Communicating risk to promote colorectal cancer screening: a multi-method study to test tailored versus targeted message strategies

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Received on 6 April 2021; editorial decision on 27 January 2022; accepted on 14 February 2022

Abstract

Colorectal cancer (CRC) screening rates are suboptimal, partly due to poor communication about CRC risk. More effective methods are needed to educate patients, but little research has examined best practices for communicating CRC risk. This multi-method study tests whether tailoring CRC risk information increases screening intentions. Participants (N = 738) were randomized with a 2:2:1 allocation to tailored, targeted, and control message conditions. The primary outcome was intention to screen for CRC (yes/no). Additional variables include perceived message relevance, perceived susceptibility to CRC, and free-text comments evaluating the intervention. A chi-square test determined differences in the proportion of participants who intended to complete CRC screening by condition. A logistic-based path analysis explored mediation. Free-text comments were analyzed using advanced topic modeling analysis. CRC screening intentions were highest in the tailored intervention and significantly greater than control (P = 0.006). The tailored message condition significantly increased message relevance compared with control (P = 0.027) and targeted conditions (P = 0.002). The tailored condition also increased susceptibility (P < 0.001) compared with control, which mediated the relationship between the tailored condition and intention to screen (b = 0.04, SE = 0.02, 95% confidence interval = 0.02, 0.09). The qualitative data reflect similar trends. The theoretical mechanisms and practical implications of tailoring health education materials about CRC risk are discussed.

Introduction

Colorectal cancer (CRC) is the second leading cause of cancer death among both men and women in the United States. In 2020, it is estimated that 147,950 new cases were diagnosed and 53,200 US adults died from CRC [1, 2]. Early detection through screening can increase the 5-year CRC survival rate to 90%, but current screening rates remain suboptimal [3]. Health education efforts to improve understanding of CRC risk is an important component of increasing screening rates, but developing strategies that are both scalable and personalized is crucial to increase adherence to screening recommendations. Thus,
the current multi-method study examines which message strategies are most effective at increasing intentions to undergo CRC screening but also explores theoretical mechanisms of increased informational relevance and susceptibility to CRC after message exposure.

Increasing perceived relevance of CRC messages
A key challenge in developing cancer screening messages is ensuring that patients perceive information about their cancer risk as personally relevant. This is important because messages that are perceived as personally relevant are associated with greater health behavior change [4–6]. Tailoring and targeting cancer risk messages are two approaches for increasing perceived relevance. Targeted messages are relevant to entire population subgroups that share some common characteristics [7–9]. Tailored messages, on the other hand, increase perceived message relevance by providing information that is only applicable to an individual message recipient [9, 10]. Tailored messages have been found to command greater attention, be processed more deeply, and be received more positively than non-tailored messages [11]. Tailored interventions can also promote informed decision-making and improve disease knowledge and decision self-efficacy toward screening [12]. However, there remains limited examination of scalable methods of easily personalizing CRC risk messages to promote screening. One possibility is to tailor CRC messages to only include personally relevant risk factors, which may increase a patient’s perceived susceptibility to CRC.

Increasing perceived susceptibility to CRC
Perceived susceptibility refers to the extent to which an individual believes themselves to be at risk of getting a disease or condition [13, 14]. Theoretically, perceived susceptibility is an important predictor of intentions to engage in preventive screening behaviors [15]. Tailored interventions have been shown to increase perceptions of susceptibility and cancer screening behaviors [16, 17]. Typical CRC screening messages consist of targeted information that communicates susceptibility by listing all potential CRC risk factors (e.g. age, red meat consumption, etc.). The underlying assumption of this approach is that patients will identify at least one personally relevant risk factor, thus increasing their perceived susceptibility. However, it is also possible that the presence of irrelevant risk factors in targeted messages may undermine these processes.

Tailoring interventions to promote CRC screening
Tailoring is an effective communication strategy to improve cancer screening rates [17], including CRC screening [18–20]. Recent computer-based interventions have successfully delivered tailored screening information at the point of care [21], whereas others have leveraged advances in technology to remotely deliver tailored virtual clinician interactions to promote CRC screening [22–26]. However, past interventions that include the provision of tailored risk information have been limited in their scalability. These limitations have centered around the modality of intervention (i.e. requiring educational materials to be printed) [19], the dosage of the intervention (i.e. requiring multiple educational materials) [27] and cost-effectiveness of the intervention (i.e. supplementing the intervention with patient navigator programs) [28–30]. Supplements to tailored message interventions are often costly and resource-intensive and have not been shown to be consistently more effective than stand-alone, simple technology-based interventions [31]. Therefore, the objective of the current study is to better understand the most efficacious approach for developing a scalable, low-touch strategy to communicate patient risk for CRC and increase screening intention. To do so, the current study compares tailored and targeted risk messages on perceived message relevance, perceived susceptibility and intentions to screen for CRC.
Method

Participants
Participants were recruited using Qualtrics Panels, a proprietary opt-in online panel company. The survey was disseminated during Colorectal Cancer Awareness Month (30–31 March 2015). Eligibility criteria included being able to read and write in English, being a permanent resident of Florida, aged 50–75 years old and reporting no personal history of CRC diagnosis. As repeat CRC screening is recommended, participants who were both up-to-date and not up-to-date with screening guidelines were included.

Procedure
Eligible participants were directed to a website containing informed consent information approved by the (blinded) Institutional Review Board. Participants consented to the study through a waiver of written consent. After reading the consent form and agreeing to participate, participants were asked to provide their first name and respond to a series of questions about their health history and behaviors. The survey algorithm then mapped the responses onto the American Cancer Society’s list of risk factors for CRC \[32\]. The list of risk factors included: age, identifying as Black or African American, a family history of CRC, a diagnosis of type 2 diabetes, eating more than 3 ounces of red meat daily, a smoking history and drinking more than two alcoholic drinks per day on average. All participants had at least one risk factor (i.e. aged 50–75). Participants were then randomized using Qualtrics ‘randomizer’ function with a 2:2:1 allocation to receive one of three message conditions: (i) a tailored risk factor message promoting CRC screening \((n = 299)\), (ii) a targeted risk factor message promoting CRC screening \((n = 289)\) or (iii) a control message promoting healthy eating and exercise \((n = 150)\). After viewing the stimuli, participants completed the dependent measures.

Instrumentation

Predictors
Stimuli. The literacy difficulty of each message was measured using the Flesch–Kincaid Readability Formula \[33\]. The control message was adapted from content on the President’s Council on Fitness, Sports, and Nutrition website \[34\] and included benefits on physical activity, diet and risk factors associated with being overweight \((\text{Flesch–Kincaid} = 8.8)\). The control message included the prompt: ‘Some of the risk factors associated with being overweight are:’ before listing the four most common risk factors. Both the targeted and tailored message conditions informed participants that March was Colorectal Cancer Awareness Month, that CRC is the second most common type of cancer in both men and women, and that CRC is the second leading cause of cancer death in the United States. The targeted message condition \((\text{Flesch–Kincaid} = 8.3)\) included the prompt: ‘Some factors put people at higher risk for colorectal cancer, including:’ before listing seven of the most common risk factors for CRC. The tailored message condition \((\text{Flesch–Kincaid} = 8.1)\) addressed each participant by their first name before priming them with the prompt: ‘Based on the responses you gave in this survey, we have identified that you are at an increased risk of developing colorectal cancer because of the following risk factors.’ Participants were then provided feedback for only their specific CRC risk factors with more directed language than the targeted condition \((\text{e.g. ‘You eat more than 3 ounces of red meat daily’ rather than ‘Eating more than 3 ounces of red meat daily’}). More specification was added within the tailored risk factors \((\text{e.g. ‘You are a [former] smoker’}) whereas the targeted condition stated ‘Smoking’ as a risk factor. Due to a failure in the tailoring algorithm, the current smoker risk factor did not display in the tailored message.
Participant characteristics. Demographic measures were dummy coded and controlled for in all analyses, including sex (male as referent), annual income (less than $50k as referent), highest education (no college education as referent), health insurance (no health insurance as referent) and race/ethnicity (White coded as referent for Black/African American and Hispanic participants). Participant screening history was dummy coded so that participants who had not screened with a colonoscopy within the past 10 years, sigmoidoscopy in the past 5 years or a home stool test in the past year were considered outside of guidelines (outside of guidelines coded as referent). Smoking history of combustible tobacco (i.e. cigarettes or cigars) in the past 30 days was included for both former and current smokers (non-smokers coded as referent). A composite score summing each participant’s CRC risk factors was also included.

Message quality. Message quality was measured using a discrete emotions approach [35], in which participants responded on a seven-point Likert scale how well each word described the Florida Healthy Living materials they read. Items included ‘reliable’, ‘believable’, ‘accurate’, ‘credible’, ‘trustworthy’ and ‘high quality’. Response ranged from ‘very poorly’ to ‘very well’ ($M = 2.91, SD = 1.24, \alpha = 0.82$).

Negative affect. Affect was measured using a discrete emotions approach [35], in which participants responded on a seven-point Likert scale how they would feel if asked to be screened for CRC by their doctor. Items included ‘worried’, ‘tense’, ‘anxious’ and ‘afraid’. Responses ranged from ‘not at all’ to ‘very much’ ($M = 2.91, SD = 1.24, \alpha = 0.82$).

Defensive information processing. Three different defensive information processing strategies were adapted from McQueen et al. [36]. These included (i) blunting through defensive avoidance (e.g. ‘I am afraid to get screened for colorectal cancer because I might find out something is wrong’); (ii) suppression through immediacy denial (e.g. ‘I have other problems more important than getting screened for colorectal cancer’) and (iii) counterarguing through barrier reinforcement (e.g. ‘Getting screened for colorectal cancer is too embarrassing’). Blunting was measured on two items ($M = 2.91, SD = 1.24, \alpha = 0.82$), suppression on two items ($M = 2.91, SD = 1.24, \alpha = 0.82$) and barrier elicitation on three items ($M = 2.91, SD = 1.24, \alpha = 0.82$). All items were measured on a seven-point Likert scale. Responses ranged from ‘strongly disagree’ to ‘strongly agree’.

Secondary outcomes and mediators

Perceived message relevance. Perceived message relevance was measured using two items adapted from a perceived message relevance scale [4, 37]. Items measured how customized the information was (e.g. ‘The information from the Florida Healthy Living message related to me personally’ and ‘The information from the Florida Healthy Living message takes into account my personal risk factors’). Items were measured on a seven-point Likert scale, with response categories ranging from ‘strongly disagree’ to ‘strongly agree’ ($M = 5.58, SD = 1.27, \alpha = 0.81$).

Susceptibility to CRC. Perceived susceptibility was measured using four items adapted from Champion’s [38] scale to measure a participant’s perceived personal risk of developing CRC (e.g. ‘It is likely I will get colorectal cancer’ and ‘My chance of getting colorectal cancer in the next few years is great’). Items were measured on a seven-point Likert scale, with response categories ranging from ‘strongly disagree’ to ‘strongly agree’ ($M = 2.91, SD = 1.24, \alpha = 0.82$).

Primary outcome

Behavioral intention to screen for CRC. Participants were asked, ‘Do you plan on getting tested for colorectal cancer?’ Response options were yes/no.

Free-text responses

After reading the message, participants were asked to provide a free-text response to the prompt: ‘In
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the space below, please tell us what you thought about the message you just read.’

**Overview of analyses**

Version 26 of SPSS was used to conduct all statistical analyses. To assess the main effect of the three message conditions on perceived message relevance and perceived susceptibility to CRC, an analysis of variance (ANOVA) was conducted to determine statistically significant differences in mean scores at an \( \alpha \) level of 0.05. To assess the main effect of the three message conditions on intent to screen for CRC, a Chi-Square Test of Independence was conducted to determine whether significant differences in the proportion of participants who intended to screen for CRC differed by message condition at an \( \alpha \) level of 0.05. Post hoc analyses were completed for both ANOVA and chi-square analyses for pairwise comparisons between conditions, corrected for multiple comparisons testing using the Bonferroni method. Power calculations were based on our primary analysis, which was to assess the effect of the tailored message condition compared with control and targeted message conditions on our primary outcome variable of intention to screen for CRC. Assuming a type 1 error rate of 0.05, the chi-squared test had 80% power (79.95%) to detect a significant difference between the conditions for the final sample size.

The PROCESS macro v3.4 was used to test for exploratory direct and indirect effects through a logistic-based path analytical framework for serial mediation (i.e. Model 6). To test this model, the three message conditions were included as categorical predictors, first using an indicator comparison method to establish the control message condition as the referent condition to compare the targeted and tailored conditions. Second, a sequential comparison method was established to compare the targeted and tailored conditions. Next, perceived message relevance and perceived susceptibility to CRC were included as the mediators in serial, with intention to screen for CRC included as the outcome measure. The model also controlled for (i) sociodemographic factors (age, sex, income, education, race and ethnicity), (ii) CRC screening guideline status, (iii) CRC risk factors (smoking status and composite risk scale), (iv) message evaluation measures (message quality and negative affect) and (v) CRC screening counterarguing (suppression, defensive avoidance and perceived barriers).

Analysis of the free-text data was conducted using Leximancer v4.5, a natural language software tool. An exploratory topic modeling analysis was conducted on the free-text comments using latent Dirichlet allocation [39]. This approach allows for the identification of probabilistic vectors (lists) of words relevant to topic clusters. These probabilistic word vectors indicate relative relevance of specific words to a topic cluster within the text corpus. Free-text comments were only analyzed for targeted and tailored message conditions to limit the scope of analysis to focus on how participants processed CRC risk and screening information.

**Results**

**Participant characteristics**

In total, 898 participants were recruited to the study. Twenty-four participants declined to participate, and 76 participants self-reported as ineligible due to a past CRC diagnosis (\( n = 66 \)), age (\( n = 3 \)) or Florida residency requirement (\( n = 7 \)). Of the 798 participants screened as eligible, 60 participants were removed prior to analysis due to failing an attention check (\( n = 39 \)), time to complete survey (\( n = 3 \)) or recorded missing data (\( n = 18 \); see Fig. 1 for CONSORT Flow Diagram). The characteristics of the remaining 738 participants are presented in Table I.

**Main effects of message conditions**

Main effects of the message conditions were compared across perceived message relevance, perceived susceptibility to CRC and intent to screen for CRC. There were statistically significant differences by message condition, with participants
randomized to the tailored message condition reporting the highest mean scores in message relevance \((M_{\text{Control}} = 5.44\) vs. \(M_{\text{Targeted}} = 5.31\), vs. \(M_{\text{Tailored}} = 5.63, P = 0.023\)) and perceived susceptibility \((M_{\text{Control}} = 2.59\) vs. \(M_{\text{Targeted}} = 2.87\) vs. \(M_{\text{Tailored}} = 2.96, P = 0.016\)). Post hoc analyses, adjusted for multiple comparison testing, identified significant mean group differences in perceived message relevance between targeted and tailored conditions \((MD = 0.32, P = 0.018\)) and in perceived susceptibility between control and tailored conditions \((MD = 0.37, P = 0.013\)).

In total, 79.1\% (584/738) of participants indicated that they intended to screen for CRC. Of those who intended to screen, there was a greater intent to screen with colonoscopy \((M = 5.66, SD = 1.86)\) than home stool screening \((M = 4.67, SD = 1.92)\). There were significant differences by message condition in the proportion of participants who intended to screen for CRC, \(X^2(2, 738) = 9.62, P = 0.008\). The tailored message condition reported the highest percentage of participants intending to screen for CRC \((\text{Control} = 106/150, 70.7\% \text{ vs. Targeted} = 229/289, 79.2\% \text{ vs. Tailored} = 249/299, 83.3\%\)), and post hoc analyses identified that the tailored message condition reported a significantly greater proportion of participants intending to screen for CRC than the control message condition \((P = 0.006)\) but not more than the targeted message condition \((P = 0.68)\).
Table I. Participant characteristics by condition

| Patient characteristics, n (%) | Total (N = 738) | Tailored (n = 299) | Targeted (n = 289) | Control (n = 150) |
|--------------------------------|-----------------|--------------------|--------------------|------------------|
| Age, mean (SD)                 | 61.51 (6.91)    | 61.47 (6.95)       | 61.24 (6.80)       | 62.09 (7.05)     |
| Sex                            |                 |                    |                    |                  |
| Male                           | 326 (44.2)      | 165 (55.2)         | 167 (57.8)         | 70 (46.7)        |
| Female                         | 412 (55.8)      | 134 (44.8)         | 122 (42.2)         | 80 (53.3)        |
| Race                           |                 |                    |                    |                  |
| Non-Hispanic White             | 552 (77.0)      | 221 (76.7)         | 217 (77.0)         | 114 (77.6)       |
| Non-Hispanic Black or African American | 68 (9.50) | 34 (11.4)         | 22 (7.6)           | 12 (8.2)         |
| Hispanic                       | 97 (13.5)       | 33 (11.5)          | 43 (15.2)          | 21 (14.3)        |
| Education                      |                 |                    |                    |                  |
| No college education           | 455 (61.7)      | 180 (60.2)         | 178 (61.6)         | 97 (64.7)        |
| College education              | 283 (38.3)      | 119 (39.8)         | 111 (38.4)         | 53 (35.3)        |
| Income                         |                 |                    |                    |                  |
| Less than $50000               | 375 (50.8)      | 156 (52.2)         | 142 (49.1)         | 77 (51.3)        |
| Greater than or equal to $50000 | 363 (49.2) | 143 (47.8)        | 147 (50.9)         | 73 (48.7)        |
| Screening history              |                 |                    |                    |                  |
| Colonoscopy                    | 294 (39.8)      | 121 (40.5)         | 118 (40.8)         | 55 (36.7)        |
| Sigmoidoscopy                  | 73 (9.90)       | 34 (11.4)          | 30 (10.4)          | 9 (6.0)          |
| Home stool                     | 183 (24.8)      | 77 (25.8)          | 73 (25.3)          | 33 (22.0)        |
| Up-to-date with CRC screening guidelines | 319 (43.2) | 133 (44.5)        | 125 (43.3)         | 61 (40.7)        |
| Risk factors                   |                 |                    |                    |                  |
| Age                            | 738 (100.0)     | 299 (100.0)        | 289 (100.0)        | 150 (100.0)      |
| Black or African American      | 70 (9.50)       | 34 (11.4)          | 24 (8.3)           | 12 (8.0)         |
| Family history of CRC          | 41 (5.60)       | 16 (5.4)           | 15 (5.2)           | 10 (6.7)         |
| Type 2 diabetes                | 136 (18.4)      | 59 (19.7)          | 45 (15.6)          | 32 (21.3)        |
| Smoking history                | 411 (55.7)      | 158 (52.8)         | 173 (59.9)         | 80 (53.3)        |
| ≥3 oz of red meat per day      | 189 (25.6)      | 81 (27.1)          | 66 (22.8)          | 42 (28.0)        |
| ≥two alcoholic drinks per day  | 82 (11.1)       | 31 (10.4)          | 33 (11.4)          | 18 (12.0)        |
| Risk composite score, mean (SD, Range) | 2.82 (1.06, 1–7) | 2.82 (1.10, 1–5)  | 2.80 (1.06, 1–7)  | 2.89 (0.95, 1–6) |

Note. Twenty-one respondents did not provide responses that matched primary racial or ethnicity classifications. Percentages are for valid responses and reflect within-column proportions.

Serial mediation model

A logistic-based path analytical framework for serial mediation was conducted to evaluate whether the tailored message condition predicted greater intent to screen for CRC (see Table II for regression models and Fig. 2 for conceptual model). The first model predicting perceived message relevance was significant, \( F(18, 694) = 27.01, P < 0.001, R^2 = 0.41 \). Compared with the control message condition, the targeted message condition was not statistically significantly better at increasing perceptions of message relevance \( (b = -0.04, t = -0.36, P = 0.72) \), but the tailored message condition was significantly better \( (b = 0.25, t = 2.22, P = 0.027) \). Compared with the targeted message condition, the tailored message condition was statistically significantly better at increasing perceptions of message relevance \( (b = 0.29, t = 3.14, P = 0.002) \). Other significant predictors of greater perceived message relevance included being younger \( (b = -0.02, t = -2.44, P = 0.015) \), having health insurance \( (b = 0.32, t = 2.09, P = 0.037) \), being within CRC screening guidelines \( (b = 0.52, t = 4.90, P < 0.001) \), reporting a greater number of CRC risk factors \( (b = 0.17, t = 2.74, P = 0.006) \), reporting greater perceptions of message quality \( (b = 0.07, t = 2.52, P = 0.012) \).
### Table II. Regression models predicting behavioral intent to screen for CRC (N = 738)

| Predictor variable                     | Perceived message relevance | Perceived susceptibility | Intent to screen for CRC |
|----------------------------------------|----------------------------|--------------------------|--------------------------|
|                                        | b (SE) t 95% CI            | b (SE) t 95% CI          | b (SE) z 95% CI          |
| **Sociodemographics**                  |                           |                          |                          |
| Age                                    | -0.02 (0.01) -2.41 -0.03, -0.00 | 0.01 (0.01) 0.77 -0.01, 0.02 | -0.04 (0.02) -2.01 -0.07, -0.00 |
| Sex (Male)                             | -0.12 (0.09) -1.20 -0.28, 0.07 | -0.07 (0.01) -0.78 -0.26, 0.11 | -0.40 (0.24) -1.62 -0.87, 0.08 |
| Income (≤ $50k)                        | 0.07 (0.09) 0.72 -0.12, 0.25 | -0.01 (0.10) -0.14 -0.21, 0.18 | 0.87 (0.25) 3.47 0.38, 1.37 |
| Education (no college)                 | -0.03 (0.10) -0.30 -0.22, 0.16 | 0.09 (0.10) 0.89 -0.11, 0.29 | 0.18 (0.27) 0.66 -0.35, 0.70 |
| Black/AA (White)                      | 0.06 (0.16) 0.36 -0.22, 0.38 | -0.50 (0.17) -2.89 -0.84, -0.16 | 1.20 (0.51) 2.38 0.21, 2.19 |
| Hispanic (White)                       | 0.13 (0.12) 1.04 -0.11, 0.37 | -0.08 (0.13) -0.62 -0.35, 0.18 | 0.16 (0.35) 0.45 -0.53, 0.85 |
| Health insurance                       | 0.31 (0.16) 1.98 0.00, 0.62 | -0.24 (0.17) -1.42 -0.57, 0.09 | 0.77 (0.35) 2.21 0.09, 1.46 |
| CRC screening (outside)                | 0.52 (0.11) 4.86 0.31, 0.73 | 0.15 (0.12) 1.31 -0.08, 0.38 | 0.39 (0.29) 1.33 -0.18, 0.95 |
| Former smoker (never)                  | 0.01 (0.12) 0.10 -0.22, 0.24 | -0.08 (0.13) -0.66 -0.33, 0.16 | 0.75 (0.33) 2.30 0.11, 1.39 |
| Current smoker (never)                 | -0.09 (0.13) -0.64 -0.35, 0.18 | 0.12 (0.14) 0.85 0.16, 0.40 | -0.20 (0.34) -0.58 -0.85, 0.46 |
| CRC risk composite                     | 0.17 (0.06) 2.74 0.05, 0.29 | 0.17 (0.07) 2.62 0.04, 0.31 | -0.30 (0.17) -1.80 -0.62, 0.03 |
| **Message evaluation**                 |                           |                          |                          |
| Message quality                        | 0.68 (0.04) 18.08 0.60, 0.75 | -0.12 (0.05) -2.40 -0.21, -0.02 | 0.15 (0.11) 1.32 -0.07, 0.37 |
| Negative affect                        | 0.07 (0.03) 2.54 0.02, 0.12 | 0.12 (0.03) 4.03 0.06, 0.17 | -0.14 (0.07) -1.91 -0.29, 0.00 |
| **Defensive information processing**   |                           |                          |                          |
| Suppression                            | -0.08 (0.05) -1.84 -0.17, 0.01 | 0.00 (0.05) 0.07 -0.09, 0.10 | -0.31 (0.11) -2.80 -0.53, -0.09 |
| Defensive avoidance                    | 0.08 (0.04) 2.08 0.00, 0.15 | 0.06 (0.04) 1.39 -0.02, 0.14 | 0.41 (0.10) 0.41 -0.16, 0.24 |
| Perceived barriers                     | -0.05 (0.05) -0.99 -0.16, 0.05 | 0.12 (0.06) 2.20 0.01, 0.24 | -0.05 (0.13) -0.35 -0.30, 0.21 |
| **Mediators**                          |                           |                          |                          |
| Message relevance                      |                          |                          | 0.29 (0.04) 7.00 0.21, 0.37 | 0.33 (0.09) 3.54 0.15, 0.52 |
| Perceived susceptibility               | -                          |                          | 0.54 (0.10) 5.34 0.34, 0.74 |
| **Message conditions**                 |                           |                          |                          |
| Control (referent) vs. targeted         | -0.04 (0.11) -0.34 -0.26, 0.19 | 0.39 (0.12) 3.20 0.15, 0.63 | 0.22 (0.28) 0.76 -0.34, 0.77 |
| Control (referent) vs. tailored         | 0.25 (0.11) 2.24 0.03, 0.47 | 0.43 (0.12) 3.52 0.19, 0.67 | 0.48 (0.29) 1.64 -0.09, 1.06 |
| Targeted (referent) vs. tailored        | 0.29 (0.09) 3.13 0.11, 0.47 | 0.04 (0.10) 0.38 -0.16, 0.24 | 0.27 (0.26) 1.03 -0.24, 0.77 |

Note. Variable in parenthesis is coded as referent condition; bolded numbers are significant at an \( \alpha \leq 0.05 \); CRC = Colorectal Cancer; Black/AA = Black or African American.
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The second model predicting perceived susceptibility to CRC was significant, $F(19, 693) = 9.38$, $P < 0.001$, $R^2 = 0.21$. Compared with the control message condition, both the targeted ($b = 0.39$, $t = 3.21$, $P < 0.001$) and tailored message conditions ($b = 0.43$, $t = 3.53$, $P < 0.001$) were statistically significantly better at increasing perceptions of susceptibility to CRC. Compared with the targeted message condition, the tailored message condition was not statistically significantly better at increasing perceptions of susceptibility ($b = 0.04$, $t = 0.38$, $P = 0.71$). Other significant predictors of greater perceived susceptibility included greater perceived message relevance ($b = 0.29$, $t = 7.00$, $P < 0.001$), being White ($b = -0.51$, $t = -2.91$, $P = 0.004$), reporting a greater number of CRC risk factors ($b = 0.17$, $t = 2.60$, $P = 0.009$), reporting lower perceptions of message quality ($b = -0.12$, $t = -2.36$, $P = 0.019$) and reporting a greater negative affect to the message ($b = 0.12$, $t = 4.04$, $P < 0.001$).

The model predicting intent to screen for CRC was significant, $X^2 (20) = 195.90$, $P < 0.001$, explaining 24.0% of the variance in intent to screen. The model, while controlling for study covariates, provides estimates for the relative direct effect ($c'$) of each message condition on intent to screen. Compared with the control message condition, neither the targeted ($b = 0.22$, $t = 0.77$, $P = 0.44$) nor tailored message conditions ($b = 0.48$, $t = 1.64$, $P = 0.10$) were statistically significantly better at increasing participant intent to screen for CRC. Compared with the targeted message condition, the tailored message condition was not statistically significantly better at increasing intent to screen for CRC ($b = 0.26$, $t = 1.02$, $P = 0.31$). However, both greater perceived message relevance ($b = 0.34$, $z = 3.60$, $P < 0.001$) and perceived susceptibility ($b = 0.53$, $z = 5.33$, $P < 0.001$) were significantly, directly associated with greater intent to screen. Other significant predictors of intent to screen included being younger ($b = -0.04$, $t = -2.04$, $P = 0.041$), reporting greater household income ($b = 0.89$, $t = 3.55$, $P < 0.001$), having health insurance ($b = 0.82$, $t = 2.36$, $p = 0.018$), identifying as Black/African American ($b = 1.21$, $t = 2.40$, $P = 0.016$), being a former smoker ($b = 0.77$, $t = 2.35$, $P = 0.019$) and reporting lower counter-arguing through suppression ($b = -0.37$, $t = -2.85$, $P = 0.004$).

**The indirect effects of message condition on intent to screen for CRC**

Figure 2 provides a visual representation of the entire model, showing the significant and non-significant indirect pathways for X1 (control vs.
targeted), X2 (control vs. tailored) and X3 (targeted vs. tailored), with the first listed condition included as the referent condition. Pathways $a_{1}b_{1}$ (i.e., message condition $\rightarrow$ perceived message relevance $\rightarrow$ intent to screen for CRC), $a_{2}b_{2}$ (i.e., message condition $\rightarrow$ perceived susceptibility $\rightarrow$ intent to screen for CRC), $a_{1}d_{21}b_{2}$ (i.e., message condition $\rightarrow$ perceived message relevance $\rightarrow$ perceived susceptibility $\rightarrow$ intent to screen for CRC) were explored across the three message comparisons (e.g., $X_{1}a_{1}b_{1}$ = control vs. targeted message condition $\rightarrow$ perceived message relevance $\rightarrow$ intent to screen for CRC). 

$X_{1}a_{1}b_{1}$ pathway was not statistically significant ($b = -0.01$, bootstrap SE = 0.05, 95% bootstrap CI = -0.11, 0.08), as participants in the targeted message condition did report greater perceived message relevance than participants in the control message. The $X_{2}a_{1}b_{1}$ pathway was also not statistically significant as the tailored message condition did not increase perceptions of message tailoring greater than the control message condition ($b = -0.09$, bootstrap SE = 0.05, 95% bootstrap CI = 0.01, 0.20). However, the $X_{3}a_{1}b_{1}$ pathway was statistically significant as the tailored condition significantly increased perceptions of message relevance when compared with the targeted message condition ($b = 0.10$, bootstrap SE = 0.04, 95% bootstrap CI = 0.03, 0.20).

Both the $X_{1}a_{2}b_{2}$ ($b = 0.21$, bootstrap SE = 0.09, 95% bootstrap CI = 0.07, 0.40) and $X_{2}a_{2}b_{2}$ pathways ($b = 0.23$, bootstrap SE = 0.09, 95% bootstrap CI = 0.09, 0.44) were significant as participants in both targeted and tailored message conditions reported greater perceived susceptibility than participants in the control message condition. However, the $X_{3}a_{2}b_{2}$ pathway was not significant ($b = 0.02$, bootstrap SE = 0.06, 95% bootstrap CI = -0.09, 0.13) as participants in the tailored message condition did not report greater perceived susceptibility than the participants in the targeted message condition.

The final pathway explored the indirect effects of the message conditions for the entire model, which included both mediators in serial. There was no significant indirect effect through the $X_{1}a_{1}d_{21}b_{2}$ pathway ($b = 0.01$, bootstrap SE = 0.02, 95% bootstrap CI = -0.05, 0.32), but there was for the $X_{2}a_{1}d_{21}b_{2}$ pathway ($b = 0.04$, bootstrap SE = 0.02, 95% bootstrap CI = 0.00, 0.08). These findings indicate that, when compared with the control condition, only the tailored message condition had a significant indirect effect on intent to screen for CRC through greater perceived message relevance and greater perceived susceptibility. Furthermore, there was a significant indirect effect through the $X_{3}a_{1}d_{21}b_{2}$ pathway ($b = 0.04$, bootstrap SE = 0.02, 95% bootstrap CI = 0.02, 0.09), indicating that when compared with the targeted message condition, the tailored message condition had a significant indirect effect on intent to screen for CRC through greater perceived message relevance and greater perceived susceptibility.

**Differences in participant comments about the intervention by condition**

As shown in Fig. 3, there were three primary topics identified through the topic modeling analysis (‘cancer’, ‘test’ and ‘informative’). The targeted message condition was more likely to prompt comments related to the topic of cancer (e.g. ‘cancer’ and ‘colon’). On the contrary, the tailored condition was less likely to prompt comments about cancer and was more likely to be associated with the behavioral recommendation in the message via the topic of testing for CRC. Participants in the tailored condition referenced the specific tests (e.g. ‘FIT’ and ‘colonoscopy’), the frequency of the test recommendation (e.g. ‘stool’ and ‘year’) and their intention to discuss completing the test with a provider (e.g. ‘need’, ‘take’ and ‘doctor’). The tailored condition also prompted greater engagement as evidenced by the larger corpus of words modeled on to the topic, as well as deeper message processing and internalization based on language associated with perceptions of susceptibility to CRC (e.g. ‘feel’, ‘scary’ and ‘risk’). The third topic, informative, was equally associated with both targeted and tailored conditions. Words associated with this
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Fig. 3. A concept map detailing topics associated with targeted and tailored message conditions.

topic focused on the provision and comprehension of useful information (e.g. ‘message’, ‘informative’ and ‘understand’), as well as readability of the message (e.g. ‘easy’ and ‘clear’).

Discussion

Despite clear evidence that CRC screening reduces CRC-related morbidity and mortality, screening remains underutilized. In the current study, we compared the efficacy of two different risk communication strategies to increase intentions to screen. The results of the experiment showed that both targeted and tailored messages resulted in greater intentions to screen for CRC as compared with the control condition. However, mediation analyses revealed that tailored messages had distinct advantages over targeted messages. Specifically, participants exposed to the tailored message condition reported higher message relevance than participants in the targeted condition. Greater perceived message relevance was associated with higher perceived susceptibility, which in turn predicted CRC screening intentions. These findings support previous literature on the benefits of tailored risk messages [5, 6, 11, 40, 41] and provide further insight into the theoretical mechanisms that underlie the efficacy of this approach.

Health education messages must achieve some degree of perceived relevance to be effective at increasing risk internalization and also influencing intention to screen [42]. Within CRC screening, perceptions about the likelihood of developing CRC consistently predict intent to screen [43, 44]. An interesting finding from the covariate analyses, which should be interpreted as exploratory, was the significant association of greater negative
affect with perceived message relevance and perceived susceptibility to CRC. This finding is both congruent with message processing theories and also highlights the challenge of tailoring cancer risk information. We can infer behavioral recommendations to improve one’s health and the internalization of risk for CRC elicited an affective appraisal. Dillard and Nabi propose that for an emotional response to exert persuasive force, it must be perceived as both caused by the message and relevant to the advocacy (i.e. promoting CRC screening) [45, 46]. Given the innately threatening nature of cancer, it is possible for emotion-inducing messages to produce both persuasive effects (i.e. message relevance and susceptibility) and appraisals that may otherwise be perceived as counter persuasive (i.e. negative affect to the message).

The topic modeling analysis of the open-text data offered a unique contribution to highlight differential patterns of message processing between the conditions. Topic modeling between the targeted versus tailored messages supported tailoring through the lens of an activating mechanism in which to encourage participants to move through the stages of behavior change. Targeted messages resulted in participants providing textual evaluation that mapped to lower levels of behavioral readiness by referencing words that reflect pre-contemplation or contemplation stages of change (i.e. that the information was important) and more superficial concept repetition (e.g. ‘cancer’). Tailored messages were more likely to encourage deeper cognitive processing, exemplified by key concept repetition of specific screening modalities discussed in the message, as well as a higher level of behavioral readiness associated with preparation and action phases of behavior change models (i.e. referencing speaking to their doctor to get screened).

The current study offered practical guidance on how to develop minimally tailored education messages to influence key mechanisms associated with greater intentions to screen. Unlike other tailoring interventions, our data demonstrate that a brief, automatically tailored intervention offers promise for feasible scalability. To enhance CRC screening rates, future interventions should aim to deliver tailored risk information through digital channels from which patients are already familiar with receiving healthcare information. Integrating tailored risk messages into patient portals, for example, offers both scalability and opportunity to deliver screening messages that patients will trust. Furthermore, integration permits risk information to be tailored directly from a patients’ electronic health record and leverages the benefits of theoretically-grounded tailored CRC screening messages. Second, the topic modeling analysis has implications for the assessment of public health cancer screening campaigns that require rapid analyses to understand public sentiment. For example, when A/B testing messages on social media platforms, concept mapping can measure beyond engagement (i.e. the number of online impressions) and permit a more in-depth understanding of what concepts—and how those concepts relate—audiences leave as comments under a CRC screening promotion campaign.

In addition to the notable strengths of this study, there are some limitations. First, a tailored risk factor for current smoking behavior failed to execute due to a faulty algorithm. Because strong epidemiological evidence links smoking and CRC [47, 48], it is unfortunate that the subgroup of participants who were current smokers did not receive this information. Theoretically, not listing current smoking status as a risk factor should have suppressed the effect of tailoring. Despite this error, the tailored condition still outperformed the targeted condition, and no differences were identified among current smokers in a sensitivity analysis. A second limitation was that African Americans comprised only 9.5% of the study sample despite reporting one of the highest CRC incidence and mortality rates of all racial groups in the United States [1]. Racial disparities in CRC screening are well known but often reflect structural barriers including low CRC knowledge, no clinician recommendation, lack of healthcare access and disadvantaged socioeconomic status [49–51]. When exposed to tailored CRC interventions, African Americans have
reported higher intentions to screen and learn about screening options [25, 26] and improved screening rates [21]. In our study, African Americans reported greater intent to screen for CRC. However, this may have been a result of receiving at least two risk factors with greater risk perceptions associated with CRC screening uptake [52]. Prioritizing the enrollment of African Americans in future studies is critical to better understand treatment effects and to have sufficient power to conduct hypothesis testing comparing racial/ethnic groups instead of examining exploratory subgroup analyses. A third limitation was that the study measured intent to screen rather than collect behavioral outcomes. There is a strong body of literature that has shown the link between intention to screen for CRC and the successful completion of a CRC screening test [44, 53].

Four, the messages were written above the recommended sixth-grade Flesch–Kincaid Grade Readability Level. While we controlled for completed formal education in our models, future interventions must be constructed to ensure equity of information across a diverse spectrum of literacy. Five, we used a Florida-based sample that could limit generalizability. The nation is rapidly aging and growing more racially and ethnically diverse [54]. In 2019, those aged 65 and older represented 16% of the population while racial and ethnic minorities accounted for 24% of older Americans [55]. The Florida population of today (20% aged 65 and older, 16% Black/African American and 26% Hispanic) embodies the United States of tomorrow and is ideal for population health research [56]. Six, we purposefully did not provide a specific timeframe on intention to screen. The goal of this study was to ascertain the effects of the intervention conditions to promote adherence to guideline recommended CRC screening. All participants in the study were eligible for CRC screening and could be either currently not adherent to recommendations or currently adherent, but all would need to screen in the future to be adherent/maintain adherence. Therefore, we preferred to ascertain the intervention effect on a general CRC screening outcome vs. individualized timeframes for participants (i.e. some participants were due to screen now vs. others were due in over 12 months from participating in the study). We chose this strategy as it reflects both national efforts and our institution’s clinical performance metrics to prioritize initial screening and maintaining guideline adherence for all our CRC screening eligible patients. Lastly, the risk factors provided by participants during the algorithm could not be verified through medical records. However, much like dietary intake or other information provided by a participant during the conduct of a medical history with a physician, the participant’s provision of information is typically entrusted.

Conclusion

A tailored risk communication approach, through simple CRC risk-factor tailoring, offers promise to improve CRC screening rates. The current study demonstrated that a tailored risk message increased perceptions of message relevance and susceptibility to CRC, which increased patient intentions to screen for CRC. Findings offer a low-burden, practical approach to evaluate and improve health education materials that promote CRC screening.

Funding

The Henry and Eugenia Graham Professional Development Fund for Science/Health Communication Award from the College of Journalism and Communications at the University of Florida.

Conflict of interest statement

The authors declare that there is no conflict of interest.
Institutional review board

Approval for this study was provided by Denise B. Long of the University of Florida’s Institutional Review Board (no. 2015-U-265).

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