

Multiple Behavioral Risk Factors for Colorectal Cancer and Colorectal Cancer Screening Status

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Abstract

Background: Individuals who are not adherent to colorectal cancer screening have a greater prevalence of several other behavioral risk factors for colorectal cancer than adherent individuals. However, previous relevant studies have typically not considered the co-occurrence of such behavioral risk factors at the individual level. In the current study, we examined the prevalence, patterns, and predictors of multiple behavioral risk factors for colorectal cancer according to colorectal cancer screening status (adherent versus not adherent).

Methods: The study sample consisted of 11,090 individuals ages 50 years and older who participated in the 2000 National Health Interview Survey. Based on responses to survey questions, individuals were categorized as being adherent or not adherent to colorectal cancer screening guidelines and were also denoted as having or not having each of seven behavioral risk factors for colorectal cancer (smoking, low

physical activity, low fruit and vegetable intake, high caloric intake from fat, obesity, high alcohol intake, and low intake of multivitamins).

Results: Individuals who were not adherent to screening reported having a greater number of risk factors than adherent individuals. For each screening group, there was a high prevalence of having low physical activity, low fruit and vegetable intake, and low intake of multivitamins. Demographic and health-related correlates of behavioral risk factor prevalence were identified in both screening groups.

Conclusions: In combination with efforts to promote colorectal cancer screening uptake and adherence, there is a need to develop interventions to modify the colorectal cancer behavioral risk factors that are common among screening-adherent and nonadherent individuals. (Cancer Epidemiol Biomarkers Prev 2007;16(3):510–6)

Introduction

Regular colorectal cancer screening has been shown to reduce colorectal cancer incidence and mortality (1, 2). However, adherence rates to colorectal cancer screening recommendations are low, with recent estimates from U.S. national surveys varying from 34.6% to 44.0% (3–6). Colorectal cancer risk is also influenced by several behaviors other than screening. Regular physical activity provides a protective effect against colorectal cancer (7), whereas obesity is associated with increased risk (8, 9). Long-term use of a multivitamin, especially one containing folate, may decrease colorectal cancer risk (10, 11). There is some evidence that a diet high in fruit and vegetables reduces colorectal cancer risk, although this association has not been observed consistently in large cohort studies (12, 13). Equivocal evidence has also been found for a link between dietary fat intake and colorectal cancer risk (14, 15). There is accumulating evidence linking increased risk for colorectal cancer with high red meat intake (16, 17), high intake of alcohol (18), and smoking (19).

In addition to efforts to increase screening rates (20), modification of behavioral risk factors (21, 22) can significantly reduce colorectal cancer risk (23), even among individuals who are adherent to colorectal cancer screening (24). Modification of colorectal cancer risk factors has the additional benefit of reducing risk for some other cancers, cardiovascular disease, and other illnesses (25).

Several previous studies have examined whether the prevalence of each of several behavioral risk factors for colorectal cancer differ between colorectal cancer screening-adherent and nonadherent individuals. Individuals who are not adherent to regular colorectal cancer screening have been found to have higher rates of smoking, lower levels of physical activity, greater alcohol intake, lower folate intake (among men), and lower intake of multivitamins than individuals who are adherent to colorectal cancer screening (3, 5, 26–31), with inconsistent study results with regard to differences in obesity and fruit and vegetable intake (3, 5, 26–29, 32–34). Overall, this pattern of results indicates that individuals who do not engage in colorectal cancer screening may be at increased risk for colorectal cancer not only due to their lack of screening but also due to their increased levels of other colorectal cancer behavioral risk factors. These prior studies have focused on each behavioral risk factor separately, thereby failing to consider any co-occurrence of risk factors at the level of the individual (35–37). Identifying the co-occurrence of multiple risk factors among individuals who are not adherent to screening provides insight on the need for, and type of, multiple behavioral risk factor interventions that may hold the greatest promise for reducing colorectal cancer incidence and mortality in this at-risk population.

Although, as noted above, individuals who are adherent to colorectal cancer screening are less likely than nonadherent individuals to have each of several behavioral risk factors for colorectal cancer (3, 5, 26–31), risk factor prevalence in this screening-adherent population may still considerably affect colorectal cancer risk (24). In a recent study, Emmons et al. (38) documented the prevalence and predictors of multiple behavioral risk factors for colorectal cancer in a group of individuals who underwent flexible sigmoidoscopy or colonoscopy and had one or more adenomatous colorectal polyps removed. Participants had an average of 2.43 of the six risk factors examined (high red meat consumption, low fruit and vegetable intake, low multivitamin intake, high alcohol

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consumption, smoking, and physical inactivity), and specific subgroups of individuals (including men and those with a lower level of education) had a greater number of risk factors. These results inform the need to develop multiple risk factor interventions for the specific high-risk population of individuals who have been diagnosed with colorectal polyps and also suggest subgroups who may be particularly in need of such interventions. However, we are not aware of studies that have examined the multiple behavioral risk factor profiles of individuals who are adherent to colorectal cancer screening but may not have been diagnosed as having adenomatous polyps. Maximal colorectal cancer risk reduction in this sizable population will likely be achieved via regular screening and appropriate modification of colorectal cancer behavioral risk factors (23, 24), making it important to assess these individuals' behavioral risk factor profiles.

In the current study, we compared the prevalence of multiple behavioral risk factors for colorectal cancer among individuals who were not adherent to colorectal cancer screening and among those who were adherent to screening. Drawing from the results of prior research (3, 5, 26-31), we hypothesized that individuals who were not adherent to screening would report having more behavioral risk factors than individuals who were adherent to screening. We also examined the most common behavioral risk factor patterns in each group. Additionally, separately for those individuals who were not adherent to colorectal cancer screening and those who were adherent, we examined whether multiple behavioral risk factor prevalence was associated with several demographic and health-related characteristics (gender, age, race/ethnicity, education, income, marital status, family history of colorectal cancer, and overall health status) that have been linked previously with behavioral risk factor prevalence (37-39) or colorectal cancer screening (40).

Materials and Methods

Participants. The participants were drawn from the Basic Module Sample Adult Core of the 2000 National Health Interview Survey (NHIS), which was conducted with a national probability sample of 32,374 U.S. adults. We used data from the 2000 NHIS, as opposed to more recent NHIS surveys, as it included a Cancer Control Module that provided data on topics not usually examined in the NHIS, including family history of cancer, cancer screening, and diet. Individuals were excluded from the present study if they were under the age of 50 years ($n = 19,697$), reported a history of colorectal cancer ($n = 179$), were missing data for the Cancer Control Module ($n = 452$), or were missing data about their colorectal cancer screening status ($n = 956$). Data for the remaining 11,090 individuals were used for the present study.

Procedure. The NHIS is an annual health survey of U.S. adults. Participants are interviewed in their own homes by interviewers from the U.S. Bureau of the Census. The NHIS uses a complex multistage clustered cross-sectional sample survey design, with stratification at the state level, and oversampling of Hispanic and Black populations. The overall response rate (which takes into account a household and individual response rate) for the data used in this study was 72.1% (41). Additional details about the survey design and procedure of the 2000 NHIS are available elsewhere (41).

Measures

Demographics. Participants indicated their gender, age, education level, annual income, race/ethnicity, and marital status.

Colorectal Cancer Risk Based on Family History. A series of questions asked whether a first-degree relative (mother, father,

sister, brother, daughter, or son) had ever been diagnosed with colorectal cancer and, if so, whether the cancer was diagnosed before the age of 50 years. Based on responses to these questions, we created the following three-level variable: average risk, no family history of colorectal cancer; intermediate risk, one family member diagnosed with colorectal cancer at age 50 years or above; and high risk, more than one family member diagnosed with colorectal cancer or one family member diagnosed with colorectal cancer below 50 years of age.

Overall Health Status. Participants completed a single item about their overall current health status (poor/fair, good, or very good/excellent).

Colorectal Cancer Screening. Participants answered a series of questions about their colorectal cancer screening history. One question asked whether they had ever had a sigmoidoscopy, colonoscopy, or proctoscopy. Individuals who reported ever having had one of these tests indicated the timing and type of their most recent test. Additional questions asked participants whether they had ever had a home fecal occult blood test and, if so, when they last had a fecal occult blood test. Based on responses to this set of questions, individuals were denoted as being adherent to colorectal cancer screening (sigmoidoscopy or colonoscopy within the last 10 years or a fecal occult blood test within the past year) or not adherent to colorectal cancer screening. In line with other studies using the NHIS 2000 data (3), we used 10 years as the cutoff for both forms of endoscopy³ (42, 43), as the questions only asked about the most recent test and did not conform to recommended guidelines for self-reported adherence to sigmoidoscopy and colonoscopy (44).

Colorectal Cancer Behavioral Risk Factors. The present study used measures from the 2000 NHIS about seven behavioral risk factors for colorectal cancer: smoking, low physical activity, low fruit and vegetable intake, high caloric intake from fat, obesity, high alcohol intake, and low intake of multivitamins (data were not available on red meat consumption). The NHIS uses validated measures of behavioral risk factors (45-47) and is a key source of information about behavioral risk factors in the U.S. population. For each risk factor, a dichotomous variable was created to represent presence versus absence of the risk factor. Individuals who reported currently smoking cigarettes every day or some days were denoted as current smokers (48). With regard to physical activity, participants answered a series of questions about the frequency and average duration of moderate and vigorous activities. Drawing from previous research using the 2000 NHIS data (3), each individual's weekly metabolic equivalent expenditure was calculated from their reported total weekly minutes of moderate and vigorous activities (calculated as $4.5 \times$ moderate minutes weekly $+ 7.0 \times$ vigorous minutes weekly; ref. 49). Participants were denoted as reporting low physical activity if their weekly metabolic equivalent expenditure was <675 (which corresponds with recommendations to engage in 150 min or more of moderate intensity activities weekly; ref. 50). Participants completed a validated 17-item food frequency questionnaire that provides indicators of multiple dietary components, including average daily servings of fruits and vegetables and percentage of caloric intake from fat (47). Individuals who reported consuming fewer than five servings of fruits and vegetables daily were denoted as reporting low fruit and vegetable intake (51). Participants were denoted as reporting a high fat intake if their caloric intake from fat was $>35\%$ (52, 53). Based on self-reported height and weight and using a standard formula for calculating body mass index, individuals with a body mass index of 30 or more were

³ Current screening guidelines for individuals at average risk for colorectal cancer include sigmoidoscopy every 5 years or colonoscopy every 10 years.

denoted as obese (54). Participants indicated their weekly frequency of consuming alcohol and the number of drinks they consume on a typical occasion. Women who reported an average intake of 8 or more drinks weekly and men who indicated consuming an average of 15 or more drinks weekly were denoted as reporting high alcohol intake (51, 53). Participants indicated their level of consumption of multivitamins during the past year. Individuals who did not report consuming multivitamins an average of four or more times weekly were denoted as reporting low multivitamin intake (11).

Data Weighting and Statistical Analysis. All analyses were conducted using SUDAAN (version 9.0.1; Research Triangle Institute, Research Triangle Park, NC), which allowed for weighting based on design, ratio, and nonresponse adjustments, and poststratification adjustments for gender, age, and race/ethnicity (41). All percentages reported in Results are weighted and all sample sizes are unweighted.

We report the demographic characteristics of the full sample and also used χ^2 tests to compare the characteristics of those who were adherent to colorectal cancer screening and those who were not adherent to screening. We examined the prevalence of each behavioral risk factor (smoking, low

physical activity, low fruit and vegetable intake, high caloric intake from fat, obesity, high alcohol intake, and low intake of multivitamins) stratified by colorectal cancer screening status (not adherent versus adherent). χ^2 tests were used to identify differences in behavioral risk factor prevalence according to screening status. We created a total risk factor variable by summing the number of risk factors reported by each participant (giving a value from 0 to 7). For each screening group, we report the percentage of individuals who reported having each number of risk factors. An independent means *t* test was used to compare the total number of behavioral risk factors reported by those who were not adherent to colorectal cancer screening and those who were adherent to screening. For each screening group (not adherent and adherent), we also report the five most common two and three risk factor combinations. Finally, separately for individuals adherent and not adherent to colorectal cancer screening, we conducted a multiple linear regression analysis with the total number of reported behavioral risk factors variable as the outcome variable and demographic and health-related factors as independent variables.

Table 1. Demographic characteristics according to colorectal cancer screening status in a sample of 11,090 adults ages 50 yrs and older drawn from the 2000 NHIS

	Full sample, % (N = 11,090)	Colorectal cancer screening status	
		Not adherent (n = 6,830), %	Adherent (n = 4,260), %
Gender			
Male	46.0	46.0	46.0
Female	54.0	54.0	54.0
Missing (n)	0	0	0
Age (y)*			
50-59	42.3	47.0	35.2
60-69	27.1	25.6	29.3
≥70	30.6	27.4	35.5
Missing (n)	0	0	0
Race/ethnicity*			
Non-Hispanic White	81.9	79.0	86.2
Non-Hispanic Black	8.7	9.5	7.5
Non-Hispanic other	2.7	3.3	1.8
Hispanic	6.7	8.1	4.5
Missing (n)	0	0	0
Education*			
≤High school 12th grade	22.8	26.3	17.4
High school graduate	32.6	33.4	31.3
Some college	23.2	22.1	24.8
College graduate	21.5	18.2	26.5
Missing (n)	90	53	37
Income*			
<\$10,000	9.2	10.5	7.3
\$10,000-\$19,999	16.2	17.1	14.9
\$20,000-\$34,999	23.2	23.3	23.1
\$35,000-\$54,999	19.0	18.9	19.1
≥\$55,000	32.3	30.2	35.5
Missing (n) †	0	0	0
Married/Partnered*			
Yes	67.2	64.5	71.3
No	32.8	35.5	28.7
Missing (n)	22	15	7
Colorectal cancer risk based on family history*			
Average	91.9	94.5	88.1
Intermediate	5.9	4.1	8.7
High	2.2	1.5	3.2
Missing (n)	55	43	12
Overall health status			
Poor/fair	19.7	19.5	20.0
Good	30.8	30.8	30.8
Very good/excellent	49.5	49.7	49.2
Missing (n)	9	3	6

NOTE: All percentages are weighted.

**P* < 0.001, not adherent versus adherent.

†There are no missing data for income, as missing values were imputed by the National Center for Health Statistics using a multiple-imputation procedure.

Table 2. Prevalence of behavioral risk factors (current smoking, low physical activity, low fruit and vegetable intake, high caloric fat intake, obesity, high alcohol intake, and low multivitamin use) according to colorectal cancer screening status in a sample of 11,090 adults ages 50 yrs and older drawn from the 2000 NHIS

	Colorectal cancer screening status	
	Not adherent (<i>n</i> = 6,830), % (95% CI)	Adherent (<i>n</i> = 4,260), % (95% CI)
Current smoking*	20.3 (19.3-21.4)	12.6 (11.4-13.8)
Low physical activity*	70.7 (69.2-72.1)	58.8 (56.9-60.7)
<5/d Fruit and vegetable*	53.7 (52.2-55.2)	49.5 (47.8-51.2)
>35% Calories from fat*	27.8 (26.6-29.0)	21.4 (19.9-23.0)
Obese	23.5 (22.3-24.6)	24.0 (22.5-25.4)
High alcohol intake [†]	4.4 (3.8-5.0)	3.5 (2.9-4.1)
Low multivitamin use*	64.4 (63.0-65.8)	52.0 (50.2-53.7)

NOTE: All percentages are weighted. Due to missing data, sample sizes vary as follows: not adherent to screening, *n* = 6,323 to 6,819; adherent to screening, *n* = 3,998 to 4,254.

Abbreviation: 95% CI, 95% confidence interval.

**P* < 0.001.

[†]*P* < 0.05.

Results

Overall, 39.7% of the participants were adherent to colorectal cancer screening. Selected characteristics of the sample are shown in Table 1. Data are shown for the full sample, as well as stratified according to colorectal cancer screening status (not adherent versus adherent). In the full sample, there was a roughly equal gender split and considerable variability on other demographic factors. Less than 1 in 10 individuals reported having a relative who was ever diagnosed with colorectal cancer, and very few of those cases were diagnosed before the age of 50 years. Individuals who were adherent to screening were more likely to be older, White, have a higher level of education and income, to be married, and to have a family history of colorectal cancer (all χ^2 s > 47.25; all *P*s < 0.001). There was no difference in colorectal cancer screening status according to gender (χ^2 = 0.00; *P* = 1.00) or overall health status (χ^2 = 0.37; *P* = 0.83).

Single Behavioral Risk Factors and Colorectal Cancer Screening Status. Table 2 shows the results of a series of χ^2 analyses examining the association between each behavioral risk factor and colorectal cancer screening status. With the exception of being obese (χ^2 = 0.32; *P* = 0.57), individuals who were not adherent to colorectal cancer screening were more likely to report having each individual behavioral risk factor (all χ^2 s > 4.07; all *P*s < 0.05).

Prevalence of Multiple Behavioral Risk Factors According to Colorectal Cancer Screening Status. We examined individuals' total number of reported behavioral risk factors according to their colorectal cancer screening status. As hypothesized, those who were not adherent to colorectal cancer screening reported having more risk factors (*M* = 2.64) than those who were adherent (*M* = 2.21; *t* = 14.44; *P* < 0.0001). As shown in Table 3, few individuals reported having none or five or more of the risk factors. Among individuals who were not adherent to colorectal cancer screening, 56.2% reported having two or three of the risk factors compared with 50.7% of those who were adherent to colorectal cancer screening. Due to missing data on one or more behavioral risk factors, 1,246 individuals were missing data for the total number of behavioral risk factors variable. Results of χ^2 analyses (data not shown) revealed that individuals with missing data were more likely to be female, had lower levels of education and income, and were less likely to be up to date with colorectal

cancer screening. No differences were found with regard to age, race/ethnicity, marital status, family history of colorectal cancer, or overall health. We conducted follow-up logistic regression analyses (data not shown), with the outcome variable of missing versus not missing data on the number of behavioral risk factors variable, to examine whether associations between demographic/health-related characteristics and having missing data on the multiple behavioral risk factor variable varied according to individuals' colorectal cancer screening status (up to date versus not up to date). None of the associations varied according to colorectal cancer screening status, indicating that there was no systematic bias (in terms of the demographic and health-related characteristics we assessed) in missing data according to individuals' colorectal cancer screening status.

Prevailing Two and Three Risk Factor Combinations. Given the high reported prevalence of having two or three risk factors, we examined the most common two and three risk factor combinations. Table 4 shows the five most frequent two and three risk factor combinations separately for the colorectal cancer screening-adherent and nonadherent groups. The most common two risk factor combinations in both groups were low physical activity and low use of multivitamins followed by low physical activity and low fruit and vegetable intake, although the prevalence of these combinations was higher among individuals who were not adherent to colorectal cancer screening. The most common three risk factor combinations in both groups were low physical activity, low fruit and vegetable intake, and low use of multivitamins. Overall, the most common two and three risk factor patterns were similar, but not identical, in the screening-adherent and nonadherent groups. The results of exploratory analyses (data not shown) revealed few gender differences in the prevailing two and three risk factor patterns. Of the two risk factor combinations, the reported prevalence of low physical activity and multivitamin use was higher among women than men (49.1% and 29.8%, respectively, among those not adherent to screening; 40.2% and 23.3%, respectively, among those adherent to screening). The combination of low fruit and vegetable intake and low multivitamin use was more prevalent among women than men (40.4% and 30.7%, respectively, among those not adherent to screening; 30.2% and 23.8%, respectively, among those adherent to screening). Consistent with these differences, women were more likely than men to report having the three risk factor combinations of low physical activity, low fruit and

Table 3. Prevalence of multiple behavioral risk factors according to colorectal cancer screening status in a sample of 11,090 adults ages 50 yrs and older drawn from the 2000 NHIS

No. behavioral risk factors	Colorectal cancer screening status	
	Not adherent (<i>n</i> = 6,009), % (95% CI)	Adherent (<i>n</i> = 3,835), % (95% CI)
0	4.4 (3.7-5.0)	9.1 (8.0-10.1)
1	14.5 (13.5-15.5)	23.0 (21.5-24.5)
2	27.5 (26.1-28.9)	28.4 (26.6-30.1)
3	28.7 (27.3-30.0)	22.3 (20.7-23.9)
4	18.1 (17.0-19.1)	12.5 (11.3-13.7)
5	5.8 (5.1-6.5)	4.1 (3.4-4.9)
6	1.0 (0.8-1.3)	0.6 (0.3-0.8)
7	0.1 (0.0-0.1)	0.1 (0.0-0.1)

NOTE: All percentages are weighted. Behavioral risk factors examined: current smoking, low physical activity, low fruit and vegetable intake, high caloric fat intake, obesity, high alcohol intake, and low multivitamin use. Due to missing data on individual behavioral risk factors, data were excluded from 1,246 participants, giving a sample size of 9,844 individuals for this analysis.

Abbreviation: 95% CI, 95% confidence interval.

Table 4. Five most common two and three behavioral risk factor combinations according to colorectal cancer screening status in a sample of 11,090 adults ages 50 yrs and older drawn from the 2000 NHIS

Current smoking	Low physical activity	<5/d Fruit and vegetable	>35% Calories from fat	Obese	High alcohol intake	Low use of multivitamins	Not adherent to colorectal cancer screening, %	Adherent to colorectal cancer screening, %
Two risk factor combinations								
	✓					✓	46.9	32.7
	✓	✓					40.2	32.2
	✓	✓				✓	35.9	27.2
	✓		✓			✓	19.5	
	✓		✓				18.9	
				✓		✓		16.7
				✓		✓		14.1
Three risk factor combinations								
	✓	✓				✓	27.7	19.3
	✓		✓			✓	13.8	8.9
	✓		✓		✓	✓	11.9	10.5
✓	✓	✓				✓	11.2	
✓	✓		✓			✓	10.9	
	✓	✓		✓		✓		9.7
	✓	✓		✓		✓		8.1

NOTE: All percentages are weighted. ✓ indicates presence of the risk factor. Behavioral risk factors examined: current smoking, low physical activity, low fruit and vegetable intake, high caloric fat intake, obesity, high alcohol intake, and low multivitamin use. Due to missing data on individual behavioral risk factors, data were excluded from 1,246 participants, giving a sample size of 9,844 individuals for this analysis.

vegetable intake, and low multivitamin use (32.6% and 22.0%, respectively, among those not adherent to screening; 22.5% and 15.7%, respectively, among those adherent to screening).

Correlates of Multiple Risk Factor Prevalence. We examined demographic and health-related correlates (gender, age, race/ethnicity, education, income, marital status, family history of colorectal cancer, and overall health status) of multiple risk factor prevalence (data not shown) separately for individuals who were adherent to screening and those who were not adherent. Among individuals not adherent to colorectal cancer screening, more risk factors were reported by younger individuals, Blacks, those with less education, individuals who were not married or partnered, those with poorer self-reported health, and individuals with a higher risk of colorectal cancer based on their family history. Among those adherent to colorectal cancer screening, more risk factors were reported by younger individuals, those with less education, individuals who were not married or partnered, and those reporting poorer overall health.

Discussion

This study documents the prevalence, patterns, and predictors of multiple behavioral risk factors for colorectal cancer among individuals who are, or are not, adherent to colorectal cancer screening. Most individuals in each screening group reported having two or more behavioral risk factors, and as hypothesized, individuals who were not adherent to colorectal cancer screening reported having more colorectal cancer behavioral risk factors than adherent individuals. We extended previous research findings by identifying commonly occurring patterns and correlates of multiple behavioral risk factors in these two screening groups.

Implications and Future Directions. Although individuals who were not adherent to colorectal cancer screening reported having more behavioral risk factors for colorectal cancer than screening-adherent individuals, the study results suggest that both groups would benefit from rigorous efforts to promote risk factor modification. Modification of these risk factors has the potential to reduce risk for colorectal cancer, even among screening-adherent individuals (24), as well as reducing the risk for other cancers and chronic illnesses (25). Future research is needed to examine potential common predictors

of lack of colorectal cancer screening and colorectal cancer behavioral risk factor prevalence, (e.g., low health value, low motivation for behavior change, and practical barriers). Identification of such predictors will provide an understanding of the underlying processes associated with lack of screening and high risk factor prevalence, which in turn will inform the development of interventions tailored to those predictors. Interventions to promote risk factor modification should also take into consideration that individuals who are not adherent to colorectal cancer screening are likely to have poorer health care access and utilization than those who are adherent to screening. Indeed, the results of ancillary χ^2 analyses in the current study showed that nonadherent individuals were less likely to have a regular source of health care than adherent individuals (89.9% and 97.3%, respectively; $P < 0.0001$) and were less likely to have visited a general practitioner in the previous 12 months than adherent individuals (71.4% and 87.9%, respectively; $P < 0.0001$).

Knowledge of the most common behavioral risk factor combinations among unscreened and screened individuals (i.e., low physical activity, low fruit and vegetable intake, and low use of multivitamins) provides insight on the colorectal cancer risk factors for which there may be the greatest need for systematic assessment and intervention, although such needs should also be guided by epidemiologic evidence about the magnitude of effect of each risk factor on colorectal cancer risk. Knowledge of the demographic and health-related correlates of risk factor prevalence among unscreened and screened individuals may offer health care providers valuable guidance in identifying individuals who may be most in need of multiple behavioral risk factor assessment and risk-reducing interventions. Of particular note was the finding that unscreened individuals with a higher risk of colorectal cancer based on their family history reported having more behavioral risk factors than individuals with a lower risk based on their family history.

For individuals who are adherent to screening for colorectal cancer, screening appointments may represent a currently underused, useful teachable moment when individuals are motivated to consider strategies for further colorectal cancer risk reduction. In that regard, Emmons et al. (22) recently reported outcome data for Project Prevent, a randomized controlled trial of an intervention to modify six colorectal cancer behavioral risk factors (high red meat consumption, low

fruit and vegetable intake, low intake of multivitamins, high alcohol intake, smoking, and physical inactivity) in a sample of individuals at high risk for colorectal cancer due to a recent diagnosis (and removal) of adenomatous polyps. Compared with a usual care group, individuals in the intervention group, who received telephone counseling and tailored print materials, reported having fewer behavioral risk factors at follow-up and were more likely to have made changes to two or more behavioral risk factors. The results of this innovative study are promising; however, only half of the participants in the intervention group dropped any of their behavioral risk factors, suggesting that future research is needed to refine interventions for this population. Future research will also determine whether similar effects will be found among individuals who undergo colorectal cancer screening and are not diagnosed as having adenomatous polyps.

Combined with results of previous studies (22, 38), the results of the current study highlight the need for interventions that address multiple behavioral risk factors for colorectal cancer among both colorectal cancer screening-adherent and nonadherent individuals. There is accumulating evidence that interventions can successfully focus on more than one behavioral risk factor (21, 22, 55-59), even when the risk factors have varying features (e.g., addictive versus nonaddictive; health damaging versus health promoting). A key issue to explore in future studies is the feasibility and efficacy of adopting a multifaceted, integrative approach to colorectal cancer prevention that might involve initial efforts to promote screening uptake and adherence followed by subsequent efforts to monitor and modify multiple behavioral risk factors for colorectal cancer. Further, being screened for one type of cancer, such as colorectal cancer, may also provide an opportunity to promote adherence to other cancer screenings (60). Incorporating such an integrative approach in primary care and other health care settings where colorectal cancer screening is conducted will require overcoming challenges at multiple levels of the health care system, including time constraints (61), reimbursement for the delivery of behavioral risk factor assessment and intervention (62), the availability of appropriate assessment tools for multiple behavioral risk factors (63), and provider willingness and ability to engage in behavior change counseling (64). Some of these challenges may be overcome, or minimized, by combining organizational practice changes (65), with the use of information technology (66) to streamline and automate the delivery of colorectal cancer preventive services.

Limitations. There are several limitations to the current study. The survey did not ask individuals whether they had been screened using a double-contrast barium enema, although this limitation is mitigated by the fact that it is rarely used as a primary screening modality (67). Colorectal cancer screening was measured via self-report, raising the possibility of recall bias. However, self-report seems to provide an acceptable estimate of actual colorectal cancer screening behavior (68). Using 10 years as the cutoff for adherence to sigmoidoscopy and colonoscopy may have lead to an overestimation of screening adherence, but there is no basis for expecting any recall or measurement bias to vary systematically according to individuals' behavioral risk factor profile. Similarly, potential underreporting of the behavioral risk factors (69) is not expected to differ according to individuals' colorectal cancer screening status. The cross-sectional nature of the study data precludes conclusions about the causal association between colorectal cancer screening and the prevalence of multiple behavioral risk factors.

Conclusions. The results of this study underscore the need to develop and test the efficacy of interventions to modify the multiple behavioral colorectal cancer risk factors that most colorectal cancer screening-adherent and nonadherent indi-

viduals present with. Future studies and interventions should be designed in view of their potential for dissemination and public health effect (70).

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