Longitudinal Changes in Lifestyle Behaviors and Health Status in Colon Cancer Survivors

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Abstract

Lifestyle changes in persons diagnosed with cancer are important because they may impact prognosis, comorbidities, and survival. This report describes longitudinal changes in lifestyle behaviors and health status among colon cancer survivors (n = 278) and population-based controls (n = 459) in North Carolina (39% African American), and examines demographic and psychosocial correlates of healthy lifestyle changes following a colon cancer diagnosis. Data are from surveys of a population-based cohort of colon cancer patients on diagnosis (the North Carolina Colon Cancer Study, NCCCS) and approximately 2 years post-diagnosis [the North Carolina Strategies to Improve Diet, Exercise, and Screening Study (NC STRIDES)], and population-based controls. Both studies collected information on demographic/lifestyle characteristics and medical history. The NCCCS reflects pre-diagnosis or pre-interview patterns, whereas NC STRIDES queried on current practices. Between the NCCCS and NC STRIDES, colon cancer survivors reported significant increases in vegetable intake, physical activity, and supplement use (all P <0.01) and a non-statistically significant increase in fruit/juice consumption (0.1 serving), with larger fruit/vegetable changes in African Americans than Whites. Controls increased physical activity and supplement use and fewer reported arthritic symptoms (P < 0.05). Survivors who were older and female had an almost 3 times higher likelihood of having used at least one new dietary supplement post-diagnosis, whereas being retired correlated with increased vegetable intake, all P < 0.05. Having more barriers to increasing fruit/vegetable intake was inversely associated with taking a new supplement (P < 0.05 only in controls). Colon cancer survivors reported making significant improvements in multiple health-related behaviors. Health care providers should communicate with persons diagnosed with colon cancer to ensure that they are making healthy lifestyle changes. (Cancer Epidemiol Biomarkers Prev 2004;13(6):1022–31)

Introduction

Colorectal cancer is a common disease in the United States and other developed countries. Colorectal cancer is the third most common cancer in the United States and is the second leading cause of cancer death (1). Approximately 105,500 new colon and 42,500 rectal cancer cases and an estimated 57,100 colorectal cancer deaths are estimated to occur in the year 2003 (1). However, when detected early, survival from a colorectal cancer diagnosis can be quite promising: the 1- and 5-year survival rates for patients with colon and rectal cancers are 83% and 62%, respectively, and when diagnosed at the earliest stages, the 5-year survival rate is close to 90% (1).

Because of this relatively high survival rate and the aging of the U.S. population, the population of colorectal cancer survivors is steadily increasing. It is estimated that there were 1.24 million colorectal cancer survivors in 1998 (2), and colorectal cancer survivors represent a significant proportion of the estimated 8.9 million cancer survivors living in the United States today (1, 3). However, there is a deficit in knowledge about issues such as the health status and health promotion needs of this growing population.

Studies have found that cancer survivors have a strong interest in making positive changes in lifestyle and health-related behaviors, including diet, physical activity, and smoking (4, 5). For example, in a recent survey, Patterson et al. (6) reported that two thirds of breast, colorectal, and prostate cancer patients reported making changes in diet, dietary supplement use, and physical activity as much as 2 years post-diagnosis. However, to our knowledge, no studies have evaluated changes in modifiable aspects of lifestyle in persons diagnosed with colon cancer in a prospective fashion, and there is no available data on how such changes may differ by race. A better understanding of lifestyle behavioral patterns after a cancer diagnosis is important because these behaviors may potentially impact prognosis, recurrence, functioning, development of a second primary cancer or secondary cancer, long-term survival, and risk for other chronic diseases such as cardiovascular and lung disease, hypertension, and obesity (7-10). It is useful to

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understand possible racial differences in health behaviors because cancer prognosis and survival differ by race; for example, African Americans have lower 5-year colon cancer survival rates than Whites at all stages of diagnosis (1). Thus, given that a cancer diagnosis offers opportunities for health promotion programs to modify unhealthy behaviors, there is a need to describe the prevalence of such behaviors in demographically diverse groups of cancer survivors to develop targeted interventions for each population subgroup. In addition, it is important to identify key factors that influence whether or not persons diagnosed with cancer change particular lifestyle behaviors.

The objectives of this report are to: (1) describe longitudinal changes (baseline to 2 years post-diagnosis) in health behaviors (diet, supplement use, and physical activity) and health status (self-rated health, body weight, and self-reported medical conditions) among persons previously diagnosed with colon cancer (survivors) and population-based controls in North Carolina and (2) to examine demographic and psychosocial factors associated with making healthy lifestyle changes following a colon cancer diagnosis. Our report contributes to the existing body of literature in two ways. First, this is one of the first studies to prospectively describe health behavior changes in a population of colon cancer survivors with comparable numbers of African Americans and Whites. Second, we have a population-based control group on whom we have similar data, which allows an examination of secular trends. Also, data from controls may inform on the impact on health behaviors of taking part in a case-control study.

Materials and Methods

Study Design. Data are from *baseline* findings from two studies on the same cohort: the North Carolina Colon Cancer Study (NCCCS) and the North Carolina Strategies to Improve Diet, Exercise, and Screening Study (NC STRIDES). Participants were originally recruited into the NCCCS and subsequently enrolled in NC STRIDES approximately 2 years later. Both studies were approved by Institutional Review Boards at the University of North Carolina, Chapel Hill.

NCCCS was a population-based, case-control study of colon cancer in North Carolina. Study participants were from 33 counties in the central portion of North Carolina, an area that includes rural, suburban, and urban counties with a diverse socioeconomic mix of African Americans and Whites. Details of the recruitment procedures in the NCCCS have been described previously (11, 12). Briefly, persons with a first diagnosis of histologically confirmed invasive adenocarcinoma of the colon between July 1, 1996, and June 30, 2000, were identified through the rapid case ascertainment system of the North Carolina Central Cancer Registry. Other case eligibility criteria included: age 40 to 80 years at the time of diagnosis, residence in the 33-county study area in North Carolina, ability to give informed consent and complete the interview, a North Carolina driver's license or identification card if under age 65 (because controls under age 65 were sampled from driver's license rosters), and permission from their primary physician to participate in the study.

The non-institutionalized population-based controls were selected from two sources: North Carolina Division of Motor Vehicle records for cases under the age of 65 and from the Center for Medicare and Medicaid Services (formerly the Health Care Financing Administration) for cases 65 years or older. These listings were used to randomly select potential controls within the same 5-year age group, sex, and race defined strata. Those identified as eligible controls were contacted in a similar fashion to the cases to schedule in-person interviews.

Completed interviews were obtained from 1,691 persons (634 cases and 1,048 controls), of whom 43% were African American. The overall study cooperation rate [interviewed/(interviewed + refused)] was 84% for cases and 63% for controls, whereas the response rate (interviewed/eligible) was 72% for cases and 61% for controls. Both cooperation and response rates were slightly higher for Whites than for African Americans (11, 12).

NC STRIDES is a randomized trial testing two health communication strategies to provide credible information and motivate healthy behavior change among colon cancer survivors and a colon cancer-free comparison group. All eligible NCCCS cases and controls were mailed a letter and brochure explaining the NC STRIDES study. NCCCS staff contacted potential participants via telephone to request their consent to participate in NC STRIDES. Because NC STRIDES was an intervention trial designed to promote higher fruit and vegetable consumption and physical activity, eligibility criteria for NC STRIDES excluded participants from the NCCCS who were terminally ill or who had advanced disease (e.g., Stage III or IV colon cancer) that would limit their ability to make these lifestyle changes. In addition, potential participants who had suffered strokes, lost physical mobility and/or ability to chew or swallow, or moved out of our 33-country catchment area were also ineligible.

Distributions of reasons for nonparticipation were as follows: unable to reach or contact (14%), died (7%), too ill (6%), and refused (23%). Compared with non-STRIDES respondents, STRIDES participants were more college educated (15.9% versus 23.7%) and White (52.8% versus 61.3%), $P < 0.05$; however, there were no statistically significant differences with respect to age, sex, health insurance coverage, fruit and vegetable intake, or multivitamin use. Eight hundred and twenty-five persons (304 survivors and 521 controls) completed the NC STRIDES baseline interview. The overall cooperation rate [interviewed/(interviewed + refused)] was 78% for survivors and 64% for controls, whereas the response rate (interviewed/eligible) was 62% for survivors and 55% for controls. These analyses include 737 persons (278 survivors, 459 controls) with complete data from both studies.

Data Collection. In the NCCCS, data were collected in person by trained nurse interviewers at the participant's home or, occasionally, at another convenient location, whereas in NC STRIDES, data were collected by telephone. Both studies collected detailed information on several factors that might relate to colon cancer, including dietary and lifestyle factors and medical history. In the NCCCS, the referent period for the interview was the year before diagnosis (survivors) or interview date (controls), whereas NC STRIDES queried on current practices.

Assessment of Health Behaviors

Fruit and Vegetable Intake. In the NCCCS, dietary intake (including fruits and vegetables) over the previous year was assessed with a modified version of the previously validated 100-item semiquantitative Block food frequency questionnaire developed at the National Cancer Institute (13). The food frequency questionnaire was modified by adding 29 foods commonly consumed in North Carolina to better assess regional dietary practices in a sample of North Carolinians that included low-income African Americans (14). Details on this instrument and its use in the NCCCS have been published (11, 12, 14).

Average daily fruit and vegetable consumption in NC STRIDES was measured using a 36-item food frequency questionnaire that was developed for and validated in a diverse Southern population by Resnicow et al. (15). Resnicow's tool was modified slightly by querying on how often foods were consumed in the past *month* (rather than the past *week*) and by excluding food items that were not fruits and vegetables. Details on computations of fruit and vegetable intake are described elsewhere.[7] For these analyses, we focused only on fruits and vegetables that were included on both food frequency questionnaires (Table 2).

Dietary Supplement Use. In the NCCCS, dietary supplement use was assessed with closed-ended questions on the duration (years), frequency (days per week), and usual dose of multiple vitamins (including antioxidant combinations) and single supplements over the previous year. In NC STRIDES, participants were asked about current use of multivitamins, single supplements, mineral supplements, or any other vitamin or mineral supplements.

Physical Activity. Physical activity in both studies was measured in metabolic equivalent task-hours per week for combined occupational, non-occupational, and non-work/weekend activities using a modified version of a validated Seven-Day Physical Activity Recall (16, 17). For these analyses, we focused only on non-occupational physical activity because employment status changed markedly between the two studies (Table 1) and occupational physical activity is generally low in older adults (18).

Demographic/Lifestyle Characteristics and Health Status. Data on age, sex, race, and case-control status were collected only in the NCCCS. NC STRIDES collected updated information on education, employment status, marital status, smoking, and alcohol consumption. In the NCCCS, trained staff measured participants' height and weight during the in-person interview using a standardized protocol, whereas in NC STRIDES, these data were collected by self-report. Studies have shown high reliability and accuracy of self-reported height and weight in older adults (19, 20). Body mass index was computed as weight (in kilograms) divided by height (in meters) squared, and further categorized as ''normal'': 18.5 to 24.9, ''overweight'': 25.0 to 29.9, and ''obese'': $\geq$30.0 (21).

Both studies also queried on self-rated health, self-reported chronic medical conditions (hypertension, diabetes, arthritic symptoms), and health insurance coverage.

Psychosocial Factors. Information on psychosocial factors related to diet and health was only collected in NC STRIDES. *Self-efficacy* for eating five or more daily servings of fruits and vegetables over the subsequent 6 months was assessed using a single item question with a five-point Likert-type response ranging from ''very sure'' to ''very unsure.'' Perceived *social support* for eating healthier foods was based on responses to four items drawn from previous research (22) with three response options ranging from ''not at all applicable'' to ''a lot,'' and a social support measure was calculated as the mean of the non-missing responses. *Barriers* to eating fruits and vegetables were assessed using six items, with four response options ranging from ''disagree a lot'' to ''agree to lot.'' The barriers score reflects the mean response across the six barrier items.

Statistical Analyses. Data analyses were done using SAS 8.01 (SAS Institute Inc., Cary, NC). Descriptive statistics were used to describe the demographic, lifestyle, and health status characteristics of study participants in both the NCCCS and NC STRIDES. Percentages were calculated for categorical variables, means, and SDs computed for continuous variables, and the differences between the NCCCS and NC STRIDES estimates presented (Tables 1-3). *P* values to test the null hypothesis of no statistically significant differences between the two studies for each variable were generated via logistic regression for dichotomous categorical variables, logistic regression with proportional odds for polytomous categorical variables, and linear regression for continuous variables, after adjustment for age (continuous), sex, race (African American, White), education (high school, some college, college graduate/advanced degree), and employment status (employed outside the home, retired). *P* values were also generated to assess whether the degree or amount of change between survivors and controls for various demographic, behavioral, and health status characteristics was statistically significant.

We calculated odds ratios (ORs) and 95% confidence intervals (CIs) from logistic regression models to determine associations of demographic and psychosocial factors with making healthy lifestyle changes (increasing vegetable intake or taking at least one new dietary supplement) between the NCCCS and NC STRIDES, controlling for the covariates listed above, that is, age, sex, education, race, and employment status (Tables 4 and 5). For each demographic or psychosocial variable of interest, three sets of *P* values were generated: one comparing each level of the variable to the reference, another comparing all levels of the variable simultaneously, and a *P* value for linear trend. Statistical tests were two-sided and *P* values less than 0.05 were considered statistically significant.

Results

Table 1 gives the demographic characteristics of the study participants. In the NCCCS, the mean age of

[7] Dr. Aimee James, personal communication.

Table 1. Demographic characteristics of colon cancer survivors and population-based controls in North Carolina (*N* = 737)

Characteristic	Survivors (n = 278)				Controls (n = 459)				P value for change*
	NCCCS	NC STRIDES	Change[c]	P value[b]	NCCCS	NC STRIDES	Change[c]	P value[b]	
Age (years)									
Mean ± SD	63.3 (10.2)	65.4 (10.4)	2.1	0.58	64.9 (9.5)	67.6 (9.6)	2.7	0.003	0.79
Sex (%)									
Males	52.9	52.9	N/A	0.99	52.9	52.9	N/A	0.88	1.0
Females	47.1	47.1	N/A		47.1	47.1	N/A		
Education (%)									
≤High school	57.4	57.4	0	0.37	49.7	51.2	1.5	0.57	0.93
Some college	21.7	18.8	−2.9		24.9	21.4	−3.5		
College graduate/ Advanced degree	20.9	23.8	2.9		25.4	27.4	2.0		
Race (%)									
White	60.8	60.8	N/A	0.72	60.8	60.8	N/A	0.91	0.94
African American	39.2	39.2	N/A		39.2	39.2	N/A		
Marital status (%)[b]									
Married/living with partner	66.4	64.6	−1.8	0.96	68.5	65.4	−3.1	0.64	0.90
Divorced/separated/widowed	28.2	30.3	2.1		28.2	32.0	3.8		
Never married	5.4	5.1	−0.3		3.3	2.6	−0.7		
Employment status (%)[b]									
Employed outside the home	50.9	35.7	−15.2	0.003	47.9	36.6	−11.3	0.08	0.30
Retired/Not employed outside the home	49.1	64.3	15.2		52.1	63.4	11.3		
Health insurance coverage (%)[b]									
Any health insurance	97.5	97.1	−0.4	0.33	96.3	96.1	−0.2	0.24	0.88

*P value for degree or amount of change between survivors and controls.
[c]Change = NC STRIDES − NCCCS.
[b]Adjusted for age, sex, race, education, and employment status.

participants was 63.3 years (cases) and 65.4 years (controls) and more than half were 65 years and older. Fifty-three percent were males, 21% had an advanced degree, two thirds were married, and 39% were African American. Not unexpectedly, significantly fewer participants were employed outside the home at the 2-year follow-up point of NC STRIDES than in the NCCCS. More than 95% of participants had health insurance coverage in both studies. There were no statistically significant differences in the degree or amount of change between survivors and controls for any of the demographic characteristics.

Table 2 gives changes in diet, physical activity, dietary supplement use, and adherence to colon cancer screening recommendations among colon cancer survivors and the population-based controls. Between the NCCCS and NC STRIDES, colon cancer survivors reported statistically significant increases in vegetable intake, non-occupational physical activity, and dietary supplement use (multivitamins, folic acid, antioxidant combinations, and mineral supplements), all $P < 0.01$. They also reported a non-statistically significant increase in fruit/fruit juice consumption (0.1 serving) and a slight decrease in mean number of alcoholic drinks per day ($P = 0.05$). For both fruit and vegetable intakes, the mean changes were larger among African Americans (0.4 servings per day) than Whites (0.1 and 0.3 servings, respectively), data not shown. Controls increased physical activity and use of all dietary supplements ($P < 0.0001$) between the NCCCS and NC STRIDES, but did not report statistically significant changes in the other health behaviors. Among controls only, there were significant increases ($P < 0.01$) in adherence to American Cancer Society colon cancer screening guidelines for barium enema, sigmoidoscopy, and colonoscopy between the NCCCS and NC STRIDES, but a 10% decrease in adherence to recommendations for fecal occult blood testing ($P = 0.0005$). The only statistically significant difference for amount or degree of change between survivors and controls was for antioxidant supplement use ($P = 0.0003$).

Changes in health status, as measured by self-rated health, body weight, body mass index, and self-reported chronic conditions among survivors and controls are given in Table 3. Survivors reported a non-statistically significant improvement in self-rated health, whereas fewer controls reported arthritic symptoms ($P = 0.007$). There were no statistically significant changes in body weight, body mass index, diabetes, or hypertension in either group. Among these measures, the amount or degree of change between survivors and controls was statistically significant for self-rated health ($P = 0.02$) and arthritic symptoms ($P = 0.006$).

Between the NCCCS and NC STRIDES, more than half of the participants (60% of survivors and 53% of controls) increased vegetable intake and over 40% reported taking at least one new supplement. Thirty-one percent of survivors and 28.3% of controls reported increasing vegetable intake (but not supplement use), 13.7% of survivors and 18.5% of controls took at least one new dietary supplement (but did not increase vegetable intake), and 27.7% of survivors and 23.5% of controls made both changes (data not shown).

Tables 4 and 5 give demographic and psychosocial factors from NC STRIDES associated with increased vegetable intake and taking at least one new dietary supplement between the two studies. All P values are

adjusted for age, sex, race, education, and employment status, and there was no effect modification by race. Increased vegetable intake was not statistically significantly associated with any demographic characteristics or psychosocial factors, except for employment status among survivors, with those not employed outside the home having a higher likelihood of increasing vegetable intake (OR = 2.0; 95% CI, 1.1-3.6, $P = 0.03$).

Among survivors, taking at least one new dietary supplement was statistically significantly associated with older age (OR = 2.8; 95% CI, 1.2-14.4) and being female (OR = 2.6; 95% CI, 1.5-4.4), both $P < 0.001$. Being female was also associated with an almost 2 times greater likelihood of taking new dietary supplements among controls ($P = 0.003$). Having barriers to consuming more fruits and vegetables was inversely associated with supplement use in both groups (OR = 0.4-0.6), but the association only reached statistical significance in controls. African American survivors and controls were half as likely as Whites to report using new dietary supplements (OR = 0.4-0.5; 95% CI, 0.3-0.8, $P = 0.004$). Similar to vegetable intake, self-rated health, self-efficacy, and social support did not significantly predict taking a new dietary supplement in either group.

Table 2. Changes in health-related behaviors (diet, physical activity, dietary supplement use, and cancer screening) among colon cancer survivors and population-based controls in North Carolina (*N* = 737)

Characteristic	Survivors (n = 278)				Controls (n = 459)				P value for change*
	NCCCS	NC STRIDES	Change[c]	P value[b]	NCCCS	NC STRIDES	Change[c]	P value[b]	
Fruits and fruit juices§, servings per day (%)									
<2	37.6	37.0	−0.6	0.86	31.3	32.0	0.7	0.60	0.48
2-4.9	49.6	48.6	−1.0		52.8	54.5	1.7		
≥5	12.8	14.4	1.6		15.9	13.5	−2.4		
Mean ± SD	2.8 (1.8)	2.9 (1.9)	0.1	0.71	3.1 (1.8)	3.0 (2.0)	−0.1	0.20	0.96
Vegetables‖, servings per day (%)									
<2	57.9	47.8	−10.1	0.01	44.4	41.2	−3.2	0.11	0.17
2-4.9	41.0	47.8	6.8		54.7	56.2	1.5		
≥5	1.1	4.3	3.2		0.9	2.6	1.7		
Mean ± SD	2.0 (0.9)	2.3 (1.2)	0.3	0.002	2.3 (1.0)	2.4 (1.2)	0.1	0.09	0.93
Non-occupational physical activity, metabolic equivalent task-hours/week, mean (SD)									
1st quartile	165 (19)	188 (8)	23	0.0001	167 (21)	188 (8)	21	<0.0001	0.99
2nd quartile	205 (5)	209 (5)	4		206 (6)	209 (5)	3		
3rd quartile	222 (4)	223 (4)	1		223 (4)	222 (3)	−1		
4th quartile	271 (46)	257 (74)	−14		259 (26)	251 (34)	−8		
Mean ± SD	179 (37)	228 (47)	49	0.0001	187 (36)	227 (27)	40	<0.0001	0.91
Alcohol consumption, drinks/day, mean (SD)									
Non-drinker (%)	65.5	67.5	2.0	0.35	66.7	61.8	−4.9	0.74	0.06
Drinker category 1	0.1 (0.1)	0.1 (0)	0		0.1 (0)	0.1 (0)	0		
Drinker category 2	0.4 (0.1)	0.4 (0.2)	0		0.4 (0.2)	0.4 (0.2)	0		
Drinker category 3	2.3 (1.5)	1.8 (1.1)	−0.5		1.7 (1.2)	1.7 (0.9)	0		
Mean ± SD	0.4 (1.0)	0.3 (0.7)	−0.1	0.05	0.3 (0.7)	0.2 (0.5)	−0.1	0.16	0.95
Dietary supplement use (%)									
Multivitamin	31.3	42.8	11.5	0.02	36.7	45.5	8.8	0.02	0.46
Folate (folic acid)	1.5	6.8	5.3	0.005	1.8	7.2	5.4	0.0004	0.95
Antioxidant combination	0.4	20.5	20.1	<0.0001	0.9	29.4	28.5	<0.0001	0.0003
Minerals	11.8	26.6	14.8	<0.0001	17.0	26.1	9.1	0.0003	0.06
Adherence to American Cancer Society colon cancer screening recommendations¶,**									
Fecal occult blood testing	—	—	—	—	32.0	21.8	−10.2	0.0005	N/A
Barium enema	—	—	—	—	10.9	16.2	5.3	0.02	N/A
Sigmoidoscopy	—	—	—	—	21.4	36.6	15.2	<0.0001	N/A
Colonoscopy	—	—	—	—	31.8	39.7	7.9	0.01	N/A

*P value for degree or amount of change between survivors and controls.
[c]Change = NC STRIDES − NCCCS.
[b]Adjusted for age, sex, race, education, and employment status.
§Fruits include bananas, apples/apple sauce, grapefruit, pears, cantaloupe/honeydew melon, strawberries/other berries, oranges, peaches/nectarines, oranges, and fruit salad. Juices include apple, grape juice, or any other fruit juices.
‖Vegetables include string beans, green peas, lima, red, pinto beans, corn, tomatoes, broccoli, cauliflower/brussel sprouts, spinach, collard greens, cabbage/coleslaw, carrots, mixed vegetables, and green/tossed salads.
¶American Cancer Society recommendations: fecal occult blood testing, 2 years; barium enema, 5 years; sigmoidoscopy, 5 years; colonoscopy, 10 years.
**No colon cancer screening data available for cases in NC STRIDES.

Table 3. Changes in health status (self-rated health, body mass index, and medical conditions) among colon cancer survivors and population-based controls in North Carolina (*N* = 737)

Characteristic	Survivors (n = 278)				Controls (n = 459)				P value for change*
	NCCCS	NC STRIDES	Change[c]	P value[b]	NCCCS	NC STRIDES	Change[c]	P value[b]	
Self-rated health (%)									
Excellent	9.7	12.6	2.9	0.82	15.5	12.5	−3.0	0.72	0.02
Very good	28.2	30.7	2.5		33.0	26.5	−6.5		
Good	36.1	40.8	4.7		33.5	44.4	10.9		
Fair	19.1	12.3	−6.8		15.3	13.8	−1.5		
Poor	6.9	3.6	−3.3		2.6	2.8	0.2		
Body mass index, kg/m^2 (%)									
Normal (18-24.9 kg/m^2)	31.4	25.6	−5.8	0.14	26.9	30.0	3.1	0.27	0.08
Overweight (25-29.9 kg/m^2)	36.8	42.3	5.5		40.2	41.9	1.7		
Obese (≥30 kg/m^2)	31.8	32.1	0.3		32.9	28.0	−4.9		
Mean ± SD	28.1 (6.2)	28.5 (6.1)	0.4	0.14	28.8 (6.3)	28.2 (5.9)	−0.6	0.43	0.93
Weight (kg)									
Mean ± SD	181 (46)	184 (44)	3	0.06	182 (44)	180 (41)	−2	0.89	0.95
Self-reported medical conditions (%)									
Diabetes	20.2	22.0	1.8	0.61	14.0	17.5	3.5	0.28	0.57
Arthritic symptoms	31.4	36.6	5.2	0.23	47.7	42.9	−4.8	0.007	0.006
Hypertension	43.0	47.6	4.6	0.29	47.3	50.6	3.3	0.87	0.25

*P value for degree or amount of change between survivors and controls.
[c]Change = NC STRIDES − NCCCS.
[b]Adjusted for age, sex, race, education, and employment status.

Discussion

We found that approximately 2 years after a colon cancer diagnosis, respondents had made positive changes concerning fruit and vegetable consumption, dietary supplement use, and physical activity. The majority reported increasing vegetable intake, almost half reported using at least one new vitamin or mineral supplement, and over a quarter reported making both changes. Overall perceptions of health status among survivors may have improved, as showed by better self-rated health. Controls increased physical activity and supplement use and fewer reported arthritic symptoms. Among both survivors and controls, demographic characteristics were predictive of use of at least one new dietary supplement, but associations with psychosocial factors were not as strong.

Although we know of no comparable longitudinal studies, we are aware of one survey that examined whether persons diagnosed with cancer change their dietary and physical activity habits, and several studies have assessed the prevalence of health behaviors in cancer survivors. Patterson et al. (6) recently published cross-sectional findings from a survey of cancer patients in Western Washington state, including 116 with colorectal cancer, which inquired about major changes in dietary intake, physical activity, and supplement use aimed at coping with cancer or reducing recurrence. Similar to our findings, respondents reported significant improvements in health-related behaviors: 66.3% of respondents reported eating more fruits and vegetables and less fat, adding new aerobic activity, and taking new dietary supplements, and a large majority strongly believed that these lifestyle changes improved their overall health.

Several studies have found a relatively high prevalence of healthy behaviors among cancer patients. For example, in a survey of 978 breast and prostate cancer survivors by Demark-Wahnefried et al. (5), 45% ate more than 5 daily servings of fruits and vegetables, 58% reported routine physical activity, and 69% reported adherence to a low-fat dietary regimen. Similarly, in another study of 352 adult cancer survivors, investigators reported that 46% stopped smoking and 47% improved their dietary habits, although 30.1% exercised less following a cancer diagnosis (4). Finally, among participants (n = 435) in the Women's Healthy Eating and Living (WHEL) Study, a clinical trial to prevent breast cancer recurrence, 80.9% reported use of dietary supplements, with demographic and personal characteristics, time passed since diagnosis, and stage of cancer at diagnosis predictive of dietary supplement use (23). Although participants in these studies may be more health conscious than comparable cancer survivors, the findings suggest a strong interest in positive health behavior modification following a cancer diagnosis.

It is interesting that there was little correlation between increased vegetable intake and any demographic or psychosocial factors (except employment status among survivors), whereas demographic characteristics, and to a lesser extent, some of the psychosocial factors (self-efficacy and barriers) were strongly associated with use of a new dietary supplement post-diagnosis. These findings generally mirror those by Patterson et al. (6), who found that strong desire for personal control and having a high locus of internal control predicted adoption of a new dietary supplement, but not changes in vegetable intake. Possibly, dietary change, which involves careful deliberation and planning, may be motivated by other psychosocial or mediating factors that we did not assess in the present study, such as a belief in the relationship between diet and health, weight concerns, food availability, taste preferences, and resources. More research is needed to identify salient modifiable factors associated with improvements in diet following a cancer diagnosis.

Table 4. Demographic and psychosocial factors associated with increased vegetable intake among colon cancer survivors and population-based controls in North Carolina (*N* = 737)

Characteristic	Survivors (*n* = 278)				Controls (*n* = 459)			
	Increased vegetable intake between NCCCS and NC STRIDES (yes)							
	N (%)	Adjusted OR* (95% CI)	*P* value[c]	*P* value[b]	*N* (%)	Adjusted OR* (95% CI)	*P* value[c]	*P* value[b]
All	166 (60)	—	—	—	245 (53)		—	
Age								
<55 years	27 (16)	1.0		0.49	30 (12)	1.0		0.72
55-64 years	43 (26)	1.7 (0.8-3.7)	0.19		39 (16)	0.7 (0.3-1.3)	0.27	
≥65 years	96 (58)	1.1 (0.5-2.3)	0.80		176 (72)	1.4 (0.8-2.7)	0.27	
P for trend		0.80						
Sex								
Males	89 (54)	1.0		0.61	120 (49)	1.0		0.35
Females	77 (46)	0.9 (0.5-1.5)	0.61		125 (51)	1.2 (0.8-1.8)	0.35	
		0.61				0.35		
Education								
≤High school								
Some college	94 (57)	1.0		0.44	121 (50)	1.0		0.27
College graduate/Advanced degree	33 (20)	1.6 (0.8-3.1)	0.21		58 (24)	1.4 (0.9-2.4)	0.15	
P for trend	39 (23)	1.2 (0.6-2.3)	0.54		61 (25)	0.9 (0.6-1.5)	0.80	
		0.30				0.68		
Race								
White								
African American	102 (61)	1.0		0.92	153 (62)	1.0		0.77
	64 (39)	1.0 (0.6-1.7)	0.92		92 (38)	0.9 (0.6-1.4)	0.77	
		0.92				0.77		
Marital status								
Never married	9 (5)	1.0		0.78	6 (2)	1.0		0.99
Divorced/separated/widowed	57 (35)	1.2 (0.3-4.6)	0.81		80 (33)	1.0 (0.3-3.5)	0.95	
Married/living with partner	99 (60)	0.7 (0.2-2.3)	0.51		159 (65)	1.0 (0.3-3.4)	0.97	
		0.97				0.96		
Employment status								
Employed outside the home	51 (31)	1.0		0.03	82 (33)	1.0		0.98
Retired/Not employed outside the home	114 (69)	2.0 (1.1-3.6)	0.03		163 (67)	1.0 (0.6-1.6)	0.98	
Self-rated health								
Fair/Poor	23 (14)	1.0		0.48	45 (19)	1.0		0.46
Good	70 (42)	1.4 (0.7-3.0)	0.32		109 (45)	0.8 (0.5-1.4)	0.42	
Excellent/Very Good	72 (44)	1.6 (0.7-3.3)	0.23		89 (37)	0.7 (0.4-1.2)	0.21	
P for trend		0.23				0.24		
Self-efficacy[§]								
Somewhat unsure/Very unsure	68 (47)	1.0		0.86	103 (48)	1.0		0.65
Sure	31 (22)	1.1 (0.6-2.3)	0.75		42 (20)	1.1 (0.6-1.8)	0.83	
Very Sure	45 (31)	1.2 (0.6-2.2)	0.60		69 (32)	1.2 (0.8-2.0)	0.35	
P for trend		0.59				0.43		
Barriers[‖]								
Disagree a lot	48 (36)	1.0		0.52	78 (37)	1.0		0.90
Disagree a little	60 (44)	0.8 (0.4-1.5)	0.48		99 (48)	1.1 (0.7-1.7)	0.65	
Agree a lot or a little	27 (20)	1.2 (0.5-3.0)	0.63		31 (15)	1.1 (0.6-2.0)	0.86	
P for trend		0.85				0.78		
Social support[¶]								
Not at all/Not Applicable	20 (14)	1.0		0.58	15 (7)	1.0		0.28
Some	45 (31)	0.6 (0.2-1.6)	0.34		85 (42)	1.8 (0.8-4.1)	0.15	
A lot	79 (55)	0.8 (0.3-2.0)	0.58		104 (51)	1.4 (0.6-3.1)	0.40	
P for trend		0.47				0.28		

*Adjusted for age, sex, race, education, and employment status.

[c]*P* value comparing each level of the variable to the reference.

[b]*P* value comparing all levels of the variable simultaneously.

[§]*Question:* How sure are you that you can have the ability to succeed in eating five or more servings of fruits and vegetables every day for the next 6 months? (Very sure, sure, somewhat sure, somewhat unsure, very unsure, don't know/refused). *Very sure = higher self-efficacy*.

[‖]*Question*: Thinking about eating more fruits and vegetables than you do now, please tell me whether you agree or disagree with the following statements. It would be hard for me to eat more fruits and vegetables than I do now because: (1) I'm not in the habit of eating them, (2) I can't get them easily when I eat out, (3) I don't have enough time to prepare them, (4) They cost too much, (5) I don't think that eating more of them will make me healthier, (6) I eat alone so I don't fix enough of them. (Agree a lot, agree a little, disagree a lot, disagree a little, don't know/refused). *Agree a lot or a little = having more barriers*.

[¶]*Question:* If you tried to eat healthier foods, how much would you count on those close to you to: (1) Encourage you, (2) Tell you about healthier foods and how to prepare them, (3) Prepare healthier foods with or for you, (4) Eat healthier foods with you. (A lot, some, not at all, don't know/refused). *A lot = more social support*.

Table 5. Demographic and psychosocial factors associated with increased dietary supplement use among colon cancer survivors and population-based controls in North Carolina (*N* = 737)

Characteristic	Survivors (*n* = 278)				Controls (*n* = 459)			
	Took ≥1 new dietary supplement between NCCCS and NC STRIDES (yes)							
	N (%)	Adjusted OR* (95% CI)	*P* value[c]	*P* value[b]	*N* (%)	Adjusted OR* (95% CI)	*P* value[c]	*P* value[b]
All	120 (43)	—	—	—	195 (42)	—		
Age								
<55 years	12 (10)	1.0		0.0005	22 (11)	1.0		0.14
55-64 years	37 (31)	5.9 (2.4-14.4)	<0.0001		40 (21)	1.3 (0.6-2.7)	0.47	
≥65 years	71 (59)	2.8 (1.2-6.4)	0.01		133 (68)	1.9 (0.9-3.7)	0.07	
P for trend		0.001				0.13		
Sex								
Males	53 (44)	1.0		0.0005	86 (44)	1.0		0.003
Females	67 (56)	2.6 (1.5-4.4)	0.0005		109 (56)	1.8 (1.2-2.7)	0.003	
P value		0.0005				0.003		
Education								
≤High school	68 (57)	1.0		0.05	92 (48)	1.0		0.26
Some college	16 (13)	0.5 (0.3-1.1)	0.08		46 (24)	1.5 (0.9-2.6)	0.10	
College graduate/ Advanced degree	35 (29)	1.4 (0.7, 2.6)	0.30		55 (28)	1.1 (0.7-1.8)	0.57	
P for trend		0.98				0.29		
Race								
White	84 (70)	1.0		0.004	136 (70)	1.0		0.0004
African American	36 (30)	0.4 (0.3-0.8)	0.004		59 (30)	0.5 (0.3-0.7)	0.0004	
P value		0.004				0.0004		
Marital status								
Never married	6 (5)	1.0		0.20	4 (2)	1.0		0.47
Divorced/separated/ widowed	31 (26)	0.4 (0.1-1.4)	0.15		58 (30)	1.5 (0.4-5.4)	0.56	
Married/living with partner	82 (69)	0.7 (0.2-2.2)	0.50		132 (68)	1.8 (0.5-6.4)	0.35	
P for trend		0.22				0.48		
Employment status								
Employed outside the home	40 (33)	1.0		0.86	73 (37)	1.0		0.21
Retired/Not employed outside the home	80 (67)	0.9 (0.5-1.8)	0.86		122 (63)	0.7 (0.5-1.2)	0.21	
Self-rated health								
Fair/Poor	15 (13)	1.0		0.18	29 (15)	1.0		0.60
Good	53 (45)	1.9 (0.9-4.2)	0.10		88 (46)	1.3 (0.7-2.4)	0.33	
Excellent/Very good	51 (43)	1.3 (0.6-2.9)	0.49		76 (39)	1.2 (0.6-2.2)	0.60	
P for trend		0.28				0.48		
Self-efficacy[§]								
Somewhat unsure/Very unsure	47 (44)	1.0			87 (49)	1.0		0.94
Sure	22 (21)	1.0 (0.5-2.1)	0.98	0.28	32 (18)	0.7 (0.4-1.2)	0.20	
Very sure	37 (35)	1.6 (0.9-3.1)	0.14		60 (34)	1.2 (0.7-1.9)	0.55	
P for trend		0.25				0.92		
Barriers[‖]								
Disagree a lot	35 (38)	1.0		0.45	70 (41)	1.0		0.06
Disagree a little	45 (48)	0.7 (0.4-1.4)	0.28		82 (49)	0.8 (0.5-1.3)	0.38	
Agree a lot or a little	13 (14)	0.6 (0.2-1.4)	0.37		17 (10)	0.4 (0.2-0.9)	0.02	
P for trend		0.21				0.02		
Social support[¶]								
Not at all/Not applicable	13 (12)	1.0		0.69	14 (9)	1.0		0.97
Some	38 (37)	1.1 (0.4-2 .8)	0.91		64 (40)	0.9 (0.4-2.2)	0.87	
A lot	53 (51)	0.8 (0.3-2.0)	0.66		83 (52)	0.9 (0.4-2.0)	0.81	
P for trend		0.79				0.83		

*Adjusted for age, sex, race, education, and employment status.

[c]*P* value comparing each level of the variable to the reference.

[b]*P* value comparing all levels of the variable simultaneously.

[§]*Question:* How sure are you that you have the ability to succeed in eating five or more servings of fruits and vegetables every day for the next 6 months? (Very sure, sure, somewhat sure, somewhat unsure, very unsure, don't know/refused). *Very sure = higher self-efficacy*.

[‖]*Question:* Thinking about eating more fruits and vegetables than you do now, please tell me whether you agree or disagree with the following statements. It would be hard for me to eat more fruits and vegetables than I do now because: (1) I'm not in the habit of eating them, (2) I can't get them easily when I eat out, (3) I don't have enough time to prepare them, (4) They cost too much, (5) I don't think that eating more of them will make me healthier, (6) I eat alone so I don't fix enough of them. (Agree a lot, agree a little, disagree a lot, disagree a little, don't know/refused). *Agree a lot or a little = having more barriers*.

[¶]*Question:* If you tried to eat healthier foods, how much would you count on those close to you to: (1) Encourage you, (2) Tell you about healthier foods and how to prepare them, (3) Prepare healthier foods with or for you, (4) Eat healthier foods with you. (A lot, some, not at all, don't know/refused). *A lot = more social support*.

On the other hand, use of dietary supplements by cancer survivors may reflect a simple, uncomplicated approach to coping with the diagnosis and gaining some control over their health. This hypothesis is bolstered by the high use of complimentary and alternative medicine among cancer survivors (24-26), and suggestions that new use of alternative medicine may be a marker of greater psychological distress and poorer quality of life (25). However, we note that a recent survey (26) found that a high percentage (83% to 97%) of cancer patients reported using alternative medicine for general health and well-being while 8% to 56% reported use for treatment of cancer. Nonetheless, given that there may be interactions between alternative and conventional medicines (27, 28) and that the possible adverse effects of many supplements are largely unknown in this high-risk population, research into cancer survivors' knowledge, attitudes, and beliefs about supplement use would be of benefit.

It was possible to examine putative race differences in this study because 39% of the sample was African American. Except for larger increases in fruit and vegetable intakes and a much lower likelihood of reporting use of new dietary supplements after diagnosis by African American survivors, the findings did not differ significantly by race. The results for supplement use are not entirely surprising, as several studies have shown that African Americans are less likely than Whites to use dietary supplements (29-31). Although we do not know of similar studies in a mixed-race sample of cancer survivors with which to compare these results, dietary intervention trials in African Americans have resulted in significant improvements (1 serving or more) in fruit and vegetable intakes (32, 33). More research is needed to better understand how demographic/lifestyle and psychosocial characteristics may explain racial differences in colon cancer prognosis and survival.

Findings from our control group are enlightening, as they inform on both secular trends in the general population and on the possible impact on health behaviors of taking part in a research study. Overall, compared with survivors, controls made fewer changes in health behaviors although they reported significant increases in non-occupational physical activity and supplement use. As with survivors, it is not clear whether increased physical activity is attributable to the fact that many participants retired after the NCCCS and may have had more time to exercise or indicative of a conscious effort to increase physical activity. The findings for dietary supplement use seem to reflect secular trends in the U.S. population, as the prevalence of supplement use in the United States has been steadily increasing among all demographic subgroups (34-36). Controls also reported an increase in adherence to all colon cancer screening methods (except fecal occult blood testing) following participation in the NCCCS. Although baseline adherence to colon cancer screening guidelines was relatively high, the additional increase suggests that taking part in the colon cancer case-control study may have heightened awareness about the disease.

There are several strengths to this study. The prospective design obviates some of the limitations of cross-sectional studies, such as temporality and recall bias. We also had a large, population-based, and demographically diverse study population, which increases the generalizability of our results. The study sample was homogeneous with respect to cancer type, which avoids potential concerns about generalizing results across various types of cancers or comparing unequal and/or small sample sizes by cancer site. Finally, the population-based comparison group permitted an understanding of secular changes and the impact on health behaviors of participating in a case-control study of cancer risk.

Several possible limitations of this study also warrant consideration. First, although retention of the NCCCS cohort was adequate (50%), there are likely differences, for example, poorer health or less favorable behavior change, as well as education level and race, between our respondents and NCCCS participants who did not take part in NC STRIDES. Therefore, our results represent a 'best case' scenario from the most motivated participants. Second, the questionnaire items in the two studies were not always identical (e.g., fruits and vegetables) and the methods of administration were different (face-to-face versus telephone), which could have impacted our findings; for example, it is possible that respondents added other fruits or vegetables to their diets between NCCCS and NC STRIDES that we were unable to assess. Using the same questionnaires and response formats in future studies would reduce such possible sources of error. Third, psychosocial predictors (rather than correlates) of adopting healthy behaviors would have been preferable to determine how baseline (pre-diagnosis) levels of the variables are associated with behavior change after diagnosis. Fourth, we have only two time points for comparison; multiple data points would allow tracking of behavior patterns at various points during the post-diagnosis period. Fifth, because the NCCCS survey was administered after colon cancer diagnosis, there is a possibility of recall bias among the survivors, particularly in comparison to unaffected controls. Sixth, results are based entirely on self-report, which introduces the possibility of social desirability bias, and information on health status could not be verified by medical records. Finally, the population-based controls are probably more health conscious than the general population, as they had volunteered to participate in at least two research studies. Also, the controls may have had other comorbidities, for example, diabetes and hypertension, that may have led to lifestyle behavior change; this may have limited differences with the survivor group than what might have been seen with truly disease-free controls.

With the growing number of cancer survivors in the United States, lifestyle behaviors are increasingly relevant with regards to prognosis, overall health status, and quality of life. Compared with colon cancer-free controls, colon cancer survivors in this study adopted multiple healthy behaviors, characterized by increases in fruit and vegetable intake, physical activity, and use of dietary supplements. These findings suggest that persons diagnosed with cancer are very motivated to try different strategies that may improve their health (such as making healthy lifestyle changes). Also, although they have access to information about the potential efficacy of these behaviors from various sources, including family, friends, the Internet, and other media, the credibility of this information is often questionable and frequently

overstated beyond the available scientific evidence. Therefore, it is important that health care providers communicate with cancer patients/survivors to ensure that the health behaviors they may be adopting are beneficial concerning overall health and quality of life. Recent recommendations from the American Cancer Society (8) could be a very useful resource for medical practitioners who are advising cancer patients. In addition, there is a need for prospective studies to determine how lifestyle behavior changes following a cancer diagnosis may impact prognosis, recurrence, development of a secondary cancer, quality of life, and long-term survival, and to identify the salient variables associated with making and sustaining healthy behavior change in cancer survivors.

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