Your personal colon cancer risk profile:

You are now in your 60s and your chances of getting colon cancer will increase as you get older.

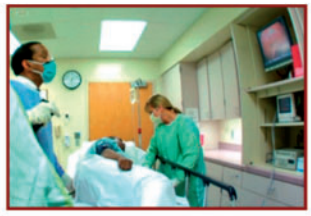




You have 1 family member who had colon cancer which makes your chances even higher.

2. Because of your risk, the best colon test for you to have is a colonoscopy.

Colonoscopy



HOW IT WORKS

Allows a doctor to look inside the entire length of your colon to find and remove polyps

HOW OFTEN

Every 10 years or as suggested by your doctor

HOW TO GET ONE

Ask your doctor to help you get scheduled for a colonoscopy

3. It's great you are considering a colonoscopy. If you have any concerns about being tested that weren't answered in the computer program, please discuss them with your doctor. Now is the time to get tested so you can CELEBRATE LIFE FOR YEARS TO COME.

TALK WITH YOUR DOCTOR TODAY!